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Why are executive functions important? How does working memory training affect them?

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June , 2016

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Agenda

- What are executive functions (EF) and why do they matter?
- What are the unresolved challenges to the constructs of executive functions?
- What is the relationship of EF to academic achievement?
- How do situational learning factors affect the expected role of EF and Cogmed?
- What factors facilitate and limit the possible impact of Cogmed?
- What have Cogmed-specific studies found?
- What are some measures that can help with assessing and monitoring progress in EF?

Executive functioning Theory & Concepts

Executive Functions: *Executive functions are theoretical constructs which have received some empirical support that help us begin to understand how different people vary in cognitive performance.*

•EF: Mental functions that are associated with the ability to engage in purposeful, organized, self-regulated and goal-directed behaviors. (Riccio, 2009).

•EF allow one to integrate, synthesize, and organize other cognitive processes (Wecker et al., 2000.)

•EF permit a person to perform certain cognitive tasks that will enable academic achievement.

•EF generally refer to higher-order cognitive processes that enable the individual to successfully manage/regulate and monitor their behavior in complex environments and over the course of time. (Barkley 1996).

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Executive functioning Theory & Concepts

•Given that executive functions (EF's) influence performance on other cognitive abilities, they will have an influence on intellectual functioning albeit not to the same degree as language development or intelligence. One may argue that EF's influence the extent to which one can capitalize upon their intelligence and language development.

•Good EF:

- •Will approach problems in an organized manner.
- •Will plan their response before initiating problem-solving.
- •Will actively learn from experience if they do make an error.

•Poor EF:

- •Difficulty initiating behavior.
- •Will give up quickly because they do not know how to search for novel solutions to problems.
- •Will perform tests haphazardly, making impulsive responses and often repeating mistakes.
- •Fail to monitor their work.
- •Lose time bonuses or points due to careless inattentive mistakes because their effort is by trial and error rather than systematic, planned and organized activity.
- •Trouble with tasks that require fluid reasoning.

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Executive Functioning (EF) Skills

There is a lack of consensus as to what are the components of executive functions. In fact it is fairly unclear which EF's have received the most empirical support. Nonetheless, here are some of the common suspects.

Working memory - The capacity to hold information in mind for the purpose of completing a task.

Inhibition - The ability to stop one's own behavior at the appropriate time, including stopping actions and thoughts. The flip side of inhibition is impulsivity; if you have weak ability to stop yourself from acting on your impulses, then you are "impulsive."

Shifting - The ability to move freely from one situation to another and to think flexibly in order to respond appropriately to the situation.

Emotional Control - The ability to modulate emotional responses by bringing rational thought to bear on feelings.

Initiation - The ability to begin a task or activity and to independently generate ideas, responses, or problem-solving strategies.

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EF Skills

Planning/Organization - The ability to manage current and future- oriented task demands. (e.g. the ability to systematically think about what the family would need to be ready for a trip and to get to the intended place on time with their needs cared for along the way.)

Organization of Materials - The ability to impose order on work, play, and storage spaces. (If you just piled things into the car rather than systematically making checklists and organizing things so important items would be easily accessible, so the space would be used efficiently, then people and "stuff" would be orderly and comfortable in the car.)

Self-Monitoring - The ability to monitor one's own performance and to measure it against some standard of what is needed or expected. (On a road trip do know how to get there, with almost no planning for what will happen along the way, and without a map or Garmin or cell phone with maps?)

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E F Examples.

Example of Executive Functions in action on an organizational level: Running an airline.

Imagine having to organize when an airplane is prepared for flight, with a trained crew, passengers, bags, and food and beverages.

Imagine the path on the runway the plane has to take to "take-off" from and flightpath to reach their destination, weather alerts, landing and air traffic control. Without monitoring of all phases there could be a crash and loss of life. Having effective EF means the plane is safe and passengers will be able to travel.

Planning, organizing, prioritizing and monitoring progress are all vital tasks in daily life and in academic achievement.

Less daunting and more personal examples still have considerable complexity:
- Making a meal and timing it so that all the food is completed at the same time.
- Planning a vacation.
- Improving reading comprehension.
- Learning to read.
- Etc.

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EF's Applied to Children

Do they get homework done? Is it on time? Can they find it to hand in at school?

Do they bring home the necessary supplies to complete homework?

Do they know & bring home the content needed to study for tests, write papers, complete projects?

Do they remember to get notes signed for field trips?

Do they remember dates for school events?

Do they recall their own sporting events and practices?

Do they allow enough time for long term school projects?

Do they interrupt others who are talking?

Do they listen carefully to instructions?

Do they bring what they need to school?

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EF Deficits and Medical conditions…

Executive functioning deficits have been associated with a variety of medical conditions.

Traumatic Brain Injury: Traumatic brain injury is often associated with diffuse, temporal lobe and frontal lobe damage (Wilde, Hunter, Newsome, Scheibel, et al, 2005) resulting in deficits in executive functioning (Brookshire B, Levin HS, Song J, & Zhang L. 2004).

Pre-natal exposure to alcohol with or without a diagnosis of Fetal Alcohol Syndrome associated with EF deficits in childhood (Mattson, Goodman, Caine, Delis, & Riley 1999).

Epilepsy (Fastenau, Shen, Dunn, Perkins, et al, 2004).

Metabolic disorders, such as phenylketonuria, may (Antshel & Waisbren, 2003) or may not (Channon, German, Cassina, & Lee, 2004) be associated with deficits in executive function but such a medical history of a metabolic disorder warrants an investigation of these skills. Obtaining the child's medical information prior to initiating testing can provide valuable information regarding potential deficits in executive functioning (Powell & Voeller, 2004).

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EF Deficits & Mental Health Disorders

ADHD
Schizophrenia
TBI
Post Traumatic Stress Disorder – childhood abuse survivors (Gould, Clarke, Heim, Harvey, Majer & Nemeroff, 2012) adult with PTSD (Schuitevoerder, Rosen, Twamley, Ayers, Sones, Lohr, Goetter, Fonzo, Holloway & Thorp, 2013).
Autism
Down syndrome

And many more…

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Unresolved challenges to the constructs of executive functions

Which EF skills compose the "core" or critical EF functions?
Which EF's have the most empirical support?
Is there empirical stability to EF skills?
Notable and complex situational factors apply to individual learning situations:

- Preschoolers learning to read.
- High school students improving reading comprehension.
- Mastering the times tables.
- Algebraic problem solving.

Situational factors make discerning the role that EF's play very difficult.

This complexity suggests that one will have to start with the learning end goal and plan from there.
This will likely include several steps.
Several individual factors come into play: developmental levels and individual strengths and weaknesses, motivation, mindsets, etc.
Cogmed, is only one step in a multi-step learning sequence.

The question is not can Cogmed "do it all". The question is can Cogmed do what it is intended to do?

And what are the implications of that? Do improved EF's play a role in facilitating far transfer?

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Cogmed was intended to improve WM: Yet most are more interested in far transfer.

Is it most wise and reasonable to accept that improved WM, the primary target of Cogmed, is the only criteria upon which successful implementation of Cogmed should be judged? ***Have Cogmed claims moved too far beyond that already? Are there any qualifications that should be emphasized?***

Over time as Cogmed research has developed new claims have been added to our claims and evidence:

CWMT leads to sustained *improvements in attention* seen in objective and subjective measures, improvements in WM are associated with *changes in functional brain activity*, ***learning outcomes in reading and math improves for many students*** following CWMT, in **clinical trials** CWMT has been shown to ***improve attentional problems in many with ADHD***, research studies of CWMT report ***improved cognitive functioning in daily life***.

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Note the Cogmed Claims with qualifications.

Learning outcomes in reading and math improves for many students following CWMT.
In **clinical trials** CWMT has been shown to ***improve attentional problems in many with ADHD***.

Note that the above two claims that come under the most scrutiny also have qualifiers: "for many students" and "In clinical trials" and "in many with ADHD".

It is not a mistake that there are qualifiers with these two claims. Learning outcomes are affected by many individual and situational variables. ADHD is a heterogeneous disorder and as a result "many" will show improvements post Cogmed in attention but not all.

These qualifications merit caution and consideration.

Yet, those of us who have worked with Cogmed for many years also become excited and intrigued by far transfer gains, but accomplishing them is quite complex.

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Attempting to understand the role of EF's with Cogmed and far transfer: promise & challenges

If through Cogmed WM improves will other EF's improve?
Do we know which EF's are more likely to improve post Cogmed other than WM?
Are EF's a critical facilitating factor in far transfer of effects?
Can we empirically derive which specific EF's are salient in which learning situations?
What other specific and general cognitive processes are needed to be the focus of intervention to facilitate far transfer?

Should activities of daily living be consider a more important area of far transfer for Cogmed?

Waiting for empirically derived answers takes time and is usually a messy and unwieldy process.
Yet, recent research has at least gives partial answers or inklings as to the answers to these questions.

First, we will generally consider EF's in light of academic achievement.
Later we will consider Cogmed specifically.

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Executive functions (EF) contribution to academic achievement among preschoolers.

(Jerauld, 2015, dissertation)

N=969 children between 54-71 months old (4.5-5.9 years old)
EF skills measured using the Dimensional Change Card Sort task (DCCS).

Will this predict math, reading, and writing achievement in 3-5 year olds?

Assessments: Phonological Awareness Literacy Screening (PALS)
Test of Early Math ability Third Edition (TEMA-3)
Sections of Battelle Developmental Inventory 2nd edition (BDI-2).

Results:
1. Early EF predicted early math, reading and writing skills.
2. EF contributed a significant portion of variance in early math, reading, and writing skills *after accounting for general development, age & SES.*
3. The contribution of EF to early reading and writing skills remained stable between 3 to 5 years old while EF was a stronger predictor of early math skills among 3-year-olds compared to 5-year-olds.

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EF's Predict Preschoolers successful adaptation to school.

(Neuenschwander, et al., 2012)

Results of a 1-year longitudinal study (*N* = 459). **Kindergarten children**. Switzerland.

Importantly, "unique contributions of executive functions (performance on tasks) to school grades were only partially mediated by children's learning-related behavior."

"…executive functions predicted performance in standardized achievement tests exclusively, with comparable predictive power for mathematical and reading/writing skills. Controlling for fluid intelligence did not change the pattern of prediction substantially, and fluid intelligence did not explain any variance above that of the two included aspects of self-regulation."

"Although effortful control and executive functions were not significantly related to each other, both aspects of self-regulation were shown to be important for fostering early learning and good classroom adjustment in children around transition to school."

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WM & Attentional control predicted growth in emergent literacy and numeracy skills.

(Welsh, et al., 2010)

N=164, Head Start children 44% African American or Latino; 57% female, followed longitudinally.
Pre-kindergartners.

"Path analyses revealed that working memory and attention control predicted ***growth in emergent literacy and numeracy skills*** during the prekindergarten year and that growth in these domain-general cognitive skills made unique contributions to the prediction of kindergarten math and reading achievement, ***controlling for growth in domain-specific skills***."

Interestingly if a child lacked literacy and numeracy skills in preschool and completed Cogmed would such children automatically improve in literacy and numeracy? ***How long might that take?***

Or would one want to ensure the development of literacy and numeracy by following Cogmed with additional remediation programs to address these possible deficits?

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Adolescent EF's: Conceptual flexibility, monitoring and inhibition contributed to academic prediction.

(Latzman, et al., 2010)

N=151, 11-16 year-old males.

"EF contributed to the prediction of all academic domains ***beyond general intellectual functioning*** in distinct ways: **Conceptual flexibility predicted reading and science, monitoring predicted reading and social studies**, and **inhibition predicted mathematics and science**. These findings suggest that demands related to specific academic domains access different cognitive abilities and have implications for both intervention and research science."

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Adolescent EF did ***not*** predict academic achievement.

(Boschloo, et al., 2014)

Self-monitoring, planning, and organizing did not predict academic achievement among n=173 healthy adolescents ages 12-18.
All "pre-university" track boys compared to girls.

"Results showed that there was no relation between the report marks obtained and the performance on executive function tests, notably the Sorting Test and the Tower Test of the Delis-Kaplan Executive Functions System (D-KEFS). Likewise, no relation was found between the report marks and the scores on the Behavior Rating Inventory of Executive Function—Self-Report Version (BRIEF-SR) after these were controlled for grade, sex, and level of parental education. The findings indicate that executive functioning as measured with widely used instruments such as the BRIEF-SR does not predict school performance of adolescents in preuniversity education any better than a student's grade, sex, and level of parental education."

The relationship of EF and academic achievement in adolescence may be less clear than among younger children.

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Domain Specific factors of play a substantial role in reading comprehension difficulties of ADHD youth.

(Martinussen & Mackenzie, 2015)

Investigation of youth (adolescents) reading comprehension of those with and without an ADHD diagnosis.

Youth with ADHD scored significantly lower than the comparison youth on a standardized measure of reading comprehension.

Poor comprehenders with ADHD vs good comprehenders with ADHD, had ***weaknesses in expressive vocabulary, mathematical reasoning, written expression and exhibited more EF difficulties reported by the teacher.***

HOWEVER, expressive vocabulary and word reading NOT teacher EF rating accounted for unique variance in reading comprehension performance and mediated the relationship between ADHD symptoms and reading comprehension.

So, to improve reading comprehension shouldn't expressive vocabulary & word reading be reasonable targets for intervention post Cogmed? Maybe possibly written expression as well?

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Severity of WM deficits among ADHD varies. What are the implications for Cogmed?

(Gomez, et al., 2014)

N=701 children with ADHD. Assessed on Visual spatial WM, spatial central executive, verbal central executive. Latent profile analysis used to separate into ADHD children into 3 groups.
Also, a clinical comparison group was used.
Group 1 (n=196): Greatest WM deficits & Lower IQ, Lower Academic abilities & more depressive disorders.
Group 2 (n=394): Worse WM than group 3 & the clinical comparison group.
Group 3 (n=111): No difference between group 3 and the clinical comparison group.

CRITICAL FINDINGS: These findings support both the notion that those with ADHD are a heterogeneous group. Some have more severe deficits in WM than others. Additionally more comorbidity tends to be associated with worse WM giving this group an even more severe level of disordered functioning. Yet, some do NOT have worse WM than other clinical comparison groups!

Possible Implication: These findings suggest that dosing of computerized cognitive training may make sense with varying levels of severity of disorder and comorbidity. Also, one would expect the possibility of varying levels of impact of Cogmed given varying levels of severity of disorder and comorbidity.

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Complicated profiles, ADHD & SLI, Complicated Outcomes.

(Cohen, et al., 2000).

Most frequent comorbid diagnosis of language impairment (LI) is ADHD.
Compared 4 groups: Those with LI, those with LI & ADHD, those with ADHD and no LI, other diagnoses with LI or without LI.

Subjects with LI "were the most disadvantaged regardless of the nature of the psychiatric diagnosis."

"***Contrary to prediction, working memory measures, used to tap core cognitive deficit of ADHD in executive functions, were more closely associated with LI than ADHD***. It was concluded that caution must be exercised in attributing to children with ADHD what might be a reflection of problems of children with LI generally."

This findings are somewhat similar to the results of the Cogmed specific study by (Roording-Ragetlie, et al., 2016) which found that the LD group did not experience the same level of benefits as did those with ADHD or those with learning problems.

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Plot thickens: Processing speed, temporal processing and WM play a role in SLI.

(Moll, et al., 2016)

N=99, 4 groups, reading disability (RD), math disability (MD), both, Typically developing (TD)

There are high comorbidity rates between RD & MD.

All 3 risk factors related to poor attention: Processing speed, temporal processing & WM.

Control for attention and RD & MD differed, but ***both RD & MD had worse verbal memory than TD students.***

RD worse processing speed but was restricted to nameable symbols.

MD associated with temporal processing and visuospatial memory deficits.
Varying deficits will require different Cogmed+ or post Cogmed interventions.

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Given this complexity does a shotgun approach of giving Cogmed to everyone make sense?

It depends upon what you are expecting.

If you hope that all or most improve on WM it could make sense. Or if you want all or most to improve upon sustained attention it may also make sense.

If the only definition of success is far transfer to improved reading or math skills then this is a fairly risky strategy. ***WHY?***

As already noted several different factors can affect each individual learning situation.

Preschoolers learning to read who have poor WM, but also have poor phonological awareness and a poor understanding of even their letters are unlikely to become significantly better readers after only Cogmed.

What if some of them don't have poor WM? What if some have extremely bad WM and others only a minor deficit? While WM is likely to improve would it be enough for improved reading?

Time is also a factor. Has enough time passed for students to begin to use better WM?

What if some of them have poor impulse control and hyperactivity too?

What if some have poor phonological awareness and some don't?

What if some are defiant?

What if some have processing speed deficits?

What if some are not motivated and others are?

With considerable complexity & individual differences impacting far transfer this becomes quite challenging.

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So, if Cogmed can result in improved WM it has the ***potential*** to have a notable impact upon learning, ***BUT*** there are limiting, facilitating & moderating factors.

Can the impact of Cogmed upon Executive Functions facilitate or moderate far transfer?

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Can improving WM open the door to gains?

Are there factors which may limit, facilitate or moderate gains?

Limiting factors?

Severity of Disorder?

ADHD-C vs ADHD-I?

Comorbid disorders?

Learning Disabilities?

Learning Problems?

Are improved EF's possibly a moderating factor?

Facilitating factors?

Dosing of Cogmed?

Motivation?

Rx?

Cogmed-Plus?

Domain general training?

Domain specific training?

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Far Transfer (red) appears more likely among those with mild to moderate severity & comorbidity while Rx is also a factor to consider.

Study	WM deficit	ADHD-I Attention problems	ADHD-C	ADHD-HI	Rx%	LD	ODD/CD
Holmes & Gathercole, 2013 (trial 1) mixed ability.	NR	NR	NR	NR	NR	NR	NR
Holmes, et al., 2009	100%	NR*	NR	NR	NR	NR	NR
Dunning, et al., 2013	100%	NR	NR	NR	NR	NR	NR
Bergman-Nutley & Klingberg, 2014	100%	Mainly Attentive problems	Attentive problems/minor HI	Minor HI	NR	NR	Minor
Holmes & Gathercole, 2013 (trial 2)	NR	NR	NR	NR	NR	100% (Low aca. Perf.=learning problems)	NR
Dahlin, 2010	NR	33% diag. 60% rated inatt.**	NR	NR	NR	9.5%***	0%
Dahlin, 2013 (not randomized)	-	33% diag. 60% rated inatt.**	22%	NR	NR	22%	0%
Klingberg, et al. 2002	-	NR	100%?	NR	43%	NR	NR
2005 Klingberg, et al. 2005	-	25%	75%	0%	0%	NR	0%
****Hovik, et al., 2013/Egeland	-	0%	100%	0%	69.6%	NR	NA/0%
Green, et al., 2012	-	42%	42%	17%	67%	0%	NR
Van Dongen-Boomsma, et al., 2014	-	7.7 %	**80.8%**	**11.5%**	**0%**	NR	3.8%/0%
Beck et al., 2010	NA	71%	29%	NR	61%	NR	46%
Chacko, et al., 2013	-	34%	66%	0%	**27%**	NR	50%/9%*
Groppe, et al., 2014	-	**51%*****	**NR**	**NR**	26%	57%	NR
Gray et al., 2012	-	NR	**100%**	**NR**	98%	**100% Severe**	**100%/0%***

Cogmed, EF & Far Transfer: A complex picture.

Study	WM deficit	ADHD-I Attention problems	ADHD-C	Executive Functioning Transfer?	Far Transfer	Rx%	LD	ODD/CD
Foy & Mann, 2014 Preschoolers.	NR	NR	NR	Executive Control	**No Improvement** on Phoneme awareness or letter knowledge.	NR	NR	NR
Bigorra, et al., 2015 Ages: 7-12 years old.	NR	0%	100%	BRIEF: Par. meta/WM, Plan/org, **Teacher: Initiate,** WM, plan/org, + monitor & shift follow. CPT reduced comm. errors & imp. detectability, perf based WM index, imp. school learn. Beh.	**No improvement** on Reading Comprehension Test	0%	0%	ODD (31% Tx, 23% cont.), 0% CD
Bergman-Nutley & Klingberg, 2014 ages 7-12	100%	Mainly Attentive problems	Attentive problems/minor HI	Following Instructions	Math fluency.	NR	NR	Minor
Green, et al., 2012 7-14 years old.	-	42%	42%	On Task behavior.	NR	**67%**	0%	NR
Roording-Ragetlie, et al., 2016 7-17 years old.	15.5% (ADHD-NOS)	28.8%	55.5%	BRIEF Parent Rating: **Total Score & WM** subscale.	NR	15.5% (only ADHD children)%	*N*=34, LP *n*=34	0%
Beck et al., 2010 7-17 years old.	NA	71%	29%	BRIEF Parent: meta/**WM**, Initiate, Plan/org, **Teacher: Initiate**	NR	61%	NR	46%
Groppe, et al., 2014 19-52 years old.	-	**51%*****	**NR**	Cognitive Failure Questionnaire	NR	26%	57%	NR
Van der Donk, et al 2016 8-12 years old.	13%	29%	58%	ADHD-C & ADHD-I Post Cogmed group showed improvement on Parent & teacher BRIEF beh. Reg. index. ADHD-C maintained. ADHD-I increased at follow up , BUT still better than ADHD-C. Teacher BRIEF beh. Reg. index & metacognition index moderated ADHD-I Cogmed fewer problems over time vs PAC.	Word reading accuracy. ADHD-C improved & kept at Follow up. ADHD-I decreased post & increased at follow up so still higher than ADHD-C.	50% (Cogmed) 60% (PAC)	*31% (Cogmed), 38% (PAC)	*31% (Cogmed), 38% (PAC)

Study	WM deficit	ADHD-I Attention problems	ADHD-C	Executive Functioning Transfer?	Far Transfer	Rx%	LD	ODD/CD
Bigorra, et al., 2015 Ages: 7-12 years old.	NR	0%	100%	BRIEF: Par. meta/WM, Plan/org, **Teacher: Initiate,** WM, plan/org, + monitor & shift follow. CPT reduced comm. errors & imp. detectability, perf based WM index, imp. school learn. Beh.	**No improvement** on Reading Comprehension Test	0%	0%	ODD (31% Tx, 23% cont.), 0% CD
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Bigorra et al., 2015:
BRIEF:
Parents: Par. Metacognitive functioning/WM, Planning/organizing.
Teacher: Initiate, WM, planning/organizing + monitor & shift at follow up.

CPT reduced commission errors & improved detectability.
Improved performance based WM index.
Improved school learning Behavior on the Weiss Functional Impairment Rating Scale.
Far transfer: No improvement on reading comprehension.

Van der Donk, et al., 2016.
BRIEF:
Parents: Behavioral regulation index.
Teachers: Behavioral regulation index, metacognition index.
ADHD-I better overall response than ADHD-C
Far Transfer: Improvement on word reading accuracy.
<u>This is a less complex task than reading comprehension.</u>

Teacher behavioral regulation index & metacognition index moderated ADHD-I effects which had fewer problems over time vs. PAC.

Cogmed with school-age ADHD children and far transfer to EF.
(Bigorra, et al., 2015)

Study	WM deficit	ADHD-I Attention problems	ADHD-C	Executive Functions	Rx%	LD	ODD/CD
Bigorra, et al 2015	NR	0%	100%	BRIEF: Parent: metacog./WM, Plan/org. Teacher: Initiate, WM, plan/org. + monitor & shift also at follow up. CPT reduced commission errors & improved detectability, performance based WM index, improved school learning behavior.	0%	0%	ODD (31% Tx, 23% cont.), 0% CD

Primary aim of study: "to analyze the efficacy of computerized WM training (CWMT) on EF rating scales."
Secondary aim: "to assess its efficacy on performance-based measures of EF (PBMEF). "
RCT to experimental group or "placebo training".
n=66, **ADHD**-C. Ages (7-12). Mean age experimental group = 8.79, mean age control group=9.04.
n=36 Treatment, n=30 control. No previous psychological or psychiatric treatment for ADHD.

Exclusion criteria: IQ <80, LD, Autism, psychosis, Affective or anxiety disorder, consumption of toxic substance, TBI in last 2 years, perceptual-motor alterations preclude computer use. "Participants whose educational or socio-economic context would make it unlikely to comply with study requirements & follow treatment procedure" (e.g. didn't speak Spanish, suspected of abuse/neglect, etc.). ***Also, if participated in fewer than 20 training sessions excluded. Or if participated in Rx or psychological treatment for ADHD before the conclusion of the study. 4 did not complete, 2 due to IT problems, 2 just dropped out. Interestingly, 6 (9.2%) dropped out due to starting pharmacological treatment, but there was not a significant different between the treatment and control groups on this issue.***

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Cogmed with school-age ADHD children and far transfer to EF.
(Bigorra, et al., 2015)

Assessments:

T0= baseline, T1=1-2 weeks post Cogmed, **T2=6 months post Cogmed**.
EF rating scales, Performance based measures of EF (PBMEF), academic achievement, questionnaires regarding clinical symptoms and functional impairment.
Parents, teachers, participants and professionals blinded to group assignment.
Results:

BRIEF: Behavior Rating Inventory of Executive Function
T1-T2, EF **parent** ratings **significant improvement on:**

WM (d'=-.86, 95% CI -.17-.35) at T1-T2 and remained significant at follow up. (d'=.61, 95% CI -1.11 to .11), &
T1-T2: plan/organize (d'=.71, 95% CI -1.21 to -.21).
T1-T2: metacognitive index, (d'=.78, 95% CI -1.28 to -.27).

T0-T1-T2, EF teacher ratings significant improvement on:
initiate T2-T0. (**d'=-.55,** 95% CI -1.05 to .05), **increased at follow up to**: (**d'=-.57**, 95% CI -1.02 to .07),
WM T2-T0. (**d'=-.36**, 95% CI -.85 to .13), **increased at follow up** to: (**d'=-.84**, 95% CI -1.35 to .33),
metacognitive index, (**d'=-.36**, 95% CI -.85 to .13), & **increased at follow up** to: (**d'=-.81**, 95% CI -1.31 to .30).

Also at follow up **monitor significantly improved to**: (**d'=-.72**, 95% CI -1.22 to .28)
& **shift subscales significantly improved** to: (**d'=-.39**, 95% CI -.88 to .10).

PBMEF performance-based measures of EF: see next slide.

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Cogmed with school-age ADHD children and far transfer to EF.
(Bigorra, et al., 2015)

PBMEF performance-based measures of EF.

Weiss Functional Impairment Rating: subscales: family, school learning behavior, life skills, child's self-concept, social activities, risk activities, total:
Significant improvement only on school learning behavior: large effect size (d'=-.86, 95% CI, -1.27 to -.35).

WISC-IV: Digit Span Backward, Letter-Number Sequencing, Wechsler memory Scale III: Spatial span backward.
From T0-T1 **significant improvement with a large effect size on WM composite** (d'=.81, 95% CI, .30 to 1.32). Persisted at follow up: (**d'**=.12, 95% CI -.67 to .61).

Commission errors of Conners' continuous performance test. From T0-T1 **significant improvement with a moderate effect size** (d'=.40, 95% CI, .89 to .09). Improvement persisted at follow up.

Detectability of CPT II: From T0-T1 **significant improvement with** (d'=.60, 95% CI, .1 to 1.10). Improvement persisted at follow up.

Total Correct score of the tower of London DX. No significant improvement.

Preservative errors of the Wisconsin card sorting test. No significant improvement.

Trail making test part B. No significant improvement.
Reading Comprehension. No significant improvement.

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Predictors & Moderators of Treatment Outcome in Cognitive Training for Children with ADHD

(Van der Donk, et al., 2016)

Study	ADHD-NOS	ADHD-I Attention problems	ADHD-C	Executive Functions	Far Transfer	Rx%	LD	ODD/CD
Van der Donk, et al 2016	13%	29%	58%	ADHD-C & ADHD-I Post Cogmed group showed improvement on Parent & teacher BRIEF beh. Reg. index. ADHD-C maintained. ADHD-I increased at follow up , BUT still better than ADHD-C. **Teacher BRIEF beh. Reg. index & metacognition index moderated ADHD-I Cogmed fewer problems over time vs PAC**	Word reading accuracy. ADHD-C improved & kept at Follow up. ADHD-I decreased post & increased at follow up so still higher than ADHD-C.	50% (Cogmed) 60% (PAC)	*31% (Cogmed), 38% (PAC)	*31% (Cogmed), 38% (PAC)

*The study did not separate LD for other comorbid disorders like ODD. So, the Cogmed group had 31% comorbidity while the PAC group had 38%.

Do clinical variables and initial cognitive abilities predict or moderate far transfer treatment outcomes of cognitive training? Groups randomly assigned to Cogmed or "Paying Attention in Class" (PAC) a new cognitive training. n=98, children ages 8-12. n=48 Cogmed, n=50 Play attention. 69% male (Cogmed), 74% male (PAC) .

Outcomes measures: Neurocognitive assessment, parent & teacher ratings of executive functioning (EF) behavior and academic performance.

Predictor variables: Rx, comorbidity, ADHD subtype, initial verbal, VWM & VSWM.

Pearson

Rx & Comorbidity as Predictors & Moderators of Treatment Outcome in Cognitive Training for Children with ADHD

(Van der Donk, et al., 2016)

Initial Verbal WM	**Cogmed**	PAC	P
Low	12 (25%)	16 (32%)	Ns
Average	30 (62.5%)	29 (58%)	Ns
Above Average	6 (12.5%)	5 (10%)	Ns
Initial Visual Spatial WM			
Low	9 (18.75%)	14 (28%)	Ns
Average	32 (66%)	32 (64%)	Ns
Above Average	7 (14.5%)	4 (8%)	

Results: Subtype of ADHD predicted & moderated Parent & teacher ratings of EF.

Subtype of ADHD & comorbidity predicted word reading accuracy.

Rx, VWM & VSWM predicted and moderated near transfer measures.

Conclusion: Cognitive training can be beneficial for certain subgroups of children with ADHD, individual differences should be taken into account in future trials.

Pearson

Rx & Comorbidity as Predictors & Moderators of Treatment Outcome in Cognitive Training for Children with ADHD

(Van der Donk, et al., 2016)

Breaking down the results:

Cogmed resulted in an improvement on VSWM for all groups that was greater than the control group. Time effects were found on several variables.

Rx: **Impacted upon VSWM**: Directly after Cogmed children on Rx benefitted the most from Cogmed in terms of VSWM which was maintained at follow up. Children without Rx also benefited with improved VSWM at the conclusion of Cogmed, but this was not maintained at follow up.

For 45 children on Rx, type of Rx was changed for 10 at follow up.

For 40 who did not use Rx during Cogmed, 4 started Rx at follow up.

Comorbidity adversely affected far transfer: Predicted effect on word reading accuracy. Children without comorbidity increased on word reading accuracy directly after treatment those with comorbidity decreased in accuracy.

Pearson

ADHD Subtype as Predictor of Treatment Outcome in Cognitive Training for Children with ADHD, Near Transfer

(Van der Donk, et al., 2016)

ADHD Subtype:
Predicted & Moderated Parent Ratings of EF:

ADHD-C: BRIEF behavioral regulation index rated by parents & teachers showed a decrease in behavioral regulation problems both directly post Cogmed and at follow up.

ADHD-I: Steep decrease behavioral problems post Cogmed, but increase at follow up.

Teacher Rating of Beh. Reg. Index & & Metacognitive Index:

ADHD-C: Decrease of problems over time (both post and follow up) & no difference between intervention groups.

ADHD-I: Decrease in problems over time.

Summary: ADHD-I group benefitted more both short and long term. In short-term ADHD-I benefitted more from Cogmed in general in terms of parent and teacher rated behavioral regulation problems. Long-term ADHD-I benefitted on teacher rated behavioral regulation, metacognition problems. ***ADHD-C still showed more problems than children with ADHD-I subtype over time.***

Children in PAC intervention: Increase of problems at follow up.

Pearson

Initial Cognitive Abilities, subtype & comorbidity as Predictors of Treatment Outcome in Cognitive Training for Children with ADHD.

(Van der Donk, et al., 2016)

Initial VSWM: Children 'below average' and 'average' shoed improvements over time.
Children 'above average' showed a decrease in performance over time, but were still higher than the other groups at all time points.

Subtype of ADHD & Comorbidity: Predicted word reading accuracy.

Pearson

ADHD Subtype as Predictor of Treatment Outcome in Cognitive Training for Children with ADHD, Far Transfer.

(Van der Donk, et al., 2016)

ADHD-C: Improved on word reading accuracy directly post Cogmed and was maintained at follow up.
ADHD-I: ***Decrease in word reading accuracy post Cogmed, but improved at follow-up & even outperformed ADHD-C children.*** THIS IS SURPRISING AND FAIRLY UNPREDICTABLE.

This finding highlights an element of unpredictability in the change process and the timing of change.

The overall trends of data in this study generally supported our hypotheses based upon previous data.

Pearson

Cogmed with children with Different Neurodevelopmental Disorders has impact upon EF (ADHD, LD, Learning Problems)

(Roording-Ragetlie, et al., 2016)

Study	**ADHD-NOS**	ADHD-I Attention problems	ADHD-C	Executive Functions	Rx%	LD	ODD/CD
Roording-Ragetlie, et al 2016	15.5%	28.8%	55.5%	BRIEF Parent Rating: Total Score & WM subscale.	15.5 (only ADHD children)%	N=34, LP n=34	0%

n=99, **ADHD** (n=45), **LD** (n=34), **learning problems** (n=20). Ages (7-17). 25 sessions of Cogmed. WM, ADHD DSM-IV rating scales BRIEF scales used to measure outcomes. N=7 of ADHD children taking medication. **Hypothesis**: "training effects may lie on a continuum with those of the LD group at the lower end and those of the learning problems group at the upper end."
Results: ***Partly confirmed the hypothesis in that all groups improved significantly with ADHD children or children with learning problems showing the best results.*** Improvement was

Roording-Ragetlie, S., Klip, H., Buitelaar, J., & Slaats-Willemse, D. (2016). Working Memory Training in Children with Neurodevelopmental Disorders. *Psychology, 7, 310-325. http://dx.doi.org/10.4236/psych.2016.73034*

Pearson

Cogmed with children with Different Neurodevelopmental Disorders (ADHD, LD, Learning Problems)

(Roording-Ragetlie, et al., 2016)

ADHD (n=45), n=7 taking Rx (6 stimulants, 1 Medikinet). Rx stable before and after Cogmed.
ADND (n=45)
•ADHD-I (n=25) (55.5%)
•ADHD-C (n=13) (28.8%
•NOS (n=7) (15.5%)

LD (n=34)
•Dyslexia (n=25)
•Dyscalculia (n=3)
•NOS (n=6)

Learning problems (n=20)

RM for all but n=4 who did JM. All diagnosed with ADHD free of Rx.
Note: Re-ran analyses excluding children on Rx, children who did JM (n=4) and children with dyslexia (n=3) and main and interaction effects remained.

Pearson

Cogmed with children with Different Neurodevelopmental Disorders (ADHD, LD, Learning Problems)

(Roording-Ragetlie, et al., 2016)

LD: Diagnosed by a registered clinical psychologist in the Netherlands (Dutch guidelines).
Learning problems: Without a DSM-IV diagnosis. "These children were experiencing academic achievement problems (lower grades than expected) and mixed neuropsychological impairments (memory- or attention problems in the classroom), as well as learning-related behavioural problems (Alloway & Alloway, 2010). Learning problems were diagnosed according to an official Dutch system that ***monitors academic achievement at school supplemented by the clinical opinion of the clinical psychologist and reports by parents and teachers about the child's development***."

Exclusion criteria:
1) a medical illness requiring immediate treatment as this meant that participating in an intensive training would be too demanding; 2) a motor or perceptual disability preventing the subject from using the computer program; 3) no access to a personal computer with an internet connection at home or in school; 4) a lack of motivation (e.g. willingness on the part of the parents to participate, but not on the part of the child); or 5) a co-morbid (psychiatric) diagnosis.

Pearson

Cogmed with children with Different Neurodevelopmental Disorders (ADHD, LD, Learning Problems)

(Roording-Ragetlie, et al., 2016)

Outcome Measures:
Dutch version of the ADHD rating scale (ADHD Vragen, Lijst, **AVL**,; Scholte & Van der Ploeg, 2005). One index was for inattention and a second for hyperactivity/impulsivity. Completed by parents.

BRIEF (Behavior Rating Inventory of Executive Function checklist). Completed by parents. Total score and WM index score were used.

Child Behavior Checklist

WM capacity measured by two Cogmed components within the training program (Training index).

Pearson

Cogmed with children with Different Neurodevelopmental Disorders (ADHD, LD, Learning Problems)

(Roording-Ragetlie, et al., 2016)

All three groups showed significant gains suggesting all groups profit from training:
•AVL-Inattention ($p<.0001$) Eta=.57
•AVL-Hyperactivity/Impulsivity ($p<.0001$), eta=.33.
•BRIEF Total ($p<.0001$) Eta=.27
•WM Index (measured within the program by averaging 2 activity scores) ($p<.0001$), Eta=.90.

However, children with LD benefited less than the other groups on:
•Hyperactivity/impulsivity
•BRIEF Total

Also post hoc Bonferroni analysis revealed that Inattention was statistically different between the ADHD and LD groups.
The hyperactivity/impulsivity was borderline statistically different between the LD and ADHD group also.

Pearson

Cogmed with children with Different Neurodevelopmental Disorders (ADHD, LD, Learning Problems)

(Roording-Ragetlie, et al., 2016)

Possible Explanations: LD group needs more time to establish behavioral and EF-related improvements in daily life (Holmes, et al., 2009). 6 months post Cogmed post Cogmed gains in mathematics were found but no improvement found immediately following Cogmed (Holmes, et al., 2009).
For the LD group the training may be primarily attention training not WM training. Holmes et al., 2009 found 37% of LD children in that study improved on attentional focus.

Other cognitive factors may play a critical role in LD: comprehension, listening and writing, phonological deficits and number module deficits.

"When looked at more closely, children in our study with *learning problems showed a considerably higher baseline measurement regarding hyperactivity/impulsivity problems (meaning more problems) compared to children with LD.* Perhaps the fact that there was less room for improvement in the LD group may explain the difference found in terms of benefit between these groups." Or these differences may be statistical error or due to the measures used.

Pearson

Cogmed & Neurodevelopmental Disorders

(Roording-Ragetlie, et al., 2016)

Limitations: "A major limitation of this study is the absence of a randomized design and a control condition. Therefore, the positive results in this study were not controlled for unspecific factors, such as invested time and attention, therapist interaction, or brain maturation."

"Another limitation could be that the only WM measurement used in this study was the WM capacity improvement index measured by the Cogmed© computer program itself, which is not a pure clinical measure and is susceptible to practice effect."

"…our study shows that Cogmed WM training might be (more) useful for children with relatively mild or subthreshold psychiatric disorders or learning disabilities at risk for a severe psychiatric disorder. This might prevent the development of a full psychiatric disorder or severe academic achievement problems. Our findings show that this "at risk-group" of children profit from a relatively short, but intensive Cogmed training program. Therefore, low cost interventions such as Cogmed WM training could possibly prevent the development of severe neuropsychiatric disorders."

Rx use is low which is partly related to how the Dutch mental health care system works there. Psychological treatments are offered as the first line of tx for children with mild ADHD.

Pearson

Far Transfer Challenge.
What is the mechanism of change? Limiting factors?

1. Leveraging WM partly hinges upon individual differences like "mindsets", growth-oriented VS static.

2. Leveraging relates to student motivation.

3. Leveraging relates to the extent to which Cogmed training is optimized: "Cogmed Plus".

LIMITING FACTORS?

Domain Specific knowledge/skills (vocabulary?)

Domain general skills (processing speed?)

FAR TRANSFER END GOAL:

Reading comprehension & Math Language acquisition

Is Near Transfer Needed?

Following Instructions, Executive Functions

Attention

Leveraging of WM may be precluded if impulsivity and/or hyperactivity interfere with training.

Then there is the issue of "domain specific knowledge" without teaching it why would better WM automatically improve skills in a specific domain?

Working memory

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

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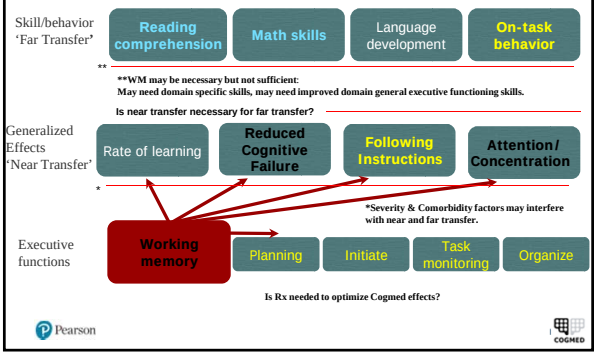
The Far Transfer Challenge.



Pearson

COGMED

Does Improved Following Instructions Facilitate Far Transfer?

Study	WM deficit	ADHD-I Attention problems	ADHD-C	Executive Functioning Transfer?	Far Transfer.	Rx%	LD	ODD/CD
Holmes, et al., 2009	100%	NR*	NR	Following Instructions	Math reasoning at 6 months.	NR	NR	NR
Dunning, et al., 2013	100%	NR	NR	Following Instructions	Written Expression	NR	NR	NR
Bergman-Nutley & Klingberg, 2014	100%	Mainly Attentive problems	Attentive problems/minor HI	Following Instructions	Math Fluency	NR	NR	Minor

Could following instructions be considered an executive function – particularly among younger children?

Pearson

WM deficit Children: Transfer increased Linearly with amount of training time & Correlated with improvement on trained tasks. WM, FI & Math Improved

(Bergman-Nutley & Klingberg, 2014)

Study	WM deficit	ADHD-I Attention problems	ADHD-C	ADHD-HI	Rx%	LD	ODD/CD
Bergman-Nutley & Klingberg, 2014	100%	Mainly Attentive problems	Attentive problems/ minor HI	Minor HI	NR	NR	Minor

n=176 children (treatment group), ages 7-14, mean age 11.1 years, all had WM deficits, **Majority were diagnosed with ADHD, but it was not verified in the study**. Based upon the rating scale noted below children had "mainly inattentive problems(score of 16) and minor problems with hyperactivity (score of 8) and ODD (score of 6)."
n=304 Typically developing children, aged 7-15. This group took same transfer tasks at the same weekly intervals for 5 weeks. They did not train.

Assessments: Disruptive Disorder Behavior Checklist, parent ratings, before training. Transfer tests administered once a week for 5 weeks:

Working memory: "odd one out" (OOO) identify which shape is the odd one out and remember its location. Based upon the AWMA, 2007

following instructions: digitized from classroom analog test developed by Gathercole, et al., 2008), practice trials with one and two items and then begins with first task of 2 items; test concluded when two items at the same level are incorrect, span task)

mathematics test: See next slide.

Pearson

WM deficit Children: Transfer increased Linearly with amount of training time & Correlated with improvement on trained tasks. WM, FI & Math Improved

(Bergman-Nutley & Klingberg, 2014)

Mathematics test: The mathematics test was a speeded arithmetic test where the participants had to solve mental arithmetic problems (addition and subtraction) with two or three terms and a sum less than 20, excluding duplicate terms and numbers with 0 in them. As many problems as possible were to be answered during 1 min. The scoring was the sum of the correctly answered trials after subtracting the number of mistakes multiplied by 0.33 (so that random performance would give a score of 0). This might be considered a test of math proficiency given the fact that it is a timed test.

Standard training format: trained 5 days/week for 5 weeks.

Compliance was very high with a mean of 24.89 days trained & 88% completed all 5 tests. Training was done during the summer of 2012.

Pearson

WM deficit Children: Transfer increased Linearly with amount of training time & Correlated with improvement on trained tasks. WM, FI & Math Improved

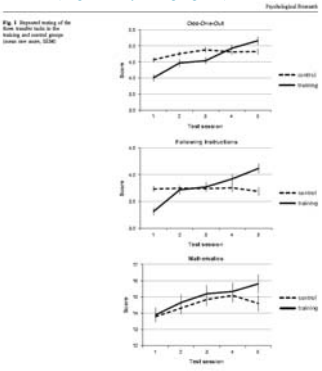
(Bergman-Nutley & Klingberg, 2014)

Take note that changes begin to be registered at about 3 or more weeks into training.

As such the role of the coach in supporting the motivation of the trainee is very important.

Realize: "Transfer increased Linearly with amount of training time & Correlated with improvement on trained tasks."

WM, FI & Math significantly Improved



Interestingly, Following instructions improves before WM and math in this study.

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WM deficit Children: Transfer increased Linearly with amount of training time & Correlated with improvement on trained tasks. WM, FI & Math Improved

(Bergman-Nutley & Klingberg, 2014)

WHY THIS STUDY MATTERS:

WM is impaired in subjects with dyscalculia & it is correlated to math performance in the general population. Performance on WM tests is predictive of future math performance. Math underachievement is associated with academic underperformance and higher risk for unemployment.

"Studies investigating the effects of WM training on mathematics have thus far presented **mixed results regarding such transfer** (Gray et al., 2012; Dunning, Holmes, & Gathercole, 2013; Holmes & Gathercole, 2013)."

"The inconsistent results of WM training on mathematics could be due to: (1) a true lack of effect or that only certain aspects of mathematics are affected; (2) that effect occurs not directly after training but later, as a result of improved WM capacity in combination with instruction; or (3) that the effect size is small, and the existing studies include too few subjects to detect a significant effect."

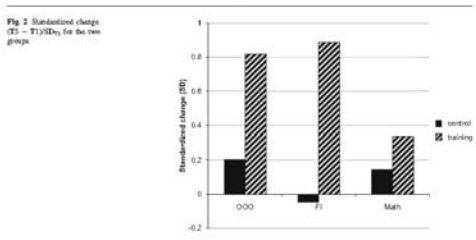
Or, EF's that may facilitate or moderate transfer of improved mathematics may or may not be improved. Other domain specific or domain general factors may limit transfer.

Pearson

WM deficit Children: 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:



Pearson

WM deficit Children: Transfer increased Linearly with amount of training time & Correlated with improvement on trained tasks. WM, FI & Math Improved
(Bergman-Nutley & Klingberg, 2014)

Improvements in FI were linear and showed minimal test-retests in the control group.
In OOO and the mat test there were test-retests effects in the control group at T2 and T3 after which they leveled off.
With all 3 measures the maximal difference between training and control group was seen in the final testing (T5).

EFFECT SIZES:
The effect for WM (OOO) was medium to strong (d-.67)
The effect size for FI was strong: (d-.90)
The effect size for math was small (d-.20).

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Using BASC-3 to assess Executive Functions?

Subscale Scores:

Problem Solving Index

Attentional Control Index: ***Could this capture "following instructions"?***

Behavioral Control Index

Emotional Control Index

Pearson

BASC-3: Attentional Control Index – Includes Items which appear to capture "*following instructions*"

Pays attention
Has a short attention span.
Listens to directions
Listens carefully
Is Easily distracted.
Pays attention when being spoken to.
Has trouble concentrating.

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BASC-3: Behavioral Control Index

Acts without thinking
Interrupts others when they are speaking
Has poor self-control
Argues when denied own way.
Interrupts parents when they are talking on the phone.

Pearson

BASC-3: Problem Solving Index

Plans well.
Sets realistic goals.
Tracks down information when needed.
Takes a step-by-step approach to work.
Finds ways to solve problems.
Gives good suggestions for solving problems.
Makes decisions easily.
Organizes chores or other tasks well.

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BASC-3: Emotional Control Index

Emotional Control: "the process of initiating, avoiding, inhibiting, maintaining, or modulating the occurrence, form, intensity, or duration of internal feeling states, emotion-related physiological, attentional processes, motivational states, and/or the behavioral concomitants of emotion in the service of accomplishing affect – related biological or social adaptation or achieving individual goals" (Eisenberg & Spinrad, 2004).

Examples of Emotional Control Items on the BASC-3:

Is overly emotional.
Overreacts to stressful situations.

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BASC-3 Flex Monitor

•The BASC-3 Flex Monitor can be used to monitor the behavioral and emotional functioning over a desired period of time.
•Users will have the ability to:
- •Choose an existing monitoring form
- •Create a form using an item bank
- •Choose a rater (teacher, parent, or student)
- •Administer digital or paper forms
- •Set up recurring administrations over a specified time period
- •Generate monitoring reports to evaluate change over time.

Pearson

D-REF: Delis Rating of executive Functions

Norm Groups: Age-adjusted or Age and gender adjusted
Ages 5-18.
Minimum reading level:
- 3rd grade for self form
- 4th grade level for parent and teacher form.

Administration time: Approximately 10 minutes.
Individual self, Parent and teacher forms with 36 questions each.
Top "5" stressors for prioritizing interventions.
3 Core indices:
- Behavioral Functioning
- Emotional Functioning
- Progress Monitoring.

Pearson

D-REF: Delis Rating of executive Functions

Behavioral functioning: Assesses the child's ability to regulate his behavior to meet demands of the environment.

Emotional functioning: Assesses the child's ability to regulate her emotions relative to the demands of the environment.

Executive functioning: Assesses the child's ability to regulate his cognitive ability to effectively adapt and function within the demands of the environment.

Total Composite: Assesses the child's ability to plan, execute and regulate her cognitive, emotional and behavioral functions to adapt to the demands of the environment.

Pearson

D-REF: Delis Rating of executive Functions Clinical Indexes.

Attention/Working memory: Assesses symptoms of inattention, deficient multi-tasking, forgetfulness, poor working memory and disorganization.

Activity level/Impulse Control: Assesses symptoms of hyperactivity, impulsivity, and poor self-monitoring.

Compliance/Anger management: Assesses symptoms of mood lability sensitivity to criticism, frustration tolerance, and rule breaking.

Abstract thinking/ problem-solving: parent and teacher forms only. Assesses symptoms of concrete thinking, cognitive rigidity and poor decision-making and problem-solving skills.

Pearson

D-Ref for measuring Executive Functions Progress Monitoring

Track changes in behavior over time.

Track the effects of Cogmed.

Tracking the effects of medication therapy.

The D-REF online scoring and reporting provides comparison data between time 1 and time 2 evaluation.

Pearson

Summary

What are executive functions (EF)? *Executive functions are theoretical constructs which have received some empirical support that help us begin to understand how different people vary in cognitive performance.*

EF are mental functions that are associated with the ability to engage in purposeful, organized, self-regulated and goal-directed behaviors. (Riccio, 2009).

Why do they matter? They have been found to be highly correlated to far transfer areas and to predict far transfer areas.

Challenges to the constructs of executive functions include lack of clarity about which are most salient or have the most empirical support and concerns about the empirical stability of EF's. Additionally a variety of situational factors relate to each learning situation which makes it rather difficult to discern what role EF's are playing in each use case.

What is the relationship of EF to academic achievement? While EF's often correlate and/or predict academic achievement in a variety of areas there are also both domain specific factors (e.g. phonological awareness, numeracy, etc.) and domain general factors (e.g. processing speed, etc.) that may need to be addressed through training or another intervention to facilitate far transfer along with individual factors (e.g. developmental level, other contributing deficits, growth mindset, motivation, etc.).

How do situational learning factors affect the expected role of EF and Cogmed? Several individual factors affect learning but also the specifics of what you hope students will learn and when also require consideration.

Pearson

Summary (2)

What factors facilitate and limit the possible impact of Cogmed? A few include: Rx, severity of disorder, comorbidity, LD vs learning problems, Cogmed + or how you complement Cogmed after completing the program.

What have Cogmed-specific studies found? A number of executive functions have improved post Cogmed, WM, metacognitive index, planning/organization, initiate and total measures of EF. If one considers following instructions a form of EF several studies have found that that improves after Cogmed. Also, CPT errors of commission, objective measures of WM (WAIS-IV, WISC-V, etc.), etc. may play a role. EF's may play a moderating and/or facilitating role in far transfer for those who complete Cogmed, but more research is necessary to determine this. Also, the research has yet to answer which EF's play the most important role in which far transfer situations when associated with those who complete Cogmed.

What are some measures that can help with assessing and monitoring progress in EF?
BASC-3 & D-REF.

Pearson

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Thank you!

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