Published in final edited form as:

J Clin Child Adolesc Psychol. 2011 ; 40(4): 519–531. doi:10.1080/15374416.2011.581620.

Patterns and Predictors of Adolescent Academic Achievement and Performance in a Sample of Children with Attention-Deficit/Hyperactivity Disorder (ADHD)

Joshua M. Langberg,

Department of Pediatrics University of Cincinnati College of Medicine, Cincinnati Children's Hospital Medical Center

Brooke S.G. Molina,

Departments of Psychiatry & Psychology, University of Pittsburgh

L. Eugene Arnold,

Department of Psychiatry, Ohio State University

Jeffery N. Epstein,

Department of Pediatrics University of Cincinnati College of Medicine, Cincinnati Children's Hospital Medical Center

Mekibib Altaye,

Department of Pediatrics University of Cincinnati College of Medicine, Cincinnati Children's Hospital Medical Center

Stephen P. Hinshaw,

Department of Psychology, University of California, Berkeley

James M. Swanson,

Department of Pediatrics, University of California, Irvine

Timothy Wigal, and

Department of Pediatrics, University of California, Irvine

Lily Hechtman

Departments of Psychiatry & Pediatrics, McGill University

Abstract

The Multimodal Treatment Study of Children with ADHD (MTA) was a National Institute of Mental health (NIMH) cooperative agreement randomized clinical trial involving six clinical sites. Collaborators from the National Institute of Mental Health: Peter S. Jensen, M.D. (currently at Columbia University), L. Eugene Arnold, M.D., M.Ed. (currently at Ohio State University), Joanne B. Severe, M.S. (Clinical Trials Operations and Biostatistics Unit, Division of Services and Intervention Research), Benedetto Vitiello, M.D. (Child & Adolescent Treatment and Preventive Interventions Research Branch), Kimberly Hoagwood, Ph.D. (currently at Columbia); previous contributors from NIMH to the early phase: John Richters, Ph.D. (currently at National Institute of Nursing Research); Donald Vereen, M.D. (currently at National Institute on Drug Abuse). Principal investigators and co-investigators from the clinical sites are: University of California, Berkeley/San Francisco: Stephen P. Hinshaw, Ph.D. (Berkeley), Glen R. Elliott, Ph.D., M.D. (San Francisco); Duke University: C. Keith Conners, Ph.D., Karen C. Wells, Ph.D., John March, M.D., M.P.H., Jeffery Epstein, Ph.D.; University of California, Irvine/Los Angeles: James Swanson, Ph.D. (Irvine), Dennis P. Cantwell, M.D., (deceased, Los Angeles), Timothy Wigal, Ph.D. (Irvine); Long Island Jewish Medical Center/Montreal Children's Hospital: Howard B. Abikoff, Ph.D. (currently at New York University School of Medicine), Lily Hechtman, M.D. (McGill University); New York State Psychiatric Institute/Columbia University/Mount Sinai Medical Center: Laurence L. Greenhill, M.D. (Columbia), Jeffrey H. Newcorn, M.D. (Mount Sinai School of Medicine); University of Pittsburgh: William E. Pelham, Ph.D. (currently at State University of New York, Buffalo), Betsy Hoza, Ph.D. (currently at University of Vermont), Brooke Molina, Ph.D. Original statistical and trial design consultant: Helena C. Kraemer, Ph.D. (Stanford University). Follow-up phase statistical collaborators: Robert D. Gibbons, Ph.D. (University of Illinois, Chicago), Sue Marcus, Ph.D. (Mt. Sinai College of Medicine), Kwan Hur, Ph.D. (University of Illinois, Chicago). Collaborator from the Office of Special Education Programs/US Department of Education: Thomas Hanley, Ed.D. Collaborator from Office of Juvenile Justice and Delinquency Prevention/Department of Justice: Karen Stern, Ph.D.

Examined predictors of academic achievement, measured by standardized test scores, and performance, measured by school grades, in adolescents (*Mean*=16.8 yr) who met diagnostic criteria for ADHD-Combined type in early childhood (*Mean* = 8.5; *N* = 579). Several mediation models were also tested to determine whether ADHD medication use, receipt of special education, classroom performance, homework completion, or homework management mediated the relationship between symptoms of ADHD and academic outcomes. Childhood predictors of adolescent achievement differed from those for performance. Classroom performance and homework management mediated the relationship between symptoms of inattention and academic outcomes. Implications for understanding the relationship between symptoms of ADHD and academic functioning are discussed.

Keywords

ADHD; Academic; Predictors; Adolescence; Grades; Achievement

Attention-Deficit/Hyperactivity Disorder (ADHD) is characterized by developmentally inappropriate symptoms of inattention, hyperactivity and impulsivity and significant impairment in multiple domains of functioning (American Psychiatric Association [APA], 2000). Impairment in the school domain is one of the most prominent difficulties faced by children and adolescents with ADHD (DuPaul & Stoner, 2003). Compared to their peers, children with ADHD earn significantly lower school grades (Frazier et al. 2007), score significantly lower on standardized achievement tests (Frazier et al. 2007) and experience higher rates of special education placements, grade retention and school dropout (Barkley, 2006; Molina et al., 2009). Given the negative long-term implications of chronic academic underachievement and underperformance on occupational functioning and financial stability, these trends are of major concern (Barkley, Murphy, & Fischer, 2008; Biederman et al., 2006).

Although it is clear that children diagnosed with ADHD commonly experience academic underachievement that persists into adolescence (Fischer, Barkley, Edelbrock, & Smallish, 1990; Massetti et al. 2008), less is known about factors that predict these negative academic outcomes. Longitudinal prediction studies are important given the observed variability in the academic outcomes of children diagnosed with ADHD. For example, the prevalence of ADHD in college settings is estimated to be between 2 and 8%, which is not that different from the prevalence in elementary school (DuPaul, Weyandt, O'Dell, and Varejao, 2009), demonstrating that many adolescents with ADHD perform well enough in secondary school to gain admission to college. It is essential to ascertain the specific, potentially malleable, childhood characteristics that are linked to persistent academic underachievement, as their identification could serve to direct early intervention efforts.

Predictors of academic underachievement have been examined in general population samples and in samples of children diagnosed with ADHD. In general population samples, attention problems during childhood have consistently been shown to predict lower academic achievement during adolescence as measured by standardized tests (Fergusson & Horwood, 1995; Fergusson, Lynskey & Horwood, 1993; Fergusson, Lynskey & Horwood, 1997) and functional outcomes, such as grade retention and school dropout (Galera, Melchior, Chastang, Bouvard, & Fombonne, 2009). The series of studies by Fergusson and colleagues demonstrated that the academic underachievement of children with ADHD is uniquely explained by attention problems. Specifically, while comorbidities such as conduct problems may contribute to academic underachievement (Galera et al., 2009), it is clear that there is an independent negative relationship between attention problems in childhood and academic outcomes in adolescence (Fergusson, Lynskey & Horwood, 1997). The evidence

collected to date also supports the assertion that academic underachievement is more strongly related to symptoms of inattention than to symptoms of hyperactivity/impulsivity (Fergusson & Horwood, 1995).

Rapport, Scanlan, and Denney (1999) expanded on the work by Fergusson and colleagues by testing the hypothesis that a Dual Pathway Model exists, whereby classroom performance mediates the relationship between attention problems and academic achievement. In a general population cross-sectional sample, Rapport et al. (1999) found that teacher-rated classroom performance significantly mediated the relationship between attention problems and academic achievement to the point where the direct relationship was rendered nonsignificant. The overall model, including attention problems, select cognitive abilities and classroom performance, accounted for 77% of the variance in achievement on standardized tests. DuPaul et al. (2004) later supported this finding by demonstrating in a general population cross-sectional sample, that teacher-rated classroom performance was more closely related to academic achievement than symptoms of ADHD.

Only a few studies have longitudinally examined predictors of academic outcome in samples of children diagnosed with ADHD. Longitudinal studies with diagnosed samples are important to support the predictive validity of an ADHD diagnosis. Further, diagnosed samples are often more severe than general population samples and different predictor variables may be important. In the most comprehensive longitudinal study of academic outcomes completed to date, Massetti et al. (2008) reported on a cohort of children diagnosed with ADHD at 4–6 years of age and assessed seven times over an 8 year period. A diagnosis of ADHD in childhood predicted lower reading, spelling and math standardized achievement test scores in adolescence after controlling for intelligence. Interestingly, children diagnosed with ADHD – Inattentive Type in childhood had lower scores in adolescence than children diagnosed with ADHD - Combined Type and comparison children. To date, the role of the predictor variables shown to be important in general population samples (e.g. classroom performance) has not been examined in samples of children diagnosed with ADHD. Further, tests of mediational relationships, such as the model presented by Rapport et al. (1999), have not been completed in longitudinal samples of any kind.

Across all of the studies reviewed above, academic outcome was most often defined as performance on standardized achievement tests. Standardized test results provide a limited definition of academic outcome, which may or may not reflect overall academic performance in school (Loe & Feldman, 2007). The educational psychology literature emphasizes that school grades and achievement scores are separate indices of academic outcome and should not be used interchangeably. Grades are strong predictors of school dropout (Keith & Benson, 1992), are often weighted more heavily than standardized test scores in the college admission process, and are highly correlated with college freshman grade point average (Zwick & Sklar, 2005). Further, malleable factors such as the child's motivation and behavior are more strongly related to grades than they are to achievement scores (Barrington & Hendricks, 1989). Finally, school grades warrant study because of their ecological validity. Grades are the most frequently used metric of learning and are viewed by parents as the primary indicator of academic success (Wentzel, 1989).

The primary goals of this study are to: 1) Examine predictors of two different types of academic outcomes (i.e. standardized test performance and grades in school); 2) Expand our understanding of variables that predict academic outcome by examining a wide range of predictor variables, including academic and service use variables; and 3) Determine if the relationship between symptoms of ADHD in childhood and academic outcome in adolescence is mediated by academic and/or service use variables.

We examined three academic predictor variables. Given the findings from the Rapport et al. (1999) and DuPaul et al. (2004) studies, we examined the predictive power of teacher-rated classroom performance. We also included parent-ratings of homework completion and homework management as academic predictors because time spent on homework and the amount of homework completed are positively correlated with class grades and achievement test scores (Cooper, Lindsay, Nye, & Greathouse, 1998; Cooper, Robinson, & Patall, 2006). For service use, we examined two commonly received services for children with ADHD: 1) psychotropic medications prescribed for ADHD; and 2) special education services. Consistent with previous research (Rapport et al., 1999), we hypothesized that teacher-rated classroom performance would mediate the relationship between symptoms of ADHD in childhood and academic outcomes in adolescence. Given that previous studies have demonstrated that homework problems are related to achievement scores and grades (Cooper et al., 2006), we predicted that the homework variables would also mediate the relationship between symptoms of ADHD and academic outcomes in adolescence.

Methods

Participants

Participants were from the multisite Multimodal Treatment Study of Children with ADHD (MTA; MTA Cooperative Group, 1999). At study entry children ($N = 579$) were 7–9.9 years of age (grades 1–4) and met the DSM-IV criteria for a diagnosis of ADHD-Combined Type. The presence of symptoms and impairment was determined using the Diagnostic Interview Schedule for Children, Parent Report (DISC-P 4.0; (Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000), supplemented with up to two symptoms from the teacher SNAP-IV (Swanson, 1992) for cases falling just below the DISC diagnostic symptom count threshold. The DISC-P identified co-occurring comorbid diagnoses of oppositional defiant disorder (42%), conduct disorder (14%), anxiety disorders (46%), and affective disorders (5%) in the MTA sample at baseline. Sixty-two percent of the sample was Caucasian, 23% was African-American, 6% was Latino and 9% was mixed decent or other ethnicity. Eighty percent were male and 20% were female. Once a diagnosis was confirmed, children were randomly assigned to receive 1 of 4 treatments: systematic medication management (MedMgt), intensive behavioral treatment (Beh), the combination of the two (Comb), or routine community care comparison (CC). The active treatment portion of the MTA study was 14 months in length. Thereafter, patients were provided with treatment recommendations to pursue in the community.

Children were assessed at baseline in follow-up at 14, 24, 36 months, and 6 years and 8 years post-baseline using a comprehensive assessment battery. Beginning at 14 months, participation rates for the variables analyzed here were 97%, 93%, 84%, 78%, and 75%, respectively. Participants lost to the 8-year follow-up were more likely to be male, have less educated parents and have lower parental income as compared to those retained (see Molina et al., 2009 for further detail). The timepoints of interest in this study for the criterion variables (achievement scores and school grades) are the 6- and 8-year assessments. Mean ages at the 6- and 8-year assessments were 14.9 and 16.8 years, respectively (see Molina et al., 2009 for further detail related to sample demographics at the 8-year assessment).

Children and their parents provided informed assent and consent to participate using each site's IRB-approved procedures and documents. These included consent for the collection of rating scales and school records reported in this study. A more complete description of the design, assessment battery, interventions, and follow-up procedures and assessment battery is described elsewhere (Arnold, 1997; Hinshaw et al., 1997; Molina et al., 2009).

Criterion Measures

Standardized Achievement Scores—All participants in the MTA were administered the Wechsler Individual Achievement Test (WIAT; Wechsler, 1992) Screener (Reading, Math, and Spelling subtests) at baseline and all subsequent assessments. The WIAT is a widely used individually administered, norm-referenced, test with exemplary psychometric properties. Split-halves reliability of the composite scales range from .88 to .98; test-retest reliability of composite scores is also very strong (Corrected $r = .91$ to .98). WIAT scores from the 6- and 8-year assessments were examined as criterion variables. WIAT Reading, Math and Spelling subtest scores were examined separately in all models. The Wide Range Achievement Test – 3rd Edition (WRAT-3) was administered to participants 18 years of age and older. The WRAT also generates reading, math and spelling subtest scores and has excellent psychometric properties (e.g., split-half reliability ranges from .94–.98).

Grades—School grades were collected at all of the MTA sites. Sixteen trained research staff coded the grades. Before coding actual MTA participant report cards, all coders had to complete ten example report cards which were then evaluated for accuracy at a central site. School grades were coded on a scale where (4 = A, 3 = B, 2 = C, 1 = D, 0 = F). Inter-rater agreement was calculated for ten report cards chosen at random from each MTA site. Grades were coded with greater than 90% inter-rater agreement across all MTA sites. Report cards were consistently collected on the MTA sample beginning with the 6-year assessment point. Grades were examined separately by subject area (Math, English, History and Science) and overall (overall Grade Point Average (GPA) = average of Math, English, History and Science grades). Grades analyzed were those collected at the point in time closest to the MTA follow-up assessments. For example, if the 8-year follow-up assessment took place in the spring, then spring semester school grades were used.

Predictor Measures

Symptoms of ADHD and ODD—ADHD and ODD symptoms at study baseline were measured using the SNAP-IV Rating Scale (Swanson, 1992). The SNAP includes the 18 ADHD items (9 DSM inattention and 9 DSM hyperactive/impulsive symptoms) and 8 ODD items from the DSM-IV. Parents and teachers respond on a 4-point Likert scale rating the severity of symptoms (i.e., 0 = not at all, 1 = just a little, 2 = pretty much, and 3 = very much). The scale yields ADHD-related factor scores for Inattention, Hyperactivity and Impulsivity and an ODD factor score. Each factor score is derived by summing the items for each symptom domain and dividing by the number of items on each factor (Inattention = 9 items; Hyperactivity/Impulsivity = 9 items). The ADHD items on the SNAP have excellent internal consistency in the MTA sample (Cronbach's $\alpha = .97$). Three SNAP scores were used as predictor variables: 1) Average of baseline parent- and teacher-rated SNAP Inattention factor score; 2) Average of baseline parent- and teacher-rated SNAP Hyperactivity/Impulsivity factor score; 3) Average of baseline parent- and teacher-rated SNAP ODD factor score.

Classroom Performance—The Social Skills Rating Scale (SSRS; K-6 version; Gresham & Elliott, 1989) was completed by all participants' teachers at baseline. The SSRS includes an Academic Competence subscale (9 items); five of these items assess teacher perception of classroom performance (as opposed to motivation, parental encouragement, and intellect). Items include perceived overall academic performance, reading and math performance relative to other students, and relative to grade-level expectations. Teachers rate performance from 1 to 5 where 1 = lowest 10% of class and 5 = highest 10% of class. Example items are, "In reading, how does this child compare with other students" and "In terms of grade level expectations, this child's skills in reading are." Analyses completed as part of the MTA 8 year paper found that the five-item subscale had excellent reliability

(Cronbach's $\alpha = .91$). This 5-item classroom performance subscale total score (i.e. sum of five items) collected at the MTA baseline was used as a predictor variable.

Homework Completion/Materials Management—Homework performance was assessed at baseline in the MTA study using the parent-completed Homework Problems Checklist (HPC; Anesko, Schoiack, Ramirez, & Levine, 1987). The HPC is a 20 item parent-report instrument. For each of 20 items, 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. 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). Factor analyses indicate that the HPC has two distinct factors (Langberg, Arnold, Flowers, Altaye, et al., 2010; Power, Werba, Watkins, Angelucci, & Eiraldi, 2006) measuring homework completion behaviors (HPC Factor I) and materials management behaviors (HPC Factor II). Example items from the Homework Completion factor include: 1) Must be reminded to sit down and start homework; and 2) Puts off doing homework, waits until last minute. Homework Materials Management items relate to organization of homework and homework materials (e.g. does not know what homework has been assigned, fails to bring home assignments, and forgets to bring assignments back to class). The Homework Completion and Homework Management factors collected at baseline were each used as predictor variables.

Special Education—The number of hours per week of special education was reported by parents on the Services Use in Children and Adolescents-Parent Interview (SCA-PI; Jensen et al., 1994). The SCAP is a structured interview that was administered every 6 months, either by phone or during the face-to-face assessments. Test-retest reliability using an 18-day between-test interval for reporting school service use on the SCAP is excellent, $\kappa = .94$ (Hoagwood et al., 2004). The special education predictor variable was the average hours per week special education services were received between the MTA baseline and the 8-year assessment.

ADHD Medication Use—Parents also reported children's ADHD medication use on the SCAP. The percent of days in the interval that any stimulant medication was taken between the last assessment and the assessment of interest was used as an indicator of ADHD medication usage. Test-retest reliability using an 18 day between test interval for reporting medication use on the SCAP is excellent, $\kappa = .97$ (Hoagwood et al., 2004). Similar to the school service use variable, the medication predictor variable was the average percentage of day's medication was used between MTA baseline and the 8-year assessment.

Additional Predictor Variables—Baseline demographic variables previously shown to be associated with academic achievement were included (see Table 1). These variables included parental education level, family income, child ethnicity, and child sex. Education level was coded on a 1–6 scale where 6 = 8th grade or less, 5 = some high school, 4 = high school graduate or GED, 3 = some college or post-high school, 2 = college graduate, and 1 = advanced graduate or professional degree. For the analyses, the highest level of education reported (i.e. mother or father) was used. Family income ranged from 1–9 where 1 = less than \$10,000 with systematically increasing increments to 9 = \$75,000 or more. Ethnicity was separated into two groups for the analyses, Caucasian and minority other. Full Scale IQ as assessed by the WISC-III (Wechsler, 1991) at the MTA baseline was also included as a baseline predictor within the demographic variable subset. Finally, MTA treatment group assignment (MedMgt, Beh, Comb, or CC) was included as a predictor variable even though previous research found no relationship between randomly assigned treatment group and outcome at 8 years (Molina et al., 2009).

Statistical Analyses

First, an average score was calculated for the outcome variables, averaging the 6- and 8-year assessments. Correlations were then calculated between the two outcome variables, achievement scores and grades. Next, correlations between each predictor and outcome variable were calculated. Predictors that were significantly correlated with outcomes at $p < 0.10$ were retained and entered simultaneously into the multivariate regression models. The liberal $p < 0.10$ cutoff was selected in order to ensure that potentially important predictor variables were not excluded from the model (Tabachnick & Fidell, 2001). This same criterion has been applied in other longitudinal studies of academic function in children diagnosed with ADHD (Masseti et al., 2008). Because we were interested in determining if predictors varied as a function of the subject area being evaluated (e.g. math versus reading), eight multivariate models were tested (i.e. four core subject areas for grades + overall GPA + three WIAT subject areas).

We chose this statistical strategy because we wanted to identify the most parsimonious set of variables that predict GPA and WIAT scores. The alternative is to start with a base model and to add variables to the base model to determine if additional variance is explained. However, this approach assumes that certain variables (e.g. ADHD symptoms) should be in the base model. There has been minimal research on predictors of school grades in children with ADHD and even less that has examined predictor variables other than ADHD symptoms or medication use. Accordingly, we treated all variables equally (i.e. rather than assuming a base model) and allowed the data (correlations) to determine which variables to include in the regression models. To assess for the potential presence of multicollinearity between the predictor variables, we calculated a variance inflation factor (VIF) for each model. The observed maximum VIF value was 2.04 indicating no problems with multicollinearity (VIF values of five or above indicate a multicollinearity problem; Kutner et al. 2004).

We used SAS PROC GENMOD to model the multivariate data using the generalized estimation equation approach (GEE) to account for the fact that the 6- and 8-year assessments were correlated. This allowed us to estimate and incorporate within subject variance in the estimate of parameters. Unlike regular regression with one observation per subject our data are correlated over time. The traditional R^2 could not be used to directly measure the amount of variation explained by the predictor variables because the resulting residuals are not independent. Zheng (2000) introduced an extension of the R^2 statistic for use with GEE models called marginal R^2 . Marginal R^2 was calculated for each model and can be interpreted as the portion of variance explained by the fitted model.

We followed the most widely used method to assess mediation, the casual steps approach described by Baron and Kenny (1986). This approach involves four steps to establish a mediation effect. First, a significant relationship between the independent and dependent variables is required. For our data, symptoms of inattention were consistently related to WIAT subtest scores and class grade subject areas but hyperactive/impulsive and ODD symptoms were not. Accordingly, we restricted our mediation analyses to the relationship between symptoms of inattention and achievement scores/grades. Second, a significant relationship between the independent variable and the hypothesized mediation variable is required. Third the mediating variable must be significantly related to the dependent variable. Fourth, the coefficient relating the independent variable to the dependent variable must be attenuated (in absolute value) when the mediating variable is entered into the equation. The difference in coefficients determines the value of the mediated or indirect effect. This difference is divided by the standard error and compared with the standard normal distribution to determine significance.

Results

Correlations Between Outcome Variables

MTA participants' Math, English, History, and Science grades were significantly correlated with their Reading, Math and Spelling WIAT subscale scores (all $p < .01$). The majority of the correlations were moderate (range = .15–.27).

Correlations Between Predictor Variables and Outcome Variables

Correlations between each of the predictor variables and the average of the 6- and 8-year academic outcomes are provided in Tables 2 and 3. Correlations that are italicized in bold in Tables 2 and 3 were trends that met the $p < .10$ cutoff and were included in the multivariate models. In summary, for the demographic set of variables, intelligence, parent education, family income, and child ethnicity met the $p < .10$ cutoff and were included in all multivariate analyses predicting grades and achievement scores with one exception (child ethnicity was not significant for math grades). For the set of predictor variables assessing ADHD and ODD symptoms, symptoms of inattention were significant and entered into all grades models and were significant and entered into all WIAT models except for WIAT Reading. Hyperactive/impulsive symptoms were only significant for English and Science grades and for overall GPA. ODD symptoms were only significant for Math WIAT, English grades, and overall GPA.

For the set of predictor variables measuring academics, the SSRS classroom performance variable and the HPC Materials Management factor were significant and included in all multivariate models. The HPC Homework Completion factor was only significant for Math and Spelling WIAT and for Math grades and overall GPA. For service use, average special education service use was significant and included for the WIAT models but was not significant for any grade models. The variable measuring average medication use between baseline and 8-year assessment was only significant and entered for WIAT Math and Spelling.

Multivariate Model Analyses

The complete results of the multivariate regression models are provided in Tables 4 and 5. The estimates presented in Tables 4 and 5 are unstandardized regression coefficients. The estimates represent the degree/magnitude of change in the dependent variable for every one point change in the predictor variable. Standardized regression coefficients, representing the relative importance of each of the predictor variables, are presented in the text below. The set of variables that best predicted grades was nearly identical across all subject areas and overall GPA. The HPC homework management factor, SSRS classroom performance variable, and parental education were significant in all final grades models with one exception (SSRS classroom variable was not significant for math grades; see Table 4). None of the ADHD or ODD symptom variables and none of the service use variables were significant in any of the multivariate grades models. Parameter estimates were in the expected direction (see Table 4), because higher scores on the classroom performance measure indicates better performance and higher scores on the homework materials management measure signifies more problems. For the parental education variable, higher levels of parental education were associated with higher school grades. Finally, child sex was significant in the final model predicting science grades. The coefficient was negative, indicating that male sex was associated with higher science grades.

The WIAT model results were also consistent across subject areas. Intelligence, family income, classroom performance, and special education services were significant in all models (see Table 5). Symptoms of inattention were significant in the models predicting

Math and Spelling achievement scores. All parameter estimates were again in the expected direction. Namely, higher classroom performance scores, intelligence and family income were associated with higher WIAT scores. Higher symptoms of inattention were associated with lower Math and Spelling achievement scores. The average receipt of special education services variable was negatively associated with WIAT scores in all models.

We calculated Standardized beta coefficients to examine the relative importance of each of the significant variables in the multivariate models. For the grades models, the three most important variables were consistently the HPC Materials Management, SSRS classroom performance, and parental education. Standardized beta coefficients ranged from $-.13$ to $-.21$ for the HPC Materials Management factor, from $.14$ to $.20$ for the SSRS classroom performance variable, and from $.12$ to $.20$ for parental education. Marginal R^2 values for the grades models ranged from $.22$ to $.37$ with the best prediction ($.37$) occurring for overall GPA. For the WIAT models, the three most important variables were consistently the SSRS classroom performance variable, intelligence, and the special education average variable. Standardized beta coefficients ranged from $.21$ to $.44$ for the SSRS academic competence subscale variable, from $.13$ to $.39$ for intelligence, and from $-.14$ to $-.23$ for special education service use. Marginal R^2 values for the overall WIAT models ranged from $.52$ to $.63$ with the best prediction ($.63$) occurring for Spelling test scores.

Mediation Analyses

Mediation of Pathway to Academic Achievement—The results of the mediation analyses are presented in Table 6. Conditions for mediation were established for the classroom performance variable mediating the relationship between symptoms of inattention and WIAT math and spelling. Specifically, there was a significant relationship between symptoms of inattention and WIAT math ($\beta = -3.70$) and WIAT spelling ($\beta = -2.91$) but not WIAT reading at the $p < .05$ level. There was also a strong and significant relationship between teacher-rated classroom performance and WIAT math ($\beta = 10.45$; $p < .0001$) and spelling ($\beta = 10.78$; $p < .0001$) and between teacher-rated classroom performance and ADHD symptoms of inattention ($\beta = -.55$; $p < .0001$). The homework materials management variable was also a significant mediator for the relationship between symptoms of inattention and WIAT math (see Table 6). Conditions for mediation were established as the relation between homework materials management and WIAT math was significant and negative ($\beta = -.35$; $p < .05$) and the relation between homework materials management and symptoms of inattention was significant and positive ($\beta = 5.02$; $p < .0001$). Mediation effects were not established for the homework completion variable or for any of the service use variables (i.e. special education and medication use).

To aid in interpretation of the data presented in Table 6, we provide an explanation of the WIAT math mediation results. The estimate of -5.75 for the mediation effect of inattention symptoms on WIAT math through classroom performance, means that for every 1 unit increase in symptoms of inattention mediated through classroom performance, there is a 5.75 decrease in WIAT math scores.

Mediation of Pathway to Performance Outcomes (Grades)—The classroom performance and homework materials management variables mediated the relationship between symptoms of inattention and math grades, history grades, and overall GPA (see Table 6). Conditions for mediation were established as there was a significant relationship between symptoms of inattention and grades (overall GPA; $\beta = -.19$; $p < .05$). There was also a significant relationship between symptoms of inattention and classroom performance ($\beta = -.54$; $p < .0001$) and homework management ($\beta = 4.85$; $p < .0001$). There was also a significant relationship between classroom performance ($\beta = .31$; $p < .0001$) and the

homework management ($\beta = -.05$; $p < .0001$) and grades. Conditions for mediation were not established for classroom performance or homework management variables for English and science grades. Conditions for mediation were not also established for any of the service use variables or for the homework completion variable.

Discussion

This study provides new information about childhood predictors of academic function in adolescence. To date, studies of academic function in samples of children with attention problems and with ADHD have focused on a narrow range of predictor variables, primarily examining the impact of symptoms of inattention and hyperactivity/impulsivity. Further, almost all previous work has focused on a single criterion measure of academic function, standardized achievement test scores. By examining a broad range of predictors and multiple indices of academic function, this study demonstrates for adolescents with childhood ADHD, standardized achievement test scores and school grades are only moderately related indices, each with different sets of predictor variables. Further, as first suggested by Rapport et al. (1999), the relationship between symptoms of ADHD and academic outcomes is best described as an indirect relationship, mediated by classroom performance and homework materials management.

Correlation analyses between grades and achievement scores suggest that these two indices of academic function are related but largely separate for adolescents diagnosed with ADHD during childhood. Specifically, while correlations between standardized achievement test scores and grades were significant, they were low to moderate in magnitude. This finding supports previous research suggesting that different capacities and skill-sets are required to perform well in school (i.e. grades) and on achievement tests (Wentzel, 1989). This disjunction is a practically important finding because treatment studies, in their desire to standardize measures of academic function, frequently rely on standardized achievement tests such as the WIAT as a measure of treatment success in the academic domain (e.g. MTA Cooperative Group, 1999). However, our findings suggest the possibility that in adolescence, if improvement in school performance is desired, grades earned (or their proximal contributors, such as homework management) will need to be directly targeted and measured.

Consistent with DuPaul et al. (2004) and Rapport et al. (1999), we found that for children with ADHD, there are a number of important factors that contribute to academic achievement and performance. Specifically, a model containing parent-rated homework materials management, teacher-rated classroom performance, and parental education level best predicted school grades. In contrast, intelligence, symptoms of inattention, teacher-rated classroom performance, receipt of special education services, and family income best predicted standardized achievement test scores. The finding that receipt of special education services is negatively associated with achievement is not unexpected given that it is typically children with the most severe academic and behavioral difficulties who receive special education services. Also consistent with previous research (Fergusson & Horwood, 1995) we found that symptoms of inattention were more closely related to academic outcomes than hyperactive/impulsive or oppositional defiant symptoms. Notably, in this study, neither medication use, nor receipt of special education, was significantly related to school grades (see Table 2).

Our results are remarkably similar to the findings reported by Rapport et al. (1999), considering the fact that the Rapport study was with a general population cross-sectional sample and the present study used a diagnosed longitudinal sample. Specifically, Rapport et al. (1999) found that the direct relationship between ADHD symptoms and achievement was

significant, but small ($-.07$). In this study, we found an almost identical direct relationship between symptoms of inattention and academic achievement (range = $-.02 - .12$; see Table 3). Further, similar to Rapport et al. (1999), we found that the relationship between ADHD symptoms and academic achievement is best described as an indirect relationship, mediated through classroom performance. That is, symptoms of inattention in childhood influence academic achievement in adolescence through their impact on classroom performance. This study adds to the Rapport study by also examining mediation effects for the relationship between symptoms of inattention and school grades. We found that symptoms of inattention influence school grades by virtue of their impact on homework materials management and classroom performance. Taken together, these findings are important because they suggest that early problems with homework management and classroom performance have significant long-term implications for academic performance. Further, these results document the importance and clinical validity of parent perceptions of homework problems and teacher perceptions of classroom performance.

Limitations

The MTA sample used in this study is technically a treatment sample. Three-fourths of participants received intensive treatment for 14 months in childhood and this could potentially limit generalizability of these findings. However, it is important to note that after 14 months, participants in the MTA no longer received any research interventions and treatment group differences in symptoms, behavior and functioning were no longer statistically significant by the 36 month follow-up assessment (Jensen et al., 2007). In addition, we included treatment group as a predictor and it was not statistically significant in any of the correlation analyses. As a treatment study, all participants met diagnostic criteria for ADHD Combined Type at the initial assessment. The fact that all participants met criteria for ADHD Combined Type means that there was a restricted range of ADHD symptoms, which could impact predictive power and our ability to find significant effects. It is worth noting however, that the relationships we found between ADHD symptoms and academic achievement were almost identical to the relationships cited in a general population sample where restriction of range is not an issue (Rapport et al., 1999). Nevertheless, it cannot be assumed that our results will generalize to general population samples or to samples of children with ADHD Inattentive Type.

There were also limitations with the way that service use was measured. Specifically, both medication and special education services were determined based upon parent-report rather than through a review of records. Further, special education was examined as one variable, when it is actually a heterogeneous set of services (e.g. resource room, individualized education plans, tutors, etc.). It is also important to note that there may be some unreliability with the measurement of school grades because grades are not standardized across schools/districts. This unreliability could be partially responsible for the low to moderate correlations we found between standardized test scores and school grades. Finally, we did not include standardized achievement scores or school grades as baseline predictor variables. Given the high stability of achievement scores over time, future studies should evaluate the longitudinal predictive power of childhood achievement scores relative to the impact of childhood ADHD symptoms.

Implications for Research, Policy, and Practice—These findings have implications for future research on predictors of academic functioning in ADHD samples. Our prediction models for grades predicted between 27% and 37% of the variance. In comparison, prediction models for achievement test scores accounted for between 52% and 63% of the variance. Future research is needed to develop models that more accurately predict school grades. It is likely that parent factors not measured in the MTA study play a significant role

in predicting school grades. We found that higher parental education but not higher family income predicted higher grades in school. Parents with higher levels of education may be structuring the home environment in a way that is more conducive to academic success. It may be that these parents are encouraging children to read more, engaging their children in conversations about school or current events, or are intervening more directly with homework completion. A measure such as the Home Observation for Measurement of the Environment (HOME) Inventory (Bradley & Caldwell, 1977) could be useful for examining these relationships.

Our results leave interesting questions regarding the relation between ADHD symptoms and academic function unanswered. It is clear that early childhood symptoms of ADHD are related to later academic achievement and performance. However, our data suggest that the relationship is indirect, and that symptoms of inattention negatively influence important academic variables such as classroom performance and homework management, which in turn, results in long-term problems with academic achievement and performance. This hypothesis is consistent with research showing that while symptoms of ADHD often decline from childhood to adolescence, academic impairments persist or worsen (Wolraich et al. 2005). That is, once ADHD symptoms have negatively influenced certain aspects of childhood academic functioning, children have failed to learn certain learning-related skills and are not likely to improve even if symptoms remit. This hypothesis would also explain why medication use had little impact on academic functioning (i.e. medication improves symptoms but key aspects of academic functioning are already impaired).

Finally, these findings have implications for the development of treatment plans for young children with ADHD. Interventions designed to improve school grades may not improve standardized achievement test scores and vice versa. This idea is supported by data from the MTA showing that while homework problems improved with the behavioral treatment, participants made minimal improvements on standardized achievement test scores (Langberg, Arnold, Flowers, Epstein, et al., 2010). This was largely attributed to the fact that the MTA interventions targeted homework problems but did not address basic reading and math skills that are central to classroom performance. Given these findings, clinicians providing diagnostic evaluations for ADHD are encouraged to routinely assess children's homework management skills and classroom performance. When problems are identified, it is important that clinicians include these areas as functional targets on treatment plans.

Acknowledgments

The work reported was supported by cooperative agreement grants and contracts from the National Institute of Mental Health to the following: University of California, Berkeley: U01 MH50461, N01MH12009, and HHSN271200800005-C; Duke University: U01 MH50477, N01MH12012, and HHSN271200800009-C; University of California, Irvine: U01 MH50440, N01MH 12011, and HHSN271200800006-C; Research Foundation for Mental Hygiene (New York State Psychiatric Institute/Columbia University): U01 MH50467, N01 MH12007, and HHSN271200800007-C; Long Island-Jewish Medical Center U01 MH50453; New York University: N01MH 12004, and HHSN271200800004-C; University of Pittsburgh: U01 MH50467, N01 MH 12010, and HHSN 271200800008C; and McGill University N01MH12008, and HHSN271200800003-C. The Office of Special Education Programs of the U.S. Department of Education, the Office of Juvenile Justice and Delinquency Prevention of the Justice Department, and the National Institute on Drug Abuse also participated in funding.

The opinions and assertions contained in this report are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of Health and Human Services, the National Institutes of Health, or the National Institute of Mental Health.

References

- American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 4th edition. Washington, DC: American Psychiatric Association; 2000. (DSM-IV)
- Anesko KM, Schoiack G, Ramirez R, Levine FM. The Homework Problem Checklist: Assessing children's homework problems. *Behavioral Assessment*. 1987; 9:179–185.
- Arnold LE, Abikoff HB, Cantwell DP, Conners CK, Elliott GR, Greenhill LL, et al. NIMH collaborative multimodal treatment study of children with ADHD (MTA): Design, methodology, and protocol evolution. *Journal of Attention Disorders*. 1997; 2:141–158.
- Barkley, RA. *Attention-Deficit Hyperactivity Disorder: A Handbook for Diagnosis and Treatment*. NY: The Guilford Press; 2006.
- Barkley, RA.; Murphy, KR.; Fischer, M. *Adult ADHD: What the science says*. New York: Guilford; 2008.
- Barrington BL, Hendricks B. Differentiating characteristics of high school graduates, dropouts, and nongraduates. *Journal of Educational Research*. 1989; 82(6):309–319.
- Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*. 1986; 51:1173–1182. [PubMed: 3806354]
- Biederman J, Faraone SV, Spencer TJ, Mick E, Monuteaux MC, Aleardi M. Functional impairments in adults with self-reports of diagnosed ADHD: A controlled study of 1001 adults in the community. *Journal of Clinical Psychiatry*. 2006; 67(4):524–540. [PubMed: 16669717]
- Bradley RH, Caldwell BM. Home observation for measurement of the environment: A validation study of screening efficiency. *American Journal of Mental Deficiency*. 1977; 81(5):417–420. [PubMed: 66872]
- Cooper H, Lindsay JJ, Nye B, Greathouse S. Relationships among attitudes about homework, amount of homework assigned and completed, and student achievement. *Journal of Educational Psychology*. 1998; 90:70–83.
- Cooper H, Robinson JC, Patall EA. Does homework improve academic achievement? A synthesis of research. *Review of Educational Research*. 2006; 76(1):1–62.
- DuPaul, GJ.; Stoner, G. *ADHD in the Schools: Assessment and Intervention Strategies*. 2nd ed.. New York, NY: Guilford Press; 2003.
- DuPaul GJ, Volpe RJ, Jitendra AK, Lutz G, Lorah KS, Gruber R. Elementary school students with AD/HD: Predictors of Academic Achievement. *Journal of School Psychology*. 2004; 42:285–301.
- DuPaul GJ, Weyandt LL, O'Dell SM, Varejao M. College students with ADHD: Current status and future directions. *Journal of Attention Disorders*. 2009; 13(3):234–250. [PubMed: 19620623]
- Fergusson DM, Horwood LJ. Early disruptive behavior, IQ, and later school achievement and delinquent behavior. *Journal of Abnormal Child Psychology*. 1995; 23:183–199. [PubMed: 7642833]
- Fergusson DM, Horwood LJ, Lynskey MT. 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*. 1993; 34:899–916. [PubMed: 8408374]
- Fergusson DM, Lynskey MT, Horwood LJ. Attentional difficulties in middle childhood and psychosocial outcomes in young adulthood. *Journal of Child Psychology and Psychiatry*. 1997; 38:633–644. [PubMed: 9315973]
- Fischer M, Barkley RA, Edelbrock CS, Smallish L. The adolescent outcome of hyperactive children diagnosed by research criteria: II. Academic, attentional, and neuropsychological status. *Journal of Consulting and Clinical Psychology*. 1990; 58:580–588. [PubMed: 2254504]
- 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]
- 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]

- Gresham, FM.; Elliott, SN. Social Skills Rating System Manual. Circle Pines: American Guidance Service; 1990.
- Hinshaw SP, March JS, Abikoff H, Arnold LE, Cantwell DP, Conners CK, et al. Comprehensive assessment of childhood attention-deficit hyperactivity disorder in the context of a multisite, multimodal clinical trial. *Journal of Attention Disorders*. 1997; 1(4):217–234.
- Hoagwood KE, Jensen PS, Arnold LE, Roper M, Severe J, Odber C, et al. Reliability of the services for children and adolescents-parent interview. *Journal of the American Academy of Child and Adolescent Psychiatry*. 2004; 43(11):1345–1354. [PubMed: 15502593]
- Keith TZ, Benson MJ. Effects of manipulable influences on high school grades across five ethnic groups. *Journal of Educational Research*. 1992; 86(2):85–93.
- Jensen PS, Hoagwood KE, Roper M, Arnold LE, Odber C, Crowe M, et al. The services for children and adolescents-parent interview: Development and performance characteristics. *Journal of the American Academy of Child and Adolescent Psychiatry*. 1994; 43(11):1334–1344. [PubMed: 15502592]
- Jensen PS, Swanson J, Arnold LE, Vitiello B, Abikoff HB, Greenhill LL, et al. MTA Findings at 36 Months Paper 1: Three-Year Follow-up of the NIMH MTA Study. *Journal of the American Academy of Child and Adolescent Psychiatry*. 2007; 46(8):989–1002. [PubMed: 17667478]
- Kutner, NN. Applied Linear Regression Models. 4th edition. McGraw-Hill: Irwin; 2004.
- Langberg JM, Arnold LE, Flowers AM, Altaye M, Epstein JN, Molina BSG. Assessing homework problems in children with ADHD: Validation of a parent-report measure and evaluation of homework performance patterns. *School Mental Health*. 2010 Prepublished November 12, 2009.
- Langberg JM, Arnold LE, Flowers AM, Epstein JN, Altaye M, Hinshaw SP, Swanson JM, Kotkin R, Simpson S, Molina BSG, Jensen PS, Abikoff H, Pelham WE, Vitiello B, Wells KC, Hechtman L. Parent-reported homework problems in the MTA study: Evidence for sustained improvement with behavioral treatment. *Journal of Clinical Child and Adolescent Psychology*. 2010; 39(2):220–233. [PubMed: 20390813]
- Loe IM, Feldman HM. Academic and educational outcomes of children with ADHD. *Ambulatory Pediatrics*. 2007; 7:82–90. [PubMed: 17261487]
- Massetti GM, Lahey BB, Pelham WE, Loney J, Ehrhardt A, Lee SS, et al. 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]
- Molina BSG, Hinshaw SP, Swanson JM, Arnold LE, Vitiello B, Jensen PS, et al. 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
- MTA Cooperative Group. A 14-month randomized clinical trial of treatment of attention deficit hyperactivity disorder (ADHD). *Archives of General Psychiatry*. 1999; 56:1073–1086. [PubMed: 10591283]
- Power TJ, Werba BE, Watkins MW, Angelucci JG, Eiraldi RB. Patterns of parent-reported homework problems among adhd-referred and non-referred children. *School Psychology Quarterly*. 2006; 21:13–33.
- Rappaport 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]
- Shaffer D, Fischer P, Lucas CP, Dulcan MK, Schwab-Stone ME. NIMH Diagnostic Interview Schedule for Children Version IV (NIMH DISC-IV): Description, differences from previous versions, and reliability of some common diagnoses. *Journal of the American Academy of Child and Adolescent Psychiatry*. 2000; 39(1):28–38. [PubMed: 10638065]
- Swanson, JM. School Based Assessments and Interventions for ADD Students. Irvine, CA: KC; 1992.
- Tabachnick, BG.; Fidell, LS. Using Multivariate Statistics. 4th ed.. Needham Heights, MA: Allyn and Bacon; 2001.
- Wechsler, D. Wechsler Intelligence Scale for Children. 3rd ed.. San Antonio, TX: The Psychological Corporation; 1991.

- Wechsler. Wechsler Individual Achievement Test Manual. San Antonio, TX: The Psychological Corporation; 1992.
- Wentzel KR. Adolescent classroom goals, standards for performance, and academic achievement: An interactionist perspective. *Journal of Educational Psychology*. 1989; 81:131–142.
- Wolraich ML, Wibbelsman CJ, Brown TE, Evans SW, Gotlieb EM, Knight JR, et al. Attention-deficit/hyperactivity disorder among adolescents: A review of the diagnosis, treatment, and clinical implications. *Pediatrics*. 2005; 115(6):1734–1746. [PubMed: 15930238]
- Zheng B. Summarizing the goodness of fit on generalized linear models for longitudinal data. *Statistics in Medicine*. 2000; 19:1265–1275. [PubMed: 10814976]
- 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, and Percentages for Predictor Variables

	M (SD) or Percentage
Child Sex	80% Male
Child Ethnicity	62% Caucasian
Family Income	
0–20,000	21%
20,000–50,000	41%
>50,000	36%
Parent Education	
≤ High School	23%
≥ Some College	77%
WISC-III IQ	100.9 (14.8)
Inattention	2.12 (0.51)
Hyper/Imp	1.94 (0.54)
ODD	1.37 (0.66)
SSRS Classroom	2.70 (0.80)
HPC Completion	23.82 (8.07)
HPC Mat Manage	8.16 (5.09)
Special Education	1.96 (3.37)
Medication Use	0.43 (0.29)

Note: $N = 436$; Inattention and Hyper/Impulsive scores are item means scores from the SNAP rating scale where 0 = not at all, 1 = just a little, 2 = pretty much, and 3 = very much; SSRS Classroom score is an item mean score with range of 1–5; HPC Completion and HPC Materials Management are the two factors generated from the Homework Problems Checklist; Special Education variable is the average hours per week of special education services received between the MTA baseline and 8-year assessment; Medication use variable is the average percent of days on ADHD medications between the MTA baseline and the 8-year assessment; WISC-III = Wechsler Intelligence Scale for Children-Third Edition.

Table 2

Correlations Between Baseline Predictor Variables and Grades

Predictors	English Grades	Math Grades	History Grades	Science Grades	Overall GPA
Demographic					
Intelligence	.28	.24	.23	.28	.27
Parent Education	.27	.23	.23	.26	.28
Family Income	.20	.16	.20	.18	.20
Child Ethnicity	-.14	-.04	-.17	-.14	-.13
Child Sex	-.14	-.06	-.06	-.09	-.11
ADHD/ODD					
Inattention	-.09	-.11	-.12	-.10	-.12
Hyper/Imp	-.14	-.06	-.07	-.15	-.12
ODD	-.13	-.05	-.01	-.08	-.09
Academic					
SSRS Classroom	.25	.24	.31	.30	.30
HPC Completion	-.07	-.10	-.06	-.07	-.10
HPC Mat Manage	-.24	-.21	-.18	-.23	-.25
Service Use					
Special Education	-.06	-.02	-.04	-.03	-.06
Medication Use	.06	.06	.07	.04	.05
Treatment Group	-.07	-.02	-.02	-.03	-.04

Note: Values in bold italics were significant at the $p < .10$ level and were entered into the multivariate model. Negative relationship for ethnicity indicates that minority status is associated with lower grades; Negative relationship for child sex indicates that female gender is associated with lower grades; Special Education variable is the average hours per week of special education services received between the MTA baseline and 8-year assessment; Medication use variable is the average percent of days on ADHD medications between the MTA baseline and the 8-year assessment; WIAT = Wechsler Individual Achievement Test; HPC = Homework Problems Checklist; SSRS Academic = Social Skills Rating System Academic Competence subscale; Only MTA ADHD participants are included.

Table 3

Correlations Between Baseline Predictor Variables and WIAT Subtests

Predictors	Reading	Math	Spelling
Demographic			
Intelligence	<i>.51</i>	<i>.66</i>	<i>.49</i>
Parent Education	<i>.21</i>	<i>.24</i>	<i>.18</i>
Family Income	<i>.28</i>	<i>.33</i>	<i>.24</i>
Child Ethnicity	<i>-.15</i>	<i>-.23</i>	<i>-.13</i>
Child Sex	-.07	-.06	-.02
ADHD/ODD			
Inattention	-.02	<i>-.12</i>	<i>-.10</i>
Hyper/Imp	-.06	-.02	-.07
ODD	-.04	<i>-.09</i>	-.08
Academic			
SSRS Classroom	<i>.50</i>	<i>.51</i>	<i>.55</i>
HPC Completion	-.05	<i>-.15</i>	<i>-.14</i>
HPC Mat Manage	<i>-.09</i>	<i>-.20</i>	<i>-.16</i>
Service Use			
Special Education	<i>-.39</i>	<i>-.40</i>	<i>-.42</i>
Medication Use	.07	<i>.14</i>	<i>.09</i>
Treatment Group	.01	.02	.01

Note: Values in bold italics were significant at the $p < .10$ level and were entered into the multivariate model. Negative relationship for ethnicity indicates that minority status is associated with lower grades; Negative relationship for child sex indicates that female gender is associated with lower grades; Special Education variable is the average hours per week of special education services received between the MTA baseline and 8-year assessment; Medication use variable is the average percent of days on ADHD medications between the MTA baseline and the 8-year assessment; WIAT = Wechsler Individual Achievement Test; HPC = Homework Problems Checklist; SSRS = Social Skills Rating System; Only MTA ADHD participants are included.

Table 4

Results of Multivariate Regression Model Predicting Grades

	English Estimate (SE)	Math Estimate (SE)	History Estimate (SE)	Science Estimate (SE)	Overall GPA Estimate (SE)
Demographic					
Intelligence	.003 (.004)	.007 (.004)	.001 (.004)	.007 (.004)	.005 (.004)
Parent Ed	-.383 (.138)**	-.301 (.151)*	-.298 (.144)*	-.417 (.157)**	-.324 (.122)**
Family Income	.029 (.021)	.025 (.021)	.024 (.023)	-.000 (.025)	.026 (.019)
Child Ethnicity	-.036 (.123)	NA	-.278 (.137)*	-.005 (.144)	.005 (.118)
Child Sex	-.203 (.109)	NA	NA	-.301 (.136)*	-.198 (.103)
ADHD/ODD					
Inattention	.149 (.109)	-.028 (.121)	.009 (.122)	.244 (.649)	.043 (.111)
Hyper/Imp	-.182 (.111)	NA	NA	-.197 (.119)	-.178 (.104)
ODD	-.009 (.088)	NA	NA	NA	.055 (.077)
Academic					
SSRS Classroom	.215 (.073)**	.113 (.074)	.262 (.082)**	.329 (.083)***	.190 (.066)**
HPC Completion	NA	.006 (.009)	NA	NA	.009 (.008)
HPC Mat Manage	-.033 (.009)***	-.038 (.013)**	-.025 (.012)*	-.037 (.013)**	-.040 (.011)***
Service Use					
Special Education	NA	NA	NA	NA	NA
Medication Use	NA	NA	NA	NA	NA
Treatment Group	NA	NA	NA	NA	NA

Note:

* $p < .05$;

** $p < .01$;

*** $p < .001$;

$N = 436$; NA = variables that were not significant at the $p < .10$ level in the correlation analyses and not entered into the multivariate model; Estimates in table are unstandardized regression coefficients; Negative coefficients for child ethnicity indicates that minority status is associated with lower grades; Negative coefficients for child sex indicates that female gender is associated with lower grades; Special Education variable is the average hours per week of special education services received between the MTA baseline and 8-year assessment; Medication use variable is the average percent of days on ADHD medications between the MTA baseline and the 8-year assessment; WIAT = Wechsler Individual Achievement Test; HPC = Homework Problems Checklist; SSRS = Social Skills Rating System.

Table 5

Results of Multivariate Regression Model Predicting WIAT Subscale Scores

	Reading Estimate (SE)	Math Estimate (SE)	Spelling Estimate (SE)
Demographic			
Intelligence	.247 (.045)***	.481 (.050)***	.214 (.056)***
Parent Ed	-.214 (1.64)	-1.68 (1.45)	-.291 (1.71)
Family Income	.692 (.217)**	.821 (.251)**	.674 (.278)*
Child Ethnicity	-.829 (1.26)	-2.65 (1.31)*	.486 (1.43)
Child Sex	NA	NA	NA
ADHD/ODD			
Inattention	NA	-2.96 (1.39)*	-3.89 (1.48)**
Hyper/Imp	NA	NA	NA
ODD	NA	.409 (.837)	NA
Academic			
SSRS Classroom	5.56 (.773)***	4.32 (.881)***	7.53 (.877)***
HPC Completion	NA	-.178 (.092)	-.131 (.102)
HPC Mat Manage	-.008 (.112)	-.195 (.153)	-.022 (.147)
Service Use			
Special Education	-.636 (.171)***	-.684 (.181)***	-.893 (.193)***
Medication Use	NA	-1.89 (2.29)	-2.53 (2.37)
Treatment Group	NA	NA	NA

Note:

*
 $p < .05$;**
 $p < .01$;***
 $p < .001$;

$N = 436$; NA = variables that were not significant at the $p < .10$ level in the correlation analyses and not entered into the multivariate model; Estimates in table are unstandardized regression coefficients; Negative coefficients for child ethnicity indicates that minority status is associated with lower grades; Special Education variable is the average hours per week of special education services received between the MTA baseline and 8-year assessment; Medication use variable is the average percent of days on ADHD medications between the MTA baseline and the 8-year assessment; WIAT = Wechsler Individual Achievement Test; HPC = Homework Problems Checklist; SSRS = Social Skills Rating System.

Table 6

Mediation Effect of Academic Variables on the Relationship Between Inattention Symptoms and Academic Outcomes

	Point Estimate	SE	Z	p
Math WIAT				
SSRS Classroom	-5.75	0.94	-6.15	<.001
HPC Completion	-0.72	0.96	-0.75	.455
HPC Mat Manage	-1.78	0.89	-2.01	.044
Spelling WIAT				
SSRS Classroom	-7.83	0.94	-6.32	<.001
HPC Completion	-0.90	0.89	-1.01	.312
HPC Mat Manage	-0.99	0.81	-1.23	.218
Overall Grade Point Average (GPA)				
SSRS Classroom	-0.16	0.04	-4.27	<.001
HPC Completion	0.11	0.06	1.80	.072
HPC Mat Manage	-0.24	0.06	-4.14	<.001
History Grades				
SSRS Classroom	-0.20	0.05	-4.10	<.001
HPC Completion	0.08	0.07	1.20	.232
HPC Mat Manage	-0.18	0.07	-2.66	.008
Math Grades				
SSRS Classroom	-0.14	0.04	-3.44	<.001
HPC Completion	0.66	0.07	0.98	.326
HPC Mat Manage	-0.21	0.07	-3.15	.002

Note. $N = 436$; Mediation effects were not significant for WIAT Reading or for English and Science grades; Mediation effects of the service use variables (special education services and medication use) were also examined but are not included in the table because no significant relationships were established. WIAT = Wechsler Individual Achievement Test; HPC = Homework Problems Checklist; SSRS = Social Skills Rating System.