Academic Impairment among High School Students with ADHD: The Role of Motivation and Goal-Directed Executive Functions

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Abstract

Attention-Deficit/Hyperactivity Disorder (ADHD) is associated with academic failure in high school; however the underpinnings of these difficulties are insufficiently understood. This study examined deficits in self-regulated learning in a sample of high school students with ADHD (n=32) compared to demographically similar classmates without ADHD (n=18). A multimethod battery of self and parent rating scales and cognitive tasks measured aspects of intrinsic motivation, extrinsic motivation, and goal-directed executive functions. A multiple regression modeled predictors of current Grade Point Average (GPA). Results indicated that high school students with ADHD placed lower value on academics (d=.99), were less likely to use goal-setting strategies (d=.95), possessed lower levels of metacognition (d=1.86), and showed significant deficits in task-based cognitive flexibility (d=.80). After controlling for covariates, the set of self-regulated learning variables explained 23% of the variance in GPA, with metacognition (6% of variance explained) and cognitive flexibility (7% of variance explained) serving as significant predictors of outcome. Findings suggest that higher-order executive function deficits play a critical role in the academic functioning of high school students and students with ADHD show large deficits in these areas. Thus, interventions that target metacognition and cognitive flexibility (i.e., the ability to think through decisions before acting, inhibit automatic responses, and make effective decisions for a desired goal) may be particularly promising to remediate ADHD-related academic problems in high school.

Keywords: ADHD, High School, Motivation, Executive Function

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It is well-established that Attention Deficit/Hyperactivity Disorder (ADHD) possesses distinct manifestations during each period of human development (Barkley, 2006; Wilens, Biederman, & Spencer, 2002). Studies link ADHD to similar neurocognitive deficits in childhood, adolescence, and adulthood (Seidman, 2006). These include dimensions of cognitive control (i.e., working memory, response inhibition, cognitive flexibility) and rewards processing (i.e., delay aversion, delay discounting, risky decision making; Castellanos, Sonuga-Barke, Milham, & Tannock, 2006; Sonuga-Barke, 2003). Yet, how these basic processes impact daily behavior is largely dependent upon context. For example, the same cognitive control deficit may lead a child with ADHD to shout out answers, an adolescent to complete peers' sentences, and an adult to take over others' vocational tasks (American Psychiatric Association, 2013). Similarly, rewards processing deficits may lead a child with ADHD to be off-task in class activities, an adolescent to appear academically unambitious, and an adult to chronically struggle with deadlines. The current investigation addresses how the neurocognitive deficits of ADHD impact academics in the high school context, with attention to the process of self-regulated learning.

Self-Regulated Learning in High School

Compared to elementary and middle school, high school is less structured and offers limited prompts, assistance, and immediate reinforcements from teachers. High school academic work is assigned in large parcels with expectations for independent work completion (Barber & Olsen, 2004). Thus, the transition to high school presents increased expectations for self-regulated learning—independent management of academic work that requires one to regulate both their motivational state and behavior (Zimmerman, 2002). Compared to peers, adolescents with ADHD show marked high school academic problems culminating in an increased risk for dropout (Barkley, Anastopoulos, Guevremont, & Fletcher, 1991; Kent et al., 2011). Hallmarks of this impairment are poor work completion and inadequate test preparation (Kent et al., 2011)—tasks that draw heavily on self-regulated learning (Zimmerman, 2002).

Self-regulated learning is bolstered by: (a) intrinsic motivation (i.e., interest in and enjoyment of academic activities); (b) extrinsic motivation (i.e., valuing the outcomes associated with academic success); and (c) goal-directed executive functions (i.e., planning, task-initiation, maintaining on-task behavior, and task shifting; Kim, 2013; Zimmerman, 2002). Due to cognitive control and rewards processing deficits, students with ADHD show impairments in all of these processes (Modesto-Lowe, Chaplin, Soovajian, & Meyer, 2013; Sonuga-Barke, 2003). Higher impairments in self-regulated learning are documented for middle versus elementary school students with ADHD (Lee & Zentall, 2017). However, no work investigates ADHD and self-regulated learning in high school, when academic demands increase even further.

ADHD and Intrinsic Motivation

With respect to intrinsic motivation, students with ADHD report lower levels of academic task interest and perceive lengthy assignments to be highly aversive (Carlson, Booth, Shin, and Canu, 2002; Morsink et al., 2017). Intrinsic motivation deficits appear tied to abnormal anticipatory dopamine response (Oudeyer, Kaplan, Hafner, 2007)—which is implicated as a core neurocognitive deficit in ADHD (Volkow et al., 2011). Thus, typical academic tasks may feel less intrinsically rewarding to individuals with ADHD (i.e., lower experiences of novelty, curiosity, enjoyment). In the high school context, these deficits may be prominent due to the repetitive and complex nature of many academic tasks (Barber & Olsen, 2004). Intrinsic motivation deficits also may be compounded by ADHD-related delay aversion (Sonuga-Barke, Sergeant, Nigg, & Wilcutt, 2008), mental discomfort when tasks contain particularly delayed rewards (i.e., long-term projects, final exams). To escape this aversive mental state, high school students with ADHD may gravitate to immediately rewarding activities, such as video games or social media (Mazurek & Engelhardt, 2013; Yen, Ko, Yen, Wu, & Yang, 2007). It is also likely that intrinsic motivation is hampered by ADHD-related learning problems that increase the aversive properties of schoolwork (Loe & Feldman, 2007).

ADHD and Extrinsic Motivation

With respect to extrinsic, value-driven motivation, students with ADHD report valuing academic achievement and mastery less than peers (Barron et al., 2006; Colomer, Berenguer, Roselló, Baixauli, & Miranda, 2017; Gut, Heckmann, Meyer, Schmid, & Grob, 2012; Olivier & Steenkamp, 2004; Zentall & Beike, 2012). Extrinsic motivation reflects the perceived utility of a task (i.e., both its reward value and the expected probability of achieving it; Wigfield & Eccles, 2000). For students with ADHD, a built-in preference for immediate rewards (i.e., deficits in delay discounting; Scheres et al., 2006) may prevent high valuation of grades, which are a long-term and symbolic reinforcer. Students with ADHD also show insensitivity to future negative consequences (Toplak, Jain, & Tannock, 2005), which may reduce extrinsic motivation to avoid negative outcomes (e.g., course failure, expulsion). Thus, high school students with ADHD may be less extrinsically motivated than peers to pursue high grades *and* avoid problematic consequences. Furthermore, high school students with ADHD may exert lower academic effort because they perceive reduced probability of achieving high grades, due to years of school failure and negative feedback from adults (i.e., reduced self-efficacy; Newark, Elsasser, & Stieglitz, 2016).

ADHD and Goal-Directed Executive Functions

Even with adequate motivation, deficits in goal-directed executive functions (Gollwitzer & Brandstatter, 1997; Zimmerman, 2002) may prevent academic success. This aspect of self-regulated learning involves using top-down cognitive processes to implement actions in support of one's values and suppress counterproductive motivational states (Kim, 2013). These functions include working memory (i.e., ability to sustain mental representation of a desired outcome), response inhibition (i.e., ability to suppress urges to engage in problematic behaviors), and cognitive flexibility (i.e., ability to shift from one strategy to another according to the demands of a new situation). Together, these basic processes promote goal-directed behaviors such as planning, task-initiation, inhibiting unproductive behaviors, and task disengagement. The executive functions associated with goal-directed behavior are notably impaired in individuals with ADHD (Castellanos et al., 2006; Sonuga-Barke, 2003). Thus, it is not surprising that individuals with ADHD show difficulties with goal setting and goal pursuit (Hoza, Waschbusch, Owens, Pelham, & Kipp, 2001; Nyman et al., 2010). Deficits in goal-directed behaviors are linked to academic performance in middle school and college students with ADHD (Gropper & Tannock, 2009; Langberg, Dvorksy, & Evans, 2013); however, similar studies are yet to be conducted in high school settings.

In sum, for high school students with ADHD, the critical process of self-regulated learning contains multiple points of vulnerability. However, almost no research examines how problems with motivation and goal-directed executive functions interfere with academics in the high school context. The nature of the high school academic environment presents unique learning demands and requires context-specific interventions for students with ADHD. Identification of candidate intervention targets requires knowledge of how ADHD-related neurocognitive deficits and their psycho-behavioral manifestations undermine academic success in high school.

Current Study

This study examined the association between academic performance and self-regulated learning in a sample of ninth grade students with ADHD (*n*=32) compared to demographically similar non-ADHD classmates (*n*=18). For high school students with ADHD, ninth grade represents peak academic impairment (Kent et al., 2011) and may represent a critical period for intervention. To better understand how ADHD-related difficulties undermine high school academic success, we implemented a multimethod battery with measures at the basic cognitive and psycho-behavioral levels. This included measures of intrinsic motivation (i.e., academic interest, delay aversion), extrinsic motivation (i.e., academic importance, delay discounting, risk decision-making), and goal-directed executive functions (i.e., goal setting, metacognition, working memory, response inhibition, and cognitive flexibility). We hypothesized significant differences between ADHD and non-ADHD groups on all three aspects of self-regulated learning—at both the basic cognitive and psycho-behavioral levels. We also examined the extent to which ADHD-related deficits predicted student grade point average (GPA), hypothesizing that aspects of intrinsic and extrinsic motivation, as well as goal-directed executive functions, would uniquely predict academic performance.

Method

Participants

Participants were regular education ninth-grade students (*N*=50) at two public high schools in a culturally diverse metropolitan region of the eastern United States. Students with ADHD (*n*=32) were recruited from a larger trial on academic interventions for high school students with ADHD symptoms. At baseline, parents of participants at two schools in the trial were approached with an opportunity to participate in the current study, which included an extended cognitive, behavioral, and neuroimaging battery designed to study ADHD symptom expression in adolescence. Out of 48 eligible students, 36 consented to the extended battery, and four were excluded due to not meeting criteria for ADHD (which was not a requirement of the larger trial). Participating and non-participating students with ADHD showed no differences in free/reduced lunch status, gender, ethnicity, medication status, baseline GPA, or IQ (all $p > .20$). Non-ADHD participants (n=18) were recruited from the same classrooms as ADHD participants and were matched to ADHD participants by school and demographic profile. There were no significant group differences between ADHD and non-ADHD participants in age, free/reduced lunch status, gender, ethnicity, or IQ (see Table 1). However, non-ADHD participants were more likely to have a parent with at least a two-year college degree. As a result, parent education level served as a covariate in all analyses.

Procedures

ADHD group recruitment. Regular education ninth-grade teachers at two high schools were asked to nominate students who displayed symptoms of ADHD in their classrooms. Teachers obtained written parental permission to nominate and completed a DSM-5 ADHD checklist and measures of academic impairment (Fabiano et al., 2006; Sibley, Altszuler, Morrow, & Merrill, 2014; Sibley & Kuriyan, 2016). Students were eligible for participation in the larger trial if they displayed at least four symptoms of either inattention or hyperactivity/impulsivity and significant academic impairment, defined as meeting two of the following four criteria: (a) at least one D or F in a core academic class; (b) at least 20% of assignments missing in one class; (c) at least a “3” on the academic impairment item of the 0-6 teacher Impairment Rating Scale

(Fabiano et al, 2006); or (d) elevated academic problems on the teacher Adolescent Academic Problems Checklist (AAPC; Sibley et al., 2014; 4 items endorsed as “pretty much” or “very much”). Participants were also required to demonstrate an IQ > 70 on the Wechsler Abbreviated Scale of Intelligence, 2nd edition (WASI-II; Wechsler, 2011). Parents of 48 enrolled participants in the larger trial were phoned by project staff to present the current study opportunity.

In addition to the criteria above, participants in the current study were required to meet DSM-5 A (symptom count) and C-E (impairment, pervasiveness, ruling out other disorders) criteria for ADHD according to combined report on the parent and adolescent semi-structured diagnostic interview (Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version-DSM-5; KSADS-PL; APA, 2013; Kaufman et al., 1997) and teacher symptom and impairment ratings. An item-level “or” rule was used to determine symptom presence (Sibley et al., 2012). The B criterion (age of onset) was waived for this study given recent research validating an adolescent-onset form of ADHD (Chandra, Biederman, & Faraone, 2016).

Non-ADHD group recruitment. A research assistant visited all regular education classrooms with at least one participant in the ADHD group and provided a brief presentation on the current study, which was described as an investigation of the teenage brain at the transition to high school. The research assistant distributed an informational flyer, a parent permission to contact form, and a parent-report DSM-5 ADHD checklist. Self and teacher reports of ADHD symptoms were also obtained. Students were eligible for the non-ADHD group if they: (a) possessed an IQ > 70; (b) possessed three or fewer symptoms of inattention and three or fewer symptoms of hyperactivity/impulsivity according to combined reports on the K-SADS-PL and teacher symptom and impairment ratings; and (c) increased the non-ADHD group’s similarity to the ADHD group (based on gender, ethnicity, and school). Comparison participants were permitted to display academic impairment and mental disorders other than ADHD.

Data collection. Participants and parents completed two study visits of approximately three hours each in duration. Visit 1 was held at the university or adolescent's home (according to parent preference). Visit 2 was held at the university neuroimaging center. Parents and participants each received $100 for completing visit 1. For visit 2, parents received $50 to offset transportation costs and students received $100 and a photograph image of their brain for participation. During visit 1, students completed cognitive tasks, a semi-structured diagnostic interview (K-SADS-PL; Kauffman et al., 1997), and self-ratings, while parents completed parent-ratings and the K-SADS-PL. During visit 2, students completed a neuro-imaging protocol. Neuroimaging data were not utilized in the present investigation. All participants who received psychoactive medication underwent a 24-hour washout period prior to both visits.

Measures

When conducting research with adolescents with ADHD, difficult choices must be made about measurement sources. Because adolescents with ADHD tend to under-report observable behavior problems (Fischer, Barkley, Fletcher, & Smallish, 1993; Sibley et al., 2012), parent ratings were utilized for all indices of observable behavior. However, because parents may not have access to internal mental states (Hope et al., 1999), adolescent report was utilized for all ratings of internal processes and motivational states.

Grade point average. Electronic gradebook data were obtained directly from schools. Grade point average was calculated by converting all academic grades (i.e., English, Math, Science, History) to a 5-point scale (i.e., 4.0=A, 3.0=B, 2.0=C, 1.0=D, 0.0=F). Grades were not weighted for class level (e.g. Honors vs. Regular). Students were recruited during the second academic quarter, and this grading period was utilized.

Intrinsic motivation. The Expectancy-Value Theory of Motivation Measure-Student Version (EVTMM; Wigfield & Eccles, 2000) is a gold-standard self-report measure of student motivation with excellent psychometric properties that consists of 11 items measured on a 5-point scale. The two "interest" items ("in general, I find working on school work interesting…" "How much do you like doing schoolwork?..") were averaged to provide an index of academic interest (Wigfield & Eccles, 2000). The combination of these two items has good reliability and validity (Jaap, Denissen, Zarrett, & Eccles, 2007). Alpha in the current study was .81. Delay aversion was measured using the 10-item self-report version of the Quick Delay Questionnaire, which shows good psychometric properties (Clare, Helps, & Sonuga-Barke, 2010). Individuals self-rate their degree of aversion and response to delayed rewards using a 5-point scale. In this sample, alpha for the Quick Delay Questionnaire was .79.

Extrinsic motivation. The EVTMM's two "importance" items (i.e., "for me being good in school is important…" "compared to most of your other activities, how important is it for you to be good in school…") were averaged to provide an index of academic importance (Wigfield & Eccles, 2000). A subscale containing these two items is validated for adolescents (Eccles & Wigfield, 1995). In the current study, alpha for this subscale was .82. A computerized Iowa gambling task (Hungry Donkey Task; Crone & van der Molen, 2004) was administered as a measure of risky decision making (i.e., sensitivity to future negative consequences). Participants were told to assist the hungry donkey to collect as many apples as possible by pressing one of four keys corresponding to four separate doors. The future yield of each door varied, with higher wins at the high paying doors (A and B), and lower wins at low paying doors (C and D).

Selecting door A or B resulted in a gain of four apples, whereas door C or D resulted in a gain of two apples. Number of low-risk doors selected minus number of high-risk doors selected was computed as an index of risky decision making (Crone et al., 2004). The task shows good convergent validity in adolescents (Crone & van der Molen, 2007). Delay discounting was measured using a computerized Choice-Delay Task (Scheres et al., 2006) in which participants were instructed to make repeated choices between a small variable reward (0, 2, 4, 6, 8, or 10 cents) that would be delivered immediately (i.e., after 0 seconds) and a large constant (10 cents) reward that would be delivered after a variable delay of 0, 5, 10, 20, or 30 seconds. After completion of the task, participants received the total earnings from the examiner. The total amount of money earned served as an index of delay discounting. This task shows developmental sensitivity (Scheres et al., 2006) and correlates with symptoms of ADHD (Scheres, Lee, & Sumiya, 2008).

Goal-directed executive functions. The goal setting and planning section of the Self-Regulated Learning Interview Schedule (S-RLIS; Zimmerman & Pons, 1986) was converted to a parent-report rating scale to measure goal setting. Six items measured the extent to which parents observed students to set short-term and long-term goals during schoolwork, when completing household tasks, and when poorly motivated. In the current sample, alpha for this measure was .87. The Behavior Rating Index of Executive Function (BRIEF-2) is a well-validated measure of executive function for youth ages 5-18 (Gioia et al., 2000). Parents rate youth executive functions on a three-point scale across nine subscales. The 32-item metacognition index measures an adolescent’s ability to initiate, plan, organize, self-monitor, and sustain working memory (Gioia et al., 2000). In the current study, alpha was .97 for the metacognition index. Working memory was measured using the National Institute of Health (NIH) Toolbox List

Sorting Working Memory Test (Weintraub et al., 2013). In this task, a series of stimuli is presented visually and orally. Participants are instructed to recall the stimuli in order of size, from smallest to largest. The List Sorting task takes approximately 7 minutes to administer and test scores consist of total items correct across all trials. This task shows excellent test-retest reliability and convergent and discriminant validity (Tulsky et al., 2013). Response inhibition was measured using a go/no-go task that uses both positively and negatively valenced emotional stimuli (Hare, Tottenham, Davidson, Glover, & Casey, 2005). Happy and sad facial expressions were alternated as go and no-go cues across the four blocks in an HSSH order, which resulted in equal numbers of happy and sad faces serving as go and no-go cues. The number of commission errors on no-go trials across the whole task was utilized as a measure of response inhibition. The task shows good convergent validity (Schultz et al., 2007) and has been validated with adolescents (Hare et al., 2008). Cognitive flexibility was measured using the NIH Toolbox Dimensional Change Card Sort Test (Weintraub et al., 2013). In this task, a target visual stimulus must be matched to 1 of 2 choice stimuli according to shape or color. The relevant sorting criterion word, “color” or “shape,” appears on the screen. An algorithm weights accuracy and reaction time. A total of 40 trials require 4 minutes. The task shows excellent developmental sensitivity and convergent validity (Zelazo et al., 2013).

Analytic Plan

In analysis 1, group differences in study variables were examined separately for each measure using a General Linear Model (GLM) with group (ADHD=1, non-ADHD=0) as the independent variable and parent education level (no degree=0; degree=1) as a covariate. A false-discovery rate correction was applied within domain to correct for multiple comparisons (Benjamini-Hochberg, 1995). In analysis 2, we investigated functions that interfere with academic performance. A multiple regression was conducted with IQ and parent education level (at least 2-year degree: yes/no) as covariates and predictors that included all constructs with at least marginally significant differences between the ADHD and non-ADHD group in analysis 1. Squared semi-partial correlations were computed for each predictor as an index of the percentage of unique variance contributed by each predictor.

Results

Group Differences

Table 2 displays group differences in each index separated by domain. After correcting for multiple comparisons, the ADHD group showed significantly lower GPAs (d=2.14), self-rated importance of academics (d=.99), parent-rated goal setting (d=.95), parent-rated metacognition (d=1.86), and task-based cognitive flexibility (d=.80). The ADHD group also showed higher levels of self-rated delay aversion (d=.69), though this effect became non-significant when applying the false discovery rate correction. There were no significant group differences in self-rated academic interest (p=.064, d=.58) or task-based working memory (p=.608, d=-.17), response inhibition (p=.593, d=-.19), delay discounting (p=.320, d=.32), or risky decision making (p=.178, d=.19).

Predictors of GPA

Prior to analyses, assumption testing occurred. All variables conformed to linearity and normality assumptions (skewness values < |3|, kurtosis values < |8|; Kline, 2005). Multi-collinearity was low (VIF range: 1.01 – 1.38). Bivariate correlations for all variables are presented in Table 3. Results are presented in Table 4. At step 1 (covariates), the overall model was significant [R^2=.22, F(2, 44)=6.05, p=.01]. The incremental change in step 2 from the contribution of behavioral and cognitive variables was significant [$R^2\Delta$=.23, $F\Delta$(6, 38) =3.19, *p*=.02], as was the overall model [R^2=.44, *F*(7, 39)=4.44, *p*=.001]. Parent-rated metacognition (*p*=.05, sr^2=.06) and task-based cognitive flexibility (*p*=.03, sr^2=.07) uniquely predicted 13% of the variance in GPA after controlling for covariates.

Discussion

This research investigated how high school classmates with and without ADHD differed on three aspects of self-regulated learning (intrinsic motivation, extrinsic motivation, goal-directed executive functions) using both basic cognitive and psycho-behavioral frameworks. We also investigated whether these difficulties account for academic impairment in high school. Results indicated that compared to non-ADHD peers, adolescents with ADHD showed deficits in how much they valued academic success, goal-setting, metacognitive behaviors (i.e., initiating tasks, planning, organizing, self-monitoring), and cognitive flexibility (a task-based executive function). They did not significantly differ from peers on academic interest or delay aversion, indices of rewards processing, or working memory and response inhibition. After controlling for IQ and parent education level, aspects of self-regulated learning accounted for 23% of the variance in GPA, with metacognitive behaviors and cognitive flexibility contributing unique variance to this prediction (13%; see Table 4).

The results of this study indicate that both motivational and goal-directed aspects of self-regulated learning are impaired in adolescents with ADHD (see Table 2). Thus, high school students with ADHD may struggle to self-motivate *and* devise and execute work completion plans—even when motivated. With respect to intrinsic motivation, our work fails to replicate studies with younger samples, which report differences between children with and without ADHD (Carlson et al., 2002; Lee & Zentall, 2017). This non-significant result may stem from insufficient statistical power after applying a false discovery rate correction (academic interest *d*=.58; delay aversion *d*=.69) because similar effect sizes are reported as significant results in childhood studies (Carlson et al., 2002; Lee & Zentall, 2017). On the other hand, intrinsic motivation shows normative declines in high school as students face increasingly complex academic work (Gottfried, Fleming, & Gottfried, 2001); thus, ADHD versus non-ADHD differences in intrinsic motivation may be more prominent in childhood. Regardless, intrinsic motivation appears to be the least impaired aspect of self-regulated learning among high school students with ADHD.

Our work replicates and extends upwards a robust finding that psychological indices of extrinsic motivation are lower in elementary and middle school students with ADHD compared to peers (for review see Smith & Langberg, 2018). However, basic cognitive measures of rewards processing indicated no significant differences between the ADHD and non-ADHD groups (*d*=.19 to .32; see Table 2). These results add to mixed findings in the literature for rewards processing tasks administered to adolescents with ADHD (Barkley, Edwards, Laneri, Fletcher, & Metevia, 2001; Scheres et al., 2006; Toplak, Jain, & Tannock, 2005). Because an exaggerated response to rewards is normative in adolescents (compared to children; Galvan et al., 2006), it is possible that group differences are less stable during this developmental period. Although students with ADHD placed a lower value on academic performance (see Table 2), extrinsic motivation problems did not specifically undermine GPA in high school students (see Tables 3 & 4).

With respect to goal-directed aspects of self-regulated learning, our results converge with findings from middle school and college ADHD samples suggesting meaningful deficits in executive function behaviors (Dvorsky & Langberg, 2019; Langberg et al., 2013). This study offers a novel finding that high school students with ADHD are less likely to use goal setting strategies than their peers— although this finding converges with the broader literature on adolescent ADHD and planning deficits (Toplak, Bucciarelli, Jain, & Tannock, 2008). In this study, there were no group differences in working memory and response inhibition, which is consistent with the findings of Barkley and colleagues (2001) but diverges from other investigations of ADHD and adolescent cognition (e.g., Martel, Nikolas, & Nigg, 2007). For students with ADHD, the most severe executive function deficit was cognitive flexibility in a task-shifting paradigm—a higher order executive function characterized by the ability to switch between mental processes to generate an appropriate behavioral response (Bunge & Zelazo, 2006). Task-shifting is achieved through an interplay of several lower-order executive functions (Dajani & Uddin, 2015). Thus, unlike in children, the cognitive deficits of high school students with ADHD may be most pronounced for higher-order cognitive processes (i.e., planning, organization, goal setting and implementation, cognitive flexibility).

Metacognition and cognitive flexibility also contributed the largest proportion of unique variance in predicting student GPA. In adolescence, these executive functions translate into the ability to think through decisions before acting, inhibit automatic responses, and choose effective actions for a desired goal (Hunter & Sparrow, 2012). The key predictive role of higher-order executive functions (i.e., metacognition and cognitive flexibility) is consistent with the theory that self-regulated learning is a multi-component process that draws heavily on metacognitive abilities and decision-making (Zimmerman, 2002). Given increasing academic task complexity in the high school context, deficits in higher-order cognitive functions may be particularly impairing. Because the academic demands of high school require higher levels of self-regulated learning, it is logical that metacognition and cognitive flexibility contribute a significant amount of variance to adolescent success. Future work should investigate whether these executive functions are also critical to the success of students with ADHD enrolled in post-secondary education—a context where demands increase even further. Future work should also consider the role of sluggish cognitive tempo symptoms (SCT; Barkley, 2013) in predicting academic impairment among high school students with ADHD. Core symptoms of SCT include drowsiness, slow response time, and fogginess. Approximately 30% of students with ADHD also show elevations in SCT symptoms, which are shown to be distinct from ADHD (Servera, Saez, Burns, & Becker, 2018). SCT does not correlate with the motivation and executive function deficits typically associated with ADHD (Barkley, 2013; Becker et al., 2013; Wilcutt et al., 2014)—therefore, this symptom cluster may represent an additional pathway (i.e., outside of self-regulated learning variables) to academic impairment among students with ADHD.

Thus, interventions to improve self-regulated learning among high school students with ADHD may be optimized by targeting metacognition and cognitive flexibility. The greatest impact on GPA may occur through teaching strategies that improve planning or compensate for cognitive inflexibility. Emerging school-based interventions for high school students with ADHD might integrate compensatory metacognitive strategies such as goal setting and implementation intentions (Gawrilow, Morgenroth, Schultz, Oettingen, & Gollwitzer, 2013), habitual practice of organization strategies (Sibley et al., 2016), and teaching cognitive techniques that facilitate task initiation and suppress urges to drift off-task (Sprich, Safren, Finkelstein, Remmert, & Hammerness, 2016). Low doses of stimulant medication improve lower order cognitive flexibility in children with ADHD (Tannock, Schachar, & Logan, 1995), though it is not clear if this finding extends to higher order task-shifting in adolescents. In typically developing children and adults, there is evidence that aerobic exercise (Masley, Roetzheim, & Gualtieri, 2009; Tuckman & Hinkle, 1986) and meditation (Moore & Malinowski, 2009;

Schonert-Reichl et al., 2015) can improve cognitive flexibility, although it is unclear whether these results extend to adolescents with cognitive deficits. Further testing is needed to refine these intervention approaches for the high school context—where almost no ADHD intervention research has occurred.

Limitations

Strengths of this study include its multimethod battery, culturally diverse and socio-economically disadvantaged sample that is typically underrepresented in research, and thorough diagnosis and inclusion criteria. One limitation of this study is its sample size, which prevented detection of some small to medium effects. However, the results of this study remain meaningful because many large effects were present, even after Type I error corrections were imposed. Because we were interested in predictors of GPA that are associated with the ADHD-profile, we did not include variables with non-significant group differences in our regression equation. However, it is possible that this led to a specification error. Despite our efforts to recruit a demographically similar group of non-ADHD classmates, participants without ADHD had higher parent education levels, requiring us to model this variable as a covariate in analyses. This difference may have emerged due to higher rates of ADHD in socio-economically disadvantaged families (Danielson et al., 2018). High levels of academic impairment were present in the ADHD group, likely because students were nominated by teachers. Although academically successful students with ADHD are typically outliers, results may not generalize to these students (Kent et al., 2011). This study was cross-sectional; longitudinal testing of the detected effects would provide a richer understanding of how aspects of self-regulated learning interact to influence academic trajectory over time. Findings also should be replicated with a larger sample, as well as higher income and non-American samples and ethnic groups that were under-represented in this sample (i.e., adolescents of European, Asian, and Native American descent).

Conclusions

High school students with ADHD possess a collection of motivational and executive functioning deficits that impair self-regulated learning. Deficits in higher-order executive functions (i.e., metacognition, cognitive flexibility) appear to be particularly debilitating in high school—thus, intervention efforts should address remediation of or compensation for these difficulties. Further work is needed to understand the interplay between ADHD and various aspects of self-regulated learning. This work should consider neurobiological, cognitive, psychological, and behavioral influences on student functioning. Future work should also consider how environmental influences, such as parenting practices and school context, influence the link between ADHD and self-regulated learning.

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Table 1

Demographic and Clinical Characteristics of the Sample

	ADHD (*n*=32)	Non-ADHD (*n*=18)	*p*
Demographic Characteristics			
Male % (*n*)	68.8 (22)	66.7 (12)	.881
Race/Ethnicity (%)			.294
African-American	25.0 (8)	5.6 (1)	
Hispanic (Any Race)	59.4 (19)	77.8 (14)	
White, Non-Hispanic	3.1 (1)	0.0 (0)	
Mixed Race	12.5 (4)	16.7 (3)	
Free/Reduced Lunch % (*n*)	96.6	83.3	.150
Age *M* (*SD*)	14.72 (.78)	14.50 (.79)	.344
Parent 2-year degree % (*n*)*	37.5 (12)	76.5 (13)	.009
Clinical Characteristics			
IQ *M* (*SD*)	94.53 (12.12)	101.22 (15.52)	.097
ADHD Subtype % (*n*)			
ADHD-Predominantly Inattentive	68.8 (22)	---	---
ADHD-Combined	31.3 (10)	---	
ODD/CD % (*N*)	18.8 (6)	0.0 (0)	.050
KSADS Symptom Count *M* (*SD*)			
Current Inattention	4.31 (2.98)	.50 (.86)	<.001
Current Hyperactivity/Impulsivity	1.50 (2.13)	.17 (.51)	.012
Teacher Symptom Count *M* (*SD*)			
Current Inattention	7.09 (1.87)	2.91 (3.32)	<.001
Current Hyperactivity/Impulsivity	.28 (.83)	.06 (.24)	.001
ADHD Medication % (*n*)	6.3 (2)	0.0 (0)	.293

Note. ADHD=Attention Deficit Hyperactivity Disorder, ODD=Oppositional Defiant Disorder; CD=Conduct Disorder; KSADS= Kiddie Schedule for Affective Disorders and Schizophrenia; *M*=Mean, *SD*=Standard Deviation *$p<.05$

Table 2

ADHD versus Non-ADHD differences in study measures

	ADHD *M* (*SD*)	Non-ADHD *M* (*SD*)	*F*	*p*	*d*
Grade Point Average	1.33 (.99)	3.13 (.66)	37.87	<.001	2.14
Intrinsic Motivation					
Academic Interest	2.24 (.96)	2.88 (1.24)	3.60	.064	.58
Delay Aversion	2.68 (.71)	2.19 (.72)	4.32	.043	.69
Extrinsic Motivation					
Academic Importance*	3.91 (.84)	4.61 (.54)	9.46	.004	.99
Delay Discounting	302.17 (62.18)	322.86 (66.90)	1.01	.320	.32
Risky Decision Making	-3.28 (11.36)	-1.17 (10.93)	1.87	.178	.19
Goal-Directed Behavior					
Goal Setting*	.86 (.74)	1.59 (.79)	9.02	.004	.95
Metacognition*	55.73 (12.69)	36.57 (7.11)	13.63	<.001	1.86
Working memory	97.95 (15.26)	95.40 (15.01)	.27	.608	-.17
Response inhibition	4.65 (2.85)	5.10 (1.91)	.29	.593	-.19
Cognitive Flexibility*	89.01 (10.09)	100.74 (18.18)	7.08	.011	.80

Note. Parent education level served as a covariate in all analyses. Means represent estimated marginal means after inclusion of covariate. *M*=mean, *SD*= standard deviation, *d*= Cohen's *d* between group effect size using a pooled standard deviation *Indicates statistical significance after Benjamini-Hochberg correction for false discovery rate was applied within category.

Table 3

Bivariate Correlations for Linear Regression Variables

	GPA	(1)	(2)	(3)	(4)	(5)	(6)
(1) IQ	.410**	--					
(2) Parent Education Status	.291*	.235	--				
(3) Delay Aversion	-.133	-.094	.005	--			
(4) Academic Importance	.245	.285*	-.203	-.337*	--		
(5) Goal Setting	.185	.191	-.020	-.067	.167	--	
(6) Metacognition	-.344*	-.050	.007	.347*	-.291*	-.174	--
(7) Cognitive Flexibility	.417**	.110	.139	-.330	.139	.208	-.304*

$*p<.05$ $**p<.01$

Table 4

Cognitive and Behavioral Predictors of GPA

	$R^2\Delta$	$F\Delta$	$p\Delta$	*b*	*SE*	*p*	sr^2
Step 1: Covariates	.22	6.05	.01				
IQ*				.03	.01	.01	.13
Parent Education Level				.53	.34	.12	.05
Step 2: Self-Regulated Learning	.23	3.19	.02				
IQ*				.03	.01	.04	.06
Parent Education Level*				.70	.32	.04	.06
Delay Aversion				.21	.22	.35	.01
Academic Importance				.28	.22	.23	.02
Goal Setting				.03	.19	.86	.00
Metacognition*				-.03	.01	.05	.06
Cognitive Flexibility*				.03	.01	.03	.07

Note. *b*=unstandardized beta, SE= standard error, sr=semipartial correlation