
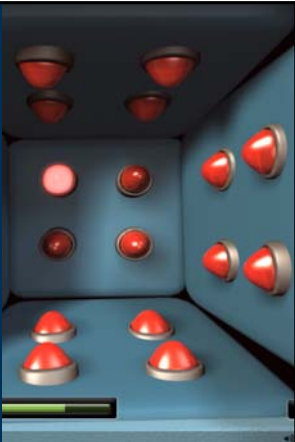


 Pearson
Differentiating Cogmed Effects: ADHD, LD and WM deficits.
 Charles Shinaver, PhD
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 November, 2016






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Agenda

- How does Working Memory, the Target of Cogmed, relate to ADHD.
- Understanding variation in the effects of Cogmed. Considering severity, co-morbidity & Rx.
- Differentiating the severity of ADHD-C from ADHD-I.
- Differentiating Learning Disabilities & Learning Problems.
- Potential limiting & facilitating factors to far transfer of Cogmed effects.
- Cogmed specific studies.



Cogmed Trains Working Memory. What is Working Memory (WM)?



A system for temporary storage and 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

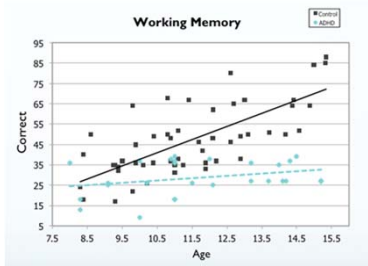
Delegates to different parts of our brain to take action - shifting

Allows us to **block out unnecessary information** - inhibition

Keeps us updated on what's happening - & **focused** on what matters



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



Westerberg et al. (2004). Visuo-spatial working memory: a sensitive measurement of cognitive deficits in ADHD. *Child Neuropsychology* 10 (3) 155-61.



“Cogmed Working Memory Training: Reviewing the reviews” (Shinaver & Entwistle, 2014) -Understanding the Effects of Cogmed

Shinaver and Entwistle (2014): Evaluate Cogmed effects upon ADHD patients in light of empirical considerations: **severity of disorder, comorbidity & control for medication effects (Rx)**. ADHD-I with no comorbidity is very different than ADHD-C with ODD & an LD. *Treatment needs vary accordingly with any treatment...*

ADHD is a heterogeneous disorder.

- 1. Presentations & Severity Varies:** Combined (ADHD-C), Inattentive (ADHD-I) & Hyperactive/Impulsive (ADHD-HI).
- 2. Comorbidity Varies:** Severe behavior disorders, oppositional defiant disorder (ODD), conduct disorder (CD), mood disorders to learning disorders.
- 3. Medication Status (Rx) Varies:** Some are taking Rx other are not.



“Cogmed Working Memory Training: Reviewing the reviews”

(Shinaver & Entwistle, 2014)

Argument: Combined type ADHD (ADHD-C) is a more severe disorder than ADHD inattentive type (ADHD-I). *The impact of this distinction has been underestimated in the Cogmed research literature.*

Comorbidity is a critical factor to consider when evaluating effects of Cogmed as is true with any intervention. ADHD-C has more severe comorbidity. ADHD-I has more comorbid learning issues.

Control for medication effects (Rx), which can get complicated as ADHD-C and ADHD-I may have differential responses to Rx.



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Is ADHD-C more severe than ADHD-I in children? Yes. More CD. With more CD & earlier referral age.

(Bilgic, et al., 2006)

Patient records of 266 children with ADHD between ages 4-18 years evaluated retrospectively.

Conduct Disorder (CD) was detected in 36.1%, Oppositional Defiant Disorder (ODD) in 25.9% and LD in 21.7% of the cases.

CD was most common among cases with ADHD-C and least common in ADHD-I.

Clinical referral age was found lower in children with comorbid disruptive behavior disorders (CD and ODD).

Maternal educational level was lower in LD cases.

Pearson

1

Childhood hyperactivity/impulsivity linked to adult antisocial behavior.

(Lopez-Williams, 2005 Dissertation)

Key findings included **marginally significant direct paths** from childhood symptoms of **hyperactivity** to status ($p < .10$) and **violent** ($p < .10$) types of **ASB (in adulthood)**, and (marginally) significant direct paths from childhood symptoms of **impulsivity** to status ($p < .10$) and **violent** ($p < .05$) types of ASB (in adulthood). **All four direct paths were large in magnitude...**

“Overall, symptoms of inattention had relatively little predictive value.” (as it related to later antisocial behavior in adulthood).

Both hyperactivity and more strongly impulsivity correlated to antisocial behavior. Inattention did not...



Pearson

1

Is ADHD-C more severe disorder than ADHD-I in adults? Yes. More ODD, hostility, paranoia, suicide attempts & arrests.

(Murphy, et al., 2002)

Adults (17-27 yrs) with attention deficit hyperactivity disorder (ADHD). 60 ADHD-C and 36 ADHD-I & community control group (n=64).

Both ADHD Groups: Less education, fewer college grads, more likely special educational in high school, Dysthymic, alcohol dependent/abuse, cannabis dependent/abuse, and learning disorders, & greater psychological distress than the controls.

Both ADHD Group: More likely took psychiatric medication and other mental health services than control adults.

BUT: “The ADHD-C-type adults were more likely to have *oppositional defiant disorder, to experience interpersonal hostility and paranoia, to have attempted suicide, and to have been arrested than the ADHD-I adults.*”



1

Is ADHD-C more severe than ADHD-I in children? YES. Worse on attention problems, ADHD scale, Inattention, ODD, Hyperactivity & Ext. Surprising?

(McConaughy, et al., 2009)

n=177, 6-11 yrs.

Participants were assigned to four groups based upon parent & teacher ratings: ADHD-C (n = 74); ADHD-I (n = 25); clinically referred without ADHD (n = 52); and controls (n = 26).

The ADHD—C scored significantly higher than the other three groups on six Test Observation Form scales: (1) *Attention Problems*; (2) *Oppositional*; (3) *Attention Deficit/Hyperactivity Problems* scale; (4) *Inattention* subscale; (5) *Hyperactivity-Impulsivity* subscale; and (6) *Externalizing*.

ADHD-C worse than ADHD-I, even on attention problems, inattention subscale and ADHD problems scale!

The two ADHD groups also scored significantly lower than controls on all WISC-IV and WIAT-II composites and lower than those clinically referred without ADHD on WISC-IV Working Memory Index and Full Scale Intelligence Quotient



1

ADHD-C is more severe than ADHD-I in children, BUT ADHD-I have more difficulty with academic achievement.

(Wolraich, et al., 1998)

“The children with ADHD-I were rated as having less overall functional impairment, but did have difficulty with academic achievement.”

“The children with ADHD-I were older, more likely to be female, and had more comorbid internalizing disorders and learning disabilities. *Individuals in the ADHD-I group were two to five times as likely to have a referral for speech and language problems.*”



1

How is ADHD-I type different from those who are impulsive or hyperactive? Fewer conduct & substance use problems, more academic problems.
(Lee, 2005, dissertation abstracts)


Preadolescent girls (N = 228) with and without attention-deficit/hyperactivity disorder (ADHD), ages 6-12 years.

Girls and their families were rigorously assessed 4.5 years later.

Baseline predictors included ADHD, overt aggression, noncompliance, covert antisocial behavior (ASB), relational aggression, and social preference.

Hyperactivity-impulsivity (HI) were most predictive of conduct problems and substance use.

Inattention symptoms most predictive of academic difficulties (lower achievement and more frequent special education placements).

 Pearson 1


How is ADHD-I different in children from those who are impulsive or hyperactive? More academic problems, fewer behavioral.
(Wolraich, et al., 1998)

County-wide study of ADHD in Tennessee. n=4323 students, 214 teachers, 10 schools.

The prevalence rates were 16.1% for ADHD-all types, 8.8% for ADHD-I (I), 2.6% for ADHD-HI, and 4.7% for ADHD-C.

The rates of problems differed mostly between ADHD-I and ADHD-HI (30% vs 68% for behavior and (56% vs 16%) for academics.

ADHD-I: Fewer behavior problems, more academic problems...

 Pearson 1

How is ADHD-I different from those who are impulsive or hyperactive? Less impaired. Girls, teens & Adults.


ADHD-C, more common in elementary school-age children especially in boys.

ADHD-I more common in girls and in adolescents and adults (Dunn & Kronenberger, 2003).

n=116 ADHD adults, (62) ADHD-C, (52) ADHD-I. 62 men 54 women. Compared measures of emotional intensity and social skills. Additional analysis was employed to examine if the findings were moderated by gender.

ADHD-C significantly impaired when compared to the ADHD/I.

(Monahan, 2009, dissertation).

 Pearson 1


**ADHD-C better Rx response than ADHD-I.
Arguably, Cogmed even more relevant.**
(Hale, et al., 2005)

N=49 children with ADHD.
Robust Rx effects observed with increasing dose, better teacher ratings and direct observations of classroom academic performance and behaviour.

Types or presentations mattered.

*ADHD-I among those more like to show minimal or no response to Rx.
ADHD-C showed dramatic Rx effects.*

Results suggest that neuropsychological impairment (ADHD-C vs. ADHD-I), but not baseline teacher ratings or classroom observations, can help clinicians determine the likelihood of medication response in children with ADHD.





To Further Complicate Matters ADHD changes over development.
(Willcutt, 2012, meta-analysis)

Inattention and hyperactivity-impulsivity stability over 5 year intervals.
Hyperactivity-impulsivity declines more.

Inattention more frequently persists. This suggests Cogmed is more relevant as those with ADHD age.

DSM-IV ADHD has “moderate stability over periods of up to 9 years, but the nominal subtypes are unstable in both systematic and unsystematic ways.”





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 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.



Sinaver & Entwistle slides 4-5



Cogmed targets working memory which is highly correlated to only one dimension of ADHD: Inattention.


Does it make sense to evaluate Cogmed effects in the same way with a group that is predominantly ADHD-C in contrast to one that is predominantly ADHD-I?

ADHD-C has a similarly severe deficit of hyperactivity/impulsivity that is not a target of Cogmed. At least ½ their disorder is not addressed with Cogmed.

Could hyperactivity or impulsivity interfere with Cogmed for ADHD-C groups?

Willcutt's et al., 2012 argues ADHD-HI is as an empirically negligible group with the exception of boys younger than 7 years old.

Is there a difference in severity between ADHD-C and ADHD-I with regard to severity of disorder that may affect the impact of Cogmed?


 Pearson 1

Learning disabilities.
(Roording-Ragette, et al., 2016)

"Learning disabilities" refers to "roughly into two groups: specific learning disorders (LD), and general learning problems."

"LD, like **dyslexia or dyscalculia**, refer to specific problems in a single domain of learning capacities or academic achievements."

"Dyslexia is characterized by a specific and significant impairment in the development of reading skills (problems with accurate or fluent word recognition, poor decoding, poor spelling), while dyscalculia is characterized by a specific impairment in the acquisition of mathematical skills (Problems with processing of numerical information, learning arithmetic facts, performing accurate and fluent calculations)."


 Pearson 100

Consider Deficits associated with Dyslexia: Poor Phonological Loop & Central Executive
(Dawes, et al., 2015)

"Poor readers" matched by age and gender with typically developing readers.

Measures: Phonological loop, central executive, visuospatial sketchpad & episodic buffer.

Poor readers were worse on phonological loop and Central Executive only.

 Pearson 101

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.

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 typically developing children.**

RD worse processing speed but was restricted to nameable symbols.

MD associated with temporal processing and visuospatial memory deficits.



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Meta-Analysis of oral language deficits in familial dyslexia

(Snowling & Melby-Lervag, 2016)

Preschoolers: Phonological processing deficits, broader language skills (letter knowledge, phonological awareness & rapid automatized naming (RAN)) deficits.

Longitudinal studies: More severe impairments in preschool language than those defined as normal. Poor phonological awareness & literacy skills. Parents lower educational levels & read less frequently to themselves.



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Pennington's multiple deficits view of dyslexia

(Carroll, et al., 2015)

Deficits in phonological awareness, print knowledge & rapid naming predict later reading difficulties. N=267 children tested with wide battery of tasks associated with dyslexia. Then tested 2, 3, and 4 years later. 42 poor readers were later identified.

Deficits: *Yes print knowledge, verbal short-term memory, phonological awareness and rapid naming were good predictors of later poor reading.*

Also deficits in visual search and auditory processing present in a large minority of poor readers.

Almost all poor readers showed deficits in at least one area.

No single deficit characterized the majority of poor readers.

HENCE: *Supported Pennington's multiple deficits view of dyslexia. Multiple interacting factors combine to result in poor reading.*

Intervening in only WM and/or STM may not address all deficits that have lead to poor reading.



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Learning Problems.

(Roording-Ragette, et al., 2016)

Difficult to differentiate. Yet has significant clinical relevance.

"The term general learning problems refers to non-specific and possibly co-occurring disabilities in the following areas: 1) receptive language; 2) expressive language; 3) basic reading skills; 4) reading comprehension; 5) written expression; 6) mathematical calculation and reasoning; and 7) attention (Lyon, 1996)."

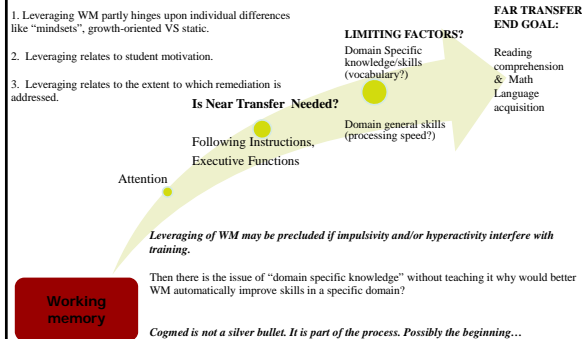
"The group of learning problems is a heterogenic group characterized by a broad range of symptoms covering diverse academic achievement problems. Although symptoms may (at some stage) not meet DSM criteria for ADHD or LD, they may be associated with sub-threshold psychiatric problems. Children with learning problems may be "overlooked" struggling students, meeting minimal academic standards, often caused by processing strength and weaknesses that adversely affect school achievement."

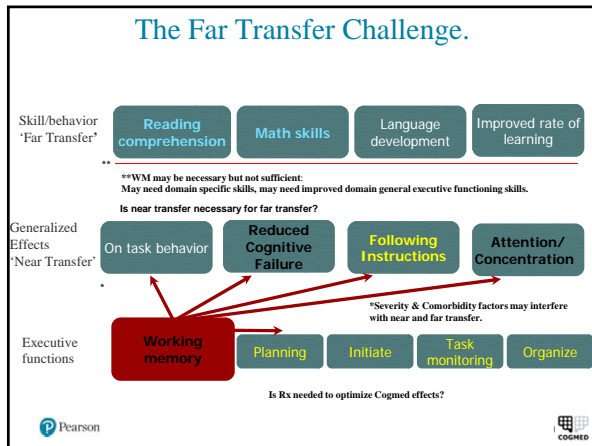
It appears somewhat more likely that WM deficits may be a bottleneck among these students, but this a diffuse and poorly defined group making this unclear.

Improved WM has potential to have a notable impact upon learning, but there are limiting or facilitating factors.



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





Can improving WM open the door to gains? It depends... factors which may limit or facilitate gains...

Limiting factors?

- ADHD-C?
- Comorbid disorders?
- Learning Disabilities?
- Learning Problems?
- Processing problems?
- Slow processing speed?
- Phonological awareness?

Facilitating factors?

- Dosing of Cogmed?
- Motivation?
- Rx?
- Cogmed-Plus/remediation?
- Domain general training?
- Domain specific training?

Pearson 129

Van der donk, et al., 2016 supports notion implicit in this table:
Far Transfer (red) is more likely among those with moderate severity & Rx is a factor to consider.

Study	WM deficit	ADHD-I Attention problems	ADHD-C	ADHD-HI	Rx%	LD	COG/CP
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
Burgman-Nolley & Kingberg, 2014	100%	Many Attention problems	Attention problems/minor HI	Minor HI	NR	NR	Minor
Holmes & Gathercole, 2013 (trial 2)	NR	NR	NR	NR	NR	100% (Low acc. Perf.-learning problems)	NR
Duinin, 2010	NR	33% diag 60% rated inatt.**	NR	NR	NR	9.5%***	0%
Duinin, 2013 (not published)	-	33% diag 60% rated inatt.**	22%	NR	NR	22%	0%
Kingberg, et al., 2002	-	NR	100%?	NR	43%	NR	NR
2005 Kingberg, et al., 2005	-	25%	75%	0%	0%	NR	0%
***Howk, et al., 2012/Engelard	-	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%
Groppa, et al., 2010 (Pearson)	-	51%****	NR	NR	26%	57%	NR
Cray, et al., 2012	-	NR	100%	NR	98%	100% Severe**	100%/0%

**Cogmed with children with Different Neurodevelopmental Disorders
(ADHD, LD, Learning Problems)**
(Roording-Ragetlie, et al., 2016)

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.

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. NOTE: The ADHD group had a majority of ADHD-I children.

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



**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.

- ADHD-I (n=25). Note: A majority of those with ADHD has this less severe type of ADHD.
- ADHD-C (n=13)
- NOS (n=7)

LD (n=34)

- Dyslexia (n=25). Note: The vast majority here are **dyslexic**, hence our focus on the literature on this group.
- Dyscalculia (n=3)
- NOS (n=6)

Learning problems (n=20)

RM for all but n=4 who did JM all of these preschoolers diagnosed with ADHD were free of Rx.

Note: Additionally, they 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.



**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.




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*.

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

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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:


- **Inattention** ($p < .0001$) $Eta = .57$ - *near transfer effect.*
- **Hyperactivity/Impulsivity** ($p < .0001$), $eta = .33$. -not target of Cogmed.
- **BRIEF Total** ($p < .0001$) $Eta = .27$ -near/far transfer of Cogmed.
- **WM** ($p < .0001$), $Eta = .90$. - *Target of Cogmed.*

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 135


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 136

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.



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

(Van der Donk, et al., 2016)

n=98, children ages 8-12.

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" a new cognitive training.

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

Predictor variables: Rx, comorbidity, ADHD subtype, initial verbal & (VWM) visual (spatial) working memory (VSWM).

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.



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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.



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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.



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' showed 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.



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.



Cogmed & Children with working memory deficits



“Does WM training lead to generalized improvements in children with low working memory? A randomized controlled trial” (Dunning, et al, 2013)

Study	WM deficit	ADHD-I Attention problems	ADHD-C	ADHD-HI	Rx%	LD	ODD/CD
Dunning, et al., 2013	100%	NR	NR	NR	NR	NR	NR

810 children ages 7-9 given Automated Working Memory Assessment (AWMA), **verbal WM** (backward digit recall) and **VS WM** test Mr. X involving recalling a series of locations, interspersed with mental rotation decisions.

n=94 children at or **below the 15th percentile on both** WM tests with English as their first language (47 boys, mean age=8 yr, 5 m).

3 groups: Adaptive training, non-adaptive training, no intervention.

6 weeks of training. Then follow-up assessments.
Follow up at 12 months: 15 schools in adaptive, 19 in non-adaptive groups.
Schools randomly assigned to adaptive or non-adaptive training.
Classroom-based tasks administered: following instructions, rhyme recall, sentence counting (processing), sentence counting (storage).

A Randomized, Controlled trial (RCT) (2) (Dunning et. al., 2013)

Training: Conducted within school in GROUPS of 6-12 under a researcher's supervision. Children received small rewards like stationery items for every 5 training sessions completed. *Not all motivational features were equated across the two programs.*

Total time spent on task: was recorded in the Cogmed log and was comparable across groups 80% adaptive 82% non-adaptive. This was a response to criticism of previous research.



RCT (3) Impact upon WM

(Dunning, et al, 2013)

	Adp. Vs non adpt.		Adp. vs no int.		Non-ad vs no int.	
	t	d	t	d	t	d
WM						
AWMA						
VSTM	1.32	.14	.43	.28	1.72	.44
VS-STM	1.50*	.87	2.73**	.57	1.87	.36
VWM	3.66***	.99	6.43***	1.63	2.83**	.59
VSWM	2.38*	.67	3.89***	.77	1.38	.14

*p<.05, **p<.01, ***p<.001.



RCT (4) Impact upon Class-based tasks

(Dunning, et al, 2013)

Class	Adp.		Vs non		Adp		Vs no int.		Non-ad		Vs no int.	
	t	d	t	d	t	d	t	d	t	d	t	d
FI	2.59*	.71	1.21	.12	1.16	.98						
Rhyme recall	.28	.11	1.50	.26	.59	.14						
Sentence counting	.59	.32	1.85	.54	1.22	.31						
Sentencing counting (processing)	.93	.70	2.37***	1.10	1.44*	.61						
Basic Reading	1.52	.36	2.26*	.62	3.62***	.85						
Written Exp.	1.99*	.69	1.42	.57	.4	.23						
Attention Omissions	.47	.19	2.53*	.32	1.98*	.24						

*p<.05, **p<.01, ***p<.001.



RCT (5)

(Dunning, et al, 2013)

Cogmed significantly boosted performance on untrained WM tasks in children with low WM.

This enhancement was substantial in magnitude and was partially sustained for 12 months.

Adaptively trained children made significantly greater improvements in tests of VS STM & Verbal and Visual Spatial WM than non-adaptively trained or those that received no intervention.

1st double-blinded RTC study on this key group of poor learners that meets stringent criteria for intervention research. Results reinforce earlier outcomes with low WM kids (Holmes, et al., 2009).



RCT (6)

(Dunning, et al, 2013)

Classroom behaviors did not show sustained improvement at one year.

At follow up accuracy in sentence counting (processing) correctly the number of words in a sentence did improve.

Suggested that scaffolding may be required for training to generalize and be effective in new situations (Wilson, 2008). (Cogmed Plus)

The greatest improvements in WM following training were observed in complex span measures strongly associated with children's academic achievements in literacy and mathematics (Swanson & Siegel, 2001; Alloway, Gathercole, Willis & Adams, 2004). **Response to research.**

It is possible that outcome measures lacked sufficient subtlety to detect changes that more process-oriented measures may find.

PRIORITY: Establish whether other training activities can be developed to promote the "application of these enhanced WM skills to less predictable memory-demanding situations in the classroom."



WM training effects on reading in ADHD or inattentive Children with learning problems (2)

(Dahlin, 2010)

Study	WM deficit	ADHD-I Attention problems	ADHD-C	ADHD-HI	R _s %	LD	ODD/CD
Dahlin, 2010	NR	33% diag, 60% rated inatt.**	NR	NR	NR	9.5%***	0%

Population: special needs children, ages 9 – 12 years

N = 57 (n = 42 in treatment group and n = 15 in control group [special needs class])

Diagnosed with ADHD or inattention and **with co-morbidity of learning problems.**

Design: Active control, Randomized, Blinded, Test-retest

T1 = Baseline, T2 = 5-6 week follow up, T3 = 6-7 month follow up

Treatment group **improved significantly on outcome measures:**

- 1) Visuo-spatial and verbal WM (Span Board; WAIS-NI & Digit Span; WISC III) (T2)
- 2) Reading comprehension (Reading narrative texts & answering questions) (T2 & T3)



WM training effects on reading in ADHD or inattentive Children with learning problems (2)

(Dahlin, 2010)

Examined the relationship between working memory and reading achievement in 57 school children with special needs.

Special needs: 33% had ADHD diagnosis, 60% rated inattentive by teachers & general learning problems

Significantly improved untrained working memory tasks, nonverbal problem solving & reading comprehension. Effect size for reading comprehension was $d=.91$, it was substantial.

Take home: Children with attention with special education needs and attention problems improved significantly on untrained working memory tasks, nonverbal problems solving and reading comprehension within the treatment group.



Children with poor Educational Achievement

(Trial 2, Holmes & Gathercole, 2013)

Data are presented separately because year 5 and year 6 have distinct status in the UK state education system. SAT's are required in year 6 and optional in year 5.

The year 5 group was trained as one group of 25 supervised by the head teacher and a classroom assistant. (Whole class)

Year 6 was trained in two smaller groups (n-13, n-12) supervised by the same staff at the end of the school day.



Children with poor Educational Achievement

(Trial 2, Holmes & Gathercole, 2013)

	Year 5			Year 6		
	Trained Group	Comp. group	d	Trained Group	Comp. group	d
English	1.48 (1.56)	2.36 (1.58)	-.56	2.00 (1.44)	1.12 (1.20)	-.67
Math	1.36 (1.29) (standard deviation)	-1.04 (2.88)	1.15	2.12 (1.13)	1.32 (1.55)	-.60



Cogmed & ADHD



10-12 year old ADHD children make and maintain significant gains in WM for 8 months. RCT

(Hovik, et al., 2013)

Study	WM deficit	ADHD-I Attention problems	ADHD-C	ADHD-HI	Rx%	LD	ODD/CD
***Hovik, et al., 2013	-	0%	100%	0%	69.6%	NR	NA/0%

RCT results: Systematic training resulted in long term gains (8 months). Evidence for both domain-general and domain-specific models. n=67, **children 100% with combined type ADHD** ages 10-12.

Note: 41 Rx stimulant (MPH) + 5 atomoxetine (Strattera) + 1 Risperidone. = **70% on Rx**

Design: Randomized, Placebo controlled Trial, RCT.

treatment vs. treatment as usual. 8 month follow up. Control group received special education treatment as usual & health care follow up.

MEASURES: 6 measures of each form of WM, divided into auditory WM, visual WM, and Manipulation WM

RESULTS: All treatment subjects significantly improved on all measures of WM. Improved significantly more on Visual WM than auditory WM. Manipulation WM gain remained after controlling for increase in simple storage.

Gains were found in both domain general and domain specific areas.



Cogmed Training results in improved psychomotor speed & reading. RCT (Same subjects as Hovik, et al., 2013)

(Egeland, et al., 2013)

Study	WM deficit	ADHD-I Attention problems	ADHD-C	ADHD-HI	Rx%	LD	ODD/CD
***Hovik, et al., 2013	-	0%	100%	0%	69.6%	NR	NA/0%

- N=67 children diagnosed with ICD-10 hyperkinetic Disorder=100% ADHD-Combined type, randomly selected into a control group or training group, **70% on Rx, RCT**. Control group received special education treatment as usual & health care follow up. Ages 10-12.

- Exclusion criteria:** 1. IQ below 70. 2. Comorbid diagnosis of Pervasive Developmental disorders, Tourette's disorder, evidence of psychosis or Bipolar disorder and **Conduct disorder**.

- Measures: Battery of NP tests, measures of mathematics and reading skills.

- Results: **Psychomotor or processing speed improved. Reading improved. Reading was improved in both speed and quality of text reading and word decoding quality improved.**

Normalization before Cogmed:

- No differences between groups regarding medications were found.
- The majority of subjects performed in the normal range on Rx on the CCP-II before Cogmed.
- On Rating scales teachers rated them in the normal range and parents rated them in the highly symptomatic range.
- Children referred for medications may be more impaired.
- They hypothesized that children who have optimized their behavior due to Rx may show less treatment effect.

- Suggestion:** Control for medication.



Summary

- Working Memory, among those with ADHD, tends to develop minimally whereas it increases substantially for typically developing children.
- To understand the varying impact of Cogmed one needs to consider the following issues:
 - ADHD-C is a more severe disorder than ADHD-I.
 - Co-morbidity can limit or interfere with the impact of Cogmed.
 - Rx for some students may be necessary along with Cogmed.
 - ADHD-I students tend to have more problems with academic problems than ADHD-C students.
 - Inattention tends to persist into adulthood whereas hyperactivity/impulsivity tends to wane.
 - More girls have ADHD-I than ADHD-C.
 - Learning Disabilities are often considered more severe than Learning Problems.
 - Learning Disabilities often include deficits in addition to WM deficits. As such after completing Cogmed additional remediation is often needed to get far transfer.
 - There are several limiting & facilitating factors to far transfer of Cogmed effects.
- Cogmed specific studies have found that among these subgroups that those with learning problems and ADHD tend to have stronger responses to Cogmed than those with diagnosed learning disabilities.



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Thank you!