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What Specific Facets of Executive Function are Associated with Academic Functioning in Youth with Attention-Deficit/ Hyperactivity Disorder?

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Abstract

The purpose of the study was to evaluate the relation between ratings of Executive Function (EF) and academic functioning in a sample of 94 middle-school-aged youth with Attention-Deficit/ Hyperactivity Disorder (ADHD; *Mage* = 11.9; 78% male; 21% minority). This study builds on prior work by evaluating associations between multiple specific aspects of EF (e.g., working memory, inhibition, and planning and organization) as rated by both parents and teachers on the Behavior Rating Inventory of Executive Function (BRIEF), with multiple academic outcomes, including school grades and homework problems. Further, this study examined the relationship between EF and academic outcomes above and beyond ADHD symptoms and controlled for a number of potentially important covariates, including intelligence and achievement scores. The EF Planning and Organization subscale as rated by both parents and teachers predicted school grades above and beyond symptoms of ADHD and relevant covariates. Parent ratings of youth's ability to transition effectively between tasks/situations (Shift subscale) also predicted school grades. Parent-rated symptoms of inattention, hyperactivity/impulsivity, and planning and organization abilities were significant in the final model predicting homework problems. In contrast, only symptoms of inattention and the Organization of Materials subscale from the BRIEF were significant in the teacher model predicting homework problems. Organization and planning abilities are highly important aspects academic functioning for middle-school-aged youth with ADHD. Implications of these findings for the measurement of EF, and organization and planning abilities in particular, are discussed along with potential implications for intervention.

Keywords

Executive Function; ADHD; Academic Functioning; School Grades

Introduction

Children and adolescents with Attention-Deficit/Hyperactivity Disorder (ADHD) frequently experience clinically significant academic impairment (Frazier, Youngstrom, Glutting, & Watkins, 2007; Kuriyan et al., 2013; Loe & Feldman, 2007). Youth with ADHD have lower

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school grades and standardized achievement scores in comparison to their peers and are significantly more likely to be retained a grade and to drop out of school (Barkley, 2006; Frazier et al., 2007; Molina et al., 2009). Initially, it was assumed that youth with ADHD struggled academically primarily due to problems with focus and distractibility. Indeed, multiple studies have documented a significant, negative relationship, between symptoms of inattention and academic outcomes (e.g., Galera et al., 2009; Massetti et al., 2008). More recently however, it has become apparent that the pathway between ADHD symptoms and academic functioning is indirect, and that other mechanisms are more directly responsible for the development of academic impairment in youth with ADHD (Rapport, Scanlan, Denney, 1999; Langberg, Molina et al., 2011).

Executive functions (EF) have received considerable research attention and have been hypothesized to underlie the functional impairments of youth with ADHD (Barkley, 2001; Barkley & Fischer, 2011). EFs are higher-order cognitive processes that are responsible for self-regulation, decision making, and goal-directed behaviors. EF entails the ability to engage in sequences of planned, goal-directed, behaviors over prolonged periods of time, by resisting distractions and inhibiting inappropriate responses (Baron, 2003; Friedman et al., 2006; Naglieri & Das, 2005). A large number of studies have documented that many youth with ADHD experience deficits in aspects of EF, such as working memory, response inhibition, planning and organization, and sustained attention (e.g., Hinshaw, Carte, Fan, Jassy, & Owens, 2007; Pennington & Ozonoff, 1996; Seidman, Biederman, Monuteaux, Weber, & Faraone, 2000; Thorell, 2007).

The hypothesis that EF deficits could underlie the academic impairments of youth with ADHD has excellent face validity when considering the contextual demands of the school setting. EFs allow individuals to set goals and to engage in specific courses of action towards achieving those goals (i.e. planning and organization), to suppress behaviors that are not consistent with the chosen path/goal (i.e. response inhibition and emotion regulation), and to self-evaluate behavior and change course if the plan is not leading to the desired outcome (i.e. self-monitoring; Barkley, 1997; Best, Miller, & Naglieri, 2011; Blair & Diamond, 2008). Developmentally, the middle childhood period is when rapid development of more complex EF skills such as planning and organization and self-regulation of these actions takes place (Anderson, 2002; Best, Miller, & Naglieri, 2011). At the same time that these skills are developing, they are becoming increasingly important for academic success as students are expected to manage classwork, homework, and test-preparation for multiple teachers (Bowers, 2011; Eccles, 2004; Jacobson, Williford, & Pianta, 2011; Randall & Englehard, 2009). In order to succeed academically in middle and high school, youth must be able to organize materials and time, plan in advance, engage in goal-directed activities, inhibit inappropriate or ineffective behaviors, and shift fluidly from one task to another (Blair & Diamond, 2008; Jacobson, Williford, & Pianta, 2011; Langberg, Epstein et al., 2011). Accordingly, it is not surprising that relations between EF and achievement (both math and reading) have been shown to be fairly robust and consistent over time in large representative general education samples (e.g., Best, Miller, & Naglieri, 2011).

There is growing empirical evidence suggesting that EF deficits play an important role in predicting the academic impairments of youth with ADHD. In one of the first studies focused on this issue, Biederman et al. (2004) cross-sectionally demonstrated that children with ADHD and EF deficits had significantly lower academic achievement and were more likely to repeat a grade in comparison to children with ADHD alone. Importantly, these analyses controlled for group differences in socioeconomic status, learning disorders, and intelligence. A significant relationship between EF and academics has also been found longitudinally in a sample of girls with ADHD followed from middle childhood through late adolescence/young adulthood (Miller & Hinshaw, 2010; Miller, Nevado-Montenegro, &

Hinshaw, 2012). In the first paper, Miller and Hinshaw (2010) reported that childhood EF predicted academic achievement and global functioning independent of intelligence at a 5-year follow-up. Miller, Nevado-Mongenegro, and Hinshaw (2012) then reported that at a 10-year follow-up with the same sample, childhood EF, and particularly measures of global EF and working memory, predicted academic functioning, defined as performance on a standardized achievement test. Finally, Thorell (2007) found that EF deficits served as a mediator between symptoms of inattention and mathematics and language skills measured with a standardized achievement test battery. In the Thorell (2007) study, EF was defined using an aggregate score from two inhibition tasks (inhibition control and response inhibition) and two working memory tasks (verbal and spatial working memory).

There are two primary limitations of the research completed to date on the relationship between EF and academic functioning in youth with ADHD. The first limitation has to do with the reliance on structured neuropsychological tests as measures of EF. The second limitation relates to the fact that most studies have defined academic functioning as performance on standardized achievement tests. First, the studies reviewed above all utilized neuropsychological tests to assess EF and most utilized an EF composite variable, which combined multiple different tasks together to form an overarching EF construct. Although this is a worthwhile line of inquiry, laboratory-based tests have been criticized for having poor ecological validity and ratings of EF have been shown to be better predictors of real-life impairment in comparison to EF tests in samples of adults with ADHD (Barkley & Murphy, 2010a, b; Barkley & Fischer, 2011). In fact, a recent review of this issue found that correlations between neuropsychological measures of EF and ratings of EF were small to negligible (Toplak, West, & Stanovich, 2012). One reason for this is that short-term in the moment neuropsychological EF tests are often highly structured and may not adequately measure youths' ability to organize behaviors and to plan a path to achieve long-term goals in real world settings (e.g., project and test completion; Barkley & Fischer, 2011; Toplak et al., 2012).

Although there is certainly no consensus for an operationalized definition of EF (Jurado & Rossellie, 2007), it is clear that EF represents a broad range of abilities, such as behavioral inhibition, shifting, and emotional control, problems in initiation, working memory, managing current and future-oriented task demands, materials organization, and self-monitoring (Barkley, 1997). It is important to note that there is some debate regarding whether components of EF (e.g., planning/organization) are conceptually distinct from ADHD symptom dimensions (Toplak et al., 2012). To date, the evidence suggests that ADHD symptoms of inattention are more strongly associated with EF than symptoms of hyperactivity/impulsivity and that the two constructs are indeed conceptually distinct (e.g. Nigg et al., 2005; Willcutt et al., 2005). If EF deficits do indeed underlie the academic impairment of youth with ADHD, then it will be important to examine precisely which facets of EF are most closely aligned with academic outcomes. To date, studies of EF and academic outcomes have used composite EF scores in analyses consisting of scores on multiple EF tasks aggregated together (e.g., Biederman et al., 2004; Thorell, 2007), or neuropsychological tasks that encompass multiple different aspects of EF (e.g., Miller et al., 2010; working memory, organization, attention to detail, and inhibitory control). A more micro-level examination of EF is needed to produce clinically relevant information, such as specific EF abilities to target with intervention. Further, it is likely that the specific aspects of EF most important in predicting academic functioning will depend on the academic outcome being studied, which leads to the second limitation of the research completed to date.

Studies examining the relationship between EF and academic outcomes in samples of youth with ADHD have utilized performance on standardized achievement tests as the primary dependent variable. In terms of defining academic outcomes, it is sometimes assumed that results from one academic outcome (e.g. achievement scores) will translate to another (grades or ratings). Broadly speaking, standardized achievement tests are examinations of academic knowledge, whereas school grades are a combination of students' academic knowledge, performance, classroom participation, effort, behavior, attendance, and homework performance (Bowers, 2011; Randall & Englehard, 2009). School grades and achievement test scores exhibit low to moderate correlations (Bowers, 2011; Langberg et al., 2011), and explain at most, 25–35% of each other (Bowers, 2009). It is quite reasonable to hypothesize that certain aspects of EF will correlate highly with achievement (e.g. working memory) whereas different aspects of EF will correlate with school grades and ratings of academic functioning (e.g. planning/organization or behavioral inhibition). For example, it has been argued that difficulties with behavior regulation are likely to impact school grades, but are unlikely to be detrimental to performance on standardized achievement tests because these tests are administered in one-to-one, controlled environments, where administrators work to minimize the impact of inattention and to promote motivation (Beebe et al., 2010; Beebe, 2011). However, almost nothing is known about the specific types of EF that predict ratings of homework problems or grades in youth with ADHD.

Accordingly, the purpose of this study is to examine the relations between ratings of EF with school grades and ratings of homework problems in a sample of middle school aged youth with ADHD. School grades are an important indicator of academic functioning because they are highly meaningful to parents and educators and important in decisions regarding grade promotion and college admittance (Wang & Eccles, 2012; Wentzel, 1989; Zwick & Sklar, 2005). Ratings of homework problems were also examined in this study because homework performance accounts for a significant portion of the variance in school grades (Cooper, Robinson, & Patall, 2006). Importantly, this study includes both parent and teacher ratings of EF and examines the various aspects of EF (e.g. planning versus working memory versus inhibition) separately in the models. Further, this study includes potential covariates known to be associated with academics such as parent education level, intelligence, achievement scores, and student gender (Klapp Lekholm & Cliffordson, 2009; Langberg et al., 2011; Mayes & Calhoun, 2007a; Mayes & Calhoun, 2007b; Mayes, Calhoun, Bixler, & Zimmerman, 2009; Rumberger, 2004; Swanson, Trainin, Necoechea, and Hammill, 2003). Finally, given that multiple studies have documented a significant relationship between ADHD symptoms of inattention and academic outcomes, the relationship between EF and academics is examined above and beyond ADHD symptom ratings. In contrast with previous studies that have primarily measured EF in elementary age youth, the measures of EF in this study were obtained from a sample of middle school aged youth with ADHD. As noted above, the middle childhood period is when development of more complex EF skills takes place (Anderson, 2002; Best, Miller, & Naglieri, 2011) and is when these skills become important for academic success (Eccles, 2004; Jacobson, Williford, & Pianta, 2011). Accordingly, we predicted that the organization and planning aspects of EF would be important predictors of grades and homework problems.

Method

In this study, participants were recruited in three separate cohorts. The EF measures analyzed in this study were only collected for cohort 2 participants. The study was reviewed and approved by the Institutional Review Board (IRB). The study procedures and consent forms were reviewed with participants face-to-face and then parents signed informed consent and youth provided assent.

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Participants

The 94 cohort 2 participants included in this study were in grades 6–8 with an age range of 10 – 14 (*Mage* = 11.93, *SD* = 0.94; see Table 1 for additional student/family demographics). Students were referred to the study in one of two ways. First, flyers describing the study were sent home to parents/guardians of all students at the involved schools. The flyers stated that students in grades 6–8 with attention problems and/or students with a diagnosis of ADHD were eligible to participate. Second, a presentation about the study was made to teachers and school mental health (SMH) providers at each of the schools. Teachers and SMH providers then developed lists of students whom they thought would be good candidates for the study assessment and/or interventions. The SMH providers then called the parents/guardians of students on those lists to ensure that the flyer had been received and to ask if the parent/guardian had any questions. Parents/guardians who called research staff to express interest in the study were read a phone script describing the study in further detail and administered a phone screen. On the phone screen, parents had to indicate that their child had diagnosis of ADHD *or* had to endorse their child as currently exhibiting at least 4 of 9 DSM symptoms of inattention in order to be scheduled for an inclusion/exclusion evaluation. 205 families called, expressed interest in the study, and completed the phone screen. 147 families were eligible based upon the phone screen and completed the inclusion/exclusion evaluation and 123 met full study criteria and were enrolled. The study was multi-site and while parent ratings of EF were completed at both sites, teacher ratings of EF were only completed at one of the sites.

The inclusionary criteria were: (a) attendance at one of the participating middle schools; (b) meeting full diagnostic criteria for Inattentive or Combined type ADHD, (c) an IQ of 80 or above as estimated using the Wechsler Intelligence Scale for Children–Fourth Edition (WISC-IV; Wechsler, 2003); and (d) not meeting criteria for a primary diagnosis of a pervasive developmental disorder or meeting diagnostic criteria for any of the following: bipolar disorder, psychosis, substance dependence other than tobacco, or obsessive-compulsive disorder. Diagnosis was determined by administration of the Parent version of the Children's Interview for Psychiatric Syndromes (P-ChIPS; Weller, Weller, Rooney, & Fristad, 1999) combined with teacher ratings on the Disruptive Behavior Disorders rating scale (DBD; Pelham et al., 1992) and Impairment Rating Scale (Fabiano et al., 2006).

A participant was considered to meet diagnostic criteria for ADHD if he/she met criteria according to the P-CHIPS after including teacher-rated symptoms of ADHD from the DBD (i.e. teacher-rated symptoms could indicate that a symptom was present that was not endorsed by parents). Although the "or" criteria was used to determine presence or absence of symptoms, parents had to endorse at least 4 symptoms in a domain on the P-CHIPS for supplementing from the teacher DBD to occur. Impairment in two or more settings was considered present if the parent endorsed impairment at both home and school on the P-CHIPS or if both parent and teacher rated at least one domain of functioning in the clinically impaired range (score ≥ 3; Fabiano et al., 2006) on the IRS.

Measures

Outcome Measures

School Grades: Report cards containing school grades were collected for all study participants. All of the districts involved in the study used the same scale for grades where A = 4.0, A− = 3.7, B+ = 3.3, B = 3.0, B− = 2.7, etc. Grade point average (GPA) was calculated as the average of participants' core class grades (math, science, history, language arts). GPA for the academic quarter corresponding with the collection of ratings for all participants was used in the analyses (*M* = 2.36; *SD* = .96).

Homework Problems Checklist (HPC; Anesko, Schoiock, Ramirez, & Levine, 1987): Homework completion and homework materials management behaviors were assessed using the 20-item parent-completed HPC. For each item, parents rate the frequency of a specific homework problem on a 4-point Likert scale (0 = *never*, 1 = *at times*, 2 = *often*, 3 = *very often*). Higher scores on the measure indicate more severe problems. Example items include: a) Must be reminded to sit down and start homework; b) Puts off doing homework, waits until last minute; c) Fails to bring home necessary materials (textbooks); and d) Doesn't know exactly what homework has been assigned (see Anesko et al., 1987 for a list of all HPC items). The measure has excellent internal consistency, with alpha coefficients ranging from .90 to .92 and corrected item-total correlations ranging from .31 to .72 (Anesko et al., 1987). The HPC Total Score was examined in the analyses and internal consistency for the items was strong (α = .95).

Predictor Measures

Demographic/Child Characteristics: Academic achievement in reading and math was assessed using the *Wechsler Individual Achievement Test, Third Edition* (WIAT-III; Wechsler, 2009). Intelligence was estimated using the Block Design and Vocabulary subtests from the *Wechsler Intelligence Scale for Children–Fourth Edition* (WISC-IV; Wechsler, 2003). In addition, parents/guardians completed a demographics questionnaire, which provided information about family income, ethnicity, parents' education level, child age, and gender. Finally, parents were interviewed regarding their child's medication use history. Forty-three percent of parents in the sample stated that their child was currently taking a medication to treat their ADHD. This variable (yes/no) was included in the regression analyses (see Table 1).

Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy, & Kenworthy 2000a): The BRIEF is a measure of youths' EF deficits in daily life, or "everyday" executive function as opposed to the EF functioning assessed by neuropsychological tests. The parent- and teacher-reported BRIEF consists of 86 items based on theoretical and empirical definition of EF. Items are rated on a three-point scale (*never*, *sometimes*, *often*), with higher ratings indicating greater EF impairment in daily life. Factor analyses support eight separate subscales on the BRIEF, including Inhibition, Shifting, Emotional Control, Initiation, Working Memory, Planning and Organizing, Organization of Materials, and Monitoring. These eight subscales combine to form two separate indexes, Behavioral Regulation Index (BRI) and the Metacognition Index (MI). The Inhibit, Shift, and Emotional Control subscales load onto the BRI and the Initiate, Working Memory, Planning and Organization, Organization of Materials, and Monitor subscales load onto the MI. The BRIEF is psychometrically valid, with adequate internal consistency (αs = .80–.98), test-retest reliability (.76–.88), and construct validity established through convergent and discriminant analyses (Gioia, Isquith, Guy, & Kenworthy 2000b; Mahone et al., 2002; McCandless & O'Laughlin, 2007). In the present study, internal consistencies were acceptable across all eight BRIEF subscales for both parent- (αsranging from .82–.90) and teacher-report versions (αs ranging from .75–.89).

Disruptive Behavior Disorders Rating Scale (DBD; Pelham et al., 1992): The DBD is a *DSM-IV*-based scale that includes all *DSM-IV* symptoms of ADHD, Oppositional Defiant Disorder (ODD), and Conduct Disorder (CD). Parents and teachers rate how frequently each symptom occurs on a 4-point Likert scale (0 = *never*, 1 = *occasionally*, 2 = *often*, 3 = *very often*). The DBD produces an Inattention score (sum of the nine inattention items) and a Hyperactivity/ Impulsivity score (sum of the nine hyperactive/impulsive items). Internal consistencies were high in the present study for the parent (Inattention α =.92, Hyperactivity/Impulsivity α =. 94) and teacher (Inattention α =.93, Hyperactivity/ Impulsivity α =.96) versions.

Data Analytic Plan

First, bivariate correlation analyses were conducted to examine which demographic and ADHD symptom predictor variables were significantly associated with each of the two academic outcome domains (i.e., school grades and homework problems). Variables correlated with a specific academic outcome variable at $p < .05$ were retained for subsequent regression analyses. For example, parent education level was significantly correlated with school grades but was not significantly correlated with parent-rated homework problems therefore, parent education level was only retained in the school grades regression models. Next, any variables significantly correlated with the academic outcome of interest were simultaneously entered into a regression (see Table 3). Variables significant in this regression model were then retained for entry in a hierarchical regression analysis. Specifically, for each academic outcome, significantly associated variables retained from the single block regression analyses were entered on Step 1, followed by the EF scales from the Metacognitive and Behavior Regulation indexes on Step 2. The Behavior Regulation and Metacognitive Index subscales were examined in separate regression models, as were parent and teacher ratings of EF. Accordingly, eight total hierarchical regressions were run, four for each outcome variable: 1) Parent-Metacognitive; 2) Parent-Behavior Regulation; 3) Teacher-Metacognitive; and 4) Teacher-Behavior Regulation.

Results

Missing Data

BRIEFS were collected for 94 of the 123 participants enrolled in the study because one of the sites was delayed in obtaining IRB approval for the measure. Of the 94 participants in the present study, 90 had parent ratings and 57 had teacher ratings (i.e. one participant had teacher ratings but no parent ratings). In comparing the demographic characteristics of those participants for whom parent BRIEF data were collected ($N = 90$) to those without parent BRIEF data ($N = 33$), no differences were found for gender, race, age, grade in school, parent- and teacher-ratings of ADHD symptoms, intelligence, achievement scores, family education level, family income, GPA, or parent-HPC ratings (ps > .05). Teacher BRIEFS were only collected at one of the two study sites and teacher BRIEFS were obtained for 57 of the 61 participants at that site.

Correlation Analyses

The results of the correlation analyses with grades and homework problems are presented in Table 1. To summarize, participant age, ethnicity, grade, gender, and medication status were not associated with either of the two academic outcomes and therefore, were not included in subsequent regression analyses. Correlations between the BRIEF, ADHD symptom measures, and academic outcomes were all in the expected direction. Correlations were positive for predicting ratings of homework problems as higher scores on both the BRIEF and HPC indicate higher levels of problems/impairment. Correlations were negative for predicting school grades (i.e. more ADHD symptoms and problems with EF = lower school grades). Parent- and teacher-ratings of ADHD symptoms of inattention and teacher-ratings of ADHD hyperactive/impulsive symptoms were significantly correlated with both academic outcomes. In contrast, parent ratings of ADHD hyperactive/impulsive symptoms were only significantly correlated only with ratings of homework problems. Parent education, family income, WIAT Math, WIAT Reading, inattention symptoms, hyperactive/ impulsive symptoms, and IQ were all significantly correlated with school grades. WIAT Math and IQ were significantly correlated with homework problems.

Correlations between parent- and teacher-rated ADHD symptoms and parent- and teacher-rated EF subscales are displayed in Table 2. While several of the EF subscales were significantly correlated with each other (within and across raters, *r*s ranging from .08 to .81) and with ADHD symptoms measures (*r*s ranging from .10 to .77) across all regression analyses, no VIF values were above 10 (values >10 are typically considered problematic) and no tolerance values were below .10 (values <.10 are typically considered problematic; Cohen et al., 2003), indicating that multicollinearity was not an issue. Further, the correlations between ADHD symptoms and ratings of EF in this sample are similar to those reported in previous work with adults with ADHD (.68 – .91; Barkley & Murphy, 2010a, b).

Regression Analyses for School Grades

When parent education, family income, WIAT Math, WIAT Reading, inattention symptoms, hyperactive/impulsive symptoms, and IQ were simultaneously entered into a regression model, only the symptoms of inattention variable was significantly negatively associated with school grades (see Table 3) and retained for entry at Step 1 in the hierarchal regression analyses (see Table 4).

Parent Behavior Regulation Index—Results indicated that parent ratings of inattention explained 13% of the variance in school grades, $F(1, 89) = 13.32$, $p < .001$. When parent-ratings of EF from the Behavior Regulation Index (i.e., Shift, Emotion Control, and Inhibition) were entered in Step 2, these predictors did not explain significant incremental variance in school grades above and beyond the variance explained by parent ratings of inattention alone on Step 1, $F(3, 86) = 2.17$, $p = .10$, $\Delta R^2 = .06$. However, as shown in Table 4, the Shift subscale was a significant predictor along with parent-rated inattention in the Step 2 model.

Parent Metacognitive Index—In Step 1, parent ratings of inattention was the only significant predictor associated with school grades, $F(1,89) = 13.32$, $p < .001$, $R^2 = .13$. When parent-ratings of EF from Metacognition Index (i.e., Initiating, Working Memory, Planning and Organizing, Monitoring and Organization of Materials) were entered in Step 2, these predictors explained an incremental 20% of the variance in school grades, $F(5, 84) = 5.09$, $p < .001$, above and beyond the variance accounted for by parent ratings of inattention. The EF Planning and Organizing, $\beta = -.98$, $t(84) = -4.46$, $p < .001$, subscale was the only significant predictor of school grades in Step 2 as parent ratings of inattention were no longer significant in the model, $t(84) = -0.83$, $p = .41$.

Teacher Behavior Regulation Index—Teacher ratings of inattention accounted for 32% of the variance in school grades on Step 1, $F(1, 55) = 25.73$, $p < .001$. Symptoms of inattention remained the only significant predictor variables when the Behavioral Regulation Index subscales were entered on Step 2. The EF predictor variables did not explain significant incremental variance in school grades above and beyond teacher ratings of inattention, $F(3, 52) = .73$, $p = .54$.

Teacher Metacognitive Index—When teacher ratings of EF from the Metacognition Index were entered in Step 2, these predictors explained an incremental 12% of the variance in school grades, $F(5, 50) = 2.19$, $p = .07$. The symptoms of inattention variable, $\beta = -.35$, $t(50) = -2.12$, $p = .04$, and the EF Planning and Organizing subscale, $\beta = -.56$, $t(50) = -2.54$, $p = .01$, predicted school grades.[1]

Regression Analyses for Homework Problems

As presented in Table 3, when inattentive symptoms, hyperactive/impulsive symptoms, WIAT Math, and IQ, were simultaneously entered into a regression model, only inattentive and hyperactive/impulsive symptoms were significantly associated with ratings of homework problems and were retained for entry at Step 1 in the hierarchal regression analyses (see Table 5).

Parent Behavior Regulation Index—Results indicated that parent ratings of inattention and hyperactivity/impulsivity explained 67% of the variance in homework problems, $F(2, 88) = 90.25$, $p < .001$. When the Behavioral Regulation Index subscales were entered on Step 2, these variables did not explain incremental variance in homework problems above and beyond the variance explained by parent ratings of inattention and hyperactivity/impulsivity $F(3, 86) = 1.51$, $p = .22$.

Parent Metacognitive Index—When parent ratings of EF from the Metacognition Index were entered on Step 2, these predictors explained an incremental 5% of the variance in homework problems, $F(5, 84) = 3.02$, $p = .02$. The ADHD symptoms of inattention variable, $\beta = .46$, $t(84) = 4.31$, $p < .001$, the ADHD symptoms of hyperactivity/impulsivity variable, $\beta = .20$, $t(84) = 2.25$, $p = .03$, and the EF Planning and Organizing subscale, $\beta = .38$, $t(84) = 2.63$, $p = .01$, were all significant predictors in the final model.

Teacher Behavior Regulation Index—Teacher ratings of inattention explained 22% of the variance in homework problems, $F(1, 55) = 15.08$, $p < .001$, and when the Behavioral Regulation Index subscales were entered on Step 2, these variables did not explain incremental variance in homework problems, $F(3, 52) = 0.58$, $p = .63$.

Teacher Metacognitive Index—When teacher-ratings of EF from the Metacognition Index were entered with teacher-rated symptoms of inattention in Step 2, these predictors explained an incremental 19% of the variance in homework problems, $F(5, 50) = 3.04$, $p = .02$. The EF Organization of Materials, $\beta = .58$, $t(50) = 3.19$, $p = .002$, subscale was the only significant predictor of homework problems in Step 2.

Discussion

This study examined the relation between ratings of EF and academic functioning in a sample of middle-school-aged youth with ADHD. To date, research in this area with children and adolescents has primarily focused on the relation between neuropsychological measures of EF and standardized achievement test scores (Biederman, et al., 2004; Hinshaw et al., 2007; Miller & Hinshaw, 2010; Miller, Nevado-Montenegro, & Hinshaw, 2012). This study expands on previous work by evaluating the relation between parent and teacher ratings of EF with multiple indicators of academic functioning (i.e. school grades and parent ratings of homework problems) above and beyond the impact of ADHD symptoms. Further, this study evaluates the unique contribution of specific aspects of EF in predicting academic functioning (e.g. inhibitory, emotional control, and planning/organizing abilities). This is important because most prior research has defined EF broadly, combining a wide-variety of EF tasks into a single construct, potentially limiting the clinical utility of the findings. By separately examining multiple aspects of EF ratings in predicting multiple indicators of academic functioning, this study provides evidence that the organization and planning

[1]In order to address the possibility that the teacher models were underpowered due to the relatively small sample size and the inclusion of multiple predictor variables, we also ran the teacher models with the Metacognitive Index (MI) and Behavior Regulation Index (BRI) total scores (i.e. rather than with each of the MI and BRI subscales included separately). In all four models, the MI and BRI total scores were not significant and did not explain incremental variance above and beyond teacher ratings of inattention (BRI predicting GPA, $\Delta F(1, 54) = .004$, $p = .95$; MI predicting GPA, $\Delta F(1, 54) = .50$, $p = .48$; BRI predicting homework, $\Delta F(1, 54) = .43$, $p = .52$; MI predicting homework, $\Delta F(1, 54) = 1.27$, $p = .27$). These findings lend support to the validity of the results with the teacher subscales included separately where the BRIEF Planning and Organizing (GPA) and BRIEF Organization of Materials (Homework Problems) were significant, even with multiple predictor variables in the models.

aspects of EF are highly important for the academic functioning of young adolescents with ADHD.

Consistent with previous research with ADHD samples (e.g., Langberg, Molina et al. 2011), correlation analyses revealed significant but small to moderate correlations between standardized achievement test scores and school grades (see Table 1). These findings highlight the importance of examining a range of indicators in studies focused on the academic functioning of youth with ADHD. This appears to be particularly important in research with EF. Specifically, the environmental conditions and structure typically associated with neuropsychological EF tests are very similar to the conditions and structure associated with achievement testing. EF tests are typically delivered one-toone, in a controlled environment with an administrator providing structure and prompting to keep the youth on task and to maintain motivation. Further, EF tests are administered over relatively brief periods of time and therefore, reflect EF abilities as applied towards short-term goal pursuit (Barkley, 1997). These conditions are very similar to achievement testing, where an evaluator is present, the environment controlled, and youth are provided with specific questions to answer in a set period of time. In contrast, rating scales assess how youth implement EF behaviors with limited structure and direction and over long periods of time. As such, it may be that neuropsychological EF tests are good predictors of achievement tests but are poor predictors of school grades, and vice versa for EF ratings. These assertions are in line with conclusions drawn in recent review, which suggested that EF tests measure efficiency in cognitive abilities under ideal conditions whereas EF ratings measure success with long-term goal pursuit in more typical day to day conditions (Toplak et al., 2012).

Differences between achievement tests and school grades may also explain why working memory was found to be an important predictor of academics in previous studies but not in this study. The Working Memory subscale on the BRIEF includes items related to youth having trouble remembering things even for a few seconds, losing track of what they were doing in the middle of tasks, and difficultly sustaining attention and performance. These behaviors have obvious implications for test-taking at school and for performance on standardized achievement tests, perhaps more so than organization and planning behaviors. For example, youth with working memory deficits are likely to lose their place and have difficulty keeping instructions in mind when completing achievement tests. Consistent with this assertion, previous longitudinal research has shown that working memory EF tasks are strong predictors of standardized achievement test scores in youth with and without ADHD (Miller, Nevado-Montenegro, & Hinshaw, 2012). However, it appears that in terms of predicting school grades, the ability to engage in the long-range planning and organization (activities assessed with EF ratings) is more important in terms of relative predictive power.

The Organization of Materials, Planning and Organizing, and Shift subscales were the only BRIEF subscales that predicted GPA and/or homework problems when included in regression models with ADHD symptoms. The Shift subscale contains items related to effectively making transitions, both between situations (e.g. one class to another), and between tasks (addition to subtraction). Periods of transition are notoriously difficult for youth with ADHD and the number of transitions youth are expected to make increases significantly in middle school (e.g. between multiple classes and subjects). The Organization of Materials subscale on the BRIEF pertains predominately to physical organization of materials (e.g. bookbag, binder, and desk). It makes sense that teacher ratings of EF would identify this subscale as important, whereas the Organization and Planning Subscale would be most highly predictive according to parent ratings. Specifically, parents witness and often facilitate the entire homework completion process, including breaking tasks into steps and planning ahead for the completion of each task (i.e. planning and organization skills). Teachers on the other hand, would have less exposure to planning activities, but would have knowledge regarding disorganized desks, binders, and bookbags (i.e. materials organization). For example, a middle school teacher is likely to witness a child with ADHD digging through papers in the backpack to find an assignment. Essentially, correlational patterns may reflect the types of activities that raters have the opportunity to observe.

It should be noted that the sample included in this study was comprised of middle-school-age adolescents with ADHD. Developmentally, planning/organization abilities are particularly relevant during middle childhood, whereas different aspects of EF may be more salient for younger children (Eccles, 2004; Jacobson, Williford, & Pianta, 2011). Surrounding the elementary to middle school transition, academic demands significantly increase as students are expected manage classwork, homework, and test-preparation for multiple teachers (Eccles, 2004; Jacobson, Williford, & Pianta, 2011). Further, grades become more heavily influenced by long-term projects, writing assignments, and by a few large exams, spaced-out across the academic semester (e.g. mid-terms/finals). These changes likely increase the importance of organizing and planning out actions in advance over extended periods of time (Akos, Queen, & Lineberry, 2005; Rudolph, Lambert, Clark, & Kurlakowsky, 2001). Accordingly, the relation between planning/organization and academic functioning may be stronger during the middle school period than during the elementary school years (Jacobson, Williford, & Pianta, 2011).

Limitations

The primary limitation is that the sample size is modest and these findings will need to be confirmed in larger samples of youth with ADHD. In particular, the small sample size for our teacher analyses (N=57) may have limited our power to detect significant effects associated with other EF subscales. As can be seen in Table 1, the Planning and Organizing subscale as rated by both parents and teachers clearly exhibited the strongest bivariate correlations with school grades. However, additional EF scales, particularly those that load on the Metacognition factor, exhibited moderate to large correlations with school grades and may have been significant in regressions with a larger sample. As such, the analyses with teacher ratings of EF should be considered preliminary.

Many of the items on the Organization of Materials and Planning and Organization subscales of the BRIEF ask specifically about organization of materials and preparation for tests/exams, and our findings could essentially indicate that the BRIEF subscales with the most items directly related to academics correlate most highly with academic outcomes. This is particularly relevant for the associations reported between the BRIEF subscales and our measure of homework problems, the HPC. The correlation between the parent-completed BRIEF Planning and Organizing subscale and the parent-completed HPC was highest, .74, which suggests considerable overlap between these two constructs. Indeed, the HPC includes multiple items related to organization of homework materials and multiple items on the BRIEF organization subscales ask about organization of materials and time in general. However, it is noteworthy that the .74 correlation between the BRIEF Planning and Organization subscale and the HPC is not much higher than the correlations between the other BRIEF MI Index scores and the HPC (see Table 1), and tests for problems pertaining to multicollinearity were not significant. Nevertheless, as discussed in previous manuscripts (Toplak et al., 2012) and in the future directions section of this paper, questions remain regarding the degree of overlap between ratings of EF and ratings of ADHD symptoms and between ratings of EF and ratings of homework/school problems.

Future Directions

As noted above, the relationship between ratings of EF and academic functioning may change across development. It may be that behavioral aspects of EF such as emotional control and the ability to inhibit behaviors are most salient in preschool and elementary school whereas the cognitive aspects are most relevant for middle and high school age students. Further, studies are needed that assess potential mediational relationships between symptoms of ADHD, EF, and academic functioning. While assessed cross-sectionally, the results of the present study suggest that organization and planning skills might mediate the relationship between ADHD symptoms of inattention and academics. Specifically, in this study, the relationship between inattention and school grades was nullified when parent-rated EF Metacognitive subscales were included. Longitudinal studies are needed to address the importance of various aspects of EF and academics over time as well as the potential mediational relationship between ADHD symptoms, EF, and academic outcomes.

These findings also raise some interesting questions regarding the role of EF assessment in school settings. One conclusion that could be drawn from this manuscript is that ratings EF should be routinely assessed in schools given that EF problems/deficits appear to strongly predict academic functioning. However, given that the initiate and organization and planning aspects of EF were most important in predicting academics, it is worth considering whether there are other existing measures that might just as adequately or perhaps more strongly, predict academic functioning. For example, the Children's Organizational Skills Scales (COSS; Abikoff & Gallagher, 2008) and the Classroom Performance Survey (CPS; Brady, Evans, Berlin, Bunford, & Kern, 2012) both assess aspects of organization, planning, and materials management, with items that are all specific to school tasks. An interesting future direction would be to examine associations between these measures.

Similarly, it could be concluded from this study that intervention development is needed focused on developing strategies to improve real world aspects of EF in youth with ADHD. However, there are multiple existing interventions that target goal setting, organization, planning, time management, and self-monitoring/management of these skills (Abikoff et al., 2012; Evans et al., 2005; 2011; Langberg et al., 2008; 2012; Pfiffner et al. 2007; 2011; Power et al. 2012). These interventions have been developed for elementary age students (Abikoff et al., 2012; Pfiffner et al., 2011) middle school age students (Evans et al., 2005; Langberg et al., 2008; 2012) and high school age students (Evans et al., 2011). Further, many of these interventions are multi-modal and target both behavioral and cognitive aspects of EF (e.g., Evans et al., 2005). Accordingly, future EF intervention development efforts will need to be distinguished from existing interventions in terms of how the targets of intervention are differ. One way this is already being done is with cognitive training interventions that are specifically designed to target unique aspects of EF such as working memory (Shipstead, Redick, & Engle, 2012).

Conclusions

The present study provides evidence that ratings of EF significantly contribute to the academic functioning of youth with ADHD. As is shown in Table 1, multiple demographic variables and aspects of parent- and teacher-rated EF exhibited significant, moderate to large, correlations with school grades and homework problems. However, only the parent and teacher ratings of youths' ADHD symptoms of inattention and their ability to plan ahead and to organize time and materials consistently predicted academic outcomes above and beyond relevant covariates. These findings suggest that organization and planning skills are highly relevant for middle-school-age youth with ADHD. It appears likely that many middle-school-age youth with ADHD will need instruction/intervention targeting goal setting, organization of materials and actions, planning out future actions, and effectively managing time in order to be successful academically.

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References

Abikoff, H.; Gallagher, R. Children's organizational skills scales: Technical manual. North Tonawanda, NY: Multi-Health Systems Inc; 2008.

Abikoff H, Gallagher R, Wells KC, Murray DW, Huang L, Lu F, Petkova E. Remediating organizational functioning in children with ADHD: Immediate and long-term effects from a randomized controlled trial. Journal of Consulting and Clinical Psychology. 201210.1037/a0029648

Akos, P.; Queen, JA.; Lineberry, C. Promoting a successful transition to middle school. Larchmont, NY: Eye on Education; 2005.

Anderson P. Assessment and development of executive function (EF) during childhood. Child Neuropsychology. 2002; 8(2):71–82. [PubMed: 12638061]

Anesko KM, Schoiock G, Ramirez R, Levine FM. The Homework Problem Checklist: Assessing children's homework problems. Behavioral Assessment. 1987; 9:179–185.

Barkley RA. Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying therapy of ADHD. Psychological Bulletin. 1997; 121:65–94. [PubMed: 9000892]

Barkley RA. The executive functions and self-regulation: An evolutionary neuropsychological perspective. Neuropsychology Review. 2001; 11:1–29. [PubMed: 11392560]

Barkley RA, Fischer M. Predicting impairment in major life activities and occupational functioning in hyperactive children as adults: Self-reported executive function (EF) deficits vs. EF tests. Developmental Neuropsychology. 2011; 36:137–161. [PubMed: 21347918]

Barkley RA, Murphy KR. The nature of executive function (EF) deficits in daily life activities in adults with ADHD and their relationship to performance on EF tests. Journal of Psychopathology and Behavioral Assessment. 2010a; 33:137–158.

Barkley RA, Murphy KR. Impairment in occupational functioning and adult ADHD: The predictive utility of executive function (EF) ratings versus EF tests. Archives of Clinical Neuropsychology. 2010b; 25:157–173. [PubMed: 20197297]

Barkley, RA. Attention deficit hyperactivity disorder: A handbook for diagnosis and treatment. 3. New York: Guilford Press; 2006.

Baron, I. Neuropsychological evaluation of the child. New York: Oxford University Press; 2003.

Beebe DW. Cognitive, behavioral, and functional consequences of inadequate sleep in children and adolescents. Pediatric Clinics of North America. 2011; 58:649–665. [PubMed: 21600347]

Beebe DW, Ris MD, Kramer ME, Long E, Amin R. The association between sleep disordered breathing, academic grades, and cognitive and behavioral functioning among overweight subjects during middle to late childhood. Sleep. 2010; 33(11):1447–1456. [PubMed: 21102986]

Best JR, Miller PH, Naglieri JA. Relations between executive function and academic achievement from ages 5 to 17 in a large, representative national sample. Learning Individual Differences. 2011; 21(4):327–336. [PubMed: 21845021]

Biederman J, Monuteaux M, Seidman L, Doyle AE, Mick E, Wilens T, Faraone SV. Impact of executive function deficits and ADHD on academic outcomes in children. Journal of Consulting and Clinical Psychology. 2004; 72:757–766. [PubMed: 15482034]

Blair C, Diamond A. Biological processes in prevention and intervention: The promotion of self-regulation as a means of preventing school failure. Development and Psychopathology. 2008; 20:899–911. [PubMed: 18606037]

Bowers AJ. Reconsidering grades as data for decision making: More than just academic knowledge. Journal of Educational Administration. 2009; 47:609–629.

Bowers AJ. What's in a grade? The multidimensional nature of what teacher-assigned grades assess in high school. Educational Research and Evaluation. 2011; 17(3):141–159.

Brady CE, Evans SW, Berlin KS, Bunford N, Kern L. Evaluating school impairment with adolescent using the Classroom Performance Survey. School Psychology Review. 2012; 41(4)

Cohen, J.; Cohen, P.; West, SG.; Aiken, LS. Applied multiple regression/correlation analysis for the behavioral sciences. 3. London, England: Routledge Academic; 2003.

Cooper H, Robinson JC, Patall EA. Does homework improve academic achievement? A synthesis of research. Review of Educational Research. 2006; 76(1):1–62.

Eccles, JS. Schools, academic motivation, and stage-environment fit. In: Learner, RM.; Steinberg, L., editors. Handbook of adolescent psychology. Hoboken, NJ: John Wiley; 2004. p. 125-154.

Evans SW, Brady CE, Harrison JR, Bunford N, Kern L, State T. Measuring ADHD and ODD symptoms and impairment based on high school teachers' ratings. Journal of Clinical Child and Adolescent Psychology. 2013; 42(2):197–207.10.1080/15374416.2012.738456 [PubMed: 23215533]

Evans SW, Langberg J, Raggi V, Allen J, Buvinger E. Development of a school-based treatment program for middle school youth with ADHD. Journal of Attention Disorders. 2005; 9:343–353. [PubMed: 16371680]

Evans SW, Schultz BK, DeMars CE, Davis H. Effectiveness of the Challenging Horizons after-school program for young adolescents with ADHD. Behavior Therapy. 2011; 42:462–474. [PubMed: 21658528]

Fabiano GA, Pelham WE, Waschbusch DA, Gnagy EM, Lahey BB, Chronis AM, Burrows-MacLean L. A practical measure of impairment: psychometric properties of the impairment rating scale in samples of children with attention deficit hyperactivity disorder and two school-based samples. Journal of Clinical Child and Adolescent Psychology. 2006; 35:369–385. [PubMed: 16836475]

Frazier TW, Youngstrom EA, Glutting JJ, Watkins MW. ADHD and achievement: Meta-analysis of the child, adolescent, and adult literatures and a concomitant study with college students. Journal of Learning Disabilities. 2007; 40(1):49–65. [PubMed: 17274547]

Friedman NP, Miyake A, Corley RP, Young SE, DeFries JC, Hewitt JK. Not all executive functions are related to intelligence. Psychological Science. 2006; 17:172–179. [PubMed: 16466426]

Galera C, Melchior M, Chastang JF, Bouvard MP, Fombonne E. Childhood and adolescent hyperactivity-inattention symptoms and academic achievement 8 years later: The GAZEL Youth study. Psychological Medicine. 2009; 39(11):1895–1906. [PubMed: 19335935]

Gioia, GA.; Isquith, PK.; Guy, SC.; Kenworthy, L. Behavior rating inventory of executive function. Psychological Assessment Resources; Odessa, FL: 2000a.

Gioia GA, Isquith PK, Guy SC, Kenworthy L. Test review: Behavior Rating Inventory of Executive Function. Child Neuropsychology. 2000b; 6:235–238. [PubMed: 11419452]

Hinshaw SP, Carte ET, Fan C, Jassy JS, Owens EB. Neuropsychological functioning of girls with Attention-Deficit/Hyperactivity Disorder followed prospectively into adolescence: Evidence for continuing deficits? Neuropsychology. 2007; 21:263–273. [PubMed: 17402826]

Hughes C. Changes and challenges in 20 years of research into the development of executive functions. Infant and Child Development. 2011; 20:251–271.

Jacobson LA, Williford AP, Pianta RC. The role of executive function in children's competent adjustment to middle school. Child Neuropsychology. 2011; 17(3):255–280. [PubMed: 21246422]

Jurado KK, Rosselli M. The elusive nature of executive functions: A review of our current understanding. Neuropsychology Review. 2007; 17:213–233. [PubMed: 17786559]

Klapp, Lekholm A, Cliffordson C. Effects of student characteristics and gender on grades in compulsory school. Educational Research and Evaluation. 2009; 15(1):1–23.

Kuriyan AB, Pelham WE, Molina BS, Waschbusch DA, Gnagy EM, Sibley MH, Kent KM. Young adult educational and vocational outcomes of children diagnosed with ADHD. Journal of Abnormal Child Psychology. 2013; 41(1):27–41.10.1007/s10802-012-9658-z [PubMed: 22752720]

Langberg JM, Epstein JN, Becker SP, Girio-Herrera E, Vaughn AJ. Evaluation of the Homework, Organization, and Planning Skills (HOPS) intervention for middle school students with ADHD as implemented by school mental health providers. School Psychology Review. 2012; 41(3):342–364.

Langberg JM, Epstein JN, Girio-Herrera E, Becker SP, Vaughn AJ, Altaye M. Materials organization, planning, and homework completion in young adolescents with ADHD: Impact on academic performance. School Mental Health. 2011; 3(2):93–101. [PubMed: 23577045]

Langberg JM, Epstein JN, Urbanowicz C, Simon J, Graham A. Efficacy of an organization skills intervention to improve the academic functioning of students with ADHD. School Psychology Quarterly. 2008; 23:407–417.

Langberg JM, Molina BSG, Arnold LE, Epstein JN, Altaye M, Hinshaw SP, Hechtman L. Patterns and predictors of adolescent academic achievement and performance in a sample of children with Attention-Deficit/Hyperactivity Disorder (ADHD). Journal of Clinical Child and Adolescent Psychology. 2011; 40:519–531. [PubMed: 21722025]

Loe IM, Feldman HM. Academic and educational outcomes of children with ADHD. Ambulatory Pediatrics. 2007; 7(1):82–90. [PubMed: 17261487]

Mahone EM, Cirino PT, Cutting LE, Cerrone PM, Hagelthorn KM, Hiemenz JR, Denckla MB. Validity of the behavior rating inventory of executive function in children with ADHD and/or Tourette syndrome. Archives of Clinical Neuropsychology. 2002; 17:643–662. [PubMed: 14591848]

Massetti GM, Lahey BB, Pelham WE, Loney J, Ehrhardt A, Lee SS, Kipp H. Academic achievement over 8 years among children who met modified criteria for attention-deficit/hyperactivity disorder at 4–6 years of age. Journal of Abnormal Child Psychology. 2008; 36:399–410. [PubMed: 17940863]

Mayes SD, Calhoun SL. WISC-IV and WISC-III predictors of academic achievement in children with ADHD. School Psychology Quarterly. 2007a; 22:234–249.

Mayes SD, Calhoun SL. Learning, attention, writing, and processing speed in typical children and children with ADHD, autism, anxiety, depression, and oppositional-defiant disorder. Child Neuropsychology. 2007b; 13:469–493. [PubMed: 17852125]

Mayes SD, Calhoun SL, Bixler EO, Zimmerman DN. IQ and neuropsychological predictors of academic achievement. Learning and Individual Difference. 2009; 19(2):238–241.

McCandless S, O'Laughlin L. The clinical utility of the behavior rating inventory of executive function (BRIEF) in the diagnosis of ADHD. Journal of Attention Disorders. 2007; 10:381–389. [PubMed: 17449837]

Miller EK, Cohen JD. An integrative theory of prefrontal cortex function. Annual Review of Neuroscience. 2001; 24:167–202.

Miller M, Hinshaw SP. Does childhood executive function predict adolescent functional outcomes in girls with ADHD? Journal of Abnormal Child Psychology. 2010; 38:315–326. [PubMed: 19960365]

Miller M, Nevado-Montenegro AJ, Hinshaw SP. Childhood executive function continues to predict outcomes in young adult females with and without childhood-diagnosed ADHD. Journal of Abnormal Child Psychology. 2012; 40:657–668. [PubMed: 22124540]

Molina BSG, Hinshaw SP, Swanson JM, Arnold LE, Vitiello B, Jensen PS. the MTA Cooperative Group. The MTA at 8 years: Prospective follow-up of children treated for combined type ADHD in a multisite study. Journal of the American Academy of Child and Adolescent Psychiatry. 2009; 48(5):484–500. [PubMed: 19318991]

Naglieri, JA.; Das, JP. Planning, Attention, Simultaneous, Successive (PASS) theory: A Revision of the Concept of Intelligence. In: Flanagan, DP.; Harrison, PL., editors. Contemporary Intellectual Assessment. 2. New York: Guilford; 2005. p. 136-182.

Pelham WE, Evans SW, Gnagy EM, Greenslade KE. Teacher ratings of DSM III R symptoms for the disruptive behavior disorders: Prevalence, factor analyses, and conditional probabilities in a special education sample. School Psychology Review. 1992; 21:285–299.

Pennington BF, Ozonoff S. Executive functions and developmental psychopathology. Journal of Child Psychology and Psychiatry. 1996; 37(1):51–87. [PubMed: 8655658]

Pfiffner LJ, Mikami AY, Huang-Pollock C, Easterlin B, Zalecki C, McBurrnet K. A randomized, comparison led trial of integrated home-school behavioral treatment for ADHD, Predominately Inattentive Type. Journal of the American Academy of Child and Adolescent Psychiatry. 2007; 46:1041–1050. [PubMed: 17667482]

Pfiffner LJ, Kaiser NM, Burner C, Zalecki C, Rooney M, Setty P, McBurnett K. From clinic to school: Translating a collaborative school-home behavioral intervention for ADHD. School Mental Health. 2011; 3:127–142.10.1007/s12310-01109059-4

Power TJ, Mautone JA, Soffer SL, Clarke AT, Marshall SA, Sharman J, Jawad AF. A family-school intervention for children with ADHD: Results of a randomized clinical trial. Journal of Consulting and Clinical Psychology. 201210.1037/a0028188

Randall J, Engelhard G. Examining teacher grades using rasch measurement theory. Journal of Educational Measurement. 2009; 46(1):1–18.

Rapport MD, Scanlan SW, Denney CB. Attention-deficit/hyperactivity disorder and scholastic achievement: A model of dual developmental pathways. Journal of Child Psychology and Psychiatry. 1999; 40:1169–1183. [PubMed: 10604396]

Romine CB, Reynolds CR. A model of the development of frontal lobe functioning: Findings from a meta-analysis. Applied Neuropsychology. 2005; 12(4):190–201. [PubMed: 16422660]

Rudolph KD, Lambert SF, Clark AG, Kurlakowsky KD. Negotiating the transition to middle school: The role of self-regulatory processes. Child Development. 2001; 72(3):929–946. [PubMed: 11405592]

Rumberger, RW. Why students drop out of school. In: Orfield, G., editor. Dropouts in America: Confronting the graduation rate crisis. Cambridge, MA: Harvard Education Press; 2004. p. 131-155.

Seidman L, Biederman J, Monuteaux M, Weber W, Faraone SV. Neuropsychological functioning in nonreferred siblings of children with attention deficit hyperactivity disorder. Journal of Abnormal Psychology. 2000; 109:252–265. [PubMed: 10895563]

Shipstead Z, Redick TS, Engle RW. Is working memory training effective? Psychological Bulletin. 2012; 138(4):68–654.

Swanson HL, Trainin G, Necoechea DM, Hammill DD. Rapid naming, phonological awareness, and reading: A meta-analysis of the correlational evidence. Review of Educational Research. 2003; 73:407–444.

Thorell LB. Do delay aversion and executive function deficits make distinct contributions to the functional impact of ADHD symptoms? A study of early academic skill deficits. Journal of Child Psychology and Psychiatry. 2007; 48(11):1061–1070. [PubMed: 17995481]

Toga AW, Thompson PM, Sowell ER. Mapping brain maturation. Trends in Neurosciences. 2006; 29(3):148–159. [PubMed: 16472876]

Toplak ME, Bucciarelli SM, Jain U, Tannock R. Executive functions: Performance-based measures and the Behavior Rating Inventory of Executive Function (BRIEF) in adolescents with Attention-Deficit/Hyperactivity Disorder (ADHD). Child Neuropsychology. 2009; 15:53–72. [PubMed: 18608232]

Toplak ME, West RF, Stanovich KE. Practitioner review: Do performance-based measures and ratings of executive function assess the same construct? Journal of Child Psychology and Psychiatry. 201210.1111/jcpp.12001

Wang M, Eccles JS. Adolescent behavioral, emotional, and cognitive engagement trajectories in school and their differential relations to educational success. Journal of Research on Adolescence. 2012; 22:31–39.

Wechsler, D. Wechsler Intelligence Scale for Children. 4. San Antonio, TX: Harcourt Assessment, Inc; 2003.

Wechsler, D. Wechsler Individual Achievement Test. 3. Psychological Corporation; San Antonio, TX: 2009.

Weller, EB.; Weller, R.; Rooney, MT.; Fristad, MA. Children’s Interview for Psychiatric Syndromes (ChIPS). Washington, D.C: American Psychiatric Association; 1999.

Wentzel KR. Adolescent classroom goals, standards for performance, and academic achievement: An interactionist perspective. Journal of Educational Psychology. 1989; 81:131–142.

Zwick R, Sklar JC. Predicting college grades and degree completion using high school grades and SAT scores: The role of student ethnicity and first language. American Educational Research Journal. 2005; 42(3):439–464.

Table 1

Means, Standard Deviations, Percentages and Correlations between Predictors and Outcomes

Variable	*M* (*SD*)	School Grades	Homework Problems
Child/Family Characteristics			
Age	11.93 (.94)	−.10	.03
Gender	77.7% Male	.05	.03
Race	78.7% Caucasian	.00	.12
Grade	6.87 (.81)	−.04	−.07
Parent's Education	14.24 (2.47)	**.30****	−.11
ADHD Medication Status	43.6% on medication	−.01	−.09
Family Income	70,691 (58,719)	.20	−.05
IQ	100.29 (13.12)	**.32***	**−.27****
WIAT Reading	97.00 (13.65)	**.34****	−.17
WIAT Math	94.39 (15.75)	**.38*****	**−.24***
Parent ADHD Symptoms			
ADHD-I	13.38 (6.03)	**−.36*****	**.81*****
ADHD-HI	8.76 (6.00)	−.21	**.67*****
Teacher ADHD Symptoms			
ADHD-I	11.59 (6.94)	**−.57*****	**.47*****
ADHD-HI	7.20 (6.87)	**−.35****	**.30****
Parent EF: BRIEF BRI Index			
Shifting	14.01 (3.83)	**−.34****	**.54*****
Emotion Control	18.27 (5.74)	−.17	**.47*****
Inhibition	18.60 (6.06)	**−.29****	**.66*****
Parent EF: BRIEF MI Index			
Initiating	16.52 (3.63)	**−.27***	**.62*****
Working Memory	21.92 (4.83)	**−.35****	**.66*****
Planning and Organizing	26.63 (5.95)	**−.50*****	**.74*****
Monitoring	17.97 (4.08)	**−.32****	**.67*****
Organization of Materials	14.40 (3.20)	−.14	**.53*****
Teacher EF: BRIEF BRI Index			
Shifting	14.54 (4.76)	−.18	**.30***
Emotion Control	12.95 (4.46)	−.19	**.29***
Inhibition	16.46 (6.01)	**−.39****	**.38****
Teacher EF: BRIEF MI Index			
Initiating	13.32 (3.49)	**−.43****	**.42****
Working Memory	18.18 (5.79)	**−.43****	**.37****
Planning and Organizing	18.98 (4.84)	**−.59*****	**.50*****

Variable	*M* (*SD*)	School Grades	Homework Problems
Monitoring	18.51 (5.26)	**−.32** **	**.40** **
Organization of Materials	12.11 (3.89)	**−.54** ***	**.62** ***

Note. N = 94; Values in bold were significant at the p<.05 level and were entered into the multivariate model; BRI = Behavioral Regulation Index; MI = Metacognitive Index; Negative relationship for school grades indicates that higher ratings of predictor measures are associated with lower grades; Positive relationship with homework problems indicates that higher ratings of predictor measures are associated with more homework problems; Participants' annual family income ranged from less than $10,000 to over $200,000 (M = $70,691; Median = $62,500). Parent's Education = total years in school for parents, where 12 = high school degree, 14 = high school plus two years, and 16 college degree; WIAT Reading = Wechsler Individual Achievement Test, Reading scale; WIAT Math = Wechsler Individual Achievement Test, Math scale; ADHD-I = attention-deficit/hyperactivity disorder inattentive symptoms; ADHD-HI = attention-deficit/hyperactivity disorder hyperactive/impulsive symptoms; School grades = grade point average for participants' core class grades.

* $p < .05$,

** $p < .01$,

*** $p < .001$.

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Table 2

Correlations between Parent and Teacher ADHD Symptom Ratings and Parent and Teacher Ratings of Executive Function on the BRIEF

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Parent ADHD-I	---	.72**	.40**	.30**	.52**	.53**	.68**	.63**	.72**	.74**	.67**	.59**	.34**	.29**	.36**	.48**	.40**	.50**	.51**	.57**
2. Parent ADHD-HI		---	.38**	.34**	.54**	.46**	.77**	.48**	.61**	.54**	.57**	.53**	.38**	.37**	.38**	.33*	.27*	.35**	.47**	.47**
3. Teacher ADHD-I			---	.70**	.36**	.28**	.49**	.32**	.46**	.42**	.34**	.21**	.47**	.49**	.55**	.67**	.66**	.68**	.62**	.68**
4. Teacher ADHD-HI				---	.24*	.21	.49**	.12	.30**	.28*	.25*	.10	.29*	.26	.73**	.31*	.42**	.43**	.53**	.47**
Parent EF: BRIEF BRI Index																				
5. Shifting					---	.67**	.66**	.72**	.69**	.68**	.61**	.41**	.39**	.22	.20	.37**	.21	.43**	.27*	.38**
6. Emotion Control						---	.54**	.53**	.59**	.54**	.51**	.49**	.53**	.36**	.13	.29*	.11	.29*	.22	.37**
7. Inhibition							---	.64**	.68**	.70**	.73**	.51**	.34*	.34**	.41**	.36**	.23	.41**	.47**	.43**
Parent EF: BRIEF MI Index																				
8. Initiating								---	.75**	.80**	.74**	.56**	.18	.13	.03	.37**	.16	.39**	.23	.39**
9. Working Memory									---	.84**	.68**	.56**	.34**	.23	.22	.55**	.38**	.55**	.44**	.57**
10. Plan and Org										---	.81**	.57**	.19	.10	.20	.41**	.32*	.50**	.37**	.56**
11. Monitoring											---	.62**	.27*	.21	.18	.30*	.23	.36**	.37**	.41**
12. Org. of Materials												---	.50**	.33*	.08	.24	.20	.36**	.34*	.48**
Teacher EF: BRIEF BRI Index																				
13. Shifting													---	.78**	.36**	.33*	.29*	.39**	.51**	.37**
14. Emotion Control														---	.49**	.33*	.24	.31*	.51**	.37**
15. Inhibition															---	.50**	.50**	.53**	.77**	.52**
Teacher EF: BRIEF MI Index																				
16. Initiating																---	.71**	.80**	.72**	.60**
17. Working Memory																	---	.71**	.64**	.67**
18. Plan and Org.																		---	.75**	.74**
19. Monitoring																			---	.64**
20. Org. of Materials																				---

Note. BRIEF = Behavior Rating Inventory of Executive Functioning; MI = Metacognitive Index; BRI = Behavior Regulation Index; ADHD-I = Inattentive symptoms; ADHD-HI = Hyperactive/Impulsive symptoms; Plan and Org = Planning and Organization subscale; Org. of Materials = Organization of Material subscale.

*$p < .05$,

**$p < .01$,

***$p < .001$.

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Table 3

Initial Regression Model with all Variables Significant in Bivariate Correlation Analyses Entered Simultaneously

DV: Grade Point Average (GPA)				
	B	***SE***	***β***	***t***
Parent-Rated IVs	$F(6,84) = 6.22^{**}$, $R^2 = .31$.			
Parent's Education	.07	.04	.17	1.50
Family Income	.001	.001	.07	0.68
WIAT Math	.01	.01	.15	1.14
WIAT Reading	.01	.01	.17	1.44
IQ	.003	.01	.03	.21
ADHD-I	−.08	.02	−.49	**−3.64** **
ADHD-HI	.03	.02	.16	1.18
	B	*SE*	*β*	*t*
Teacher-Rated IVs	$F(7,50) = 8.82^{**}$, $R^2 = .44$.			
Parent's Education	.03	.04	.08	.73
Family Income	.001	.001	.01	.05
WIAT Math	.01	.01	.18	1.50
WIAT Reading	.01	.01	.14	1.30
IQ	.001	.01	.02	.17
ADHD-I	−.07	.02	−.53	**−4.38** **
ADHD-HI	.003	.02	.02	.20
DV: Homework Problems Checklist (HPC)				
	B	*SE*	*β*	*t*
Parent-Rated IVs	$F(4,90) = 56.28^{**}$, $R^2 = .72$.			
WIAT Math	−.11	.06	−.13	−1.78
IQ	−.12	.08	−.12	−1.60
ADHD-I	1.49	.18	.67	**8.23** **
ADHD-HI	.38	.18	.17	**2.05** *
	B	*SE*	*β*	*t*
Teacher-Rated IVs	$F(4,53) = 7.42^{**}$, $R^2 = .27$.			
WIAT Math	−.08	.11	−.09	−.76
IQ	−.15	.13	−.15	−1.18
ADHD-I	.82	.26	.43	**3.15** **
ADHD-HI	.02	.26	.01	.08

Note - WIAT Reading = Wechsler Individual Achievement Test, Reading scale; WIAT Math = Wechsler Individual Achievement Test, Math scale; ADHD-I = attention-deficit/hyperactivity disorder inattentive symptoms; ADHD-HI = attention-deficit/hyperactivity disorder hyperactive/ impulsive symptoms

* $p < .05$,

** $p < .01$,

*** $p < .001$.

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Table 4

Hierarchical Regression Analyses of Parent- and Teacher-Ratings of ADHD and EF in Predicting GPA

	DV: Student GPA							
	Step 1 Model Summary				**Step 2 Model Summary**			
	B	***SE***	***β***	***t***	***B***	***SE***	***β***	***t***
Parent-Rated IVs	$F(1,89) = 13.32^{**}$, $R^2 = .13$.				$\Delta F(3,86) = 2.17$, $\Delta R^2 = .19$, $R^2 = .06$			
ADHD-I	−.08	.02	−.49	**−3.64****	−.05	.02	−.34	**−2.42***
Behavior Regulation Index								
BRIEF Shifting	--	--	--	--	−.09	.04	−.38	**−2.44***
BRIEF Emotion Control	--	--	--	--	.04	.02	.24	1.69
BRIEF Inhibition	--	--	--	--	.01	.02	.06	.41
	B	*SE*	*β*	*t*	*B*	*SE*	*β*	*t*
Parent-Rated IVs	$F(1,89) = 13.32^{**}$, $R^2 = .13$.				$\Delta F(5,84) = 5.09^{**}$ $R^2 = .34$, $\Delta R^2 = .20$			
ADHD-I	−.08	.02	−.49	**−3.64****	−.02	.02	−.12	−.83
Metacognition Index								
BRIEF Initiating	--	--	--	--	.07	.04	.26	1.62
BRIEF Working Memory	--	--	--	--	.04	.04	.18	1.01
BRIEF Planning and Organizing	--	--	--	--	−.16	.04	−.98	**−4.46****
BRIEF Monitoring	--	--	--	--	.03	.04	.14	.84
BRIEF Organization of Materials	--	--	--	--	.05	.04	.16	1.29
	Step 1 Model Summary				Step 2 Model Summary			
	B	*SE*	*β*	*t*	*B*	*SE*	*β*	*t*
Teacher-Rated IVs	$F(1,55) = 25.73^{**}$, $R^2 = .32$.				$\Delta F(3,52)= .73$, $R^2 = .35$, $\Delta R^2 = .03$			
ADHD-I	−.08	.02	−.57	**−5.07****	−.08	.02	−.56	**−3.89****
Behavior Regulation Index								
BRIEF Shifting	--	--	--	--	.01	.04	.05	.30
BRIEF Emotion Control	--	--	--	--	.03	.04	.18	.61

DV: Student GPA	Step 1 Model Summary				Step 2 Model Summary			
	B	***SE***	***β***	***t***	***B***	***SE***	***β***	***t***
BRIEF Inhibition	--	--	--	--	−.03	.02	−.16	−1.13
	B	*SE*	*β*	*t*	*B*	*SE*	*β*	*t*
Teacher -Rated IVs	$F(1,55) = 25.73^{**}$, $R^2 = .32$.				$\Delta F(5,50) = 2.19$, $R^2 = .44$, $\Delta R^2 = .12$			
ADHD-I	−.08	.02	−.57	**−5.07****	−.048	.02	−.35	**−2.12***
Metacognition Index								
BRIEF Initiating	--	--	--	--	.04	.05	.14	.70
BRIEF Working Memory	--	--	--	--	.01	.03	.08	.48
BRIEF Planning and Organizing	--	--	--	--	−.11	.04	−.56	**−2.54***
BRIEF Monitoring	--	--	--	--	−.04	.04	−.16	−.91
BRIEF Organization of Materials	--	--	--	--	.04	.03	.20	1.17

Note. Parent-ratings $n = 94$; Teacher-ratings $n = 57$; Parent's Education = total years in school for parents; ADHD-I = attention-deficit/hyperactivity disorder inattentive symptoms; ADHD-HI = attention-deficit/hyperactivity disorder hyperactive/impulsive symptoms; WIAT Reading = Wechsler Individual Achievement Test, Reading scale; WIAT Math = Wechsler Individual Achievement Test, Math scale; BRIEF = Behavior Rating Inventory of Executive Functioning;

* $p < .05$,

** $p < .01$.

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Table 5

Hierarchical Regression Analyses of Parent- and Teacher-Ratings of ADHD and EF in Predicting Homework Problems

DV: Homework Problems Checklist								
	Step 1 Model Summary				**Step 2 Model Summary**			
	B	***SE***	***β***	***t***	***B***	***SE***	***β***	***t***
Parent-Rated IVs	$F(2,92) = 90.25^{**}$, $R^2 = .67$.				$\Delta F(3,86) = 2.17^{*}$, $R^2 = .19$, $\Delta R^2 = .06$			
ADHD-I	1.50	.20	.68	**7.71****	1.40	.21	.63	**6.74****
ADHD-HI	.41	.20	.18	**2.07***	.18	.23	.08	.79
Behavior Regulation Index								
BRIEF Shifting	--	--	--	--	.44	.33	.13	1.31
BRIEF Emotion Control	--	--	--	--	−.11	.20	−.05	−.55
BRIEF Inhibition	--	--	--	--	.25	.24	.11	1.01
	B	*SE*	*β*	*t*	*B*	*SE*	*β*	*t*
Parent-Rated IVs	$F(2,92) = 90.25^{**}$, $R^2 = .67$.				$\Delta F(5,84) = 3.02^{*}$ $R^2 = .72$, $\Delta R^2 = .05$			
ADHD-I	1.50	.20	.68	**7.71****	1.02	.24	.46	**4.31****
ADHD-HI	.41	.20	.18	**2.07***	.44	.20	.20	**2.25***
Metacognition Index								
BRIEF Initiating	--	--	--	--	.09	.38	.02	.24
BRIEF Working Memory	--	--	--	--	−.34	.33	−.12	−1.04
BRIEF Planning and Organizing	--	--	--	--	.85	.32	.38	**2.63***
BRIEF Monitoring	--	--	--	--	.05	.36	.02	.14
BRIEF Organization of Materials	--	--	--	--	−.07	.33	−.02	−.21
	Step 1 Model Summary				Step 2 Model Summary			
	B	*SE*	*β*	*t*	*B*	*SE*	*β*	*t*
Teacher-Rated IVs	$F(1,55) = 15.08^{**}$, $R^2 = .22$.				$\Delta F(3,52) = .58$, $R^2 = .24$, $\Delta R^2 = .03$			
ADHD-I	.902	.232	.467	**3.88****	.67	.30	.35	**2.22***
Behavior Regulation Index								

DV: Homework Problems Checklist

	Step 1 Model Summary				**Step 2 Model Summary**			
	B	***SE***	***β***	***t***	***B***	***SE***	***β***	***t***
BRIEF Shifting	--	--	--	--	.33	.56	.12	.59
BRIEF Emotion Control	--	--	--	--	−.17	.62	−.06	−.27
BRIEF Inhibition	--	--	--	--	.38	.34	.17	1.11
	B	*SE*	*β*	*t*	*B*	*SE*	*β*	*t*
Teacher -Rated IVs	$F(1,55) = 15.08^{**}$, $R^2 = .22$.				$\Delta F(5,50) = 3.04^{*}$, $R^2 = .40$ $\Delta R^2 = .19$			
ADHD-I	.902	.232	.467	**3.88****	.18	.33	.10	.55
Metacognition Index								
BRIEF Initiating	--	--	--	--	.45	.78	.12	.57
BRIEF Working Memory	--	--	--	--	−.45	.41	−.19	−1.08
BRIEF Planning and Organizing	--	--	--	--	.24	.63	.09	.38
BRIEF Monitoring	--	--	--	--	−.14	.46	−.05	−.30
BRIEF Organization of Materials	--	--	--	--	2.01	.63	.58	**3.19****

Note. ADHD-I = attention-deficit/hyperactivity disorder inattentive symptoms; ADHD-HI = attention-deficit/hyperactivity disorder hyperactive/impulsive symptoms; BRIEF = Behavior Rating Inventory of Executive Functioning; Higher scores on the BRIEF, ADHD, and HPC all indicate more deficits/problems so positive correlations would be expected;

$^{*}p < .05$,

$^{**}p < .01$.