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Substance Use, Substance Abuse, and LD Among Adolescents with a Childhood History of ADHD

Brooke S. G. Molina and William E. Pelham

Abstract

A clinic-referred sample of 109 children with attention-deficit/hyperactivity disorder (ADHD) was followed into adolescence for the ascertainment of alcohol and other drug use and abuse. Learning disability (reading or math) in childhood was examined as a predictor of adolescent substance use and substance use disorder for alcohol and marijuana. No statistically significant group differences for children with LD versus those without LD emerged even after using different methods to compute LD. IQ/achievement discrepancy scores were similarly not predictive of later use or abuse. However, children with ADHD who had higher IQs and higher levels of academic achievement in childhood were more likely to try cigarettes, to smoke daily, and to have their first drink of alcohol or first cigarette at an early age. Children with ADHD who had higher reading achievement scores were less likely to have later alcohol use disorder. Although these findings are necessarily preliminary, due to the small number of children interviewed, the pattern of results suggests that level of cognitive functioning—rather than discrepancy between IQ and achievement—is important for the prediction of later substance use and abuse, at least in this clinic-referred sample of children with ADHD. Further, different mechanisms of risk related to cognitive functioning may be operating for experimentation with legal drugs such as alcohol and tobacco, regular cigarette smoking, and problematic alcohol use.

Substance abuse among adolescents occurs predominantly in the context of associated psychopathologies (Bukstein, Brent, & Kaminer, 1989; Hovens, Cantwell, & Kirizkos, 1994; Rohde, Lewinsohn, & Seeley, 1996). The extent to which these psychopathologies drive or depend upon the development of drug use and abuse remains an open question. One clinical disorder that has received increased attention in recent years as a possible predictor of the development of drug abuse in adolescence is attention-deficit/hyperactivity disorder (ADHD). This interest stems primarily from the substantial overlap among features of the disorder (e.g., impulsivity), associated problems (e.g., delinquency, academic difficulties, family history of alcoholism), and known risk factors for substance use and abuse (Molina & Pelham, 1999).

Some clinic-based longitudinal studies, depending upon the age of the sample and specific substance of interest, found that children meeting research diagnostic criteria for ADHD were more likely to use or abuse drugs and alcohol in adolescence than were comparison adolescents without psychiatric disorders (Barkley, Fischer, Edelbrock, & Smallish, 1990; Gittelman, Mannuzza, Shenker, & Bonagura, 1985; Milberger, Biederman, Faraone, Chen,

& Jones, 1997). Our own clinic-based follow-up data confirmed this finding when comparing adolescents with childhood ADHD to demographically similar adolescents without ADHD (Molina & Pelham, 1999). Not surprisingly, most of these adolescents using substances or having substance abuse problems are also deviant in other ways, which are manifested as high rates of conduct disorder (CD) comorbidity (Barkley et al., 1990; Gittelman et al., 1985; Molina & Pelham, 1999). Indeed, other longitudinal studies found that children with ADHD *and* CD are likely to have more adverse outcomes than children with either disorder alone (Loeber, Brinthaup, & Green, 1990; Moffit, 1990). Our cross-sectional study of middle school children has also shown this to be the case specifically for early adolescent substance use (Molina, Smith, & Pelham, 1999). Thus, precocious adolescent substance use or substance abuse by adolescents with childhood ADHD may consist mostly of the Type II or Type B variety (Babor et al., 1992; Cloninger, 1987; Zucker, 1987), which is typically associated with early onset and delinquency or emerging antisocial behavior.

One mediator of risk for these children may exist in the domain of cognitive deficits related to learning and academic performance. Poor academic performance is a known predictor of later substance use and abuse (Holmberg, 1985; Jessor, 1976; Robins, 1980; Smith & Fogg, 1978), and delinquent adolescents are consistently found to have IQ deficits (Moffitt, 1993). In particular, children with ADHD and CD have displayed deficits on measures of verbal functioning (e.g., reading achievement, verbal IQ test performance, Moffitt & Silva, 1988). Learning disabilities (LDs), which represent one method of operationalizing academic difficulty, are frequently diagnosed among children with ADHD, although a precise estimate of the percentage of children with LD in the ADHD population has been elusive. Estimates range widely, due in large measure to the inconsistent criteria used to diagnose LD (Semrud-Clikeman et al., 1992). When more rigorous approaches, such as the regression-based formula recommended by Reynolds (1984), are used to diagnose LD, estimates of the disorder have ranged from 8% to 39% for reading LD, 12% to 30% for math LD, and 12% to 27% for spelling LD (Barkley, 1998).

There is some uncertainty regarding the extent to which LD per se might be predictive of substance use or abuse, or even more broadly with the behavioral and emotional adjustment of children later in adolescence and in young adulthood. For example, Maughan and colleagues found a trend toward higher rates of juvenile offending in both poor readers from inner London with CD and those without CD who had been diagnosed as such earlier in childhood (Maughan, Gray, & Rutter, 1985). However, at adulthood, individuals who had been poor readers as children were no more likely to have records of officially recorded offending or alcohol problems than adults without this childhood history (Maughan, Pickles, Hagell, Rutter, & Yule, 1996). These findings held for boys whose reading was below age-based expectations but consistent with IQ and for boys whose reading was below expectation based on age and IQ. Thus, although LD, operationalized as a discrepancy between intellectual ability and achievement, is a conceptually appealing and widely used construct in clinical and school settings, it is unclear whether IQ/achievement discrepancies would explain an increased risk for precocious substance use or substance abuse in adolescence by children with ADHD.

The current study examined whether LD in childhood predicted substance use and abuse in adolescence for a sample of children diagnosed with ADHD in childhood. Because of the controversies surrounding LD measurement and definition (Beitchman & Young, 1997; Reynolds, 1984), we tested the predicted relationship to substance use and abuse using four methods of defining reading and math disabilities. Reynolds (1984), who reviewed the problematic measurement issues surrounding the diagnosis of LD, recommended use of a regression-based formula that takes into account the correlation between the achievement and intellectual functioning tests, as well as the reliabilities of the measures to predict achievement from IQ. The resulting diagnosis of LD is based on a statistically significant discrepancy between the predicted and obtained achievement scores. We used this method (Method 1) to calculate disability, and we also identified those participants who had achievement scores at or below 1 standard deviation of the population mean after meeting the regression formula criteria (Method 2). Method 2 addressed concerns raised by some investigators that the LD diagnosis should only include individuals who are performing below their expected level for age or grade (Beitchman & Young). Third, we calculated LD as a simple 15-point discrepancy between the IQ and achievement standard scores (Method 3), which is a widely used clinical practice because of its ease of calculation, but which can lead to overdiagnosis (e.g., Barkley, 1998). Method 4 added to Method 3 the requirement that achievement be at or below 1 standard deviation for the population mean. Furthermore, because each of these definitions used cutoff points along a continuum of discrepancy scores, and because power is typically higher when variables are continuous rather than categorical, we also predicted substance use from the discrepancy scores calculated using Methods 1 and 3.

There is considerable controversy surrounding the use of the IQ/achievement discrepancy score model (Beitchman & Young, 1997). An assumption of such a model is that IQ has a unidirectional influence on achievement. IQ scores from this type of model also set an upper limit on the expected level of achievement (Berninger & Abbott, 1994; Siegel, 1989). Thus, rather than focus on discrepancy, other (if not most) researchers of cognitive deficits have chosen to examine the relation between performance on specific cognitive performance tests and later outcome, taking a more focused neuropsychological approach (Karniski, Levine, Clarke, Palfrey, & Melzer, 1982). For the current study, although we did not have a comprehensive neuropsychological battery of measures that allowed us to distinguish among a variety of cognitive deficits, we had childhood performance on standardized measures of IQ and achievement. We therefore were able to examine the prediction for substance use and abuse from general intellectual functioning, verbal comprehension, and achievement, with the expectation that children with ADHD who performed poorly on these measures would be at greater risk for later substance abuse.

Method

Participants

Participants were adolescents previously enrolled in a summer day-treatment program (STP) for children with ADHD who were 5 to 15 years old (Pelham et al., 1996; Pelham & Hoza, 1996). The program was a treatment option offered by the ADD Program Specialty Clinic at

the University of Pittsburgh Medical Center. Adolescents were eligible for the study if they were currently between the ages of 13 and 18 and if they met criteria from either the third revised or fourth editions of the *Diagnostic and Statistical Manual of Mental Disorders (DSM-III-R/DSM-IV)*; American Psychiatric Association, 1987, 1994) for ADHD at the time of their entry into the STP. Diagnosis of ADHD was based on parent and teacher reports of ADHD symptomatology using the Disruptive Behavior Disorders scale (DBD; Pelham, Gnagy, Greenslade, & Milich, 1992) and a structured clinical interview with clinicians at the master's or doctoral levels. Exclusionary criteria assessed at the time of the STP included an IQ of less than 80 and a history of psychotic, sexual, pervasive developmental, or organic mental disorders (see Note 1). From a pool of 195 eligible adolescents, 80% were located, and 111 participated (a 57% participation rate). To determine whether the participants represented the ADHD population from which they were recruited, we compared the interviewed adolescents to (a) those who refused and (b) those who were not located on baseline functioning measures of diagnosis from structured interviews and teacher/parent rating scales, behavior frequency counts from the STP observation schemes, IQ, and achievement. There were no statistically significant group differences for 30 comparisons among the groups, suggesting that the interviewed adolescents were representative of the target population.

At the time of follow-up, the 111 adolescents ranged in age from 13 to 18 (mean age = 15.01, $SD = 1.50$), and they were mostly male (97.3%) and Caucasian (90.1% White, 8.1% African American, 1.8% other). Socioeconomic status was diverse, with total family income before taxes ranging from under \$10,000 to \$300,000 (median = \$45,000) and parent education ranging from partial high school to graduate/professional. The adolescents' first enrollment in the STP (some participated more than once) was an average of 5.28 years ago ($SD = 2.21$), beginning in 1987 and ending in 1995. Two adolescents were interviewed for this study at the time of their first STP participation and were excluded from the longitudinal analyses, yielding a final sample of 109 adolescents.

Procedure

Adolescents and at least one of their parents participated in a one-time office-based interview. Family members were interviewed individually by research assistants and project staff. Confidentiality of information was assured as part of informed consent procedures, which included a Certificate of Confidentiality obtained from the U.S. Department of Health and Human Services. Exceptions to confidentiality included suspicion of child abuse or neglect or impending danger to self or others.

Measures

Intellectual Functioning—At the time of assessment for the STP, most children (83.8%) were administered the Wechsler Intelligence Scale for Children–Revised (WISC-R; Wechsler, 1974). The remaining children were administered the Wechsler Intelligence Scale for Children, third edition (WISC-III; Wechsler, 1991). Because of a change in clinic

¹One adolescent had a Full-Scale IQ of 65 when enrolled in the STP. However, his data were retained in the analyses because his VIQ score was in the range considered acceptable for entry into the study (VIQ = 80; PIQ = 55).

procedures beginning in 1994, seven children administered the WISC-III received estimates of Full-Scale IQ (FSIQ) from administration of the Block Design and Vocabulary subtests only (Sattler, 1992). This short form of the IQ test was chosen because the Vocabulary and Block Design subtests have excellent reliability and they correlate highly with the FSIQ (Sattler). Reliabilities (internal consistency) for the FSIQ for each test were .96 (WISC-R, source: WISC-R manual) and .96 (WISC-III, source: WISC-III manual). Half of the children (50%) were medicated (usually methylphenidate) when tested, and 72.6% of the children were tested by clinicians or educational specialists at the ADD Program Specialty Clinic. IQ scores in the sample were diverse. The mean IQ for the 109 children was 105.67 ($SD = 13.57$), and scores ranged from 65 (next highest IQ = 80) to 144.

Achievement—At the time of assessment for the STP, most children (71.2%) were administered the Woodcock-Johnson Psycho-Educational Battery achievement tests (WJ; Woodcock & Johnson, 1977) yielding the broad reading and broad math age-based standard scores used in this study. The remaining children were administered either the revised form of the same test (WJ-R; Woodcock & Johnson, 1989; 1990) or the Wechsler Individual Achievement Test screener (WIAT; Wechsler, 1992), which also provides age-based reading and math standard scores with a mean of 100 and a standard deviation of 15. Reliabilities (internal consistency) for the reading and math tests respectively, were .96 and .92 for the WJ (source: Woodcock, 1978), .95 and .95 for the WJ-R (source: Woodcock & Mather, 1989, 1990), and .92 and .89 for the WIAT (source: Wechsler, 1992). Slightly over half of the children (55.6%) were medicated when tested, and 95.4% of the children were tested by clinicians or educational specialists at the ADD Program Specialty Clinic. Achievement scores in the sample were diverse. The mean reading achievement score was 99.83 ($SD = 14.51$), and scores ranged from 60 to 133. The mean math achievement score was 100.72 ($SD = 15.08$), and scores ranged from 56 to 136. Sixteen (14.7%) of the children fell at or below a standard reading score of 85; 13 (11.9%) fell at or below a standard math score of 85; and 8 (7.3%) were in both of these groups.

Substance Use—Adolescents reported their use of alcohol, tobacco, and illicit drugs (including misuse of prescribable drugs) using a paper-and-pencil questionnaire administered during the interview. The measure, developed by the first author, included some original and adapted items from existing questionnaires, including the National Household Survey on Drug Abuse (1992), Health Behavior Questionnaire (Jessor, Donovan, & Costa, 1989), the Teen Drinking Questionnaire (Donovan, 1994), and items written by Chassin and Barrera (1987). To encourage truthful responding, adolescents verbally provided answers to the interviewer for initial “screening” questions about substance use. The remaining questions were read aloud by the interviewer, but adolescents recorded their answers on their own separate paper-and-pencil copy, which they gave to the interviewer after sealing the completed form in an envelope. Lifetime substance use variables for analysis included the following:

1. “ever had a drink of alcohol”
2. “ever drunk from alcohol”
3. “ever tried a cigarette”

4. “ever smoked cigarettes daily”
5. “ever used smokeless tobacco”
6. “ever tried marijuana”
7. “ever tried inhalants, cocaine, hallucinogens, heroin, sedatives/barbiturates, or stimulants”

Current use (in the past 6 months) included frequency of five or more drinks, average daily quantity of cigarette use, and frequency of marijuana use. Adolescents also reported the age at which they first drank alcohol (more than a sip), were drunk, tried cigarettes, began daily smoking, and tried marijuana. Alcohol and marijuana use disorders were assessed with a fully structured version of the Structured Clinical Interview for *DSM-IV*, Non-Patient Edition (SCID-NP; First, Spitzer, Gibbon, & Williams, 1996) substance use modules that were adapted for adolescents by Martin and colleagues (Martin et al., 1995). Two life-time variables were calculated for both substances: a symptom score that summed responses (0, 1, 2) across items and a disorder score (no disorder vs. *DSM-IV* abuse or dependence). Power transformations were used to reduce skewness and kurtosis in the current marijuana use and lifetime symptom score variables.

Calculating LD and IQ/Achievement Discrepancy Scores

For the current study, LD for reading or math was calculated using four methods:

1. the regression formula method recommended by Reynolds (1984),
2. the regression formula method plus the requirement that achievement be at or below a standard score of 85,
3. the simple difference method requiring an achievement standard score at least 15 points below the FSIQ, and
4. the simple difference method plus the requirement that achievement be at or below a standard score of 85.

Four IQ/achievement test combinations were possible in our dataset: WISC-R/WJ (71 % of the children had this combination); WISC-R/WJ-R (13%); WISC-III/WJ-R (8%); and WISC-III/WIAT (8%). In addition to the internal consistency reliabilities reported previously, the following IQ/achievement correlations were used for the regression formula calculations of LD:

- .61 /.60 for WJ reading/math with WISC-R FSIQ (McGrew, Werder, & Woodcock, 1991, averaged across estimates from third and fifth graders)
- .66/.71 for WJ-R reading/math with WISC-R FSIQ (same source)
- .54/.73 for WJ-R reading/math with WISC-III FSIQ (unpublished data provided by Riverside Publishing Company, April 1999)
- .57/.72 for WIAT reading/math with WISC-III (WIAT manual, 1992).

Two continuous IQ/achievement (discrepancy) scores were used to represent the underlying continuum of discrepancy between achievement and intellectual functioning and to increase

the power to test the association between IQ/achievement discrepancy and substance use. One variable used the difference between the actual achievement score received and the achievement score predicted from IQ (Reynolds, 1984). The variable for analysis was the maximum of the differences across math and reading discrepancies, with higher scores meaning predicted achievement was higher than actual achievement. The second variable for analysis was the difference between the IQ and achievement scores, with higher scores indicating an IQ higher than achievement. Again, the maximum discrepancy across math and reading was used.

Results

Percentages of Children with LD

Table 1 shows the percentages of children in the sample meeting criteria for reading LD, math LD, or either, using one of the four different formulas for calculating the disorder. The highest estimate of disability was obtained using the simple difference method. The lowest estimates of disability (about 11% for either reading or math LD) were obtained when achievement scores were required to be less than or equal to a standard score of 85. Eleven children (10.1%) met criteria for reading or math LD regardless of the formula used (all of the children meeting Method 2 criteria and all but one of the children meeting Method 4 criteria). These rates of LD are quite similar to those reported for another referred sample of children with disruptive behavior disorders that used the regression and simple IQ/achievement methods for calculating LD (Frick et al., 1991).

Relationship Between Childhood LD and Adolescent Substance Use

Two types of analyses were conducted to examine the relationship between LD (either reading or math disability) in childhood and substance use or substance use disorder in adolescence. One-way analyses of variance (ANOVAs), with LD as the independent variable and substance use as the dependent variable, were conducted for the five continuous measures of substance use (frequency of five or more drinks in the past 6 months, alcohol symptom score, average daily quantity of cigarettes used in the past 6 months, frequency of marijuana use in the past 6 months, and marijuana symptom score). Two-by-two chi-square tests (LD in Childhood $\times$ Substance Use/SUD) were conducted for the nine remaining measures of substance use that were dichotomous (e.g., "ever tried cigarettes"). These analyses were first conducted using the regression formula definition of LD (Method 1) and were repeated using each of the remaining three methods for calculating LD. Results from the analyses using Method 1 are displayed in Table 2.

No statistically significant differences between the children with LD and without LD in childhood were found for any of the substance use variables. Only two differences approached conventional levels of statistical significance: Children with LD were slightly *less* likely to drink heavily (five or more drinks) in adolescence ($p = .12$), and they were slightly more likely to have tried cigarettes ($p = .12$). The magnitude of effect for both of these findings was small ($\eta^2 = .02$). In contrast, with a possible exception of other illicit drug use, there was a striking absence of differences between the groups. When analyses were repeated using the alternative definitions of LD (Methods 2–4), findings were generally

similar, with slight shifting of the statistical significance level up or down. For example, using the simple IQ/achievement difference method for calculating LD (Method 3), it was found that children with LD were slightly more likely to try cigarettes than children without LD—68.6% LD versus 49.3% nonLD, $\chi^2(1, N = 102) = 3.55, p < .06$. However, the differences in the percentages of children with and without LD who reported smoking daily in their lifetime did not approach statistical significance (29.9% of nonLD versus 28.6% of LD).

Relationship Between Childhood LD and Age of First Drug Use

ANOVAs were used to examine the association between LD status in childhood and age of first use of alcohol, tobacco, and marijuana. The results are shown in Table 3, where it can be readily seen that the numbers of children available for analysis (particularly users with LD) were quite small, so findings should be interpreted with this in mind. Using Method 1, we found that children with LD reported a later age of first cigarette use than did children without LD ($p < .05$); $\eta^2 = .09$, which is about a medium effect size. The other group differences were in the same direction but—not surprisingly, given the small numbers of children available for analysis—were nonsignificant. When we repeated the analyses using the remaining methods for calculating LD (Methods 2–4), the findings were similar. The means were in the direction, although the significance level shifted toward nonsignificance ($p = .10$ for Method 2, $p = .13$ for Method 3, $p = .06$ for Method 4).

Relationship Between Continuous Measures of LD and Adolescent Substance Use

Correlations were used to test the association between the discrepancy scores and substance use. One-way ANOVAs were used to compare the mean discrepancy scores between the adolescents who had positive and negative answers for the dichotomous substance use variables (e.g., had never tried cigarettes versus had tried them). Findings paralleled those obtained using the categorical definitions of LD. With the possible exception of two marginally significant results obtained when using the simple IQ minus achievement score, children who had smoked a cigarette had higher discrepancy scores, $F(1, 100) = 2.10, p = .15$; and children who had tried marijuana had higher discrepancy scores, $F(1, 107) = 2.12, p = .15$, but none of the associations between the discrepancy scores and substance use (lifetime or current) met conventional levels of statistical significance.

Relationship Between Adolescent Substance Use and IQ and Achievement

Correlations and regression analyses (ordinary least squares for continuous substance use variables; logistic regression for dichotomous substance use variables) were used to examine the bivariate and unique relations between IQ, reading scores, math scores, and substance use in adolescence. These correlations are presented in Table 4.

Most correlations were not statistically significant. However, children with higher IQs were slightly less likely to be heavy drinkers in adolescence, and children who had higher reading achievement scores were significantly less likely to meet the criteria for an alcohol disorder. Conversely, higher IQ was associated with increased likelihood of trying cigarettes, and all three IQ/achievement variables were marginally and positively associated with daily

cigarette smoking. That is, children with higher IQs and higher achievement scores were slightly more likely to smoke cigarettes daily in adolescence.

Table 5 shows the correlations between IQ/achievement and age of first use of alcohol, tobacco, and marijuana. The associations between IQ/achievement and age of first use were generally negative in direction, suggesting that higher functioning children were likely to try alcohol, tobacco, and marijuana at an earlier age. These associations were statistically significant only for the prediction from achievement to age when cigarettes were first tried.

A small number of adolescents reported ages of first substance use that were prior to (or by) the age at which they had enrolled in the STP (see Note 2). The correlational analyses discussed previously were repeated only for those children who had used the particular substance of interest *after* their first STP; thus, analyses were limited to only those children for whom IQ and achievement data were collected prior to use of substances. Interestingly, the magnitude of the correlations between IQ/achievement and the age of first drink, age of first cigarette use and age of first marijuana use increased. In particular, in addition to the findings above, children with higher IQs had their first drink of alcohol at an earlier age, and they were slightly more likely to try marijuana at an earlier age. Children with higher reading achievement scores were slightly more likely to have their first drink at an earlier age, and children with higher math scores were slightly more likely to try marijuana at an earlier age. In summary, higher performance on IQ and achievement in childhood associated with earlier experimentation with alcohol and cigarettes and somewhat associated with marijuana use. These associations were not apparent for drunkenness and daily use of cigarettes.

The correlational analysis results were replicated for most effects of IQ/achievement on substance use and abuse when IQ, reading achievement, and math achievement were simultaneously entered into regression equations to predict use, abuse, or age of first use. Because of the strong association between reading and math scores, in some instances these effects lost their predictive significance even though they had been statistically or marginally significant in correlational analyses. However, when tested separately with IQ, the correlational analyses were replicated, suggesting overlap in prediction from reading and math scores but not between IQ and achievement. Variance inflation factors were always below three, suggesting no substantial statistical problems with multicollinearity. One exception to this pattern of findings was noted for the prediction of age of first drink from IQ/achievement where higher IQ and reading scores were associated with earlier age of first drink, but higher reading achievement associated with a later age of first drink. Each of these effects reached only marginal levels of statistical significance.

Because there is evidence that verbal IQ deficits may be particularly prominent for children with both ADHD and delinquent behavior, we examined the prediction of the substance use variables from the Verbal Comprehension Index (VCI; mean of Information, Similarities, Vocabulary, and Comprehension subscale scores; Wechsler, 1991). The VCI was highly

²The mean age at follow-up was compared using an ANOVA for those children who had and had not used substances by their first STP. There were no statistically significant differences.

correlated with the FSIQ ($r = .84$). Not surprisingly, all correlations between childhood VCI and later substance use were similar to those obtained using the FSIQ, with the exception of the following: $r = .13$, *ns*, for “ever tried a cigarette”; $r = .26$, $p < .05$ for “ever smoked daily”; $r = .29$, $p < .01$ for “average daily quantity in the past 6 months.”

Discussion

This study was the first to examine performance on standardized IQ and achievement tests as predictors of later adolescent substance use and abuse in children with ADHD. The results suggest that IQ/achievement discrepancies per se do not predict adolescent substance use or abuse for children with ADHD. There was a clear absence of effects across four methods for computing LD, even when continuous variables were used that represented the underlying discrepancy score continua. In fact, if any conclusions from our data are to be drawn about prediction to substance use from LD, it would be that ADHD children *without* LD are more likely to try cigarettes at an early age.

Our findings also suggested that more predictive power may be gained by the use of IQ and achievement scores per se instead of adherence to the discrepancy score model. The children with ADHD who had higher IQs were more likely to try cigarettes by the time of their follow-up interview in adolescence and to have their first drink of alcohol at an early age; those children with better verbal comprehension ability were more likely to smoke daily and more heavily, and those children with higher achievement scores were more likely to try cigarettes at an early age. In contrast, better readers were less likely to have an alcohol disorder, suggesting that higher cognitive functioning among children with ADHD may operate differentially regarding the development of sustained tobacco and alcohol use.

Other research groups have reported positive associations between cognitive performance variables and substance use. Fleming, Kellam, and Brown (1982) reported that for an inner city sample of African American children (the well-known Woodlawn Study in Chicago), higher reading readiness and IQ predicted earlier and more frequent use of alcohol in adolescence. Kandel and Davies (1991) also reported that higher IQ predicted higher lifetime cocaine use in young adults ages 19 to 26 years in a national probability sample. At least for adolescence, taken together, these findings might suggest a pathway for at-risk children whereby greater intellectual capacity and performance lead to more rapid experimentation with “grown-up” behaviors such as cigarette smoking and alcohol use. Another possibility, given the particular characteristics of our sample and the well-established peer relationship difficulties among children with ADHD, is that cigarette smoking is used as a means of identifying with peers. Other research with adolescent schoolchildren has shown this to happen (Ennett & Bauman, 1994). Finally, interest has risen rapidly in the potential for children with ADHD to become addicted to tobacco because of the stimulant properties of the drug. We can only speculate that our adolescents who smoked and who, on average, had higher IQ scores in childhood, were aware of this possibility and chose to use because of it. It is most likely that a combination of these pathways were involved.

In contrast, alcohol disorder occurred less often among children with higher reading achievement scores in childhood. The prediction for alcohol disorder from the VCI was also in the negative direction but was nonsignificant. This finding is in line with Moffit and Silva's (1988) report that verbal deficits in particular are associated with comorbidity of ADD and delinquency, and it is also in line with the theories of Hirschi and Hindelang (1977) and Buikhuisen (1987) that verbal learning deficits lead to antisocial behavior through school failure. We recently reported our finding that for this sample the highest rates of alcohol use disorder were among those adolescents who also met diagnostic criteria for conduct disorder in adolescence. In sharp contrast, rates of daily smoking were high, whether or not CD had developed (Molina & Pelham, 1999). Thus, at least in our sample, delinquency comorbidity was more strongly associated with the development of problematic alcohol use, such as that leading to arguments with parents and peers or a drop in school grades, than it was with cigarette smoking. In addition to highlighting the importance of testing differential concomitants and predictors of these substances, our findings suggest that the development of alcohol problems in children with ADHD may be explained in part by failure to perform in settings requiring adequate verbal skill development. This skill deficit is probably part of a broad network of interrelated factors such as parental education and resourcefulness, interventions used by the schools to respond to reading deficits, success in the school domain, and gravitation toward deviant activities and away from conventional ones. In contrast, cigarette use may be affected by other variables such as peer smoking, differential physiologic responsiveness to tobacco, and parental modeling of smoking. We did not examine whether indicators of actual academic performance in school (such as grades), which would be affected by specific language deficits as well as ADHD core symptomatology, mediated the link between verbal skill deficits and alcohol disorder. Such a finding would lend further support to the school failure hypothesis.

Several caveats regarding our findings are in order. Our study used global measures of reading and math achievement. Thus, our ability to pin-point the specific deficits involved in the risk toward substance use for our probands is necessarily limited. However, our finding that IQ and achievement bore unique predictive relations with substance use when used as simultaneous predictors suggests that each of these measures may capture unique, nonoverlapping elements of cognitive functioning. Second, our sample size of 111 adolescents with childhood ADHD, while moderately large in relation to other well-known follow-up studies of children with ADHD (Barkley et al., 1990; Gittelman et al., 1985), limited our power to test LD/nonLD differences in substance use. We were therefore quite liberal in our reporting of marginal and conventionally statistically significant effects so as to discern patterns in the data for study with larger samples. That said, the dramatic absence of patterns in the data with regard to prediction from discrepancy scores leads us to believe that the discrepancy score model is not useful for explaining substance use risk. In general this finding is not new, as other investigators have been led to draw similar conclusions (Fletcher, Francis, Rourke, Shaywitz, & Shaywitz, 1993). Finally, and perhaps most importantly, our study of prediction to substance use and abuse from cognitive performance variables was conducted within a clinic-based sample of children with ADHD rather than with a community or epidemiologic sample comparing delinquents and nondelinquents. Thus, our study cannot lead to conclusions about the extent to which IQ and achievement explain

substance use or abuse in the general child and adolescent population. Instead, we have noted some consistencies between our findings and those reported by others studying more representative populations, and we encourage further research to confirm our results.

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AUTHORS' NOTES

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Biographies

Brooke S. G. Molina, PhD, is an assistant professor of psychiatry at the University of Pittsburgh, School of Medicine. Her current research interests include the etiology and treatment of adolescent and young adult substance abuse and psychopathology.

William E. Pelham, PhD, is a professor of psychology and director of clinical training at the State University of New York at Buffalo. His interests are in the development and treatment of ADHD.

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TABLE 1

Percentages of Children with ADHD Who Met Discrepancy Formula Criteria for LD

Discrepancy formula	Reading LD (%)	Math LD (%)	Reading or math LD
Method 1: Regression formula	13.8	9.2	17.4
Method 2: Regression formula & achievement 85	7.3	6.4	10.1
Method 3: IQ minus achievement 15	27.5	21.1	33.0
Method 4: IQ minus achievements 15 and achievement 85	8.3	6.4	11.0

Note. N = 109.

TABLE 2

Relationship Between Regression Formula for LD (Reading or Math) in Children and Substance Use or Substance Use Disorder in Adolescence

Type of substance use	% or mean (<i>SD</i>)		χ^2 or <i>F</i>	<i>p</i>
	nonLD	LD		
Ever had a drink of alcohol (more than just a sip)	50.0%	42.1%	.39	.53
Ever drunk	32.2%	26.3%	.26	.61
Frequency of five or more drinks in the past 6 months	1.66 (1.37)	1.16 (.50)	2.48	.12
Alcohol symptom score	1.92 (4.10)	1.16 (2.71)	.58	.45
Alcohol disorder	11.1%	10.5%	.01	.94
Ever tried a cigarette	52.4%	72.2%	2.46	.12
Ever smoked cigarettes daily	29.8%	27.8%	.03	.87
Average daily quantity of cigarette use in the past 6 months	1.43 (.81)	1.61 (1.14)	.64	.43
Ever tried smokeless tobacco	41.7%	33.3%	.44	.51
Ever tried marijuana	32.2%	21.1%	.98	.32
Frequency of marijuana use in the past 6 months	2.03 (2.25)	1.74 (2.23)	1.23	.27
Marijuana symptom score	1.90 (5.51)	.95 (2.91)	.50	.48
Marijuana disorder	13.3%	10.5%	.12	.73
Ever used any other illicit drug	22.2%	10.5%	1.51	.22

Note. *n* = 90 nonLD children; *n* = 19 children with LD. Means and standard deviations for all variables are presented in the original metric. The nonLD and LD groups were not significantly different in age at follow-up.

TABLE 3

Relationship Between Regression Formula for LD (Reading or Math) in Childhood and Age of First Substance Use

First substance use	Mean age at first use (<i>SD</i>)		<i>F</i>	<i>p</i>
	nonLD	LD		
Drink	13.00 (2.49) <i>n</i> = 45	12.38 (2.13) <i>n</i> = 8	.45	.51
Drunk	13.34 (2.66) <i>n</i> = 29	14.40 (1.67) <i>n</i> = 5	.72	.40
Tried cigarettes	10.51 (2.25) <i>n</i> = 43	12.23 (2.86) <i>n</i> = 13	5.12	.03
Smoked daily	12.72 (2.07) <i>n</i> = 25	13.60 (1.14) <i>n</i> = 5	.84	.37
Tried marijuana	13.70 (1.66) <i>n</i> = 27	14.25 (.96) <i>n</i> = 4	.41	.53

Note. *n* = 90 nonLD children; *n* = 19 children with LD. The nonLD and LD groups were not significantly different in age at follow-up.

TABLE 4

Correlations Between Adolescent Substance Use and Childhood IQ and Reading and Math Achievement Scores

Type of substance use	IQ	Reading	Math
Ever had a drink of alcohol (more than just a sip)	.10	.08	.14
Ever drunk	-.05	-.10	-.05
Frequency of 5 or more drinks in the past 6 months	-.16 [*]	.02	-.06
Alcohol symptom score	-.02	-.05	.04
Alcohol disorder	-.10	-.21 ^{**}	-.08
Ever tried a cigarette	.20 ^{**}	.04	.13
Ever smoked cigarettes daily	.19 [*]	.18 [*]	.18 [*]
Average daily quantity of cigarette use in the past 6 months	.14	.10	.10
Ever tried smokeless tobacco	.17	.06	.05
Ever tried marijuana	-.03	.06	.07
Frequency of marijuana use in the past 6 months	.06	.09	.06
Marijuana symptom score	.01	-.05	.02
Marijuana disorder	.10	-.01	.06
Ever used any other illicit drug	.11	.13	.13

Note. Correlations among IQ and achievement were IQ/reading = .41***, IQ/math = .64***, reading/math = .67***.

^{*}
 $p < .10$.

^{**}
 $p < .05$.

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

TABLE 5

Correlations Between Age of First Substance Use and Childhood IQ and Reading and Math Achievement Scores

Age of first substance use	IQ	Reading	Math	<i>n</i>
All adolescents who had used				
First drink	-.22	-.21	-.03	53
First drunk	-.14	-.16	-.09	34
First tried cigarettes	-.09	-.36***	-.34***	56
First smoked daily	.02	.01	-.15	30
First tried marijuana	-.20	-.13	-.29	31
Adolescents who had used after their first STP				
First drink	-.31**	-.27*	-.10	46
First drunk	-.16	-.09	-.05	29
First tried cigarettes	-.21	-.44***	-.40**	39
First smoked daily	.03	.02	-.10	28
First tried marijuana	-.34*	-.15	-.36*	26

Note. Correlations among IQ and achievement were IQ/reading = .41***, IQ/math = .64***, reading/math = .67***. STP = summer day-treatment program.

*
 $p < .10$.

**
 $p < .05$.

 $p < .01$.