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Attention Deficit Hyperactivity Disorder and Scholastic Achievement: A Model of Mediation via Academic Enablers

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Abstract. The current study examined the influence of symptoms of attention deficit hyperactivity disorder (ADHD) on student academic achievement in reading and in mathematics in a sample of 146 first- through fourth-grade students, 103 of which were identified as having ADHD and academic problems in reading and/or math. A theoretical model was examined using structural equation modeling wherein student academic enablers (motivation, study skills, interpersonal skills, and engagement) and prior academic achievement served as mediators of the relationship between ADHD and academic achievement in mathematics and reading. Results of these analyses indicate that after controlling for the influence of prior achievement, ADHD influences motivation, which influences study skills to promote academic achievement. The article concludes with a discussion of the practical implications of these findings and how they extend prior research on the relationship between ADHD and academic achievement.

Attention deficit hyperactivity disorder (ADHD) is a psychiatric diagnosis typified by developmentally inappropriate levels of inattention, response disinhibition, and overactivity that result in functional impairment in more than one setting (American Psychiatric Asso-

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ciation, 2000). The primary long-term outcome associated with pure ADHD (i.e., ADHD in the absence of a more severe disruptive behavior or mood disorder) is academic underachievement (Mannuzza, Gittelman-Klein, Bessler, Malloy, & LaPadula, 1993). Although a significant minority of children diagnosed with ADHD is also classified with a learning disability due to deficits in the acquisition of specific academic skills (DuPaul & Stoner, 2003; Knivsberg, Reichelt, & Nodland, 1999; Semrud-Clikeman, Biederman, Sprich-Buckminster, Lehman, Faraone, & Norman, 1992), it has been documented that up to 80% of students with ADHD may exhibit academic performance problems (Cantwell & Baker, 1991).

Studies examining differential developmental outcomes for children with disruptive behavior disorders have found evidence suggesting that the symptoms of ADHD but not conduct disorder (CD) are associated with later academic problems, whereas the symptoms of CD but not ADHD are associated with later delinquency (Farrington, Loeber, & Van Kammen, 1990; Fergusson & Horwood, 1995; Fergusson, Horwood, & Lynskey, 1993; Fergusson, Lynskey, & Horwood, 1997; Frick et al., 1991). For example, Fergusson and Horwood (1995) conducted a longitudinal study of 709 children in New Zealand wherein disruptive behavior problems and intelligence (IQ) were assessed at age 8, scholastic achievement was assessed at age 13, and rates of delinquency were measured at age 15. They found early attention deficit behaviors and conduct problems to be highly correlated, early conduct problems to be strongly associated with later delinquency, early IQ and attention deficit behaviors to be predictive of later scholastic achievement, and early conduct problems to be unrelated to later scholastic achievement except for their correlation with early attention deficit behaviors and IQ. A more recent study conducted by Fergusson et al. (1997) found similar results, this time following children into young adulthood. Missing from these studies was exploration of mediating variables between early disruptive behavior and later outcomes.

Rapport, Scanlan, & Denney (1999) replicated the model of Fergusson and colleagues (1993, 1995) with a sample of 325 students in Hawaii between 7 and 16 years of age wherein ADHD and IQ were correlated variables predicting scholastic achievement, whereas CD was correlated with ADHD but associated with scholastic achievement only in terms of its correlation with ADHD. Rapport et al. subsequently extended this model by examining dual pathways of mediators (cognitive, behavioral) from the predictors (ADHD, CD, IQ) to scholastic achievement. Within this extended model, a cognitive pathway mediates the impact of ADHD on achievement via vigilance and memory, where vigilance (measured via a continuous performance test) imparts an influence on memory (measured via a paired associate learning test), which in turn influences academic achievement. Concurrently, a behavioral pathway mediates the effect of ADHD on achievement through its influence on classroom behavior as measured by teacher ratings of academic functioning. In this dual pathway model (DPM), CD remained unrelated to achievement once its correlations with ADHD symptoms and IQ were taken into account. The DPM greatly improved the prediction of scholastic achievement over Fergusson's model (77% variance accounted for, compared to 31%). Although the DPM accounts for considerable variance in explaining the connection between ADHD and academic achievement, the explanatory value of this model may be enhanced by incorporating constructs from other causal models of academic achievement that examine interrelationships among students' academic attitudes and behaviors.

Models of Academic Achievement

Several educational researchers (e.g., Bennett, 1978; Carroll, 1963; Glaser, 1976) have proposed theoretical models to explain direct and indirect influences on students' educational outcomes. One empirically tested theory is Walberg's (1981) theory of educational productivity, which posits that psychological characteristics of individual students and their immediate environments influence educational outcomes (cognitive, behavioral,

and attitudinal; Reynolds & Walberg, 1992). Walberg identified nine specific variables that influence educational outcomes and engaged in a program of research exploring the effects of these variables on students' academic achievement and attitude (e.g., Parkerson, Lomax, Schiller, & Walberg, 1984; Walberg, Fraser, & Welch, 1986). Other researchers (e.g., Anderson & Keith, 1997; Cool & Keith, 1991) also have tested models of academic achievement influenced by Walberg's theory of educational productivity. These researchers consistently found one student variable, prior achievement, had the largest direct effects on current achievement, and another student variable, motivation, had significant total effects on achievement. One potential limitation of these studies, however, was that the tested models omitted other key student variables (e.g., study skills, interpersonal skills) that may significantly contribute to academic achievement.

Since the proposal of Walberg's model, additional researchers have documented positive relationships between students' attitudes and behaviors and their academic achievement. Wentzel (1993) examined the relationship between measures of academic outcomes (i.e., grades and standardized achievement test scores) and students' social and academic behavior. In this study, teacher ratings of students' prosocial, antisocial, and academic behavior were significant, independent predictors of students' grade point averages. Prosocial and antisocial behavior also contributed indirectly to grade point average through academic behavior. Only prosocial behavior, however, was a significant, independent predictor of standardized achievement test scores.

Malecki and Elliott (2002) extended the work of Wentzel through the use of standardized measures completed by multiple informants (i.e., parent, teacher, and student) to explore the relationships between social behaviors and academic outcomes. In addition, Malecki and Elliott collected data at two points in time to allow for replication of the relationships among variables and explored the predictive relationship between social behaviors at Time 1 and academic outcomes at Time 2. Like Wentzel (1993), Malecki and Elliott (2002) concluded that social skills have a significant predictive relationship with academic outcomes.

Additional evidence supporting the relationships between academic achievement and the student variables of social skills, motivation, engagement, and study skills resulted from the development and standardization of the Academic Competence Evaluation Scales (ACES; DiPerna & Elliott, 2000), a teacher rating scale designed to measure students' skills, attitudes, and behaviors that contribute to academic success in the classroom. The authors of the ACES have conducted several studies (e.g., DiPerna & Elliott, 1999, 2000) to explore the psychometric properties of the instrument. The results across each of the studies have indicated that the academic enablers (AEs; motivation, study skills, interpersonal skills, and engagement) measured by the ACES primarily demonstrate moderate relationships with report card grades and standardized tests of achievement (see DiPerna & Elliott, 2000, for a summary of this evidence).

Based on this research, DiPerna, Volpe, and Elliott (2002) proposed and tested a causal model of student achievement featuring multiple AEs. Their model hypothesized that motivation plays an indirect but central role in the promotion of academic achievement. Motivation influences two other skills—engagement and study skills—that directly influence academic achievement. Prior achievement and interpersonal skills, however, influence a student's level of motivation for academic learning. Initial application of this model to early reading achievement provided support for the model with an elementary sample (DiPerna et al., 2002).

As opposed to viewing student classroom behaviors as a unitary construct (cf. Rapport et al., 1999), the achievement models of DiPerna et al. (2002) and Walberg (e.g., Reynolds & Walberg, 1992) provide insight regarding relationships among student variables that may mediate the relationship between ADHD and academic achievement. As noted by Barkley (1998), because of its ability to explain situational variability in child per-

formance and its association with neurological substrates in the regulation of motor movement and incentive by dopamine pathways, motivation or effort is an essential construct to include in theory construction pertaining to ADHD. Further, impairment in social functioning (Pelham & Bender, 1982), academic engagement and productivity (Abikoff et al., 2002; Barkley, DuPaul, & McMurray, 1990), and academic or study skills (Barkley, 1998) are well documented in children with ADHD.

The purpose of the present study was twofold. First, we sought to extend the work of Rapport and his colleagues (1999) by examining more closely the behavioral pathway from ADHD to academic achievement. Specifically, the assessment of child classroom behaviors was expanded (based on prior modeling studies conducted by DiPerna and colleagues) to include teacher ratings of those child behaviors (motivation, interpersonal skills, study skills, engagement) considered important to the promotion of academic achievement. In addition, the present study extended the work of DiPerna and his colleagues by including the construct of ADHD into a model examining the relationship between key AEs and student academic achievement. Finally, this investigation extended prior work by including a mixed sample of children with and without ADHD, as prior studies used nonreferred samples exclusively. Such a mixed sample of affected and nonaffected children permitted consideration of the effects of ADHD symptoms in the clinical range, while maintaining sufficient variance in the data to allow the detection of important relationships between variables.

The model resulting from examination of studies concerning academic impairment experienced by children with ADHD (Figures 1 and 2) hypothesized that ADHD has an influence on prior achievement as well as an effect on the development of study skills and motivation. Motivation also is influenced by prior achievement and interpersonal skills, while it has an indirect but significant effect on academic achievement. Motivation was hypothesized to influence two other skills— engagement and study skills—that directly influence academic achievement. Finally, the model accounted for the influence of prior achievement on current achievement.

Method

Participants

The participant group was comprised of a subsample of a larger study investigating models of academic intervention for children with ADHD (cf. DuPaul et al., 2004). Participants included 103 students (78 boys, 25 girls) attending first through fourth grade (M age = 8.5 years; SD = 1.2) in public elementary schools in eastern Pennsylvania who were identified as having ADHD, and an additional 43 students (21 boys, 12 girls) from the same schools and grades as the children with ADHD (age: M = 8.6 years; SD = 1.2 years) who served as normal controls. Both groups were primarily comprised of Caucasian children (ADHD, n = 69; control, n = 36), but also included children from Latino (ADHD, n = 23; control, n = 4) and African American (ADHD, n = 10; control, n = 3) backgrounds. There was also one child meeting criteria for ADHD who was Native American. Participants were recruited from schools in urban, rural, and suburban settings with the percentage of students in these schools receiving free and reduced lunch ranging from 0 to 78% (M = 30.7%; SD = 26.7%).

Students with ADHD were referred to this study by their teachers because of concerns regarding inattentive and/or hyperactive-impulsive behavior as well as difficulties with reading and/or math achievement. Further, to be identified as having ADHD for the purposes of this study, children needed (a) to have received parent and teacher ratings on the ADHD Rating Scale—IV (DuPaul, Power, Anastopoulos, & Reid, 1998) at or above the 90th percentile on either the Inattention or Hyperactivity-Impulsivity subscales using appropriate age and gender norms; and (b) to have met *Diagnostic Statistical Manual* (4th ed.—text revision; DSM-IV-TR; American Psychiatric Association, 2000) criteria for one of the three subtypes of ADHD based on a

parent interview using a computerized version of the NIMH Diagnostic Interview Schedule for Children—IV (DISC; Shaffer, Fisher, & Lucas, 1998). Three hundred twenty-seven students were referred, of whom 182 were deemed eligible as participants with ADHD. Parental consent was provided for 175 of these children, 103 of whom had complete data for inclusion in the current study.

Typically developing children were recruited from the same grades and schools as the participants with ADHD but were in different classrooms. They were reported by their teachers to demonstrate "average" classroom behavior and academic achievement. To be included in the study as a control participant, children (a) received parent and teacher ratings on the ADHD Rating Scale—IV below the 90th percentile for their age and gender on both the Inattention and Hyperactivity-Impulsivity subscales; and (b) did not meet DSM-IV criteria for any of the disruptive behavior disorders (ADHD, oppositional defiant disorder [ODD], or CD) according to a parent interview with the DISC.

Of the 103 children with ADHD, 72 were identified with the combined type, 25 with the predominantly inattentive type, and 6 with the predominantly hyperactive-impulsive type. In addition, 43 children met DSM-IV criteria for ODD and another 19 met DSM-IV criteria for CD. All of the children with ADHD were placed in general education classrooms for at least a portion of the school day, with a small minority ($n = 5$) receiving part-time special education services. Thirty-four children (33%) in the ADHD group were receiving psychotropic medication including psychostimulants ($n = 26$), antidepressants ($n = 1$), and other medications ($n = 7$). None of the control participants received special education or psychotropic medication.

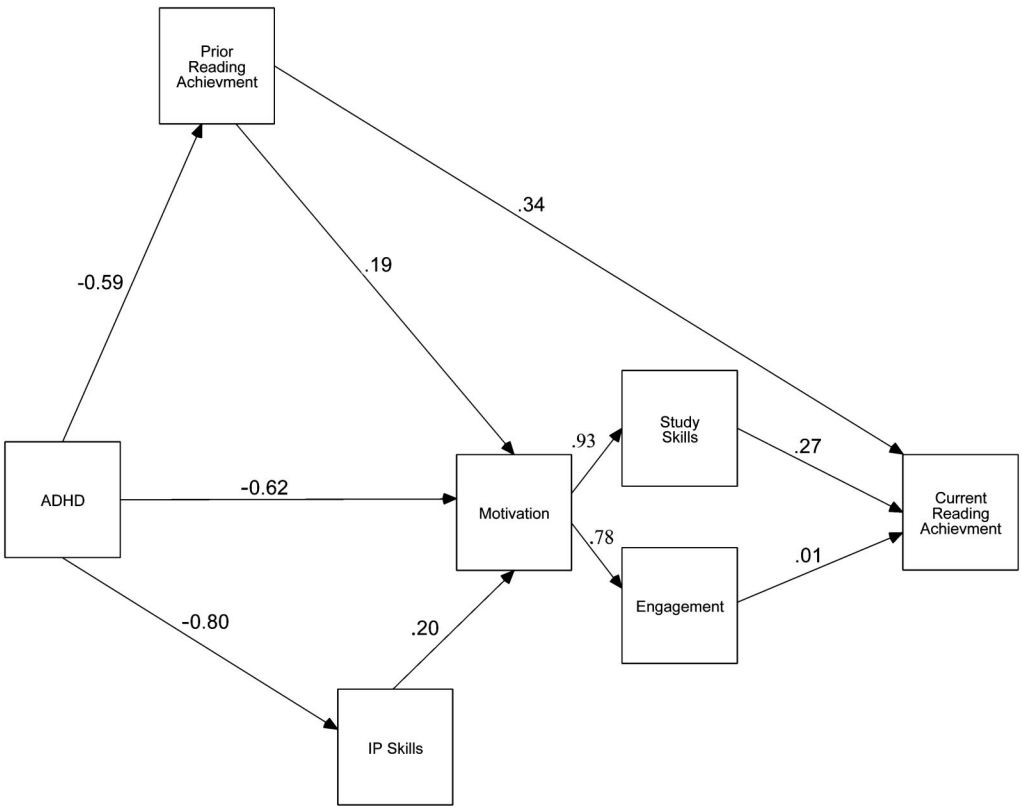

Figure 1. Best-fitting model for achievement in reading.

As expected, children with ADHD and children in the control group differed with respect to parent and teacher ratings on the ADHD Rating Scale—IV ($p < .01$). Further, a significantly higher percentage of the control participants were Caucasian as compared to participants with ADHD ($p < .05$). Alternatively, there were no significant differences with regard to age and gender.

Measures

Screening measures. The ADHD Rating Scale—IV (DuPaul et al., 1998) is a behavior rating scale that includes items directly related to the 18 symptoms of ADHD based on the DSM-IV-TR (American Psychiatric Association, 2000). Home and school versions are available for completion by parents and teachers, respectively. Items are scored on a 0 (*never or rarely*) to 3 (*very often*) basis. Normative data based on age and gender are available and the psychometric properties of this instrument are well established (DuPaul et al., 1998). The stability and internal consistency of the ADHD-IV generally are strong. These findings were based on a study of 71 nonreferred students (35 males, 36 females) between 5 and 17 years of age. Test–retest coefficients (4-week latency) ranged from 0.88–0.90 for the school version to 0.78–0.86 for the home version. Coefficient alphas (0.86–0.92) were consistently high for both versions of the checklist (DuPaul, Power, McGoey, Ikeda, & Anastopoulos, 1998).

The Computerized NIMH Diagnostic Interview Schedule for Children (Parent Version; Shaffer et al., 1998) is a structured diagnostic interview that is administered using computer software. The Disruptive Behavior Disorders module was administered by a

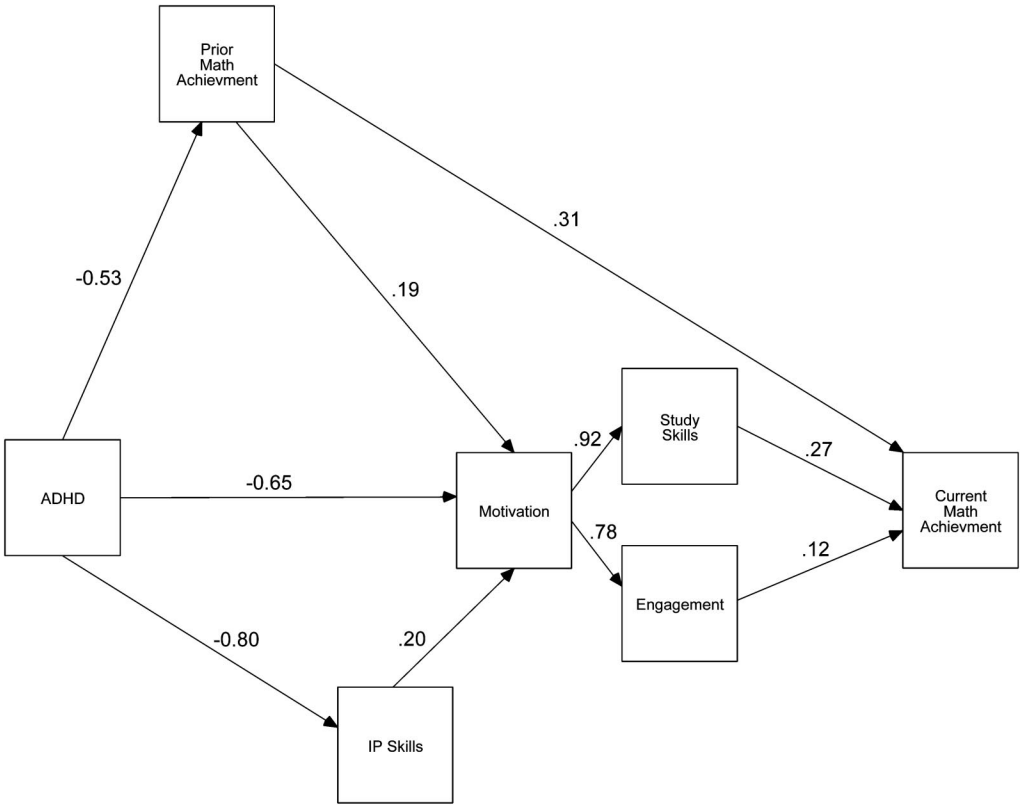

Figure 2. Best-fitting model for achievement in mathematics.

trained interviewer either in person or by phone. The ADHD category of the DISC has been shown to demonstrate good test–retest reliability ($\kappa = .60$) (Schwab-Stone et al., 1996) as well as scale reliability ($ICC = 0.84$) (Shaffer et al., 1996). All DISC interviews for the current study were audiotaped and a random subsample (21%) was reviewed by a second trained interviewer to assess interdiagnostician agreement. Agreement was 100% across all interviews with respect to overall diagnosis and subtype designation.

Measures of academic achievement. Standard scores on the Broad Reading and Broad Math subtests of the Woodcock-Johnson III Tests of Achievement (WJ-III; Woodcock, McGrew, & Mather, 2001) served as outcome measures in the models of academic achievement. Broad Reading is a composite score based on a student's performance on three subtests: Letter-Word Identification, Reading Fluency, and Passage Comprehension. Broad Math is a composite score based on a student's performance on the Calculation, Math Fluency, and Applied Problems subtests. The WJ-III is a widely used, individually administered, norm-referenced achievement test that has exemplary psychometric properties (Mather & Woodcock, 2001).

Report card grades in reading and mathematics served as measures of prior achievement because they represented student performance over the previous marking period. Grades provided by classroom teachers in these subject areas were converted to numerical scores ranging from 1 (*F*) to 5 (*A*).

Measures of mediating variables. Several measures were included as potential predictors of academic achievement, including teacher ratings of ADHD symptoms, academic skills, and achievement-related behaviors.

Percentile scores on the Inattention and Hyperactivity-Impulsivity subscales of the ADHD Rating Scale-IV (School Version; DuPaul et al., 1998) served as measures of ADHD symptomology, and percentile scores on the Conduct Problems subscale of the Behavior Assessment System for Children (BASC; Reynolds & Kamphaus, 1992) reflected levels of disruptive behavior related to ODD and CD. The BASC is used frequently in research studies with this population and has adequate psychometric properties (Reynolds & Kamphaus, 1998). The Conduct Problems subscale includes ten items that are scored on a 4-point Likert scale ranging from *never* to *almost always*.

Raw scores on the AE subscales (interpersonal skills, engagement, motivation, and study skills) of the ACES (DiPerna & Elliott, 2000) provided teacher perceptions of children's academic skills and achievement-related behaviors. The Interpersonal Skills subscale measures communication, cooperation, and self-control behaviors necessary to interact with other students and adults in the classroom. The Motivation subscale assesses initiative, persistence, and goal-directed behavior regarding academic tasks. The Study Skills subscale reflects behaviors and skills that facilitate the acquisition of new information. Finally, the Engagement subscale assesses active participation in the classroom (e.g., asking questions, volunteering answers). For each scale, item frequencies were scored on a 1 (*never*) to 5 (*almost always*) Likert scale. In the initial research exploring the psychometric properties of the ACES, scores from AE subscales have demonstrated strong reliability and validity (DiPerna & Elliott, 1999, 2000). Internal consistency coefficients (Cronbach's alphas) ranged from 0.94 to 0.98, and 6-week test–retest stability coefficients ranged from 0.92 to 0.96. Correlations between the ACES enabler subscales and students' scores (Total, Math, Reading, and Language) from the Iowa Test of Basic Skills ranged from low (.37) to high (.71), with the majority falling in the moderate range.

Procedures

Local school administrators were informed of a study examining the effects of academic interventions for students with ADHD and were asked to refer children with ADHD-related behaviors who also were experiencing difficulties in reading and/or math.

Table 1
Correlations, Means, and Standard Deviations of the Variables Included in Models of ADHD and Academic Achievement

Measure	1	2	3	4	5	6	7	8	9
1. WJ-III BR	—	0.73	0.50	0.42	−0.50	0.29	0.51	0.47	0.35
2. WJ-III BM		—	0.41	0.51	−0.59	0.42	0.57	0.50	0.45
3. RC Read			—	0.72	−0.59	0.51	0.66	0.61	0.54
4. RC Math				—	−0.53	0.45	0.59	0.52	0.52
5. ADHD-IV					—	−0.79	−0.89	−0.82	−0.68
6. ACES IP						—	0.78	0.72	0.70
7. ACES MO							—	0.88	0.78
8. ACES SS								—	0.68
9. ACES EN									—
M	94.77	100.49	3.63	3.78	66.18	36.18	26.16	28.47	26.16
SD	16.08	14.70	1.08	1.11	32.79	9.16	7.67	13.21	7.68

Note: All correlations statistically significant $p < .001$. WJ-III BR = Woodcock-Johnson Tests of Achievement III Broad Reading; WJ-III BM = Woodcock-Johnson Tests of Achievement III Broad Mathematics; RC Read = Report Card Reading; RC Math = Report Card Mathematics; ADHD-IV = ADHD Rating Scale-IV Total Score; ACES IP = ACES Interpersonal Skills; ACES MO = ACES Motivation; ACES SS = ACES Study Skills; ACES EN = ACES Engagement.

Parents and teachers of referred children completed the ADHD-IV and parents of those children who met criteria on behavior ratings were then interviewed by phone or in person using the DISC. Parents of children who met inclusion criteria on the DISC were asked if they wanted to consent to their child participating in the study. Upon obtaining parental consent, teachers were then solicited to identify potential control participants from the same grade levels as participants with ADHD but different classrooms to avoid potential bias in teacher ratings owing to a contrast effect. Students referred for the control group were screened using the ADHD-IV and DISC. Parents of those children who met criteria were asked to provide informed consent for participation.

After consent was obtained, predictor and outcome measures were collected during an approximate 1-month period in the middle of the school year (between December and February). All measures were collected prior to academic interventions being implemented in classrooms (i.e., during the baseline period of the larger study). Trained graduate students in school psychology, special education, and counseling psychology administered the WJ-III. Research assistants were blind to the purposes of the study and to group membership of participating children. Behavior ratings were distributed directly to teachers by data collectors and were returned to the investigators by mail. A stipend of $25 was provided to teachers upon completion of the packet of rating scales. Schools or parents provided photocopies of the most recent report card grades in reading and math.

Results

The means and standard deviations for all of the measured variables included in the models of academic achievement in reading and mathematics are summarized in Table 1. Tests of univariate normality across the student variables indicated that skewness and kurtosis did not significantly depart from a univariate normal distribution. Similarly, tests for multivariate outliers via calculation of Mahalanobis distances[1] revealed only a small number of observations in each model that

were falling improbably far ($p < .01$) from the centroid, assuming a multivariate normal data distribution. Inspection of the raw data for these cases indicated no errors in data entry or patterns in responses. Thus, these observations were retained for the modeling analyses.

Pearson product moment correlations between all variables in the models of achievement are also reported in Table 1. Correlations between scales or categories of the same instruments were generally moderate to high and statistically significant. Likewise, the associations between variables from different forms or methods measuring the same or similar constructs were generally moderate to high and statistically significant. For example, the correlation between Broad Reading and Broad Math scores on the WJ-III and report card grades in the same content areas were moderate ($r = 0.50$ and $r = 0.51$) respectively. Correlations between teacher ratings of ADHD and measures of achievement were generally moderate (range between −0.50 and −0.59) and correlations between teacher ratings of ADHD and teacher ratings of AEs were generally high (range between −0.68 and −0.89).

Models of Academic Achievement

A two-phase modeling approach was employed to address the goals of the current study. First, a simplified mediation model (Figure 3) was examined to assess the relative influence of ADHD and CD on academic achievement and to investigate directly whether the influence of ADHD on achievement was mediated through students' academic behaviors (AE total score). A simplification of our full model was necessary to address directly the question of mediation. In separate analyses for reading and mathematics achievement, a composite measure of AEs, AE total raw score, was expected to mediate the influence of ADHD on current academic achievement. Prior achievement was expected

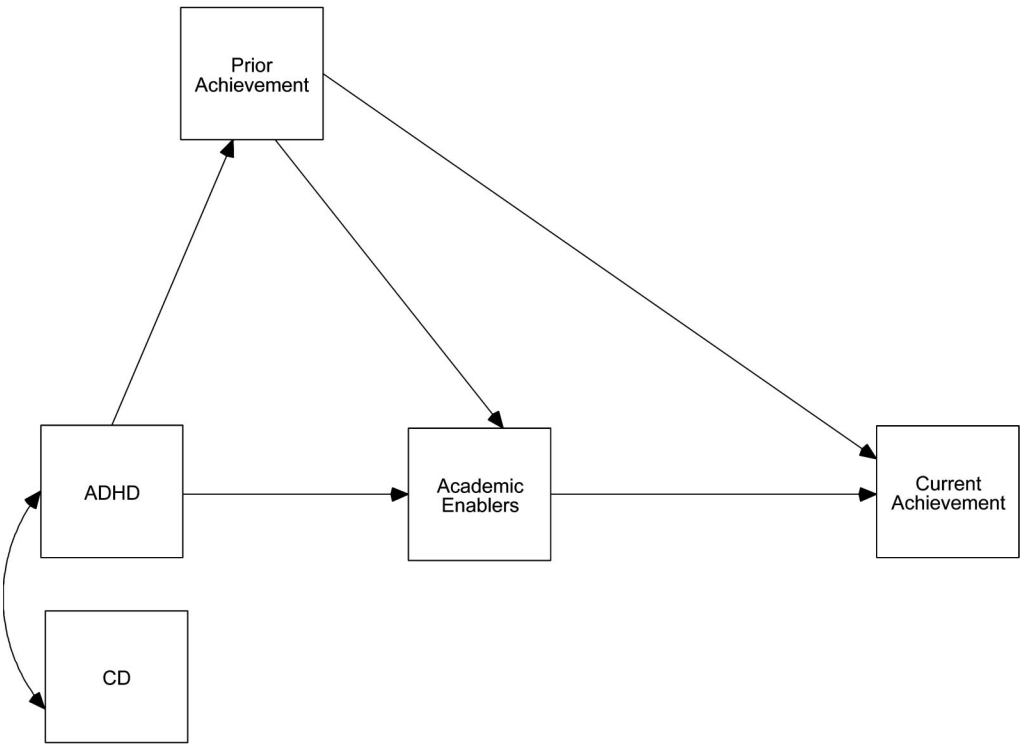

Figure 3. Basic mediation model.

to account for significant variance in the prediction of current achievement, and CD and ADHD were expected to be significantly associated with each other and with prior achievement, but CD was not expected to have a significant effect on current achievement once its association with ADHD was considered. Next, an expanded model of mediation was examined wherein the influence of ADHD on AEs was examined more closely (Figures 1 and 2).

Structural equation modeling analyses examining the hypothesized models for achievement in reading and mathematics were performed using Amos (Version 4.01) statistical software (Arbuckle, 1999). All model parameters were estimated via maximum likelihood estimation. Based on the recommendation of Bollen (1989), χ^2 and several indices were used to assess the fit of the proposed models. These indices included the comparative fit index (CFI), adjusted goodness of fit index (AGFI), Bentler-Bonett normed fit index (Δ_1), and root mean squared error of approximation (RMSEA). These indices assess various aspects of model fit and have different criteria for identifying a model demonstrating good fit. The CFI, Δ_1, and AGFI are bounded between the values of 0 and 1, with 1 indicating a perfect fit. Models demonstrating a good fit will yield a nonsignificant χ^2, CFI, AGFI, and $\Delta_1 > 0.90$, and RMSEA < 0.08 (Browne & Cudeck, 1993; Kline, 2005).

Basic Mediation Model

To test the question of the mediating influence of the AEs directly, we employed the strategy suggested by Hoyle and Smith (1994) wherein the following criteria must be met to establish the mediating influence of AEs on the relationship between ADHD and achievement: (1) a model expressing a direct relationship between ADHD (A) and achievement (C) must demonstrate an adequate fit (A $\rightarrow$ C), (2) the A $\rightarrow$ B, B $\rightarrow$ C, and A $\rightarrow$ C pathways should be significant, (3) the full mediation model must demonstrate adequate fit (A $\rightarrow$ B $\rightarrow$ C), and (4) there should be a significant difference in fit when the A $\rightarrow$ C pathway is constrained to zero as compared to when that pathway is not constrained.

The basic mediation model fit the data well for the analysis of achievement in reading, $\chi^2(3) = 2.38$, $p = .50$, CFI = 0.99, AGFI = 0.97, $\Delta_1 = 0.99$, and RMSEA = 0.00, but somewhat less well for achievement in mathematics, χ^2 (3) = 10.53, $p = .02$, CFI = 0.98, AGFI = 0.87, $\Delta_1 = 0.98$, and RMSEA = 0.13. Significant covariances between ADHD, CD, and prior achievement were found (see Figure 3), and all pathways were statistically significant ($p < .01$). As expected, the relationship between CD and achievement was accounted for by CD's association with ADHD. Squared multiple correlations indicated that this model predicted 33 and 37% of the variance in reading and mathematics scores, respectively.

Although we found significant pathways between ADHD and AEs, and AEs and current achievement across models for reading and mathematics, when a direct pathway was added between ADHD and current achievement in reading, neither the pathway between ADHD and achievement nor the pathway between AEs and achievement was significant (standardized regression coefficients were -0.17 and 0.14, respectively). The results were different when the pathway between ADHD and achievement was added to the model for mathematics. Specifically, although the pathway between AEs and achievement was no longer significant (standardized regression coefficient = 0.07), the pathway between ADHD and achievement was significant (standardized regression coefficient = -0.38; $p < .01$). Although neither model satisfied Hoyle and Smith's (1994) criteria for tests of mediating effects, these analyses suggested important differences in the relationships of these variables across academic subjects. Hence, we proceeded to our second phase of analysis.

Academic Enablers Model (AEM)

We next examined an expanded model of the mediating effects of AEs (Figures 1 and 2). Because the influence of CD on achievement had been accounted for by ADHD in

prior studies and in our basic mediation model, it was excluded from the AEM for clarity. In the AEM it was hypothesized that the symptoms of ADHD would be associated with prior achievement and would impose a direct influence upon interpersonal skills and motivation. Based on prior modeling studies of AEs (e.g., DiPerna et al., 2002), interpersonal skills was hypothesized to influence motivation, motivation was expected to influence study skills and academic engagement, which in turn were expected to influence current academic achievement. This theoretical model was tested separately for student achievement in reading (Figure 1) and mathematics (Figure 2).

The analysis examining the AEM for achievement in reading (Figure 1) fit the data well, $\chi^2(9) = 8.34$, $p = .50$, CFI = 1.0, AGFI = 0.95, $\Delta_1 = 0.99$, and RMSEA = 0.00, yet predicted only 30% of the variance in student reading achievement. Standardized direct, indirect, and total effects of variables upon current achievement in reading are summarized in Table 2. Symptoms of ADHD had a marked negative effect on reading achievement (−0.43), which was similar in magnitude to the effect of prior reading achievement (0.39). The effects of interpersonal skills (0.05) and engagement (0.01) on current achievement were small compared to the effects of motivation (0.26) and study skills (0.27). All pathways in the model of reading achievement were statistically significant with the exception of the influence of engagement on current achievement.

The fit for the AEM for achievement in mathematics (Figure 2) was comparable to that for reading, χ^2 (9) = 16.50, $p = .06$, CFI = 0.99, AGFI = 0.90, $\Delta_1 = 0.98$, and RMSEA = 0.08, though this model predicted slightly more variance in student achievement (34%) than the model for reading. The pattern of standardized effects (Table 2) was highly similar to that of the model for reading, with ADHD responsible for the largest effect on current achievement (−0.47) followed by prior achievement (0.36), motivation (0.35), and study skills (0.27). As in the model for reading, engagement and interpersonal skills had small effects on current achievement (both standard total effects = 0.06). Likewise, the pathway leading from engagement to current achievement was small and not statistically significant.

Table 2
Direct, Indirect, and Total Effects of Variables Included in the Models of Reading and Mathematics Achievement

	Standardized Effect		
Variable	Direct	Indirect	Total
Reading			
ADHD symptoms	—	−0.43	−0.43
Prior reading achievement	0.34	0.05	0.39
Interpersonal skills	—	0.05	0.05
Motivation	—	0.26	0.26
Study skills	0.27	—	0.27
Engagement	0.01	—	0.01
Mathematics			
ADHD symptoms	—	−0.47	−0.47
Prior reading achievement	0.31	0.05	0.36
Interpersonal skills	—	0.07	0.07
Motivation	—	0.35	0.35
Study skills	0.27	—	0.27
Engagement	0.12	—	0.12

Discussion

We first examined a basic mediation model to test whether a composite of AEs would mediate the relationship between ADHD and current achievement in reading and mathematics. Although the test of mediation was inconclusive, it was clear that CD demonstrated significant covariation with ADHD and prior achievement in reading and mathematics, but no direct association with current achievement in either subject area. This is consistent with the findings of Rapport et al. (1999) and others that have found differential developmental outcomes for ADHD and CD.

An expanded model of AEs fit the data well for achievement in both reading and

mathematics. In this model, the relationship between ADHD and academic achievement was mediated through the effects of ADHD on prior achievement and the effects of ADHD on AEs. Specifically, ADHD appeared to influence study skills and motivation. Motivation was also associated with prior achievement and interpersonal skills, while demonstrating an indirect but noteworthy association with current academic achievement. Motivation demonstrated an association with both engagement and study skills. However, an unexpected finding was that study skills but not engagement was significantly associated with current achievement. DiPerna et al. (2002) found engagement to be comparable to study skills in its influence on achievement for students at the intermediate level (Grades 3–6), and found engagement to be the superior of the two variables at the primary level (Grades K–2). One explanation for this finding, given the large number of students with ADHD in the current sample, is that the majority of students had relatively low levels of engagement. This would have the effect of diminishing the predictive power of this variable.

Although the model fit well across skill areas, the fit was somewhat better for achievement in reading. Prior studies have identified important differences across these academic skill areas (cf. DuPaul et al., 2004); however, the structure of the AEM model was equivalent across subject areas in the current study, lending support for the cross-subject validity of the AEM.

Interpretation of Findings Relative to Previous Research

The current study extended prior research investigating the relationship between ADHD and academic achievement (e.g., Fergusson & Horwood, 1995; Rapport et al. 1999) in several important ways. First, by examining closely student attitudes and behaviors that influence achievement, the current study identified several AEs as appropriate targets for interventions designed to enhance the academic achievement of students with ADHD. In addition, whereas prior modeling studies have viewed academic achievement as a single outcome, the current study examined models for achievement in both mathematics and reading achievement separately. Furthermore, the measures of academic achievement in the current study were composite scores from a well-validated, individually administered test of scholastic achievement (WJ-III) as opposed to the group-administered tests (e.g., Rapport et al., 1999) or teacher judgment measures (e.g., DiPerna et al. 2002) used in previous modeling studies. Finally, although prior modeling studies have utilized samples of typically developing children, the majority of participants in the current study were identified as having ADHD (70%). Thus, our findings may have more direct relevance for clinically referred samples of children exhibiting symptomatic behaviors of ADHD.

The percentage of variance in current achievement accounted for in our AEM was relatively small (30% for reading, 34% for mathematics) in comparison to Rapport et al.'s (1999) model (77%), which closely examined children's cognitive abilities. However, it should be noted that the influence of student classroom behavior (behavioral pathway) in the Rapport et al. study was relatively small compared to the influence of cognitive mediators (vigilance, memory). Nevertheless, the behavioral mediators should be of interest to school psychologists, as they may be more amenable to intervention. Another factor limiting the amount of variance accounted for could be the large number of students with ADHD in the current study, which restricted the range of scores across measures compared to studies examining normative samples.

In addition to extending the modeling literature regarding ADHD and academic achievement, the current study also advances the literature regarding the relationships between AEs and academic achievement. One of the primary limitations of the modeling work of DiPerna et al. (2002, 2005) is that these studies have used teacher judgments to assess all constructs, including student achievement. The current study addressed this limitation through the use of an individualized, norm-referenced test to measure prior and current

achievement. In addition, prior research regarding models of academic enablers and achievement have featured samples from the general student population rather than students at risk or with identified disabilities. As such, the current study provides insight regarding the utility of these models with the student populations who may benefit most from the identification of influential pathways between AEs and academic achievement.

Limitations

There are several limitations that should be considered before drawing conclusions from this study. First, compared to prior modeling studies that collected outcome (i.e., achievement) data years after the measurement of predictors, with the exception of our measure of prior achievement, our data are cross-sectional. In addition, the lack of cognitive measures (as in Rapport's model) in this study fails to consider cognitive aspects of ADHD that could share much of the variance accounted for in the current study. Although a mixed sample of typically developing children and those with ADHD was required to have sufficient variability across ADHD symptomatology, this may serve to limit the generalizability of these findings to more homogeneous samples. An alternative sampling procedure that could maximize generalizability for children with ADHD would be to employ less stringent inclusion criteria, thus increasing variability of ADHD symptoms without including children with no significant problems in this regard. Finally, our study also demonstrates a weakness common to the literature examining models seeking to explain the relationship between ADHD and academic achievement. Specifically, these models focus exclusively on child factors and may omit important ecological variables (cf. Christenson & Anderson, 2002; Walberg, 1981).

Although the aforementioned limitations must be considered before drawing firm conclusions, there are several potential implications based on the results of the current study. When helping students experiencing academic difficulty, educational professionals must prioritize which skills and/or behaviors to target for assessment and intervention services. The results of this study suggest that the four AEs included in the model (i.e., motivation, engagement, study skills, and interpersonal skills) are domains worth considering when developing assessment protocols for students experiencing academic difficulty. The findings also suggest that, in addition to targeting the symptoms of ADHD and academic skills directly, those who wish to assist children with ADHD in reaching their full academic potential may be well served to consider designing interventions that also affect several AEs, especially motivation and study skills.

In addition to implications for assessment and intervention, a model of academic enablers can be considered as a framework for conceptualizing target skills for prevention-oriented services. If AEs contribute in meaningful ways to academic achievement, then educators need to consider what is being done to *promote* the development of AEs for all students—particularly those students with identified disabilities. Academic skills should continue to be the primary focus of instruction in schools; however, in light of growing empirical support indicating that AEs meaningfully contribute to academic achievement, there may be additional skills and behaviors that should be taught explicitly to maximize students' opportunity to learn in formal educational settings.

Footnotes

[1]Mahalanobis distance is a common method of identifying multivariate outliers where the distance of each case from the centroid (a point where the means of all variables converge) can be examined using a χ^2 distribution.

References

Abikoff, H. B., Jensen, P. S., Arnold, L. E., Hoza, B., Hechtman, L., Pollack, S., et al. (2002). Observed classroom behavior of children with ADHD: Relationship to gender and comorbidity. *Journal of Abnormal Child Psychology, 30*, 349–360.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed.—text revision). Washington, DC: Author.

Arbuckle, J. L. (1999). *Amos User's Guide Version 4.0.* Chicago: Small Waters Corporation.

Barkley, R. A. (1998). *Attention deficit hyperactivity disorder: A handbook for diagnosis and treatment* (2nd ed.). New York: Guilford.

Barkley, R. A. DuPaul, G. J., & McMurray, M. B. (1990). A comprehensive evaluation of attention deficit disorder with and without hyperactivity. *Journal of Consulting and Clinical Psychology*, *58*, 775–789.

Bennett, N. (1978). Recent research on teaching: A dream, a belief and a model. *Journal of Education*, *160*, 5–38.

Bollen, K. A. (1989). *Structural equations with latent variables.* New York: Wiley.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J.S. Long (Eds.), *Testing structural equation models* (pp. 136–162). Newbury Park, CA: Sage.

Cantwell, D. P., & Baker, L. (1991). Association between attention-deficit hyperactivity disorder and learning disorders. *Journal of Learning Disabilities*, *24*, 88–95.

Carroll, J. B. (1963). A model of school learning. *Teachers College Record*, *64* 723–733.

Christenson, S. L., & Anderson, A. R. (2002). Comentary: The centrality of the learning context for students' academic enabler skills. *School Psychology Review*, *31*, 378–393.

DiPerna, J. C., & Elliott, S. N. (1999). The development and validation of the academic competence evaluation scales. *Journal of Psychoeducational Assessment*, *17*, 207–225.

DiPerna, J. C. & Elliott, S. N. (2000). *Academic Competence Evaluation Scales.* San Antonio, TX: The Psychological Corporation.

DiPerna, J. C., Volpe, R. J., & Elliott, S. N. (2001). A model of academic enablers and elementary reading/language arts achievement. *School Psychology Review*, *31*, 298–312.

DiPerna, J. C., Volpe, R., & Elliott, S. N. (2002). A model of academic enablers and elementary reading/language arts achievement. *School Psychology Review*, *31*, 298–312.

DiPerna, J. C., Volpe, R. J., & Elliott, S. N. (2005). An examination of academic enablers and achievement in mathematics. *Journal of School Psychology*, *43*, 379–392.

DuPaul, G. J., Power, T. J., Anastopoulos, A. D., & Reid, R. (1998). *ADHD Rating Scale—IV.* New York: Guilford Press.

DuPaul, G. J., Power, T. J., McGoey, K., Ikeda, M., & Anastopulos, A. D. (1998). Reliability and validity of parent and teacher ratings of attention-deficit/hyperactivity disorder symptoms. *Journal of Psychoeducational Assessment, 16*, 55–68.

DuPaul, G. J., & Stoner, G. (2003). *ADHD in the schools: Assessment and intervention strategies* (2nd ed.). New York: Guilford.

DuPaul, G. J., Volpe, R. J., Jitendra, A. K., Lutz, J. G., Lorah, K. S., & Gruber, R. (2004). Elementary school students with AD/HD: Predictors of academic achievement. *Journal of School Psychology, 42*, 285–301.

Farrington, D. P., Loeber, R., & Van Kammen, W. B. (1990). Long-term criminal outcomes of hyperactivity, impulsivity, attention deficit and conduct problems in childhood. In L. N. Robins & M. Rutter (Eds.), *Straight and devious pathways from childhood to adulthood* (pp. 62–81). Cambridge: Cambridge University Press.

Fergusson, D. M., & Horwood, L. J. (1995). Early disruptive behavior, IQ, and later school achievement and delinquent behavior. *Journal of Abnormal Child Psychology*, *23*, 183–199.

Fergusson, D. M., Horwood, L. J., & Lynskey, M. T. (1993). The effects of conduct disorder and attention deficit in middle childhood on offending and scholastic ability at age 13. *Journal of Child Psychology and Psychiatry, 34*, 899–916.

Fergusson, D. M., Lynskey, M. T., & Horwood, L. J. (1997). Attentional difficulties in middle childhood and psychosocial outcomes in young adulthood. *Journal of Child Psychology and Psychiatry*, *38*, 633–644.

Frick, P. J., Kamphaus, R. W., Lahey, B. B., Loeber, R., Christ, M. A. G., Hart, E. L., & Tannenbaum, L. E. (1991). Academic underachievement and the disruptive behavior disorders. *Journal of Consulting and Clinical Psychology, 59*, 289–294.

Glaser, R. (1976). Components of a psychology of instruction: Toward a science of design. *Review of Educational Research*, *46*, 1–24.

Hoyle, R. H., & Smith, G. T. (1994). Formulating clinical research hypotheses as structural equation models: A conceptual overview. *Journal of Consulting and Clinical Psychology, 62*, 429–440.

Kline, R. B. (2005). *Principles and practice of structural equation modeling* (2nd ed.). New York: The Guilford Press.

Knivsberg, A., Reichelt, K. L., & Nodland, M. (1999). Comorbidity, or coexistence, between dyslexia and attention deficit hyperactivity disorder. *British Journal of Special Education*, *26*, 42–47.

Malecki, C. K., & Elliott, S. N. (2002). Children's social behaviors as predictors of academic achievement: A longitudinal analysis. *School Psychology Quarterly*, *17*, 1–23.

Mannuzza, S., Gittelman-Klein, R., Bessler, A., Malloy, P., & LaPadula, M. (1993). Adult outcome of hyperactive boys: Educational achievement, occupational rank, and psychiatric status. *Archives of General Psychiatry*, *50*, 565–576.

Mather, N., & Woodcock, R. W. (2001). *Examiners manual: Woodcock-Johnson III Tests of Achievement.* Itasca, IL: Riverside Publishing.

Pelham, W. E., & Bender, M. E. (1982). Peer relationships in hyperactive children: Description and treatment. In K. Gadow & I. Bailer (Eds.), *Advances in learning and behavioral disabilities* (Vol. 1, pp. 365–436). Greenwich, CT: JAI Press.

Rapport, M. D., Scanlan, S. W., & Denney, C. B. (1999). Attention-deficit/hyperactivity disorder and scholastic achievement: A model of dual developmental pathways. *Journal of Child Psychology and Psychiatry, 40*, 1169–1183.

Reynolds, C. R., & Kamphaus, R. W. (1992). *Behavior Assessment System for Children.* Circle Pines, MN: American Guidance Service.

Schwab-Stone, M. E., Shaffer, D., Dulcan, M. K., Jensen, P. S., Fisher, P., Bird, H. R., Goodman, S. H., Lahey, B. B., Lichtman, J. H., Canino, G., Rubio-Stipec, M., & Rae, D. S. (1996). Criterion validity of the NIMH Diagnostic Interview Schedule for Children Version 2.3 (DISC-2.3). *Journal of the American Academy of Child and Adolescent Psychiatry, 35*, 878–888.

Semrud-Clikeman, M., Biederman, J., Sprich-Buckminster, S., Lehman, B. K., Faraone, S. V., & Norman, D.

(1992). Comorbidity between ADDH and learning disability: A review and report in a clinically referred sample. *Journal of the American Academy of Child and Adolescent Psychiatry*, *31*, 439–448.

Shaffer, D., Fisher, P., & Lucas, C. (1998). *Computerized Diagnostic Interview Schedule for Children (CDISC 4.0).* New York: New York State Psychiatric Institute.

Shaffer, D., Fisher, P., Dulcan, M. K., Davies, M., Piacentini, J., Schwab-Stone, M. E., Lahey, B. B., Bourdon, K., Jensen, P., Bird, H. R., Canini, G., & Regier, D. A. (1996). The NIMH Diagnostic Interview Schedule for Children Version 2.3 (DISC-2.3): Description, acceptability, prevalence rates, and performance in the MECA study. *Journal of the American Academy of Child and Adolescent Psychiatry, 35*, 865–877.

Walberg, H. J. (1981). A psychological theory of educational productivity. In F. H. Farley & N. Gordon (Eds.), *Psychology and education* (pp. 81–110). Chicago: National Society for the Study of Education.

Wentzel, K. R. (1993). Does being good make the grade? Social behavior and academic competence in middle school. *Journal of Educational Psychology*, *85*, 357–364.

Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). *Woodcock-Johnson III tests of achievement*. Itasca, IL: Riverside Publishing.

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