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## Academic and Social Functioning Associated with Attention-Deficit/Hyperactivity Disorder: Latent Class Analyses of Trajectories from Kindergarten to Fifth Grade

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### Abstract

Children with attention-deficit/hyperactivity disorder (ADHD) are known to exhibit significantly lower academic and social functioning than other children. Yet the field currently lacks knowledge about specific impairment trajectories experienced by children with ADHD, which may constrain early screening and intervention effectiveness. Data were analyzed from a nationally representative U.S. cohort in the Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999 (ECLS-K) for 590 children (72.7% male) whose parents reported a formal diagnosis of ADHD. Children's math, reading, and interpersonal skills were assessed at 5 time points between kindergarten and fifth grade. Growth mixture model analyses indicated 4 latent trajectory classes for reading, 8 classes for math, and 4 classes for interpersonal skills. Membership in reading and math trajectory classes was strongly related; overlaps with interpersonal skills classes were weaker. Trajectory class membership was correlated with demographic characteristics and behavioral functioning. Children with ADHD display substantial heterogeneity in their reading, math, and interpersonal growth trajectories, with some groups of children especially likely to display relatively severe levels of academic and social impairment over time. Early screening and intervention to address impairment, particularly reading difficulties, among kindergarten students with ADHD is warranted.

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#### Conflict of Interest

The authors declare that they have no conflict of interest.

## Keywords

ADHD; mathematics; reading; social behavior; growth

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Children with attention-deficit/hyperactivity disorder (ADHD) display significant impairments in academic and/or social functioning (Barkley, 2015). Such impairments are a defining feature of the disorder because children's behavioral symptoms must be accompanied by academic and/or social difficulties to receive an ADHD diagnosis (American Psychiatric Association, 2013). Yet, and although prior studies have examined trajectories of children's ADHD behavioral symptoms generally (e.g., Arnold et al., 2014), very few have specifically examined variability in the trajectories of the children's academic and social functioning. Examining whether and to what extent there is heterogeneity in ADHD children's achievement and social impairment trajectories is important because children with ADHD typically are referred for treatment primarily on the basis of impairment exhibited in school settings (Angold, Costello, Farmer, Burns, & Erkanli, 1999). Assessment of impairment is known to have direct impact on disorder identification rate in that ADHD prevalence estimates are more conservative when symptoms must be associated with significant impairment (McKeown et al., 2015). In addition, intervening to remediate children's lower academic and social functioning may help address ADHD's well-documented sequelae of grade retention, academic underachievement, identification for special education services, and school drop-out (Barkley, Fischer, Smallish, & Fletcher, 2006; Frazier, Youngstrom, Glutting, & Watkins, 2007; Kent et al., 2011). Understanding to what extent children with ADHD display variability in their impairments in social as well as academic functioning is important to more effectively direct interventions. Children with ADHD are known to often experience difficulties interacting with peers and adult authority figures, problems building and sustaining friendships, and peer rejection (Efron et al., 2014; Hodgens, Cole, & Boldizar, 2000; Hoza, 2007; Stormont, 2001).

Despite well-documented evidence regarding academic and interpersonal difficulties experienced by children with ADHD, important gaps in the field's knowledge base remain. Most studies have examined functioning at only one or two points in time (e.g., Efron et al., 2014). Few longitudinal investigations have assessed academic and social functioning across multiple time points (e.g., Bussing et al., 2012; Molina et al., 2009). These few studies have not specifically focused on the shape or slope of trajectories, resulting in ambiguity as to whether the children's impairments increase, decrease, or remain stable over time. The slope of these trajectories has implication for intervention efforts. For example, if the impairments of children with ADHD increase over time, this would suggest that intervention efforts would be most effective if delivered early on during children's school careers.

One analytic method that has been used to identify subgroups of children with ADHD on the basis of various characteristics is latent class analysis and related methods (e.g., latent profile analysis). Specifically, researchers have reported latent classes based on ADHD symptom counts and/or symptom severity at one point in time (e.g., Elia et al., 2009; Neuman et al., 1999; Volk, Todorov, Hay, & Todd, 2009), trajectories of symptoms over time (Arnold et al., 2014; Larsson, Dilshad, Lichtenstein, & Barker, 2011), and presence of

comorbid symptoms (e.g., Acosta et al., 2008; Ostrander, Herman, Sikorski, Mascendaro, & Lambert, 2008). Children's latent class membership in regards to relative reading and writing achievement varies with respect to risk for ADHD (Cogo-Moreira et al., 2013). The trajectories of reading and math achievement vary significantly among groups of children differing with respect to ADHD diagnosis and special education status (Bussing et al., 2012) as well as on the basis of response to treatment latent class membership (Molina et al., 2009). Yet, to date, no previous study has examined possible latent classes of academic and social functioning trajectories over time within the ADHD population.

Furthermore, it is also possible that classes of children with ADHD experience joint or dual trajectories and so, for example, those experiencing low reading achievement over time may also experience low mathematics achievement and/or interpersonal skills over time. In support of this possibility, low reading and mathematics achievement has been found to covary in some children (Jordan, Kaplan, & Hanich, 2002). Thus, an additional clinical implication of analyses of children's latent class trajectories across multiple indicators of functioning would be the possible need to deliver multi-faceted interventions that target distinct types of skills simultaneously (Morgan, Farkas, & Wu, 2009).

Establishing the degree to which distinct trajectories of academic and social functioning among children with ADHD are associated with child or family characteristics could also lead to more effective screening and intervention delivery. For example, Larsson et al. (2011) found that large family size, divorced parents, and low SES were significant predictors of membership in the most severe ADHD symptom latent trajectory class. Currently, however, the factors that predict more severe academic or interpersonal impairment trajectories (as opposed to symptom trajectories) have yet to be identified.

In summary, it is well established that children with ADHD as a group exhibit significantly lower academic achievement and social performance difficulties beginning in elementary school and continuing into college. Yet, other than the aforementioned Bussing et al. (2012) and Molina et al. (2009) studies, the field currently knows very little about whether and to what extent the within-group impairment trajectories of children with ADHD may vary. Thus, there is an implicit, but possibly mistaken, assumption that the general population of children with ADHD exhibits uniform levels of initial and over time growth in academic achievement and social functioning. No prior studies have sought to determine ADHD subgroups based specifically on patterns of impairment over time, nor have previous investigations employed population-based analyses in identifying trajectory classes. Further, no previous work has focused on identifying variables that may be associated with membership in subgroups based on trajectories of impairment.

The current study had several aims. First, we sought to identify subgroups of children diagnosed with ADHD on the basis of latent impairment trajectories from kindergarten to 5<sup>th</sup> grade in reading, mathematics, and social or interpersonal skills. Second, we examined the joint probabilities of membership in reading, math, and interpersonal skills trajectory classes. We hypothesized that membership in reading and math trajectory classes would be highly correlated given prior evidence for a strong association in development of these academic skills in other child populations (Durand, Hulme, Larking, & Snowling, 2005). In

the absence of substantial prior research, the degree of overlap between reading and mathematics with interpersonal skill trajectory classes is essentially unknown. However, we expected moderate association between academic performance and social behavior, albeit at a lower magnitude than between reading and math trajectory classes due to their greater similarities between the latter two domains. Our final aim was to identify academic (e.g., teacher ratings), and behavioral (e.g., teacher and parent ratings) characteristics at kindergarten entry that vary across latent trajectory classes while controlling for child/family characteristics (e.g., gender, SES). Doing so should help identify factors associated with more severe levels of impairment over time, thus helping guide clinician-directed screening and early intervention efforts.

## Method

### Sample

Data were analyzed from the Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999 (ECLS-K; Tourangeau, Nord, Le, Sorongon, & Najarian, 2009), a nationally representative longitudinal survey of children, their parents, teachers, and school administrators in the United States. Data were collected in spring of 1999, fall of 1999, spring of 2000, spring of 2002, and spring of 2004. All research activity met relevant ethical and legal guidelines including informed consent from parents/guardians and approval from university institutional review boards (IRB). The analytic sample for the current study was comprised of 590 children whose parents reported children to have received a formal diagnosis of attention-deficit disorder, ADHD, or hyperactivity in kindergarten, first, third, or fifth grade. Specifically, children were included in the ADHD sample on the basis of a parent's response of "yes" to each of three separate survey questions (i.e., "yes" to the child being evaluated by a professional in response to a problem in paying attention, learning, behaving, or in activity level; "yes" to receiving a diagnosis by this professional; and "yes" to the diagnosis being for ADHD, ADD, or hyperactivity). Children also must have had at least beginning (Spring 1999) and ending point (Spring 2004) values to be included in analyses for a specific measure. In addition, most of the 590 participants had complete data across the three intervening assessment phases for Math ( $n = 580$ ), Reading ( $n = 570$ ), and Interpersonal Skills ( $n = 520$ ).

Descriptive statistics for the analytic sample are presented in Table 1 along with characteristics for the full sample of students with ADHD who were participants in ECLS-K but had missing values on either beginning or ending point values for analysis variables ( $N = 1,330$ ). The analytic sample closely approximated the full sample of children with ADHD who entered kindergarten on many socio-demographic variables. The analytic sample was somewhat less at risk on some socio-demographic characteristics including having a smaller percentage of lowest SES families, a higher percentage of highest SES families, a higher percentage of White children, a lower percentage of children from Hispanic backgrounds, and a lower percentage of individuals with ADHD diagnosis in kindergarten or first grade. Nevertheless, the analytical sample included substantial percentages of children and families with these risk indicators as well as a higher percentage receiving ADHD medication in 5<sup>th</sup> grade.

## Measures of Academic and Social Functioning

**Academic Functioning**—Children were individually administered achievement measures in reading and mathematics at each assessment phase specifically designed by the National Center for Education Statistics (NCES) for use in the ECLS-K (U.S. Department of Education, 2002). Both measures were developed based on expert panel review and following initial field testing. In each subject area, children initially received a 12- to 20-item routing test that guided selection of one of several alternative second-stage forms. The latter contained items of appropriate difficulty for children's ability level based on their routing item performance. Reading and mathematics achievement items assessed skills appropriate for children's grade levels. For example, the kindergarten reading achievement measure assessed children's knowledge of letter recognition, beginning sounds, ending sounds, sight words, and words in context. The mathematics achievement measure evaluated children's knowledge of counting, number shape; ordinality, sequence; and arithmetic operations (addition and subtraction). Standardized *T*-scores ( $M = 50$ ;  $SD = 10$ ) (internal consistency reliabilities range from .88 to .95) were used to evaluate growth from a norm-referenced perspective (i.e., performance in relation to the child's age-matched population). The measures display strong psychometric properties, including concurrent validity (U.S. Department of Education, 2002). One-year test-retest correlation coefficients for the sample examined in this study were .76 (Reading) and .80 (Math).

**Social Functioning**—General education teachers in kindergarten, first, third, and fifth grades independently rated the frequency of children's interpersonal skill behaviors by using the Social Rating Scale, a psychometrically validated behavioral measure adapted for the ECLS-K from the Social Skills Rating System (Gresham & Elliott, 1990). The Interpersonal Skills subscale items measure five social skills including forming and maintaining friendships; getting along with people who are different; comforting or helping other children; expressing feelings, ideas, and opinions in positive ways; and showing sensitivity to the feelings of others. Teachers reported the frequency of each behavior on a 4-point Likert scale including 1 (*Never*), 2 (*Sometimes*), 3 (*Often*), and 4 (*Very Often*). Split-half reliability for this scale was .89. The measure displays both discriminant and convergent validity (U.S. Department of Education, 2002). The one-year test-retest correlation for the sample included in the present study was .64. The mean item rating (range 0.0 to 4.0) was used for all analyses. In the case where two teachers provided student ratings in a given year, the average score across teachers was used. For the ECLS-K sample as a whole, the mean Interpersonal Skills score was 3.0 ( $SD = 0.6$ ).

## Child Demographic, Academic, and Behavioral Characteristics

Several demographic variables were used as covariates including child gender, race/ethnicity, and SES. Racial/ethnic categories included Hispanic (7.5%), non-Hispanic African-American (9.7%), non-Hispanic White (76.1%), and other races/ethnicities (6.8%; includes Asian, Native Hawaiian, Pacific Islander, American Indian, and Alaskan Native and those described as being more than one race). Due to small sample sizes within the ADHD subgroup population, we used a single dummy variable for children's race/ethnicity (i.e., Non-Hispanic White vs. all other races/ethnicities combined). Information on the mother's and father's education and occupation, along with family income, were used to create a

composite scale of family SES. Dummy variable coding for three SES classifications (i.e., lowest third, middle third, highest third) was used.

Given that Arnold et al. (2014) found ADHD medication treatment to be associated with milder symptom trajectories, this variable was included as a covariate in our analysis. In the fifth-grade survey, parents were asked whether their child was currently receiving any prescription medication (e.g., methylphenidate, amphetamine, atomoxetine) related to ADHD. It is also possible that latent trajectory class membership varied as a function of ADHD symptom severity. As a proxy for severity status, we examined the degree to which trajectory classes varied as a function of ADHD diagnosis in early elementary school (i.e., parent report of diagnosis in kindergarten or first grade). Further, it is possible that functioning trajectories, especially in reading and math, may be influenced by whether children also were identified as having learning disabilities (LD) or otherwise receiving special education services. Thus, teachers reported whether children received special education services and whether they had been identified with LD.

Initial behavioral functioning and academic performance were assessed using parent and teacher ratings from the first assessment phase. Three subscales (Language and Literacy, General Knowledge, and Mathematics) from the teacher-completed Academic Rating Scale (ARS) were included. The Language and Literacy subscale includes seven items assessing child performance in speaking, listening, early reading, writing, and computer literacy. The General Knowledge subscale contains four items regarding proficiency in social studies and science. The Mathematics subscale includes five items assessing concept of numbers, solving number problems, use of math strategies, data analysis and graphing, and measurement. Each item on the ARS is rated from 0 (*child has not yet demonstrated skill, knowledge, or behavior*) to 4 (*child demonstrates skill, knowledge, or behavior competently and consistently*). Analyses were conducted using mean item scores for each subscale. Internal consistency for the ARS ranged from .87 to .92 across subscales.

Teachers and parents also completed the Social Rating Scale (SRS). The teacher SRS contains five subscales: Approaches to Learning, Self-Control, Interpersonal Skills, Externalizing Problem Behaviors, and Internalizing Problem Behavior. The Interpersonal Skills subscale was described previously and was used as the dependent measure of social functioning. Approaches to Learning includes six items assessing attentiveness, task persistence, eagerness to learn, learning independence, flexibility, and organization. Self-Control contains four items including respecting others' property rights, accepting peer ideas for group activities, controlling temper, and responding appropriately to peer pressure. Externalizing Problem Behaviors includes five items rating the frequency of argues, fights, gets angry, acts impulsively, and disturbs ongoing activities. Internalizing Problem Behavior contains four items tapping anxiety, loneliness, low self-esteem, and sadness. All items are rated on a scale of one (Never) to four (Very often). Split-half reliabilities for SRS subscales ranged from .79 (Self-Control) to .90 (Externalizing Problem Behaviors).

The Parent SRS also contained five subscales including Approaches to Learning, Self-Control, Social Interaction, Impulsive/Overactive, and Sad/Lonely. Approaches to Learning included six items regarding eagerness to learn, interest in a variety of things, creativity,

persistence, concentration, and responsibility. Self-Control contained five items including ability to control behavior, fights, argues, throws tantrums, and gets angry. Social Interaction contained three items tapping ease in joining play, ability to make and keep friends, and positively interacting with peers. Impulsive/Overactive consisted of two items addressing children's impulsivity and activity level. Finally, Sad/Lonely contained four items including problems with being accepted and liked by others, sadness, loneliness, and low self-esteem. As was the case for the Teacher SRS, each item was rated from 1 (never) to 4 (very often). Split-half reliabilities ranged from .46 (Impulsive/Overactive) to .74 (Self-Control).

### Analytic Method

Growth mixture modeling analyses were conducted separately for reading, math, and interpersonal skills using PROC TRAJ in SAS. Model fit was determined using Bayes Information Criteria (BIC) as well as considering the conceptual and clinical utility of obtained solutions (Nagin, 2005). This analysis requires a minimum of two data points (beginning and ending values) to determine trajectories and, as described previously, most of the participants had at least 4 of the 5 data points available. Next, dual trajectory analyses (Nagin, 2005) were conducted to examine joint probabilities for reading and math trajectories, reading and interpersonal skills trajectories, and math and interpersonal skill trajectories. Finally, classes within each functioning area were compared on child demographic, academic, and behavioral characteristics using  $X^2$  or analysis of covariance (ANCOVA) depending on the level of measurement of the specific variable. Child gender, ethnicity, SES, and ADHD medication status were included as covariates. An alpha level of .05 was used for omnibus tests of between-class differences given that these were exploratory analyses. Following a statistically significant omnibus test, a Bonferroni correction for family-wise error was used for follow-up pairwise comparisons across classes.

### Results

BIC values measuring goodness of fit became less negative as more classes were added to the fitted models, until good fits with reasonable clinical interpretations and population shares were achieved with four classes for Reading, eight classes for Math, and four classes for Interpersonal Skills (see Table 2 and Figures 1–3). The quadratic Reading model solution had four trajectory classes with varied intercept and growth parameters (see Figure 1). Two trajectory classes, representing 39.7% of the sample, started below the population mean and remained there through fifth grade. Three of the four classes showed no significant growth over time. By fifth grade, children with ADHD belonging to Classes 1 and 2 obtained reading achievement scores 1.5 to 3 standard deviations below children with ADHD in Class 4.

In the eight-group quadratic Math model, four of the trajectory classes (39.4%) started below the population mean and remained there through fifth grade (see Figure 2), two classes (27.6%) started above the population mean and remained there, one of the remaining classes (5.8%) started below the mean and increased significantly over time, while another class (27.3%) started at the mean and decreased slightly over time. Thus, by fifth grade,



children in Classes 1, 2, and 4 obtained math achievement scores that were 2.5 standard deviations below the children belonging to Class 8.

In the four-group linear Interpersonal Skill trajectory model, two classes (52.7%) started below the ECLS-K sample mean with one class showing improvement over time (see Figure 3). One class (24.6%) started at about the ECLS-K group mean and sharply decreased over time, while the remaining class (22.7%) started above the mean and remained there through fifth grade. Thus, by fifth grade, children in Class 1 obtained interpersonal skill ratings nearly 2 standard deviations below children belonging to Class 4.

### Dual Trajectory Analyses

We conducted a series of dual trajectory analyses to examine the degree to which group membership overlapped across the three areas of functioning (reading, math, and interpersonal skills). For each pairwise combination of variables (Reading-Math, Reading-Interpersonal, Math-Interpersonal), we examined the probability of (a) membership in trajectory classes in one area (e.g., Interpersonal) being conditional on membership in trajectory classes in a second area (e.g., Reading); and (b) group membership for the reverse conditional relationship (e.g., Reading conditional upon Interpersonal). In addition, Spearman rho rank correlations were calculated for each pairwise combination, i.e., to reflect the strength of the relationship between latent trajectory classes across domains.

The vast majority (approximately 78%) of children belonging to the lowest functioning reading achievement class (i.e., Class 1) also belonged to the two lowest functioning math classes (i.e., Classes 1 and 2) (see Supplementary Materials). All children in the lowest math trajectory class belonged to the lowest reading trajectory class. Those children in medium range reading classes (i.e., Classes 2 and 3) were highly likely (over 65%) to belong to medium range math classes (i.e., Classes 3, 4, and 5) and vice versa. Finally, children in the highest functioning reading class (i.e., Class 4) were almost universally (90.5%) members of the two highest math trajectory groups (i.e., Classes 7 and 8). The Spearman rho rank correlation for math trajectory class conditional on reading class membership was .80, while this correlation was .82 for reading trajectory class conditional on math class membership.

An association between reading and interpersonal skills trajectory class membership was also evident; however, this relationship was not as strong as for the two achievement domains and was relatively stronger in one direction. The majority of children (63.1%) in the lowest reading trajectory class (i.e., Class 1) were members of the lowest interpersonal skills class (i.e., Class 1) (see Supplementary Materials). Similarly, more than a third of the highest achieving readers (i.e., Class 4) were members of the highest-rated interpersonal skills group (i.e., Class 4). The Spearman rho rank correlation for interpersonal trajectory class conditional on reading class was .26. Conversely, membership in specific interpersonal skills classes did not strongly impact probability of membership in specific reading classes. For example, children in the lowest interpersonal skill trajectory class (i.e., Class 1) were most likely to be members of the second-lowest functioning reading class (i.e., Class 2) and were also present in the other three reading classes (Spearman rho = .20 for reading class conditional on interpersonal class).

This relatively weaker relationship in class membership was also evident for math and interpersonal skills. Children belonging to the two lowest math trajectory classes (i.e., Classes 1 and 2) were very likely (61.6%) to belong to the lowest interpersonal skills trajectory class (i.e., Class 1) (see Supplementary Materials). Alternatively, conditional probabilities were lower and more dispersed across interpersonal skill trajectory classes for the remaining math trajectory classes. The Spearman rho rank correlation for interpersonal class conditional on math class was .17. In addition, children in the various interpersonal skill trajectory classes were dispersed across all eight math trajectory classes with little apparent relation between the two (Spearman rho = .16 for math class conditional on interpersonal class).

### Demographic and Clinical Characteristics Across Trajectory Groups

Between-group differences across trajectory classes in parent/teacher ratings of academic and behavioral functioning were examined within each area of functioning (Reading, Math, and Interpersonal Skills). As noted previously, child gender, race/ethnicity, SES, and ADHD medication status served as covariates for these analyses. Reading trajectory groups were significantly different in terms of Math *T*-score and Kindergarten (Fall) Interpersonal Skills score; all Teacher SRS and ARS subscales; parent ratings of self-control, approaches to learning, and impulsive/overactive; and percentage of children receiving special education services (see Table 3). The lowest achieving trajectory class (i.e., Class 1) was associated with the most extreme (in the negative direction) scores on most variables indicative of significantly below average academic and behavioral functioning with a significantly higher prevalence of LD diagnosis and special education services. Conversely, the highest functioning trajectory class (i.e., Class 4) obtained the most extreme (in a positive direction) scores on most variables with academic-related scores being in the average to above average range.

Math trajectory groups were significantly different regarding Reading *T*-score and Kindergarten (Fall) Interpersonal Skills score; teacher ratings of Approaches to Learning, Literacy, Math, and General Knowledge; and receipt of special education services after kindergarten (see Table 4). Trajectory groups did not differ in parent ratings or ADHD diagnosis in early elementary school. The greatest number and largest size differences were found between the lowest (Class 1) and highest (Class 8) math trajectory classes with the former including a higher percentage of children with LD, higher percentage receiving special education services, lower reading achievement score, and lower teacher ratings for academic and interpersonal skills.

Interpersonal trajectory groups were significantly different for percentage of children with LD; Reading and Math *T*-scores; all teacher ratings; parent ratings of social interaction, self-control, and impulsive/overactive behavior; and receipt of special education services after kindergarten, but not for percentage of children receiving an ADHD diagnosis in early elementary school (see Table 5). Class 1 was significantly different from the other three classes in exhibiting higher externalizing behavior (as rated by teachers), lower approaches to learning (as rated by teachers), poorer self-control (as rated by parents and teachers), poorer social interaction skills (as rated by parents), greater impulsive-overactive behavior

(as rated by parents), greater percentage of males, and higher percentage of students receiving special education services after kindergarten.

Additional analyses were conducted to evaluate whether children who demonstrated consistently low or eventual below-average performance across reading, math, and interpersonal domains differed in academic and behavioral characteristics from children who exhibited consistently average or above-average performance or showed improved performance over time in all three domains. Two groups were formed for these analyses. Low performers (13.6% of total sample) included children in Reading Classes 1 or 2 and Math Classes 1, 4, or 5 and Interpersonal Classes 1 or 3. High performers (16.9% of total sample) included children in Reading Classes 3 or 4 and Math Classes 2, 3, 6, 7, or 8 and Interpersonal Classes 2 or 4. Ethnicity, SES, and ADHD medication status served as covariates. Independent sample *t*-tests indicated that high performers received significantly lower teacher ratings of externalizing behavior at the beginning of kindergarten and obtained significantly higher ratings for approaches to learning, self-control, interpersonal skills, literacy, and math ( $p < .05$ ; see Supplementary Materials). Parents also reported high performers to be significantly less impulsive and overactive while exhibiting greater self-control and better approaches to learning ( $p < .05$ ). High performers also obtained significantly higher scores in both Reading and Math at the beginning of kindergarten ( $p < .001$ ).

## Discussion

This study is the first to identify subgroups of children with ADHD with distinct impairment trajectories in reading, mathematics, and interpersonal skills. A significant percentage of children with ADHD showed consistently below average performance (i.e., cross-temporal impairment) in Reading (39.7%), Math (39.4%), and Interpersonal Skills (23.9%). In addition, some children exhibited average performance in kindergarten followed by diminished scores and below average performance in fifth grade (i.e., gradual impairment over time) for Math (27.3%) and Interpersonal Skills (24.6%), while a smaller percentage showed initial below average performance that improved to average or above average by fifth grade (i.e., recovery from impairment over time) in Math (5.8%) and Interpersonal Skills (28.8%). Further, reading performance was highly stable over time while math performance showed more changes at least for five of eight trajectory classes. Interpersonal Skills trajectories were mixed regarding change over time with two of four trajectory classes showing improvement or decline and the other two remaining relatively stable. Thus, for children with ADHD, reading impairment appears to be readily identifiable early in elementary school with little change over time while math and interpersonal skills are somewhat more likely to vary over time.

These findings also demonstrate that functional trajectory class membership overlaps to a large degree across academic skill areas and to a much lesser extent between academic and social performance. Specifically, children with ADHD who were impaired in reading were also likely to show similar low performance levels in math. This finding is consistent with prior research indicating a significant overlap in reading and math achievement for most students (Durand et al., 2005; Hecht, Torgesen, Wagner, & Rashotte, 2001), the significant

influence of early reading skills on mathematic performance (Grimm, 2008), and the comorbidity of reading, math, and behavioral difficulties (Lin et al., 2013). Similar albeit less pronounced relationships were also evident between Math and Interpersonal Skill trajectory groups. Thus, although causal relationships cannot be inferred from dual trajectory analyses, it seems that if a child with ADHD is impaired academically, that child is highly likely (> 60% probability) to also be impaired with respect to social relationships. Alternatively, the converse is not necessarily true (i.e., if a child exhibits impaired interpersonal skills, they may or may not be impaired academically).

The risk for pervasive impairment is particularly high for poor readers. Poor reading achievement has been theorized to result in children experiencing increasingly generalized deficits in their socio-emotional adjustment (Stanovich, 1988), particularly as their lack of reading proficiency becomes evident to their peers thus leading to feelings of isolation and interpersonal hostility (Chapman, 1988). Although causal relationships cannot be established based on our correlational analyses, the obtained findings are consistent with prior work indicating a largely unidirectional pathway from reading to behavioral difficulties in the general population of U.S. schoolchildren (e.g., Lin et al., 2013; Morgan, Farkas, & Maczuga, 2012; Morgan, Farkas, Tufis, & Sperling, 2008) and indicate that poor reading may be predictive of impaired socioemotional functioning in children with ADHD.

Our findings also identified multiple correlates of trajectory class membership for all three areas of functioning while controlling for variance accounted for by child gender, ethnicity, SES, and ADHD medication status. Despite the fact that all four Reading trajectory groups were reported by teachers and parents to exhibit significant ADHD-related behaviors, there were clear differences among the groups with respect to externalizing and internalizing difficulties as well as social skills. Math trajectory groups also differed regarding demographic characteristics and behavior and academic functioning; however, these differences were not as large as found for Reading trajectory groups. In addition to displaying greater variability in mathematics achievement over time, trajectory groups were more similar in terms of initial academic and behavior functioning than were the reading achievement trajectory groups. Thus, behavioral factors may be less relevant in accounting for variability in math skill trajectories across students than for reading achievement. Further, it is possible that math achievement is more sensitive to factors that vary across schools (e.g., climate, student support) than is reading (Mandeville & Anderson, 1987). Indeed, in addition to students exhibiting heterogeneity in functioning across subject areas (as reported here), research has documented the substantial degree to which schools vary in effectiveness across subject areas (Ma, 2001).

Interpersonal skills trajectory groups also differed regarding demographic characteristics, academic abilities, and behavior. Interestingly, Class 2 exhibited improvements in teacher-rated interpersonal skills over time so it may be that having relatively adequate social behaviors at home at kindergarten entry increases the odds for improvement in school-based interpersonal skills. Conversely, children in Class 3 show a decrease in interpersonal skills over time so that they essentially trade places with children in Class 2 by fifth grade. It is unclear why this decrement is occurring. To the extent that this trajectory class is replicable, future studies should examine possible time-varying covariates (e.g., change in medication

status, family or life changes) that could account for decreased quality of interpersonal skills across time.

When examining the characteristics of children who exhibit low performance across all three domains of reading, math, and interpersonal skills throughout elementary school, it is clear that this group of students is entering kindergarten behind many of their peers with ADHD in terms of behavioral self-control, social skills, and early literacy and numeracy abilities. That is, children with ADHD who begin elementary school with the combination of significant behavioral and academic deficits are unlikely to show improvement over time even when receipt of ADHD medication and/or special education are taken into account. Conversely, children with ADHD who exhibit performance that is at least average and/or improving over time across all three areas appear more ready to learn as they enter elementary school. This finding implies that identification of children with or at-risk for ADHD should occur during the preschool years so that academic and behavioral support strategies can be implemented to reduce the degree to which students enter kindergarten behind their peers. Otherwise, existing school support and ADHD treatment strategies may not be sufficient to overcome the children's initial impairment. Research with other populations at-risk for educational difficulties (e.g., children from lower SES backgrounds) indicates that academic resilience can be promoted; however, school policies that actively limit children's experience with adversity and promote a positive school-family connection may be necessary to obtain positive outcomes (Borman & Overman, 2004).

### Limitations

Conclusions based on the obtained findings are limited by several factors. First, diagnostic status was determined solely on the basis of parent report of children having been diagnosed as ADHD by a professional. Although medical record documentation of the presence or absence of ADHD is preferable, parents have been consistently found to be valid and reliable reporters of ADHD diagnosis, symptoms, and receipt of treatment (Biederman, Faraone, Milberger, & Doyle, 1993; Biederman, Faraone, Monuteaux, & Grossbard, 2004; Bussing, Mason, Leon, & Sinha, 2003; Visser et al., 2014). Second, no information was available regarding ADHD subtype or presentation. Thus, possible differences in impairment trajectories across symptom presentation groups were not examined. Given that children with the Inattentive presentation of ADHD have been found to have lower reading, math, and spelling scores over time relative to other ADHD presentation groups (Masseti et al., 2008), this is an important direction for future studies of ADHD impairment trajectories. Third, the analytic sample included in this study was more White and affluent and less likely to have an ADHD diagnosis in early elementary school relative to the full sample of ECLS-K participants with ADHD. To the degree that SES, race/ethnicity, and ADHD diagnosis at a younger age are associated with functional impairment trajectories, it is possible that our analytic sample exhibited more positive outcomes than might be evident for the ADHD population as a whole. Alternatively, children in the analytic sample were more likely to receive medication for treatment of ADHD, to have been identified with LD, and to have an IEP. These factors may indicate more problematic academic and social outcomes for this subsample. Nevertheless, the analytic sample included children from all SES and racial/ethnic groups as well those with and without LD, ADHD medication and an IEP; thus

allowing us to examine the degree to which these characteristics were associated with academic and social trajectories. Finally, different teachers provided ratings of interpersonal skills as well as academic and behavioral functioning for each child over the course of the study. This change in instrumentation could increase measurement error; however, this is a common and unavoidable issue in the context of a longitudinal research design.

### Conclusions and Implications

The results indicated that ADHD is a heterogeneous condition in regards to academic and social impairment during early and middle childhood. Thus, it would be scientifically unjustifiable to assume a unitary effect of ADHD symptoms on school functioning. Instead, clinicians should always assess academic performance and social behavior (i.e., extend evaluation beyond measurement of symptoms). Further, it appears that reading achievement is a keystone functioning area in children with ADHD. Significant impairment in reading may be chronic in children with ADHD and is strongly linked to additional impairment in math achievement and interpersonal skills over the entire elementary school time period. Therefore, early screening and intervention for potential reading difficulties among kindergarten students with ADHD may be particularly critical. Finally, it is imperative that clinicians identify preschool-aged children with ADHD who are likely to begin kindergarten exhibiting a combination of reading, math, and social behavior impairment as these children will likely require early and ongoing academic and psychosocial intervention to increase their readiness for school as well as to increase their school functioning trajectories as they age. The need for combined treatment over time to address multiple impairments is consistent with both empirical evidence (Evans, Owens, & Bunford, 2014) and clinical practice guidelines (e.g., American Academy of Pediatrics, 2011). Future work should identify child, family, and school variables that reliably predict early and chronic cross-area impairment. It will be especially important to focus on potentially malleable factors for early screening and intervention for multiply impaired children with ADHD.

### Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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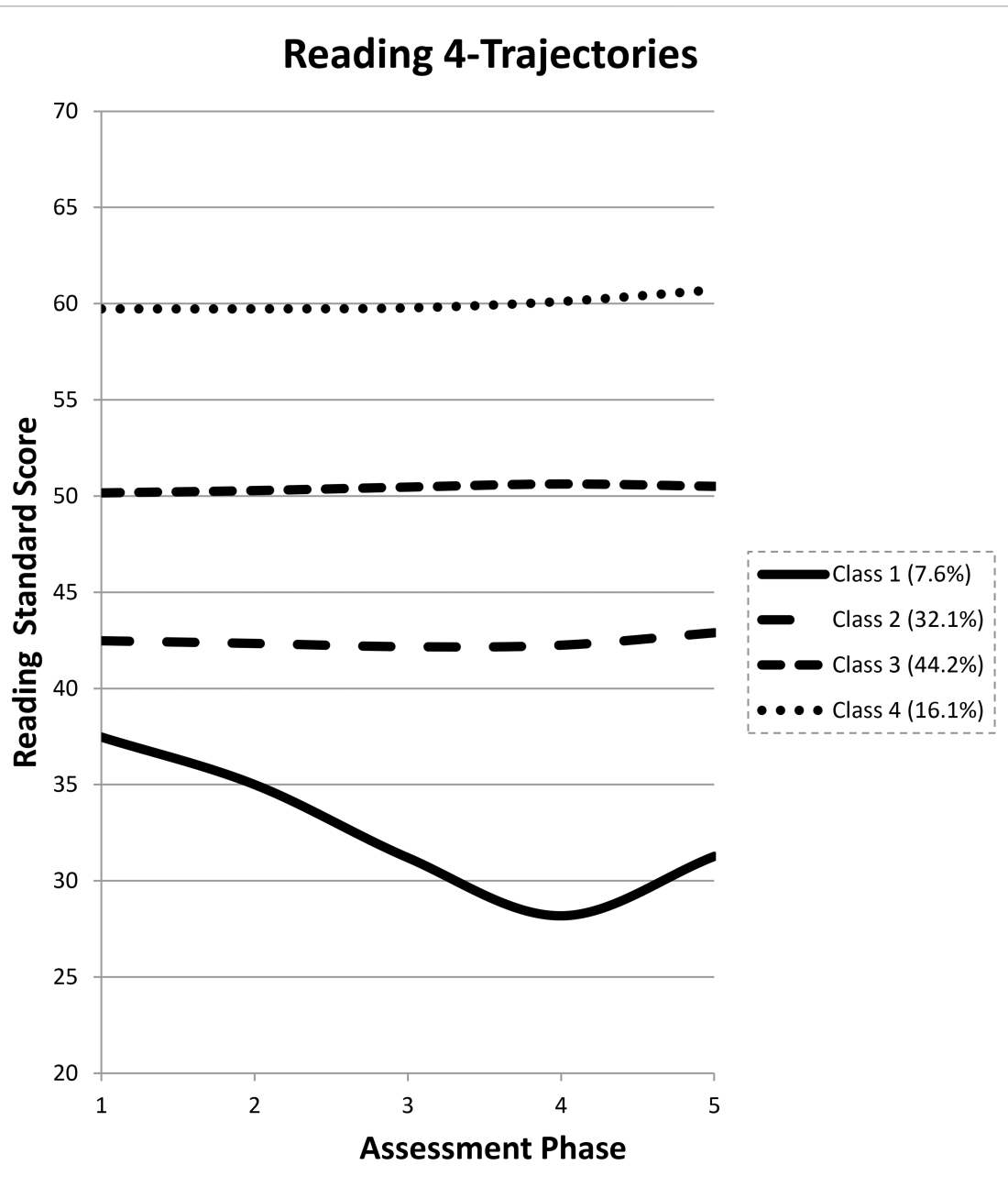
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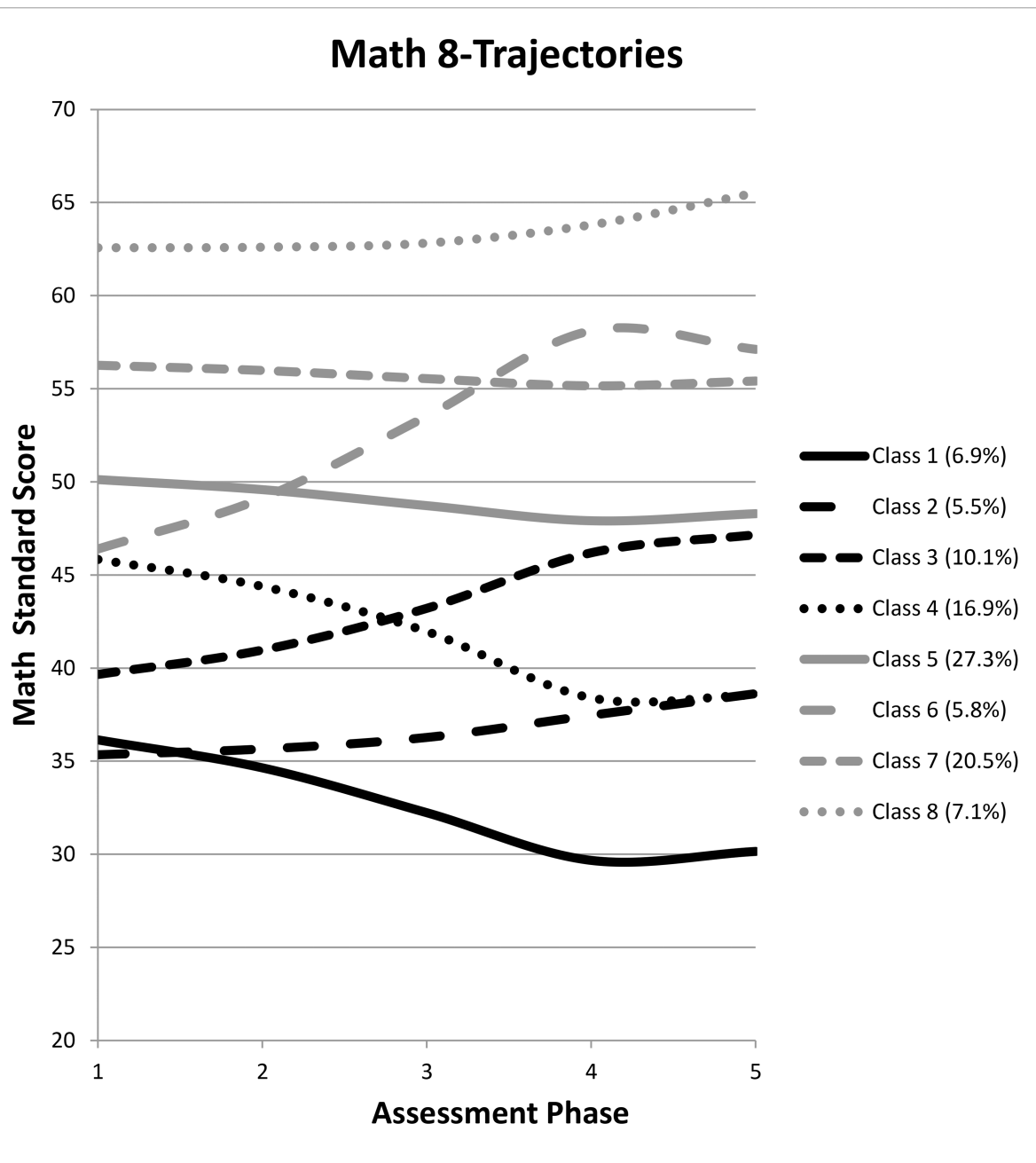
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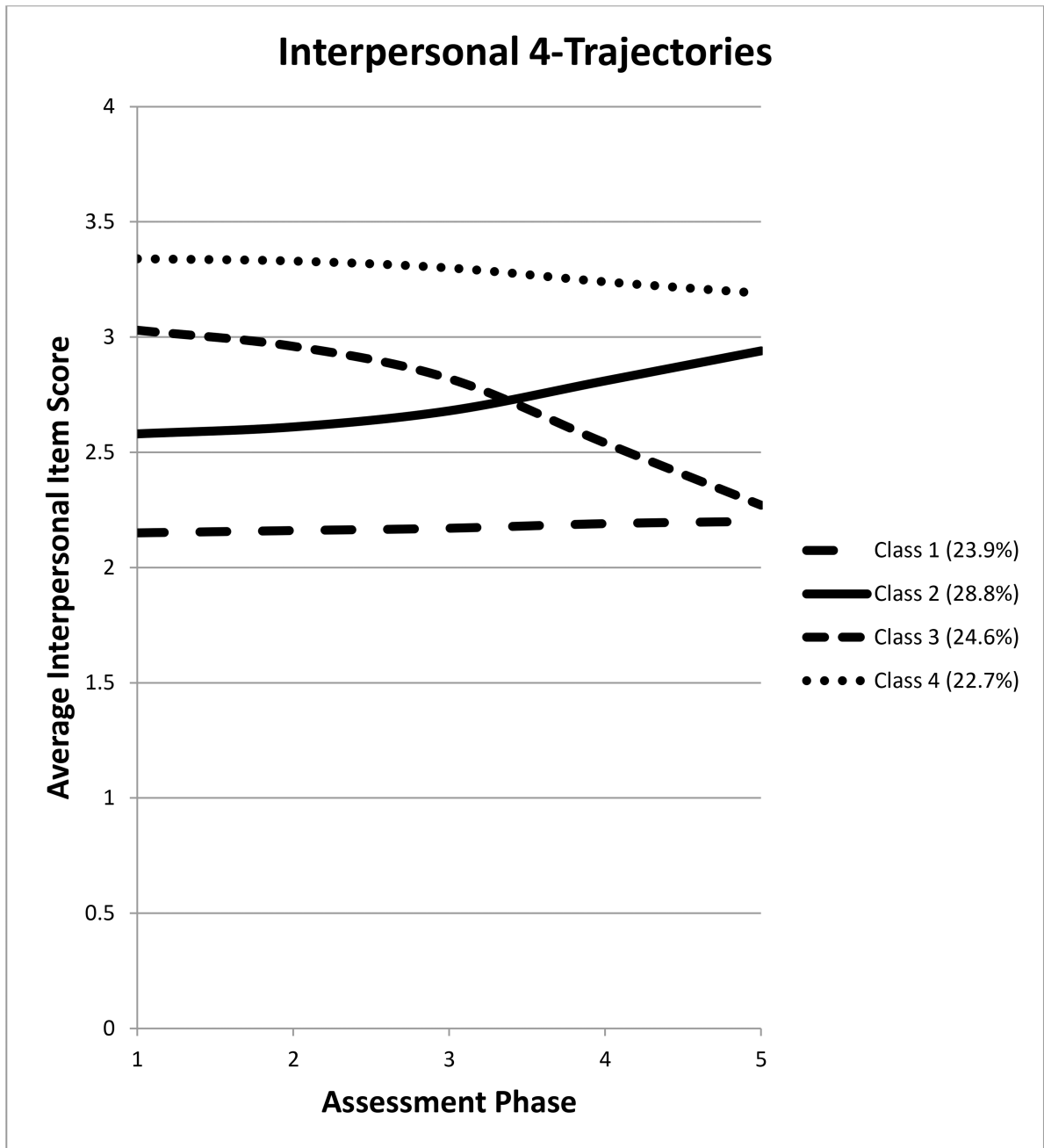
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**Figure 1.** Growth mixture model latent classes of Reading standard score trajectories for children with ADHD ( $N = 590$ ) in the Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999 (ECLS-K) sample across five assessment phases including Kindergarten (Fall), Kindergarten (Spring), 1<sup>st</sup> grade (Spring), 3<sup>rd</sup> grade (Spring), and 5<sup>th</sup> grade (Spring).



**Figure 2.** Growth mixture model latent classes of Math standard score trajectories for children with ADHD ( $N= 590$ ) in the Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999 (ECLS-K) sample across five assessment phases including Kindergarten (Fall), Kindergarten (Spring), 1<sup>st</sup> grade (Spring), 3<sup>rd</sup> grade (Spring), and 5<sup>th</sup> grade (Spring).



**Figure 3.** Growth mixture model latent classes of Interpersonal Skill score trajectories for children with ADHD ( $N = 590$ ) in the Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999 (ECLS-K) sample across five assessment phases including Kindergarten (Fall), Kindergarten (Spring), 1<sup>st</sup> grade (Spring), 3<sup>rd</sup> grade (Spring), and 5<sup>th</sup> grade (Spring).

**Table 1**

Demographic Characteristics of the ADHD Analytic and Full Samples

Demographic Characteristic	ADHD Subsample ( <i>N</i> = 590) <i>M</i> ( <i>SD</i> ) or %	Full Sample ( <i>N</i> = 1,330) <i>M</i> ( <i>SD</i> ) or %	<i>t</i> - test or $\chi^2$ Difference
Child Age at Fall Kindergarten (in months)	68.7 (4.8)	69.1 (5.1)	
Child Age at Spring of 1 <sup>st</sup> Grade (in months)	86.9 (4.7)	87.4 (5.1)	
Child Age at Spring of 3 <sup>rd</sup> Grade (in months)	111.2 (4.8)	111.5 (5.1)	
Child Age at Spring of 5 <sup>th</sup> Grade (in months)	134.8 (4.9)	135.1 (5.1)	
Socio-Economic Scale, Lowest Quintile	12.7 %	19.1%	***
Socio-Economic Scale, Second Lowest Quintile	22.5 %	23.5%	
Socio-Economic Scale, Middle Quintile	21.3 %	20.1%	
Socio-Economic Scale, Second Highest Quintile	19.7 %	19.2%	
Socio-Economic Scale, Highest Quintile	23.8 %	19.1%	*
Child is Male	72.7 %	74.5%	
Child is White	76.1 %	70.8%	*
Child is African-American	9.7 %	12.2%	
Child is Hispanic	7.5 %	10.7%	*
Child is Other Race	6.8 %	6.4%	
ADHD Diagnosis, Kindergarten or First Grade	26.4 %	42.8 %	***
Medication Use for ADHD at 5 <sup>th</sup> Grade	55.8 %	39.4 %	***
Child has Learning Disability Spring Kindergarten	1.7 %	2.0 %	
Child has Learning Disability Spring 1 <sup>st</sup> Grade	4.2 %	4.9 %	
Child has Learning Disability Spring 3 <sup>rd</sup> Grade	9.0 %	10.2 %	
Child has Learning Disability Spring 5 <sup>th</sup> Grade	16.8 %	13.0 %	*
Child has an IEP Spring Kindergarten	11.7 %	12.4 %	
Child has an IEP Spring 1 <sup>st</sup> Grade	16.6 %	17.7 %	
Child has an IEP Spring 3 <sup>rd</sup> Grade	24.4 %	24.0 %	
Child has an IEP Spring 5 <sup>th</sup> Grade	29.3 %	21.8 %	***

\*  $p < .05$ ,\*\*  $p < .01$ ,\*\*\*  $p < .001$

**Table 2**

Growth Mixture Model (GMM) Analysis of Reading, Math, and Interpersonal Skills Followed from Kindergarten to Fifth Grade: Comparison of Different GMM Models

Variable of Interest	Number of Classes	Order	BIC Growth (N = 2,920)	BIC (N = 590)
Reading T-Score	3	Linear	-9955.67	-9948.49
	4		-9868.52	-9858.93
	5		-9819.88	-9807.9
Reading T-Score	3	Quadratic	-9959.56	-9949.98
	4		-9868.37	-9855.59
	5		-9818.61	-9802.65
Interpersonal Rating	3	Linear	-2577.11	-2570.11
	4		-2565.27	-2555.94
	5		-2572.65	-2560.98
Interpersonal Rating	3	Quadratic	-2588.07	-2578.74
	4		-2576.11	-2563.67
	5		-2585.8	-2570.24
Math T-Score	5	Linear	-9655.1	-9643.1
	6		-9630.57	-9616.18
	7		-9626.85	-9610.06
	8		-9623.22	-9604.03
	9		-9619.12	-9597.53
Math T-Score	5	Quadratic	-9667.46	-9651.46
	6		-9639.52	-9620.33
	7		-9628.84	-9606.45
	8		-9630.17	-9604.58
	9		-9625.49	-9596.7

**Table 3**

## Academic and Behavioral Characteristics of the Latent Class Trajectories for Reading

	<b>Group 1 Mean or % (Std)</b>	<b>Group 2 Mean or % (Std)</b>	<b>Group 3 Mean or % (Std)</b>	<b>Group 4 Mean or % (Std)</b>
<b>Percentage of Sample</b>	7.6 %	32.1 %	44.2 %	16.1 %
<b>Teacher Behavior Ratings, Fall Kindergarten</b>				
Externalizing Problem Behaviors	2.48 (0.88) A	2.05 (0.85) BC	2.10 (0.80) B	1.86 (0.84) C
Approaches to Learning	2.12 (0.70) D	2.37 (0.68) C	2.66 (0.64) B	2.86 (0.67) A
Internalizing Problem Behaviors	1.85 (0.61) A	1.64 (0.59) B	1.63 (0.55) B	1.54 (0.58) B
Self-Control	2.44 (0.77) C	2.70 (0.73) B	2.81 (0.68) AB	2.92 (0.72) A
Interpersonal Rating	2.33 (0.73) C	2.58 (0.71) B	2.77 (0.67) A	2.89 (0.70) A
<b>Parent Ratings, Fall Kindergarten</b>				
Sad/Lonely	1.67 (0.49) A	1.64 (0.47) A	1.61 (0.44) A	1.58 (0.46) A
Self-Control	2.32 (0.66) C	2.56 (0.63) B	2.73 (0.59) A	2.76 (0.62) A
Approaches to Learning	2.99 (0.55) AB	2.89 (0.53) B	3.02 (0.50) A	3.07 (0.52) A
Social Interaction	3.22 (0.65) A	3.27 (0.62) A	3.34 (0.58) A	3.40 (0.61) A
Impulsive/Overactive	2.74 (0.89) A	2.37 (0.86) B	2.31 (0.80) B	2.33 (0.83) B
<b>Teacher Academic Ratings, Fall Kindergarten</b>				
Literacy ARS Score	1.82 (0.64) D	2.08 (0.63) C	2.48 (0.58) B	2.89 (0.60) A
Math ARS Score	1.73 (0.96) D	2.13 (0.91) C	2.56 (0.86) B	3.08 (0.89) A
General Knowledge ARS Score	1.95 (1.09) C	2.23 (1.13) C	2.74 (1.07) B	3.15 (1.04) A
<b>Achievement Test Scores, Fall Kindergarten</b>				
Math T-Score	37.98 (7.28) D	43.42 (7.05) C	51.03 (6.63) B	57.66 (6.94) A
Reading T-Score	38.85 (6.97) D	42.90 (6.74) C	50.38 (6.34) B	59.28 (6.64) A

*Note.* Means followed by the same letter within each row are not significantly different at the 0.05 level. For example, in the self-control row under the Teacher Behavior Ratings, Fall Kindergarten heading, 2.44 is significantly different from the other numbers because none of them has a C; 2.81 is not significantly different from either 2.70 or 2.92, because these have either an A or B.

**Table 4**

Academic and Behavioral Characteristics of the Latent Class Trajectories for Math

	Group 1 Mean or % (Std)	Group 2 Mean or % (Std)	Group 3 Mean or % (Std)	Group 4 Mean or % (Std)	Group 5 Mean or % (Std)	Group 6 Mean or % (Std)	Group 7 Mean or % (Std)	Group 8 Mean or % (Std)
<b>Percentage of Sample</b>	6.9 %	5.5 %	10.1 %	16.9 %	27.3 %	5.8 %	20.5 %	7.1 %
<b>Teacher Behavior Ratings, Fall Kindergarten</b>								
Externalizing Problem Behaviors	2.43 (0.87) A	2.35 (0.81) A	2.02 (0.83) B	2.01 (0.86) B	1.98 (0.76) B	2.35 (0.84) A	2.10 (0.81) B	1.90 (0.80) B
Approaches to Learning	1.98 (0.68) C	2.00 (0.64) C	2.33 (0.65) B	2.49 (0.68) B	2.72 (0.60) A	2.54 (0.66) AB	2.77 (0.64) A	2.76 (0.63) A
Internalizing Problem Behaviors	1.79 (0.60) AB	1.87 (0.56) A	1.70 (0.58) AB	1.62 (0.60) B	1.59 (0.53) B	1.75 (0.58) AB	1.58 (0.57) B	1.52 (0.55) C
Self-Control	2.44 (0.76) BC	2.39 (0.69) BC	2.76 (0.71) A	2.80 (0.74) A	2.88 (0.66) A	2.77 (0.71) AB	2.79 (0.70) A	2.75 (0.69) AB
Interpersonal Rating	2.30 (0.72) BC	2.30 (0.68) BC	2.58 (0.69) BC	2.82 (0.72) A	2.81 (0.63) A	2.64 (0.70) AB	2.74 (0.67) A	2.72 (0.66) A
<b>Parent Behavior Ratings, Fall Kindergarten</b>								
Sad/Lonely	1.63 (0.47) A	1.72 (0.46) A	1.62 (0.48) A	1.65 (0.48) A	1.61 (0.42) A	1.64 (0.46) A	1.59 (0.45) A	1.57 (0.43) A
Self-Control	2.52 (0.64) A	2.48 (0.62) A	2.48 (0.65) A	2.68 (0.65) A	2.70 (0.57) A	2.62 (0.63) A	2.71 (0.60) A	2.70 (0.59) A
Approaches to Learning	2.98 (0.54) A	2.91 (0.52) A	2.94 (0.54) A	3.00 (0.55) A	2.96 (0.48) A	3.08 (0.53) A	2.99 (0.51) A	3.09 (0.49) A
Social Interaction	3.28 (0.63) A	3.21 (0.61) A	3.32 (0.64) A	3.36 (0.64) A	3.29 (0.56) A	3.37 (0.62) A	3.30 (0.59) A	3.44 (0.57) A
Impulsive/Overactive	2.46 (0.86) AB	2.50 (0.83) AB	2.64 (0.88) A	2.37 (0.87) AB	2.25 (0.77) B	2.31 (0.84) AB	2.40 (0.81) AB	2.26 (0.78) B
<b>Teacher Academic Ratings, Fall Kindergarten</b>								
Literacy ARS Score	1.71 (0.64) C	1.89 (0.59) C	2.10 (0.61) BC	2.31 (0.65) B	2.40 (0.57) B	2.29 (0.61) B	2.70 (0.59) A	2.82 (0.58) A
Math ARS Score	1.67 (0.92) D	1.82 (0.86) D	2.02 (0.87) D	2.26 (0.97) D	2.53 (0.82) C	2.25 (0.86) CD	2.82 (0.84) B	3.23 (0.81) A
General Knowledge ARS Score	1.89 (1.13) CD	1.90 (1.03) CD	2.17 (1.04) C	2.58 (1.23) B	2.74 (1.05) AB	2.42 (1.08) B	2.97 (1.03) A	2.88 (1.01) AB
<b>Achievement Test Scores, Fall Kindergarten</b>								
Math T-Score, Fall Kindergarten	37.10 (5.34) F	35.32 (5.02) F	39.22 (5.14) E	46.16 (5.32) D	50.05 (4.71) C	45.34 (5.19) D	56.46 (5.02) B	62.15 (4.93) A
Reading T-Score, Fall Kindergarten	41.13 (7.35) E	40.38 (6.91) E	40.78 (7.07) E	47.28 (7.33) D	49.24 (6.48) C	46.14 (7.14) D	53.52 (6.91) B	59.53 (6.79) A

Note. Means followed by the same letter within each row are not significantly different at the 0.05 level. For example, for Approaches to Learning under the Teacher Behavior Ratings, Fall Kindergarten heading, 1.98 is not statistically significant from 2.00, but it is statistically significant from the other numbers in the row, because none of them has a C. Where there are two letters, each provides information. For example, in this same row, 2.54, while significantly different from 1.98 and 2.00, is not significantly different for any of the other numbers in the row, because they each have an A or B, and 2.54 has both.



**Table 5**

Academic and Behavioral Characteristics of the Latent Class Trajectories for Interpersonal Skills

	<b>Group 1 Mean or % (Std)</b>	<b>Group 2 Mean or % (Std)</b>	<b>Group 3 Mean or % (Std)</b>	<b>Group 4 Mean or % (Std)</b>
<b>Percentage of Sample</b>	23.9 %	28.8 %	24.6 %	22.7 %
<b>Teacher Behavior Ratings, Fall Kindergarten</b>				
Externalizing Problem Behaviors	2.76 (0.66) A	2.15 (0.67) B	1.84 (0.64) C	1.51 (0.67) D
Approaches to Learning	2.15 (0.57) D	2.38 (0.59) C	2.80 (0.55) B	2.95 (0.58) A
Internalizing Problem Behaviors	1.84 (0.53) A	1.72 (0.54) B	1.49 (0.51) C	1.48 (0.54) C
Self-Control	2.14 (0.52) D	2.64 (0.54) C	3.02 (0.51) B	3.32 (0.54) A
Interpersonal Rating	2.04 (0.45) D	2.44 (0.46) C	3.05 (0.43) B	3.32 (0.45) A
<b>Parent Behavior Ratings, Fall Kindergarten</b>				
Sad/Lonely	1.69 (0.44) A	1.60 (0.45) AB	1.62 (0.42) AB	1.58 (0.44) B
Self-Control	2.47 (0.58) C	2.65 (0.60) B	2.68 (0.57) AB	2.81 (0.58) A
Approaches to Learning	2.95 (0.50) A	2.94 (0.51) A	3.03 (0.48) A	3.03 (0.50) A
Social Interaction	3.19 (0.58) B	3.35 (0.59) A	3.35 (0.56) A	3.38 (0.58) A
Impulsive/Overactive	2.58 (0.79) A	2.32 (0.80) B	2.39 (0.76) B	2.16 (0.78) C
<b>Teacher Academic Ratings, Fall Kindergarten</b>				
Literacy ARS Score	2.26 (0.63) B	2.29 (0.65) B	2.45 (0.60) A	2.53 (0.64) A
Math ARS Score	2.30 (0.92) B	2.33 (0.93) B	2.57 (0.87) A	2.63 (0.93) A
General Knowledge ARS Score	2.36 (1.07) B	2.44 (1.11) B	2.74 (1.03) A	2.84 (1.05) A
<b>Achievement Test Scores, Fall Kindergarten</b>				
Math T-Score, Fall Kindergarten	47.32 (8.17) B	48.29 (8.33) B	50.36 (7.88) A	49.26 (8.28) AB
Reading T-Score, Fall Kindergarten	47.12 (8.19) C	47.93 (8.35) BC	50.01 (7.90) A	49.79 (8.30) AB

*Note.* Means followed by the same letter within each row are not significantly different at the 0.05 level. For example, for Internalizing Problem Behaviors under the Teacher Behavior Ratings, Fall Kindergarten heading, 1.84 is significantly different from 1.72, and both are significantly different from 1.49 and 1.48 with the latter two values not significantly different from each other.