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Different presentations of ADHD & Different Cogmed Outcomes

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Agenda

- Distinctions Salient for understanding the Effects of Cogmed on those with ADHD: Severity of Disorder (ADHD-C vs. ADHD-I), Comorbidity & Controlling for Rx.
- Empirically-based Hypotheses about differential responses of ADHD patients to Cogmed.
- Results of a Cogmed-specific study controlling for these variables

"Cogmed Working Memory Training: Reviewing the reviews" (Shinaver & Entwistle, 2014)

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.

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"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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"ADHD" Is a term that is used loosely.

"ADHD" is often used to refer to ***at least two*** distinct presentations: Inattention (ADHD-I) and hyperactivity/impulsivity (ADHD-C).

The third "type" or presentation: ADHD predominantly hyperactive/impulsive (ADHD-HI) is rarely mentioned alone in the literature.

If investigators say Cogmed does or doesn't work with ADHD what are they talking about?

Does ADHD-C and ADHD-I merit distinct consideration when considering the potential impact of Cogmed?

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Is one type of "ADHD" more represented in the literature?

Barkley (2002), most research used male subjects with ADHD-C.

Barkley (2002): …most outcomes for ADHD should be thought of as male outcomes for the ADHD-C subtype.

Future ADHD researchers should study outcomes for girls and women and for people with ADHD-I.

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Dimensions of Inattention & hyperactivity-impulsivity are "overwhelmingly" supported, but 3 distinct ADHD types are not.

(Willcutt, et al., 2012)

Willcutt, et al., (2012): subtype differences accounted for by "relative levels of inattention and hyperactivity-impulsivity symptoms that define the subtypes." No need to "sub-type".

The ADHD-H (predominantly hyperactive type) has weak evidence for its validity after first grade (Willcutt, et al., 2012).

All three subtypes show marked instability.

He supports ***dimensional modifier model*** reflecting the number of attention and hyperactivity-impulsivity symptoms at time of assessment, not subtypes.

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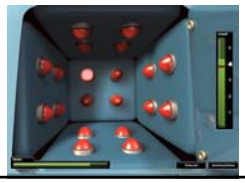
Counter-Point: ADHD-C & ADHD-I are distinct & unrelated disorders.

(Milich, Balentine & Lynam, 2001)

"Important differences among subtypes were found in several areas of study, ***supporting the conclusion that ADHD/C and ADHD/I may best be characterized as distinct disorders***..." Possibly consistent with the severity distinction…

Debate isn't over, but there are differences in ADHD/I and ADHD/C.



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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?

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Is ADHD-C type more severe than ADHD-I? One Clue: They get Rx sooner & Longer.

2014 Barbaresi, et al., Long-term stimulant medication treatment of ADHD.
Results from a population-based study.
N=379 of a research-identified ADHD cohort in 1976 to 1982. This cohort was followed from birth to age 17.2 years old.

INTERESTING CLUE:
"Treatment was ***initiated earlier for children with either ADHD combined type or ADHD hyperactive-impulsive type*** than for children with ADHD predominantly inattentive type and ***duration of treatment was longer for ADHD combined type.***"

For children with ADHD-C or HI and who are not mediated does this limit Cogmed impact? Especially young children?

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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.

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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…

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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*. "**

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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

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Is ADHD-C more severe than ADHD-I in children? Yes, but ADHD-I do have 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***."

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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).

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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…

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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.

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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).

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How is ADHD-I different from those who are impulsive or hyperactive? ADHD-C parents divorce more often.

(Heckel, et al., 2009)

n=1,201 children (6-18 yrs.) pediatric practice, Sydney, Australia. Either ADHD-C or ADHD-I.

N=213 children parents divorced. ADHD-C, especially boys with comorbid conduct disorder/oppositional defiant disorder (CD/ODD) were more common in the divorced group. ADHD-I with comorbid learning disabilities were overrepresented in nondivorced families.

Results suggest that divorce is associated with disruptive behavior patterns in children with AD/HD.

The importance of including marital status as an important correlate in AD/HD treatment outcomes is discussed.

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How is ADHD-I different from those who are impulsive or hyperactive? More sluggish tempo, less ODD.

(Heckel, et al., 2009)

ADHD-C = **More oppositional behavior, more intrusive**, more ADHD problems, more HI, & higher total problems. Lower on DOF on task score vs controls.

ADHD-I = **More sluggish cognitive tempo, attention problems, Inattention** & total problems & DOF on-task score vs. controls.

Trained classroom observers used the Direct Observation Form (DOF; McConaughy & Achenbach, 2009) to rate n=163, (6-11 years old) in classrooms.

Participants were assigned to four groups based on a parent diagnostic interview and parent and teacher rating scales: ADHD-C (*n*=64); ADHD-I (*n*=22); clinically referred without ADHD (*n*=51); and nonreferred control children (*n*=26).

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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.*"

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Co-Morbidity Differences between ADHD-C & ADHD-I Meta-analysis.

(Willcutt et al., 2012)

Meta-Analysis of Co-Morbidity in ADHD-C vs ADHD-I (Willcutt et al., 2012)

	ODD	CD	GAD	SAD	MDD	BIPOLAR	LD	Speech/ language	Tics
ADHD-C	51.8%	21.6%	11.3%	13.5%	9.8%	6.9%	24.2%	14.8%	15.8%
ADHD-I	24.9%	7.1%	10.4%	8.7%	9.5%	3.2%	**29.1%**	**17.8%**	12.1%

ODD= Oppositional Defiant Disorder, CD=Conduct Disorder, GAD=generalized anxiety disorder, SAD= seasonal affective disorder, MDD= Major depressive disorder, LD=Learning disorder. Data is from Willcutt et al., (2012).

Substantial difference between comorbidity of ADHD-C vs. ADHD-I.

Suggests possibility that ADHD-C may be a more severe form of the disorder.

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Why Control for Rx? Impact of training and medication (Rx) on WM of children with ADHD

(Holmes et al., 2010)

Compared Cogmed and pharmacological intervention (Rx) on the WM of children with ADHD, who had been diagnosed for at least 6 months with **no co-morbid disorders indicated.**

Single test-retest, design (teachers did not want off Rx whole grading period)

Assessed 4 aspects of WM (verbal and visuo-spatial STM & verbal and visuo-spatial WM) in 25 children ages 8 -11 years with clinical diagnosis of ADHD for 6 months or longer and receiving quick release stimulant medication (e.g. Methylphenidate).

T1 = Off medication, pre-training. 12 subtests of AWMA & IQ (WASI; Weschler, 1999)
T2 = On medication, pre-training. 8 WM tasks from AWMA & IQ
T3 = On medication, post-training. 8 WM tasks from AWMA & IQ
T4 = On medication, 6 month follow-up. 4 WM tasks from AWMA & IQ

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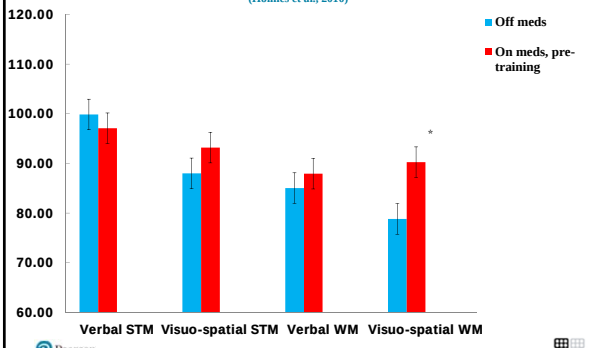
Impact of training and medication on WM of children with ADHD

(Holmes et al., 2010)



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Slides courtesy of Dr. Joni Holmes

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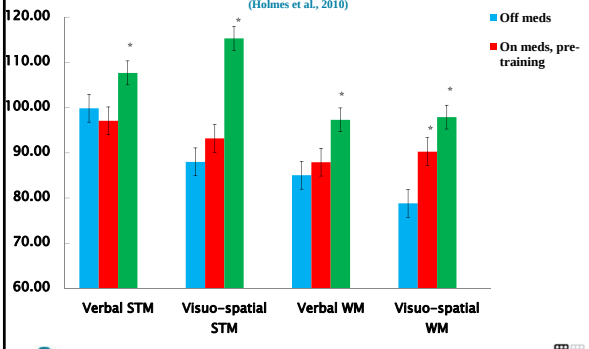

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Impact of training and medication on WM of children with ADHD

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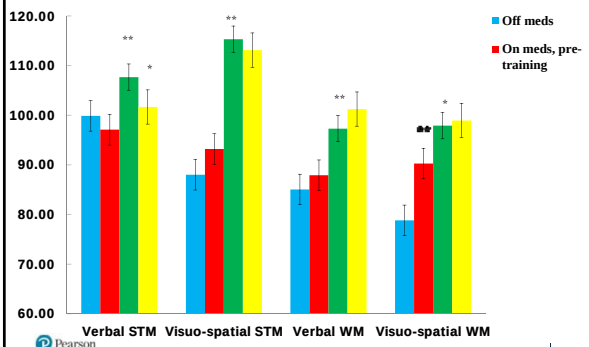

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Summary

(Holmes et al., 2010)

Significant but distinctive gains in working memory in children with ADHD, no IQ effect.

Pharmacological intervention, (Rx):

- Significant gains in visuo-spatial reflects predominant influence of medication on right hemisphere structures associated with visuo-spatial WM (Bedard et al., 2004)

Behavioural intervention:

- Significant gains in non-trained working memory tasks, which extended across all four aspects of working memory (low-average to average range) for up to 6 months.

Take home: Children with ADHD show up to 6 months lasting effect of Cogmed WM training. Wider effect on executive functioning than stimulant medication alone.

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Our empirically-derived hypotheses about impact of Rx, comorbidity and ADHD subtype upon Cogmed Effects.

Rx Effect: Additive effect upon increase in VSWM. Possibly additive affect upon VWM given common near transfer to this area.

Comorbidity: Possibly interfere with compliance with Cogmed.
May limit both near and far transfer.

ADHD subtype:

ADHD-C:
Possibly more limited transfer overall.
Possibly more limited near transfer to EF
Potentially Greatest limitation in far transfer.

ADHD subtype hypotheses partly presume that EF may function as a mechanism of change and we expect less change in EF for ADHD-C. Therefore we expect less far transfer also.

Also, other various behavioral problems are more likely to interfere with far transfer.

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Our empirically-derived hypotheses about impact of Rx, comorbidity and ADHD subtype upon Cogmed Effects.

ADHD subtype:

ADHD-I:
Expected greater transfer overall.
Expected greater transfer to EF.
Expected greatest far transfer.

ADHD subtype hypotheses partly presume that EF may function as a mechanism of change and we expect more change in EF for ADHD-I. Therefore we expect more far transfer also.

If WM is the primary and/or only bottleneck to learning it is expected that improved WM is more likely to result in greater far transfer.

However, in the case for those with ADHD-I and a learning disorder other interventions may be necessary to facilitate far transfer.

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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 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.

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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.

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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.

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Cogmed Claims & Evidence
Specific ADHD Samples.

(May, 2015)

In clinical trials, CWMT has been shown to improve attentional problems in many with ADHD (3, 11, 25, 47)

a) as evident in rating scales (3, 11, 47)
b) or measured with objective measures (25)

http://www.cogmed.com/research "Claims & Evidence"

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Cogmed Claims & Evidence
Also Relevant to ADHD.

(May, 2015)

1) CWMT leads to ***sustained improvements in working memory***, from childhood to adulthood, as seen in
   a) preschoolers (6, 16, 41, 42)
   b) children and adolescents (1, 3, 7, 13, 18, 25-27, 33, 34, 36, 45, 52, 53)
   c) adults and old adults (5, 15, 22, 28, 37, 38, 46, 47)

2) CWMT leads to ***sustained improvements in attention*** seen in both
   a) subjective measures of attention (3, 11, 14, 18, 26, 38, 31, 47)
   b) and objective measures of attention (5, 6, 15, 22, 25, 28)

3) ***Improvements in working memory following CWMT are associated with changes in functional brain activity***
seen as changes in the neurochemistry (9), functional activity related to working memory (2, 4, 22), and functional connectivity at rest (52) 52: Astle, et al., 2015. "Cognitive Training Enhances Intrinsic Brain Connectivity in Childhood" http://www.cogmed.com/research "Claims & Evidence"

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

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

Leveraging relates to student motivation.

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

FAR TRANSFER END GOAL:

Reading comprehension? & Math? Language acquisition?

LIMITING FACTORS?
Domain Specific knowledge (vocabulary?)

Near Transfer Needed:

Domain general skills (processing speed?)

Following Instructions, Executive Functions

Attention

However, the leveraging of WM may be precluded if impulsivity and/or hyperactivity interfere with training.

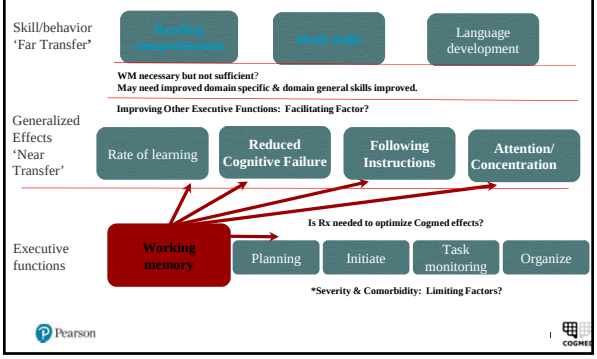
Other pragmatic issues may impede training or interfere with the leveraging WM

Working memory

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

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

Far Transfer Challenge.
How do presentations of ADHD affect it?



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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	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.)	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/England	-	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., 2013	-	**51%*****	**NR**	**NR**	26%	57%	NR
Gray et al., 2012	-	NR	**100%**	**NR**	98%	**100% Severe**	**100%/0%***

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Cogmed Claims & Evidence
Relevant to ADHD. Another Far Transfer factor to consider: Age.
(May, 2015)

4) Learning outcomes in reading (13, 35, 45) and math (34, 43, 45) improves for many underperforming students following CWMT
13 Dahlin, K.I.E. (2011). Effects of working memory training on reading in children with **special needs**. Reading and Writing, 24, 479-491.doi:10.1007/s11145-010-9238-y. **"Special needs was defined as attention issues with learning difficulties" (*Not learning disorders*)*33% diag. with ADHD, 60% rated inatt.**, 9.5%*** LD, the rest had learning difficulties. 9-12 years old.**

34 Dahlin, K.I.E. (2013). Working memory training and the effect on mathematical achievement in children with attention deficits and special needs. ***(Not learning disorders)*** Journal of Education and Learning, 2(1), 118 – 133. doi:10.5539/jel.v2n1p118. Simil**ar to sample #13. 9-12 years old.**

35 Egeland, J., Aarlien, A.K., & Saunes, B-K. (2013). Few effects of far transfer of working memory training in ADHD: A randomized controlled trial. PLoS ONE, 8(10), e75660.doi:10.1371/journal.pone.0075660. **Sample all combined type ADHD, but 70% medicated. Ages 10-12.**

43 Bergman-Nutley, S. & Klingberg, T. (2014). Effect of working memory training on working memory, arithmetic and following instructions. Psychological Research, 78, 869–877. doi: 10.1007/s00426-014-0614-0. ***WM DEFICIT CHILDREN. Mainly Attentive problems, minor HI.* Ages 7-14.**

45 Holmes, J. & Gathercole, S.E. (2014). Taking working memory training from the laboratory into schools. Educational Psychology: An International Journal of Experimental Educational Psychology, 34(4), 440-450. doi:10.1080/01443410.2013.797338. **Trial 1 mixed ability. *Trial 2 Subjects identified based upon lowest academic performance. (Note: study originally published online in 2013 and listed herein as 2013). Ages 9-11.***

Pearson

Cogmed Claims & Evidence
Relevant to ADHD. Cogmed Far Transfer Factors to Consider.

(May, 2015)

Far Transfer Empirical Facts:

1. 4/5 studies finding far transfer post Cogmed appear to be subjects who were moderate severity range.
2. 4/5 studies finding far transfer post Cogmed the subjects were within a 9-12 year old age range.
3. The 5th study included a range of 7 to 14 years & falls within the moderate severity range.
4. 3/5 studies finding far transfer included arguably ADHD-I.
5. 1/5 studies finding far transfer included ADHD-C, but 70% were taking Rx.
6. 1/5 studies finding far transfer were only identified by "low academic achievement".

Pearson

Why Working Memory is the Target of Cogmed.

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

Pearson

COGMED

"Normal Children":
Working Memory Increases 4 to 15 years

(Gathercole, et al, 2004)

- From 6 years onward, a model consisting of **3** distinct but correlated **factors** corresponding to the working memory model (**phonological working memory, visual spatial working memory, central executive working memory**) provided a good fit to the data.
- The results indicate that the **basic modular structure of working memory is present from 6 years of age and possibly earlier**, with each component ***undergoing sizable expansion in functional capacity throughout the early and middle school years to adolescence.***

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Critical Distinction between "Normal Children" & ADHD: Normal = WM Continues to Develop until Young Adulthood.

(Huizinga, et al, 2006).

4 age groups (**7, 11, 15, and 21 year olds**) carried out nine basic experimental tasks (three tasks for each EF), the **WCST** (Wisconsin Card sort Task), and the **ToL** (tower of London).

Analyses of (co)variance revealed a continuation of EF development into adolescence. Confirmatory factor analysis yielded **two common factors:**

Working Memory and Shifting.

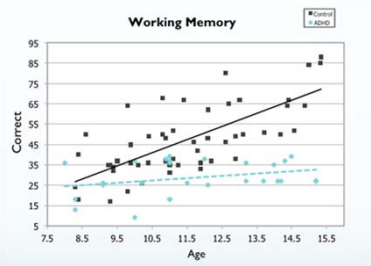
Variables assumed to tap Inhibition proved unrelated to EF.

Shifting was seen to continue to develop into adolescence, while Working Memory continued to develop into young-adulthood.

Regression analyses revealed that **Working Memory contributed most strongly to WCST performance in all age groups**.

Pearson

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.

Pearson

COGMED

How does 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.

Pearson

Working Memory deficits correlate with Reading Comprehension Problems: Meta-analysis.

(Carretti, et. al., 2009)

Good comprehenders vs poor comprehenders:

"...memory tasks that are demanding in terms of **attentional control and that require verbal information processing** are best at distinguishing between" between these two groups.

"...**suggesting that both domain-specific factors as well as general factors of working memory contribute to reading comprehension performance."**

Prd Ll

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Visual Spatial WM (VSWM) & VS ST memory ***PREDICT*** Math achievement.

(Bull et al, 2008)

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

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

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

EF (executive functioning) skills **predicted learning in general.**

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Growth in WM predicts better math problem solving

(Swanson, et. al., 2008)

n=353 at risk elementary school children 1st-3rd grades.

Assessed children at risk for serious math problems.

Is growth in working memory an important predictor of children's problem solving in math? YES.

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

Pearson

Why Cogmed focus upon WM:

WM & Attention are critical during "Encoding" which is the basis for skill acquisition.

Encoding: Hold instructions in mind & the content upon which one applies instructions &/or integrate with existing knowledge.

Repetition of applying instructions to content is how one develops skill and, with enough repetition, **fluency**.

Limited WM or attention affects acquiring new skills.

Over time as skill sets are layered upon each other, students with WM deficits or attention deficits fall further behind thereby following an "**adverse trajectory of development**"

Pearson

How much Cogmed? Transfer increased linearly with amount of training time & correlated with improvement on trained tasks. WM, FI & Math Improved

(Bergman-Nutley & Klingberg, 2014)

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 WM deficits, Majority diagnosed with ADHD, but not verified. Rating scales showed children had "mainly inattentive problems & minor problems with hyperactivity & ODD."

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, parents 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.

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How much Cogmed? Transfer increased linearly with amount of training time & correlated with improvement on trained tasks. WM, FI & Math Improved

(Bergman-Nutley & Klingberg, 2014)

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.

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How much Cogmed? Transfer increased linearly with amount of training time & correlated with improvement on trained tasks. WM, FI & Math Improved

(Bergman-Nutley & Klingberg, 2014)

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."

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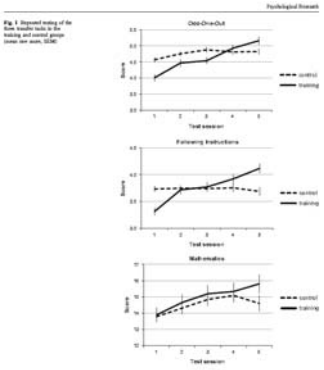
Cogmed: Beginning of change? Transfer increased linearly with amount of training time & correlated with improvement on trained tasks. WM, FI & Math Improved

(Bergman-Nutley & Klingberg, 2014)

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



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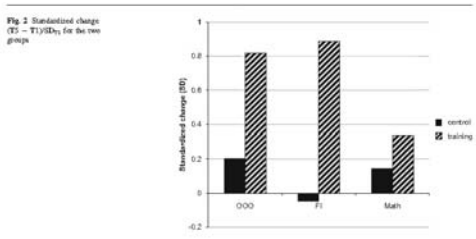
How much Cogmed? Transfer increased linearly with amount of training time & correlated with improvement on trained tasks. WM, FI & Math Improved

(Bergman-Nutley & Klingberg, 2014)

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



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How much Cogmed? Transfer increased linearly with amount of training time & correlated with improvement on trained tasks. WM, FI & Math Improved
(Bergman-Nutley & Klingberg, 2014)

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).

When effect size was calculated with age-normalized scores, the effect size (Cohen's delta) for math was medium (d-.39).

"An alternative way to calculate the effect sizes is analyzing the change in mean scores relative to the standard deviation of the change (T5t - T1t) - (T5c - T1c)/SDT2-T1,pooled, and the ***EFFECT SIZES:***

- 0.60 for OOO,
- 0.69 for FI and
- 0.44 for Math."

Pearson

The ADHD puzzle has not been completely solved.

-*Cogmed provides part of the solution.*
-*However, the presentation of ADHD and resultant severity of the disorder may affect those outcomes.*
-*Comorbidity may inhibit effects of Cogmed and require distinct and complementary interventions.*
-Medication may also be part of the solution.
-Your coaching and interventions from your practice or school may provide the rest.
Skills training (Executive functioning skills, reading comprehension skills, language skills, etc.) in a salient and complementary area you can recommend or provide may be necessary to optimize Cogmed effects = Cogmed +.

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The goal is to move from improved WM/attention to better skills, a higher level of functioning and greater success.

In the case of ADHD it is rare and unexpected that a singular layer of intervention or training will provide a satisfactory or comprehensive solution. Instead one expects layers of training and/or interventions that address specific areas of deficit individualized to the person.

You, as a Cogmed provider, play an integral role in that process.

Pearson

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