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RESEARCH ARTICLE

Examining the Impact of Motivation on Working Memory Training in Youth With ADHD

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Abstract

Objective: Working memory (WM) is often a deficit in children with attention deficit hyperactivity disorder (ADHD) and is related to other impairments within this clinical population. Cogmed, a computerized WM training program, is sometimes prescribed as a treatment for ADHD youth – although the efficacy of this intervention remains controversial. Our main objective was to explore whether ADHD youths' motivational style predicted training engagement or performance on outcome measures. A second objective was to obtain a more nuanced understanding of potential benefits of the program via interviews. **Method:** The current study focuses on 10 ADHD youth (age 8 – 14 years) randomized to a modified 30-session Cogmed protocol, as part of a larger clinical trial. Youth completed an adapted Self-Regulation Questionnaire (SRQ) and participated in a semi-structured interview at three-month follow-up. **Results:** All youth showed adherence to the modified Cogmed protocol. More externally motivated youth started training at a higher level of performance and also reached higher peak performance. At follow-up, higher levels of external forms of motivation correlated with better spatial working memory but worse academic performance. In addition, greater endorsement of external motivation was associated with lower self-concept. Qualitative analyses suggested that youth displayed multiple motivational styles with regard to participation and noted subjective improvements in their everyday lives. **Conclusions:** Youth endorsed both extrinsic and intrinsic motivation and reported that training was useful. Larger studies should consider assessing individual differences in motivational style and incorporating qualitative methodology to identify additional intervention outcome variables to consider amongst ADHD youth.

Key Words: *ADHD, intervention, Cogmed, motivation*

Résumé

Objectif: La mémoire de travail (MT) est souvent en déficit chez les enfants souffrant du trouble de déficit de l'attention avec hyperactivité (TDAH) et est liée à d'autres déficiences dans cette population clinique. Cogmed, un programme informatique d'entraînement de la MT, est parfois prescrit comme traitement aux adolescents souffrant du TDAH – bien que l'efficacité de cette intervention demeure controversée. Notre principal objectif était d'explorer si le style motivationnel des adolescents souffrant du TDAH prédisait l'engagement ou le rendement à l'entraînement dans les mesures de résultat. Un deuxième objectif était d'obtenir une compréhension plus nuancée des bénéfices potentiels du programme par les entrevues. **Méthode:** La présente étude porte sur 10 adolescents souffrant du TDAH (de 8 à 14 ans) randomisés à 30 séances modifiées du protocole Cogmed dans le cadre d'un essai clinique plus vaste. Les adolescents ont rempli un questionnaire d'autorégulation (QAR) adapté et ont participé à une entrevue semi-structurée au suivi de 3 mois. **Résultats:** Tous les adolescents ont démontré une observance du protocole Cogmed modifié. Les adolescents plus extérieurement motivés ont commencé l'entraînement à un degré de rendement plus élevé et ont aussi atteint un rendement plus optimal. Au suivi, des niveaux plus élevés de formes extérieures de la motivation corrélaient avec une meilleure mémoire de travail spatiale, mais avec un rendement scolaire moins bon. En outre, un degré d'appui plus élevé à la motivation extérieure

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était associé à un concept de soi plus faible. Les analyses qualitatives suggéraient que les adolescents présentaient de multiples styles motivationnels à l'égard de la participation et remarquaient des améliorations subjectives dans leur vie quotidienne. **Conclusions:** Les adolescents appuyaient la motivation tant extrinsèque qu'intrinsèque et estimaient que l'entraînement était utile. Des études plus vastes devraient envisager d'évaluer les différences individuelles de style motivationnel et d'incorporer la méthodologie qualitative afin d'identifier les variables additionnelles du résultat de l'intervention à prendre en compte chez les adolescents souffrant du TDAH.

Mots clés: *TDAH, intervention, Cogmed, motivation*

Clinical Trial Registry:
ClinicalTrials.gov Identifier: NCT02610244 (https://clinicaltrials.gov/ct2/show/NCT02610244)

Introduction

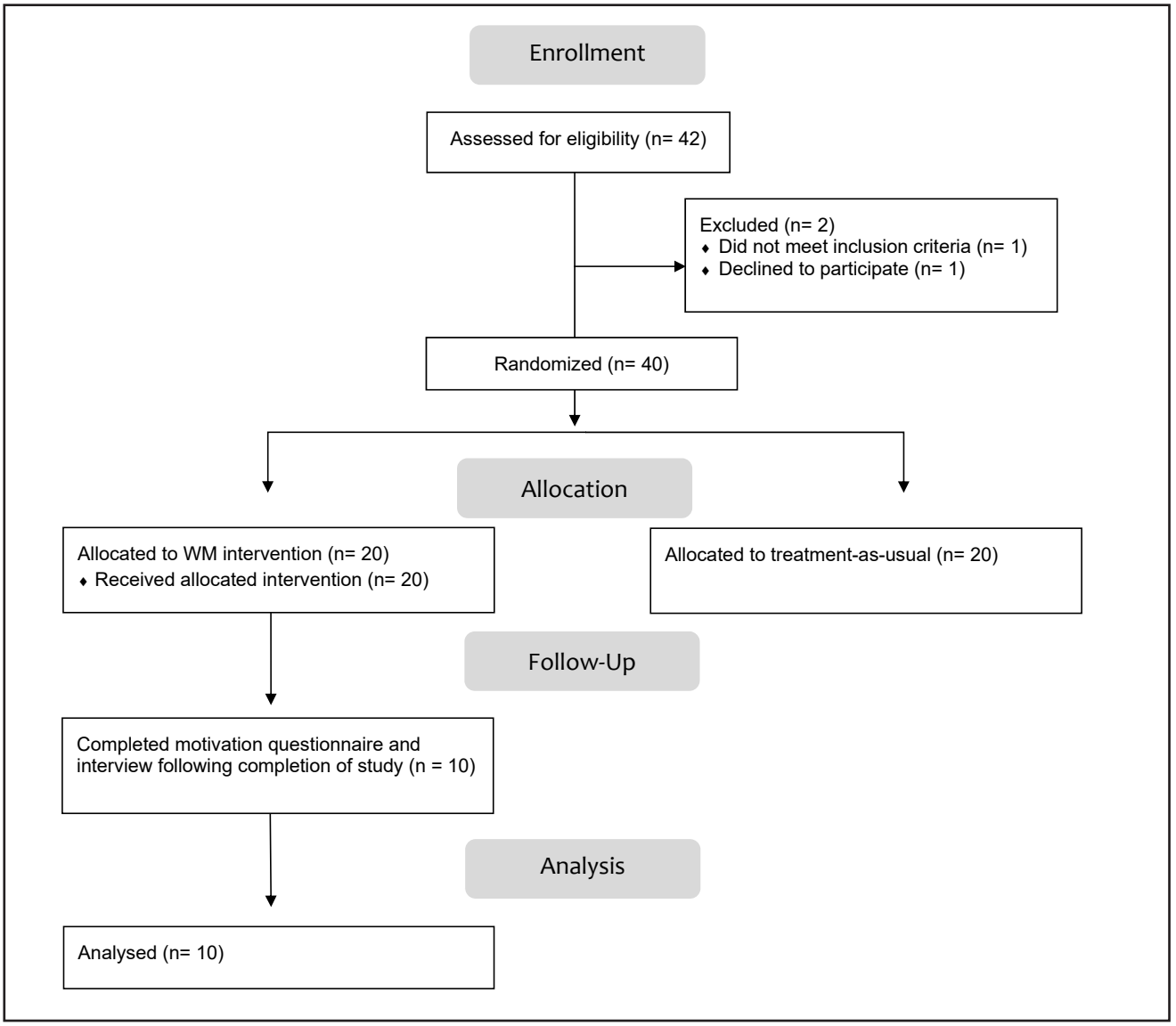
Attention-deficit/hyperactivity disorder (ADHD) is a prevalent and highly persistent childhood-onset neurodevelopmental disorder (APA, 2013). Working memory (WM), the ability to temporarily store and manipulate task-relevant information, is often compromised in individuals with ADHD and is associated with a broad range of ADHD-related impairments (Alderson et al., 2013; Chiang & Gau, 2014; Martinussen et al., 2005). Non-medication based efforts to target clinically meaningful change have led to the development of regimens that purport to "train up" this particular cognitive skill, an example of which is Cogmed (Pearson, 2016). An intense and adaptive intervention program delivered in a video-game format, Cogmed was initially developed for use with ADHD youth but has since expanded in scope for application with diverse child and adult populations (e.g., Klingberg, Forssberg, & Westerberg, 2002; Sadeghi et al., 2017; Till et al., 2017; Van der Molen et al., 2010). Although participation in Cogmed generally yields improvement on tasks that are integrated within the program (i.e., verbal and visual working memory), meta-analytic reviews of cognitive training interventions administered to ADHD youth – including studies that have employed Cogmed specifically – suggest that benefits do not extend beyond these practiced tasks (Cortese et al., 2015; Rappaport et al., 2013).

One caveat to the above is heterogeneity in meta-analytic findings, which may indicate that there are some youth with ADHD for whom this kind of WM training is effective (e.g., Cortese et al., 2015). We suggest that motivation is an individual differences factor that may be particularly relevant to understanding ADHD youths' experiences with Cogmed. Motivational factors have been identified as a corollary of ADHD (Gut et al., 2012), exacerbate the WM deficits evidenced by ADHD youth (Plamondon & Martinussen, 2015) and contribute to their engagement with conceptually similar WM intervention programs (Prins et al., 2011). Though not specific to ADHD, related work further indicates that motivational factors may have some bearing on outcome measures that are theoretically related to WM training (Bjorkdahl, Akerlund, Syensson, & Esbjornsson, 2013; Jaeggi, Buschkuel, Shah, & Jonides, 2014).

One approach to conceptualizing motivation is provided by self-determination theory (SDT; Ryan & Deci, 2000a). In the context of youth, SDT differentiates amongst four motivational styles that range from extrinsically controlled to fully autonomous (e.g., Ryan & Connell, 1989). Different motivational styles have the potential to be beneficial pending the nature of the outcome that is under consideration: autonomous motivation is more strongly associated with subjective aspects of task performance (e.g., depth of knowledge; Cerasoli, Nicklin, & Ford, 2014), whereas extrinsic motivation is more strongly associated with objective task indicators (e.g., grades achieved in school; Burton et al., 2006). Recent work has further demonstrated that individuals can express and regulate multiple motivational styles at one time depending on the task at hand (Miele & Scholer, 2018). Cogmed itself places a salient emphasis on objective training gains and absolute levels of performance, hence it more closely resembles the latter kind of outcome. So, too, do many commonly used transfer measures in the Cogmed literature – including most tasks of attention, working memory, and academic proficiency, thereby rendering them qualitatively different than parent and teacher perceptions of youths' ADHD symptoms and real-world impairment. We are aware of no studies with any clinical population that have explored whether motivational styles influence youths' engagement with Cogmed or these different kinds of outcome.

To date, the prevailing approach used to investigate potential outcomes associated with Cogmed training has entailed the use of performance-based transfer measures that are administered to participants following completion of the intervention program. Whilst this approach affords greater experimental control, it may lack ecological validity given that many of the more commonly used performance-based measures do not clearly align with everyday function (e.g., Franzen, 2000). For this reason, some recent studies have adopted a more qualitative approach to further elucidating the experience of Cogmed – including works undertaken with clinical populations (Sadeghi et al., 2017; Till et al., 2017). Interestingly, when interviewed about their subjective experience with Cogmed, the majority of participants in these studies have perceived improvements in their everyday attention and memory even when evidence of

Figure 1. Participant recruitment and enrollment flow.



improvement on performance-based outcome measures has been lacking (Sadeghi et al., 2017; Till et al., 2017). These findings suggest that asking youth about their personal experience with Cogmed may afford a more nuanced perspective on the potential utility of this particular intervention program. Though subjective improvements are not a proxy for performance-based outcomes, it is possible that the use of qualitative measures such as interviews allows for elucidation of perceived utility of interventions despite mixed quantitative findings.

This study was undertaken as part of a larger clinical trial to address two aims. The first aim was to explore the potential impact of motivational styles on ADHD youths' engagement with Cogmed training and performance on post-intervention outcomes. Because quantitative outcomes are strongly associated with external varieties of motivation (e.g., Sansone, Smith, Thoman, & Macnamara, 2012), we predicted that an extrinsic motivational style would be strongly associated with ADHD youths' engagement with Cogmed training as well as their performance on outcome measures in which there were quantifiable indicators of task performance (e.g., tasks of working memory and academic achievement vs. ratings of youths' real-world behaviours). At the same time, however, we also expected that ADHD youth would likely demonstrate more than one regulatory style - consistent with recent work showing that individuals can flexibly regulate their motivational approach within a task (Miele & Scholer, 2018). The second aim was to better understand ADHD youths' subjective experience with Cogmed by adding a semi-structured clinical interview to the typical armamentarium of quantitative outcome measures. Though exploratory, we expected that youth would identify positive experiences and changes associated with

Table 1. Demographic and clinical characteristics of ADHD youth included in the current study and full sample

	MCT			
	Interview (n = 10)	No Interview (n = 10)	Total (n = 20)	Control (n = 20)
Mean age in years (SD)	11.03 (1.74)	12.08 (2.75)	11.62 (2.08)	11.62 (2.08)
% female	10	10	10	35
% ADHD-Combined	90	100	95	100
% ODD	40	40	40	15
% Stimulant Medication	70	70	70	50
Mean estimated IQ (SD)	110.4 (12.9)	102.6 (15.2)	106.5 (14.2)	101.4 (15.1)

their involvement in Cogmed, which may not be reflected in quantitative outcomes that tend to be used in this kind of intervention research.

Methods

This study was jointly approved by the Office of Research Ethics at the University of Waterloo and Tri-Hospital Research Ethics Board for Cambridge Memorial Hospital (CMH) in Waterloo Region. Written informed consent (and assent) was obtained from all participants after initial phone screening, prior to baseline assessment at CMH. This study is registered as a clinical trial at clinicaltrials.gov, ID number NCT02610244.

Participants and Recruitment

Forty-two youth were recruited through the CMH Outpatient Mental Health Clinic (Figure 1). Parents/guardians completed phone screens to evaluate current ADHD symptomatology using the CADDRA ADHD checklist (CADDRA, 2014). All youth were identified as having at least six of nine traits of inattention and/or hyperactivity-impulsivity at a clinically significant threshold (i.e., responses indicating that the trait was *pretty much* or *very much* evident). Two youth were excluded because they did not meet the minimum reading requirement (i.e., grade two level) or could not commit to the full duration of the study. The ensuing group of 40 eligible youth were then randomized into a group in which they received treatment-as-usual under the care of the referring physician or the modified Cogmed training (MCT) group. The study occurred in two cycles, each occurring within a school year to ensure that the same teacher provided ratings of participants during their involvement in the study. The subset of ten youth who are the focus of this paper were enrolled in the second cycle and randomized to the MCT group. As shown in Table 1, demographic and clinical characteristics of these youth and those in the broader sample were statistically comparable (all *p*s > .11) – suggesting that they are representative of ADHD youth who participated in the clinical trial. Although groups were statistically comparable on IQ, we note that one youth in the MCT group was a high outlier.

Procedure

Youth and their families were invited to CMH for a two-hour baseline visit, which included a diagnostic assessment with a child and adolescent psychiatrist to confirm their ADHD diagnosis, assess potential comorbid diagnoses, and ascertain treatment history. Youth were then administered self-report questionnaires and standardized cognitive tests by a registered clinical psychologist or by trained personnel working under the psychologist's supervision (WASI-II; WIAT-III; AWMA; TOVA). This battery, other than the WASI-II, was re-administered immediately following the ten-week intervention period (post 1) and again three months later (post 2). Additionally, questionnaires were completed by all youths' parents/guardians and teachers, with the same informant providing ratings at each time point (BYI-II; ASEBA CBCL & TRF; BRIEF-2). A final feedback session was held approximately two weeks after the last assessment. Prior to feedback, ten youth with ADHD completed a self-regulation questionnaire and participated in a semi-structured interview with a graduate student in clinical psychology regarding their subjective experiences in the intervention program. All participants received compensation for transportation/parking, a two-dollar Tim Hortons gift card for each session attended at CMH, and a $100 iTunes gift card at final feedback. Youth were allowed to keep the mini-iPad that was used to administer modified Cogmed training. Measures that are the focus of this investigation are presented below.

Measures

Modified Self-Regulation Questionnaire. The Self-Regulation Questionnaire – Academic (SRQ-A; Ryan & Connell, 1989) is a 32-item rating scale assessing behavioural regulation in various situations through multiple-choice

Table 2. Types of motivation assessed by the modified Self-Regulation Questionnaire (SRQ)

	Less Self-Determined			More Self-Determined
Regulatory Style	Extrinsic	Introjected	Identified	Integrated
Locus of causality	Based solely on external contingencies	Partial internalization of external contingencies but no integration into values of the self	Recognition and acceptance of prescribed value of behavior and instrumental gain	Integration of ideas about value of behaviour with other aspects of the self
Sample modified SRQ-A responses	*"It was what I was supposed to do"*	*"I wanted my parents/ coach to think I'm a good student"*	*"It was important to me"*	*"I enjoyed doing the training"*
	"I'll get in trouble if I don't do the training"	*"I would have felt bad about myself if I didn't do the training"*	*"I wanted to learn new things"*	*"The training was fun"*

format. In our study, the SRQ-A was modified to relate to Cogmed training (e.g., "*It's important to me to try to do well in school*" became "*it was important to me to try to do well in the program*"). Items were presented verbally by a researcher not involved in the WM training, with response options visible to youth. Answers ranged on a four-point scale from *not true at all* (1) to *very true* (4). Consistent with the SRQ-A, item responses were totalled and mean values were calculated for four scales reflecting varying levels of motivation, including extrinsic (M = 1.85, SD = 0.53, a = .71), introjected (M = 2.13, SD = 0.53, a = .83), identified (M = 3.40, SD = 0.54, a = .92), and integrated (M = 3.25, SD = 0.57, a = .85) – which are described, with illustrative item examples, in Table 2. The integrated regulation scale on the SRQ represents intrinsic motivation, considered to be the most self-determined type of motivation in youth (Ryan & Deci, 2000b).

Cogmed RM (Pearson, 2016). Our modified version of this computerized program required youth to complete three training sessions per week for a ten-week period, rather than five sessions per week for five weeks – thereby increasing the total number of sessions and delivering them over a longer consolidation period. All 30 sessions occurred with a clinical psychologist or trained research assistant (i.e., designated coach) in a quiet room with a computer at the hospital, as opposed to the standard at-home administration. As described elsewhere (Klingberg et al., 2005), Cogmed RM consists of 12 visual or auditory WM exercises that adjust task difficulty to the performance of each participant, thereby ensuring that participants are working at their optimal level of challenge. Participants completed eight of the 12 exercises at each training session. Each session lasted approximately 35 minutes, during which time the coach remained in the room with youth to answer any questions and provide motivational support. Coaches also had access to progress reports provided by Cogmed, tracking trial-by-trial performance and overall weekly performance. These reports were used to provide individualized feedback to youth, in addition to feedback built-in to the computer program as participants completed exercises. Because adherence was 100% in our sample, we did not include it in our assessment of engagement, and instead used Cogmed-generated outcome measures alone to assess a proxy of engagement with the program. To assess average improvement on overall performance, the program calculated an "Improvement Index" by subtracting the Start Index (score on third day of training) from the Max Index (best score throughout training). Given potential unreliability of difference scores (Webster & Bereiter, 1963), we analyzed the Start and Max Indices (M = 75.30, SD = 9.10 and M = 102.30, SD = 14.00 respectively).

Automated Working Memory Assessment (AWMA; Alloway, 2007). Four subtests were administered on a computer, all beginning with two-item lists and increasing by one as youth completed trials correctly. Scores were awarded up to the highest span correctly recalled. To measure WM, processing scores from subtests requiring complex manipulations (rather than rote memorization) were selected. Auditory WM was assessed using listening processing, which required youth to decide whether sentences were true or false and then report the last word of each sentence in reverse order. Visuospatial WM was assessed using spatial processing, which required youth to decide if two shapes were identical or opposites and then recall the locations of a red dot that appeared in one of each shape in reverse order.

Wechsler Individual Achievement Test – Third Edition (WIAT-III; Wechsler, 2009). Four subtests were used to assess academic achievement. The reading composite was derived from tests of reading fluency and comprehension, and the math composite was based on word problem solving and numerical operations. Raw scores were converted into age-normed standard scores.

Behaviour Rating Inventory of Executive Function – Second Edition (BRIEF-2; Gioia et al., 2015). Parent and teacher versions of the 63-item questionnaire were used to assess

Table 3. Pearson Correlations of Self-Regulation Questionnaire (SRQ) Scales with Cogmed Indices, Baseline, and Outcome measures.

		Correlation with SRQ Scale (r)			
Measure	M (SD)	Extrinsic	Introjected	Identified	Intrinsic
Cogmed metrics					
Start Index	75.30 (9.10)	.36	-.15	.09	-.07
Max Index	102.30 (14.00)	.42	-.01	-.07	.07
Baseline					
AWMA Listening Processing	36.60 (20.27)	-.21	-.48	-.11	-.39
AWMA Spatial Processing	47.00 (21.75)	.06	-.28	-.12	-.16
WIAT-III Reading Composite	103.30 (16.19)	.45	-.33	-.45	-.04
WIAT-III Math Composite	102.60 (14.56)	-.08	-.42	-.04	.25
BRIEF2-Parent GEC	140.40 (18.39)	-.34	-.13	-.16	.14
BRIEF2-Teacher GEC	110.00 (23.85)	-.41	-.09	-.12	-.33
CBCL ADHD	10.80 (2.62)	-.26	-.23	.08	.50
TRF ADHD	14.30 (7.09)	-.41	.03	-.02	-.21
BYI Self Concept	42.40 (4.79)	-.03	-.54	-.31	.09
Post 1 Follow-up					
AWMA Listening Processing	110.35 (13.49)	.06	.27	.03	-.09
AWMA Spatial Processing	113.53 (16.74)	.46	-.07	-.01	-.15
WIAT-III Reading Composite	107.90 (12.01)	-.18	-.78**	-.63	-.48
WIAT-III Math Composite	101.10 (12.04)	-.32	-.65*	.08	.18
BRIEF2-Parent GEC	69.50 (10.65)	-.31	-.28	-.29	-.11
BRIEF2-Teacher GEC	60.80 (13.08)	-.15	-.03	-.37	-.39
CBCL ADHD	69.30 (7.92)	-.32	-.38	.05	.09
TRF ADHD	60.80 (7.18)	-.37	.12	.02	-.20
BYI Self Concept	53.30 (3.80)	-.18	-.52	-.25	-.02
Post 2 Follow-up					
AWMA Listening Processing	109.22 (15.13)	-.08	.01	.07	-.47
AWMA Spatial Processing	109.68 (13.70)	.76*	.22	-.15	-.38
WIAT-III Reading Composite	108.30 (12.98)	-.02	-.71*	-.74*	-.45
WIAT-III Math Composite	101.20 (13.56)	-.10	-.40	.24	.39
BRIEF2-Parent GEC	69.30 (9.52)	-.29	.14	-.26	.03
BRIEF2-Teacher GEC	59.60 (15.23)	-.31	-.14	-.34	-.27
CBCL ADHD	68.50 (5.66)	.19	.20	.07	.48
TRF ADHD	63.00 (9.71)	-.29	.01	-.34	-.27
BYI Self Concept	55.70 (5.06)	-.73*	-.32	.39	.10

executive functioning skills evidenced by youth during a one-month period at home and school, respectively. Ratings were on a three-point Likert scale ranging from *never* (1) to *often* (3), with a total score reflecting overall executive dysfunction. Raw scores for this General Executive Composite were converted into *T*-scores using the normative sample.

Achenbach System of Empirically Based Assessment (ASEBA; Achenbach, 2010). Parents and teachers provided ratings of youth's behaviours during a six-month period on a three-point Likert scale ranging from *not true* (0) to *very true* (2). Of interest to our study were parent and teacher perceptions of ADHD symptomatology, which were converted to normative-based standard scores.

*Beck Youth Inventories – Second Edition (*BYI-II; Beck, Beck, & Jolly, 2005). This 20-item self-report questionnaire assessed youths' thoughts of self-competency and self-worth during a 2-week period, with responses ranging on a four-point Likert scale from *never true* (0) to *always*

Table 4. Identified Themes and Sample Quotes from Post-Training Interviews (n = number of individuals endorsing subtheme).

Theme	Subtheme	n	Sample quote
Reasons For Training	To improve memory	7	"At my house, my mom would ask me to do something, I would quickly forget about it."
	To improve focus/pay attention	8	"Sometimes when someone says something to me, the moment they stop talking to me I'm like, what did you say?"
	To reduce ADHD symptoms	3	"I don't want to have ADHD, its hard."
	To engage in a challenging activity	3	"Helping myself and being able to learn and teach myself."
	To improve organization	3	"I play hockey, so before getting my equipment in the change room I would just start talking and be late for the ice."
	To help others with ADHD	2	"Because I would help other kids."
Subjective Changes Post-Training	Improved Cogmed scores	7	"I think I did really well in the game that you had to complete."
	Improved Focus	6	"I felt like I was more aware of what I was doing because of the programs. Because they make you sit down and think about what you're doing."
	Improved memory	6	"I remember in the morning when my mom gives me a list of chores to do in the afternoon."
	Improvements in specific goals set out before training, including improved grades, math skills, or organization	7	"My grades have improved a lot."
Supports/Rewards Used for Training	Internal motivation	6	"Having the determination to come in every day."
	Gift received (iPad)	6	"I thought I would really like the iPad."
	Parents, Cogmed coach, or school teacher	6	"When [my coach] was encouraging me that was nice of him. And that also encouraged me to keep going."
	Enjoyment of program	6	"I just thought it would be fun."
	Food or activity reward	2	"We'd get a donut. But not every single time."

true (3). An overall *T*-score was examined, with higher scores representing lower levels of distress.

Post-Intervention Interview. A semi-structured interview was administered by a researcher not involved in the WM intervention, in which youth were asked open-ended questions regarding their reasons for training, subjective changes experienced post-intervention, and perceived supports or reinforcements. These interviews were audio recorded and transcribed. QSR International's NVivo 11 was used to qualitatively analyze post-intervention interviews. Qualitative analyses were conducted using focused coding, one type of coding drawn from grounded theory, for themes noted to recur across participants, after open-coding for full variation and comparison of all interview content (Charmaz, 2014; Strauss & Corbin, 1997). Using focused coding, responses were searched to find main themes shared amongst all participants. Individual responses were grouped based on the most frequent conceptually similar phrases that each participant gave per question, to create main identified themes (e.g., a participant's description of their choice to complete Cogmed was coded as "reasons for training"). Within each theme, subthemes were identified from keywords within each participant's response (e.g., a participant describing their memory as a reason for training was coded for the subtheme "improve memory" under the already-emerged theme of "reasons for training"). Trustworthiness was increased by using lines of questioning that were effective in a previous study (Sadeghi et al., 2017), using iterative questioning throughout the interview, and interviewing all ten youth regardless of individual performance on any measure. Data saturation, a concept that represents when themes are likely to be replicable and further coding not necessary (O'Reilly & Parker, 2012), was limited by the nature of the study; however, it is noteworthy that no new subthemes emerged when interviewing later participants.

Results

Association of motivational styles and WM training engagement

Associations between motivational styles in relation to the WM training regimen and Cogmed metrics are presented in Table 3. Given our small sample, we expected that only associations large in magnitude would reach a level of statistical significance. Whilst no associations were statistically significant (all *p*s > .36), it is worth noting that associations involving external regulation with the Start Index and Max Index were of moderate magnitude.

Association of motivational styles and outcome measures

Table 3 also shows associations between motivational styles and outcome measures at baseline and follow-up (i.e., post 1 and post 2). There were no significant associations between motivational styles and near outcomes (i.e., working memory) at any time point – an exception being performance on the spatial processing task and youths' external motivation at post 2 (r = .76, p = .01). These results indicate that youth who demonstrated higher levels of visuospatial working memory following completion of WM training were significantly more likely to endorse higher levels of controlled (i.e., extrinsic) motivation with regards to the WM training regimen.

Associations between motivational styles and far-transfer outcomes (i.e., academic achievement, parent and teaching ratings of executive function and ADHD, youths' report of self-esteem) also were mostly non-significant with a few notable exceptions. First, performance on the reading composite demonstrated trend-level or significant associations with both introjected and identified motivation at post 1 (introjected r = -.78, p = .007; identified r = -.63, p = .05) and post 2 (introjected r = -.71, p = .02; identified r = -.74, p = .02). A similar pattern was observed with the math composite and identified motivation at post 1 only (r = -.65, p = .04). These results suggest that far-transfer outcomes are negatively linked to more controlled (i.e., extrinsic) motivation, since both motivational styles are considered to be extrinsic styles of motivation as per self-determination theory (Deci & Ryan, 2000). Second, there was a significant association between youths' self-concept three-months following the intervention and their level of expressed extrinsic motivation with regards to the WM training regimen (r = -.73, p = .02). In other words, higher self-concept appeared negatively linked to extrinsic motivation.

Subjective appraisals of WM training

Amongst the ten youth who completed post-training interviews, a summary of themes that emerged through qualitative analyses is presented in Table 4. Most youth who completed training cited wanting to improve their focus/attention (n = 8) and memory (n = 7) as reasons for undertaking the intervention. The most oft-cited subjective changes noted by youth post-training were improved scores within Cogmed itself (n = 7), improved focus at school or home (n = 6), and improved memory (n = 6). Youth endorsed that driving factors in their completion of Cogmed were their internal motivation to complete the training program (n = 6), the support they received from parents, teachers, and/or their Cogmed coach (n = 6), the fun they experienced during the intervention (n = 6), and the iPad they received at the end of training (n = 6).

Discussion

One objective of this study was to determine whether motivation accounted for variation in ADHD youths' experience of Cogmed training. As predicted, ADHD youth who endorsed higher levels of extrinsic motivation on the SRQ were more engaged with Cogmed as reflected in their initial and peak levels of performance. This finding joins a growing body of evidence suggesting that different motivational styles can be beneficial depending on the nature of the outcome that is considered. In the case of Cogmed, our results with ADHD youth indicate that a more externally-regulated style of motivation may be sufficient to elicit their engagement with the intervention program. Indeed, since high incentive and feedback have been linked to high engagement in previous studies (Carlson & Tamm, 2000; Konrad et al., 2000; McInerney & Kerns, 2003), these built-in features of Cogmed may be enough to solicit the buy-in of ADHD youth and could explain their expression of higher levels of extrinsic motivation specifically.

At the same time, administration of a qualitative interview with ADHD youth further revealed that they had flexibility in their motivation to engage with Cogmed. Most endorsed several types of motivation as reasons for undertaking the training – including external rewards (e.g., receiving an iPad) as well as more internal motivators (e.g., wanting to improve attention or memory). These findings highlight multi-finality in the motivation of our ADHD youth: they completed a single task for achievement of several goals, each of which may have been internally and/or externally regulated (see also Eccles & Wigfield, 2002; Kruglanski, Chernikova, Babush, Dugas, & Schumpe, 2015). Though this is a newly burgeoning area of motivational work, it is likely that flexible motivational approaches are not unique to ADHD but rather have broad implications for youths' self-regulation toward tasks in general (Miele & Scholer, 2018).

A related objective of this study was to determine whether motivation was linked to ADHD youths' performance on outcome measures. Higher endorsement of extrinsic motivation was linked to better spatial processing scores following completion of the intervention program. We expected

that external motivation would be associated with transfer measures that emphasize absolute levels of performance. In addition, the spatial processing task is conceptually similar to tasks that are trained within the Cogmed program and it is presented in a near-identical video game format. It may be the case that these kinds of near-transfer measures require less internal motivation from ADHD youth because their completion entails doing similar tasks. Supporting this idea, improvement on a distal transfer measure of reading achievement was negatively associated with higher endorsement of introjected motivation (a style that is relatively external) – further hinting that tasks that differ substantially from those within Cogmed may require more interest and thus self-determination for ADHD youth. Having at least some internal motivation may also be relevant to how ADHD youth perceive themselves following participation in this kind of intervention program. ADHD youth who were more extrinsically motivated in our study actually endorsed a lower self-concept post-intervention. Though speculative, it may be the case that ADHD youth who are more motivated to undertake training due to the promise of external rewards are less likely to attribute their accomplishments to something within themselves – leading them to have lower levels of self-esteem relative to their more internally motivated peers. Our results suggest that, moving forward, one important direction for intervention science will be examining the confluence of expressed motivational style and the type of outcome that is measured – particularly for ADHD youth.

A secondary aim of our study was to incorporate a qualitative approach into our research design, supplementing the quantitative analyses that typify the Cogmed literature. The balance of quantitative research suggests that ADHD youth do not evidence improvement on performance-based tasks following completion of the training program (e.g., Cortese et al., 2015) – however, these tasks are limited in ecological validity and may not capture changes that youth themselves perceive with regards to their lived experience in everyday life. Indeed, when asked about subjective changes post-intervention via qualitative interview, ADHD youth mentioned improvements that were consistent with those reported in other qualitative studies (e.g., Sadeghi et al., 2017; Till et al., 2017). Specific examples included improvements in focus, memory, and meeting personal goals they had set for themselves at the outset of the program (e.g., enhanced school success, being more organized). Importantly, we did not capture these improvements on performance-based measures and thus these improvements may be most suggestive of perceived utility of the program, rather than effectiveness of the intervention. Overall, ADHD youth endorsed personal success with the Cogmed intervention. For interventions such as Cogmed, this finding emphasizes that subjective experiences with the intervention may be separable from gains on more objective psychometric measures and that both should potentially be explored when adjudicating the efficacy and effectiveness of this program. For clinicians who are working with ADHD youth, one point of consideration that logically follows from the above is that youths' perceptions may not necessarily align with what is often considered to be hard data (i.e., test performance or rating scales). Without the inclusion of questions that invite ADHD youth to reflect and report upon their subjective experience of an intervention program, clinicians may miss learning about how ADHD youth evaluate their personal contribution to the intervention effort and the extent to which they believe it has or has not 'worked'.

The results of our study should be considered preliminary and interpreted within the context of limitations. Although our participants were randomly assigned to groups that were statistically comparable on clinical-demographic characteristics, numerically there were more youth in the treatment group who were male, had a co-morbid diagnosis of ODD, and were taking stimulant medication. Further, because the impetus for the study occurred after our clinical trial was underway, only ADHD youth who were enrolled toward the end of the trial were able to complete motivational measures. This necessarily limited our sample size. As well, there is an increased potential for Type 1 error given the exploration of multiple correlations in our study. Lastly, ADHD youth completed the ad hoc measures after Cogmed – though before a final feedback session with their parents/guardians. Because the intervention was delivered in a highly-structured format (e.g., a dedicated coach at every session, explicit feedback embedded within the program), we speculate that their level of external motivation was likely to have been stable throughout the study. In contrast, however, internal motivation may have increased after completion of Cogmed given previous work showing that internal motivation is linked with engagement and sustained effort on tasks (Scholer & Miele, 2016). Given these considerations, it will be important that future research endeavor to replicate and extend our findings with a larger sample of ADHD youth – including better representation of females with ADHD as well ADHD youth who present with less clinical complexity – with motivational measures administered at the outset of the study.

In conclusion, our results show that ADHD youth bring to Cogmed training multiple motivational styles that are important for different reasons. External motivation predicted better engagement with the training initiative and higher levels of performance on some post-intervention measures that were similar to trained Cogmed tasks. Conversely, intrinsic motivation (i.e., integrated motivation in our youth) was positively associated with more distal transfer measures and had implications for ADHD youths' self-esteem. When asked directly about their subjective experiences with Cogmed, all ADHD youth reported that it was successful and identified positive improvements in their functioning at home and at school. Given these links between different

motivational styles and the type of goal that is being evaluated, further consideration of motivational styles may assist clinicians who are looking to better understand their clients' desire for change, reasons for pursuing goals, or identify potential setbacks in treatment. Supplementing traditional outcome measures with open-ended questions that encourage clients to reflect upon their subjective experiences may also lead to a more balanced view of treatment gains (or lack thereof) following an intervention program like Cogmed. Notably, the inclusion of subjective experience measures is not meant to capture change in hard-to-define concepts such as everyday attention, purported to improve after interventions such as Cogmed, but instead to elucidate what participants perceive to have gained in functioning. For researchers, incorporating the construct of motivation into intervention work and integrating quantitative and qualitative approaches holds promise insofar as leading to a more nuanced understanding of treatments for ADHD youth.

Acknowledgments / Conflicts of Interest

Cogmed and Cogmed Working Memory Training are trademarks, in the U.S. and/or other countries, of Pearson Education, Inc. or its affiliate(s). Pearson Education did not play a role in the design or conduct of the study; analysis or interpretation of the data; or preparation or review of the manuscript. Many thanks to Martyn Gabel and Meagan Koufis for their work as Cogmed coaches.

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