# Evaluation of Underlying Mechanisms in the Link Between Childhood ADHD Symptoms and Risk for Early Initiation of Substance Use

Michael L. Vitulano University of Tennessee Paula J. Fite University of Kansas

Derek R. Hopko University of Tennessee John Lochman University of Alabama

Karen Wells Duke University School of Medicine Irfan Asif University of Tennessee Graduate School of Medicine

Although there has been support for attention-deficit/hyperactivity disorder (ADHD) as a risk for early substance use, this link is not fully established or understood. Furthermore, the potential mechanisms explaining these associations are unclear. The current study examined peer rejection, school bonding, and internalizing problems as potential mediators of the association between childhood ADHD symptoms and risk for early initiation of substance use. The sample included a control group of 126 students with problematic aggression (79% African American, 66% male) from an intervention study following children from fourth to ninth grade. Results suggested that ADHD symptoms follow a path to early initiation of tobacco use through the combined effects of peer rejection and internalizing problems as well as through internalizing problems alone. ADHD symptoms were also associated with the cubic slope of marijuana use initiation, such that increased ADHD symptoms were associated with a strong cubic trend (e.g., a more rapid acceleration of risk for initiation). ADHD symptoms were not associated with risk for early initiation of alcohol use. Identification of important vulnerability factors in children with ADHD symptoms highlight the need for primary prevention and psychological interventions that target these factors and decrease the likelihood of early tobacco and marijuana use initiation.

Keywords: ADHD, substance use, internalizing

One of the most common behavioral disorders in children and adolescents is attention-deficit/hyperactivity disorder (ADHD), with prevalence rates between 3% and 7% (APA, 2000). ADHD symptoms are associated with significant functional impairment, including peer difficulties (Hoza et al., 2005), academic underachievement (Loe & Feldman, 2007), internalizing problems that include depression and anxiety (Ostrander & Herman, 2006), and deficient rule-governed behavior (Barkley, 2006). One of the most concerning issues associated with ADHD symptoms is the risk for early substance use (Molina & Pelham, 2003), which often persists into adulthood and often progresses into substance use disorders (Biederman et al., 1995). Although

the link between ADHD symptoms and substance use has been supported, controversy still exists (De Sanctis et al., 2008) and there is little research on developmental pathways explaining increased risk of substance use.

Examination of potential mediating mechanisms in the risk for early substance use is essential toward better understanding the development of ADHD, and critical to the development and refinement of effective behavioral interventions (Ferguson, 2000). Potential mediators of this developmental risk may include academic attitudes and peer relations, as both are associated with symptoms of ADHD and are precursors to substance use (Hawkins, Catalano & Miller, 1992; Flory, Malone, & Lamis, 2011). Although these are similar and likely related constructs, examining their differential associations with ADHD and future impairments may provide useful areas of intervention for reducing the risk for substance use. Another potential mediator is internalizing problems, based on high comorbidity rates among ADHD symptoms, depression, anxiety, and substance use disorders (e.g., Fischer et al., 2002). Accordingly, the primary aim of this study was to use survival analyses to examine the role of school bonding attitudes, peer rejection, and internalizing problem in the development of ADHD symptoms to risk for early initiation of substance use (tobacco, alcohol and marijuana) from fourth to ninth grade.

Michael L. Vitulano, Department of Psychology, University of Tennessee; Paula J. Fite, Department of Psychology, University of Kansas; Derek R. Hopko, Department of Psychology, University of Tennessee; John Lochman, Department of Psychology, University of Alabama; Karen Wells, Department of Psychiatry and Behavioral Sciences, Duke University School of Medicine; Irfan Asif, Department of Family Medicine, University of Tennessee Graduate School of Medicine.

Correspondence concerning this article should be addressed to Michael Vitulano, Austin Peay Builidng, University of Tennessee, Knoxville, TN 37996. E-mail: mvitulan@vols.utk.edu

## **ADHD** and Substance Use

ADHD has been linked to risk for early initiation of substance use and subsequent substance use disorders (Biederman et al., 1995; Elkins, McGue, & Iacono, 2007; Molina & Pelham, 2003), particularly nicotine (Milberger et al., 1997; Pomerleau et al., 2003). The link between ADHD and substance use is hypothesized to follow a general developmental pathway in which ADHD symptoms emerge initially, followed by less severe behavioral problems and then more severe conduct problems that include substance use (Waschbusch, 2002). Due to overlap with such behavioral problems, there is debate whether the risk for substance use in ADHD is primarily accounted for by other diagnoses such as conduct disorder. In particular, other factors in childhood have been found to predict adolescent substance use independent of ADHD, such as maltreatment (De Sanctis, et al., 2008) and conduct disorder (Brook, Brook, Zhang, & Koppel, 2010). Although evidence is mixed on the issue (Lynskey & Hall, 2001; Thompson, Riggs, Mikulich, & Crowley, 1996), ADHD symptoms may in fact account for significant incremental variance in predicting substance use and substance dependence beyond that accounted for by conduct disorder, including tobacco, alcohol, marijuana, and other illicit drug use (Flory, Milich, Lynam, Leukefeld, & Clayton, 2003). However, further evidence is needed to better conceptualize the unique associations of ADHD in substance use.

## School Bonding Attitudes as a Potential Mediator

Children with ADHD are likely to experience poorer academic performance, which may be a function of associated neurocognitive deficits (Diamantopoulou, Rydell, Thorell, & Bohlin, 2007; Langberg et al., 2011). In addition to increased conflict in school, students with ADHD symptoms demonstrate less academic engagement compared with their peers (Vile Junod, DuPaul, Jitendra, Volpe, & Cleary, 2006). As such, school adjustment may mediate the link between ADHD symptoms and substance use (Flory et al., 2011). That is, as suggested by social control theory (Hirschi, 1969), an individual failing to bond to conventional society (i.e., attachment in social relationships, commitment to educational goals, involvement in conventional activities, belief in social rules) is vulnerable to delinquency. Thus, less commitment to school-related activities may be related to aberrant behavior that includes substance use (Hawkins et al., 1992).

Individuals who fail to thrive in school and become disengaged from prosocial peer groups are more likely to involve themselves with antisocial peers and become socialized to engage in deviant behavior such as substance use (Dishion, Patterson, Stoolmiller, & Skinner, 1991). In adolescence, substance use is predicted by poor academic achievement and other stressful life events, supporting its coping function for teens (Bryant, Schulenberg, O'Malley, Bachman, & Johnston, 2003; Newcomb & Harlow, 1986). Thus, ADHD symptoms may result in poor school bonding (attitude/commitment toward school), which in turn may be associated with increased risk of substance use (e.g., as a coping mechanism).

## Peer Rejection as a Potential Mediator

As noted above, impairment in social skills is another prominent feature associated with ADHD symptoms (Molina et al., 2009).

Given the impulsive, disruptive, and distractible behaviors of ADHD, children with ADHD often struggle to form friendships, evidenced by fewer close friendships and greater peer rejection (Bagwell, Molina, Pelham, & Hoza, 2001; Hoza, 2007). For example, children with ADHD are rated lower on social preference, disliked by children of higher status, and over 50% are rejected by peers (Hoza et al., 2005). In turn, peer rejection, peer isolation, and low social competence are risk factors for early substance use (Hawkins et al., 1992; Lochman, Wells, & Murray, 2007). For example, in a study of fourth graders, rejected children had higher rates of substance use 5 years later (Ollendick, Weist, Borden, & Geene, 1992). Similar findings occurred in a diverse sample of fifth graders, where rejected children were more likely than average or popular children to engage in delinquency, including substance use, 7 years later (Kupersmidt & Coie, 1990). Rejection by peers may result in decreased investment and motivation to pursue and develop adaptive relationships with teachers, parents, and other children due to low perceived social competence (Lochman et al., 2007). Additionally, early peer problems may lead to later involvement with deviant peers and increase vulnerability to negative peer influences for conduct problems and substance use (Fergusson, Woodward, & Horwood, 1999). Thus, peer rejection may partially account for the link between ADHD symptoms and risk for early substance use initiation.

# **Internalizing Problems as a Potential Mediator**

Although an association between ADHD symptoms and internalizing problems (i.e., depression, anxiety, somatic problems) has been established (Fischer et al., 2002), the mechanisms that account for this link are not clearly explicated. Based on the biological origins of ADHD, demonstrating that ADHD symptoms emerge in early childhood, internalizing symptoms such as depression tend to develop later, typically during adolescence (Kessler, Berglund, Demler, Jin, & Walters, 2005; Lewinsohn, Clarke, Seeley, & Rohde, 1994). Extending theories of internalizing problems and ADHD to understand this link, children with ADHD demonstrate impairment in self-control (Barkley, 1997) and are more likely to report an external locus of control (Linn & Hodge, 1982). This external locus of control may account for the link between symptoms of ADHD and depressive symptoms based on cognitive theories of depression and anxiety (Arslan, Dilmac, & Hamarta, 2009; McCauley, Mitchell, Burke, & Moss, 1988). More specifically, depressed and anxious children and adolescents often exhibit a cognitive style that attributes positive events to external, unstable, and specific factors, with effective interventions targeting this cognitive style (Garber & Horowitz, 2002; McCauley et al., 1988). This attributional style often manifests among children with symptoms of ADHD (Ostrander & Herman, 2006), suggesting a unifying link between the two conditions. Indeed, lifetime prevalence of depression in youth with ADHD is between 26% and 45% (Biederman et al., 1996; Fischer et al., 2002).

Moreover, as children with ADHD are likely to be rejected by peers (Hoza, 2007) and fail to adequately affiliate with the school environment (Vile Junod et al., 2006), similar experiences are etiologically related to depression (Drabick, Gadow, & Sprafkin, 2006). A failure to bond with peers, teachers, and the academic system has been shown to influence social and emotional adjustment, including increased depression (Loukas, Suzuki, & Horton,

2006). In addition, peer rejection is also connected to internalizing symptoms (Prinstein & Aikins, 2004). Accordingly, peer rejection and decreased bonding and acceptance of conventional social networks and academic settings that children with ADHD symptoms experience may result in internalizing problems (Drabick et al., 2006; Ostrander & Herman, 2006; Prinstein & Aikins, 2004).

Internalizing problems are directly linked to substance use (Audrain-McGovern, Rodriguez, & Kassel, 2009). The association between internalizing problems and substance use is most commonly understood by the self-medication or emotion regulation hypothesis, which posits that individuals with depression and anxiety use drugs and alcohol to avoid aversive internalizing symptoms (Barlow, Allen, & Choate, 2004; Khantzian, 1985). There is evidence for this link during adolescence, as depressive symptoms and suicidal ideation in teenagers is related to drug and alcohol use (Audrain-McGovern et al., 2009; Kandel, Raveis & Davies, 1991). Adolescents with depression or anxiety may lack coping resources to effectively reduce stress and resort to drugs to regulate emotional problems (Lewinsohn, Gotlib, & Seeley, 1995).

Thus, ADHD may directly and indirectly (through peer rejection and poor school bonding) result in increased internalizing problems due to an external locus of control, and internalizing problems may ultimately lead to risk for early substance use as a function of maladaptive coping strategies. Note that although the relation between internalizing problems and substance use may be reciprocal (i.e., the effects of substance use causing depression/anxiety; Marmorstein, Iacono, & Malone, 2010), the current study focuses on internalizing problems as a precursor of subsequent substance use in attempting to explain the link between childhood ADHD symptoms and risk for early substance use initiation.

# **Current Study**

This longitudinal study was designed to identify specific pathways from fourth-grade ADHD symptoms to risk for early initiation of alcohol, tobacco, and marijuana use from fourth to ninth grade. Survival analysis was used to evaluate study hypotheses. Early onset of substance use is an important component outcome to consider, as it is associated with later substance use disorders and related problems (Hoffman, Sussman, Unger, & Valente, 2006; Pitkanen, Lyyra, & Pulkkinen, 2005). Peer rejection and poor school bonding were examined as mediators of the ADHD to substance use link, directly and indirectly, through internalizing problems (see Figure 1). We hypothesized that both peer rejection and poor school bonding would mediate the ADHD to substance use link separately, as well as through a complex three chain pathway with internalizing problems. However, it was unclear which pathway would provide the strongest associations between variables.

The substance use outcomes of tobacco, alcohol, and other drug use were examined separately due to differential risks for timing of initiation (Kandel & Logan, 1984). The proposed pathways were examined in a high-risk sample of aggressive youth for two reasons. The first was due to the low base-rate of ADHD symptoms in nonclinical samples (Biederman, Mick, & Faraone, 2000). Therefore, the current sample was more likely to present with ADHD symptoms and other developmental risk factors and behavioral problems described above. Second, aggressive behavior is a risk factor and developmental precursor for substance use (Timmermans, Van Lier, & Koot, 2008), providing a sample more prone to internalizing problems and early substance use, allowing for better identification of proposed developmental pathways to substance use. To control for the effects of aggression, aggressive behavior was included as a covariate in all statistical analyses of substance use behaviors.

## Method

## **Participants**

The current study included participants from an intervention study designed to evaluate the effectiveness of the Coping Power

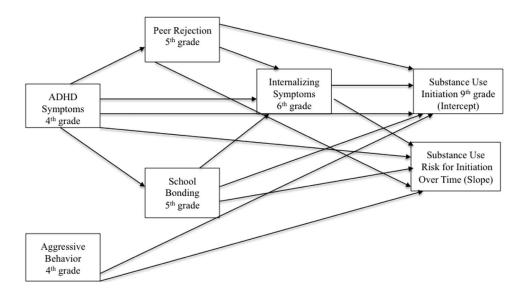


Figure 1. Hypothetical model for survival pathways to initiation of and risk for substance use (i.e., tobacco, alcohol, and marijuana). Covariances and disturbances (error) not pictured for clarity purposes.

program for childhood aggression (Lochman & Wells, 2002, 2003). Participants were recruited from 17 elementary schools in Durham, North Carolina. Children were initially screened for aggression for study inclusion. Three teacher ratings were obtained on each child (verbal aggression, physical aggression, and disruptiveness) on a scale of 1 to 5. Based on these items, the most aggressive children (i.e., top 31%) were selected as a pool of potential participants (N = 245). Participants were randomly assigned to treatment and control conditions. For the purposes of this study, only participants in the control groups (N = 126) were included to avoid confounding study results with intervention effects. Children were recruited into the study at the end of the fourth-grade school year (M = 10.4 years, SD = 0.51). The participants were 66% boys and racially representative of the urban setting in which the study was conducted: 79% African American, 17% White, and 4% of other racial/ethnic groups.

Study data regarding the family and child behavior was collected from the primary caregiver over the past 6 months. Most primary caregivers were mothers (90%), and fathers, grandparents, other relatives, and foster parents made up the remaining group of caregivers. The Hollingshead index (Hollingshead, 1975) was used as measure of socioeconomic status (SES), indicating 17.7% of the families were unskilled workers, 15.3% were semiskilled workers, 14.5% were skilled workers, 29.8% were minor professionals, and 22.6% were major professionals, indicating that 50% of the families were middle to upper class. Quite impressively, the study maintained an 86% retention rate over 6 years. Study attrition was as follows, Year 1: N = 126 (0%); Year 2: N = 111 (12%); Year 3: N = 108 (14%); Year 4: N = 101 (20%); Year 5: N = 100 (21%); Year 6: N = 108 (14%).

## **Procedure**

Informed consent was obtained from primary caregivers, and assent was obtained from children prior to each data collection interval, annually over 6 years. At the end of each school year, assessment was conducted separately with parents and children. Measures were collected from primary caregivers in the home or research laboratory, based on the caregiver's preference. During each session, interviewers read the questions aloud while participants followed along with their copy of the measures. Interviewers were research staff who held the minimum of a bachelor's degree and were trained by practicing reading interviews with other interviewers and role-playing mock interviews with experienced interviewers. Interviewers were trained to a level of competency deemed appropriate only by the principal investigator of the study. Child-reported measures were collected in school, at home, or in the research office. The majority of parent and child interviews (> 90%) occurred in the home. Both caregivers (\$40) and children (\$10) were compensated for their participation at each data collection interval.

Late elementary school is an ideal time to examine ADHD symptoms and associated variables because diagnostically, ADHD symptoms may manifest up to age 7 (APA, 2000). Also, developmental research suggests many children grow out of "normal" behavior problems by elementary school, and thus many behaviors become clinically significant only after children begin school (Campbell, Pierce, Moore, Marakovitz, & Newby, 1996). Further, elementary school is an appropriate setting to examine peer rela-

tions because children interact with the same group of children for the entire school day. Accordingly, ADHD data were collected in fourth grade and peer social preference data were collected in fifth grade. Consistent with the literature, adolescence is the most common period of onset for depression and anxiety (Kendall, Kortlander, Chansky, & Brady, 1992; Lewinsohn et al., 1994) and thus internalizing problem data were collected in the sixth grade. Substance use research suggests adolescents' average age of onset for a substance is age 14 (Newes-Adeyi, 2005), and initiating prior to age 15 puts individuals at increased risk for alcohol dependence over the lifetime (NSDUH, 2004). Thus, pathways were examined from ADHD symptoms to risk for early initiation of substance use from fourth to ninth grade.

#### Measures

**Substance use.** The initiation of substance use was assessed by children's report on the Center for Substance Abuse Prevention (CSAP) Student Survey. The survey was adapted from the California Student Survey (Pentz et al., 1989). Three items were used in the current study to assess tobacco, alcohol, and marijuana initiation (e.g., "Have you EVER had a drink of alcohol?"). Initiation of each substance was examined annually at each grade level. Items were coded as yes (1) or no (0) for analyses.

ADHD symptoms. Caregivers' reports on the attention problems subscale of the Child Behavior Checklist (CBCL/4-18; Achenbach, 1991) was used to query the caregiver about the child's behavior in the past 6 months. The attention problems subscale consists of 11 items, including concentration difficulties ("Can't concentrate, can't pay attention for long"), hyperactivity ("Can't sit still or restlessness"), and impulsivity ("Can't stand waiting, wants everything now"). Caregivers responded using a 3-point scale (0 = Not True, 1 = Somewhat or Sometimes True,2 = Very or Often True). The scale has adequate predictive validity (r = .60 with a clinical diagnosis of ADHD) and strong reliability ( $\alpha = .84$ , test-retest: r = .93; Achenbach, 1991). The subscale also shows good diagnostic discrimination of ADHD in psychiatric samples (Steingard, Biederman, Doyle, & Sprich-Buckminster, 1992) and in a school sample (Doyle, Ostrander, Skare, Crosby, & August, 1997). Items were summed for analyses. Internal consistency of the measure in the current sample was good  $(\alpha = .79).$ 

**Peer rejection.** Peer rejection was assessed using a peer nomination system of classroom sociometrics at fifth grade. Children wrote down the names of the three peers they liked most and the three peers they liked least within their classroom. Peer nominations were standardized within each classroom. Each individual was then given two scores, one based on the total number of peers that identified them as "liked most" and a score based on the total number of peers that identified them as "liked least." Then each individual's "liked least" score was subtracted from his or her "liked most" score to determine a social preference score (see Coie, Dodge, & Coppotelli, 1982). Scores were then recoded, such that high values indicate high levels of peer rejection. This is a widely used measure and a good method for discriminating between sociometric groups (Fite, Colder, Lochman, & Wells, 2007; Terry & Coie, 1991). This sociometric measure has good convergent validity, as it correlates moderately with other methods of assessing peer status (e.g., unidimensional rating-scale system; Terry & Coie, 1991).

**School bonding.** Children completed the Kentucky School Bonding measure to assess attachment to their school and teachers. The Kentucky School Bonding measure is a 9-item self-report scale developed at the University of Kentucky. Sample items include, "I like my teachers" and "It is important to do a good job on homework." Children responded with *agree* (1) or *disagree* (0), with items summed for analyses. This measure has been used previously to assess children's academic engagement (Lochman & Wells, 2004). The measure has adequate internal consistency ( $\alpha = .64$ ) as well as adequate 1 year test–retest reliability (r = .45).

Internalizing problems. Caregivers reported on child internalizing behavior at sixth grade using the internalizing scale of the CBCL (Achenbach, 1991). The scale consists of 31 items including the anxious/depressed (e.g., cries a lot), withdrawn (e.g., would rather be alone than with others), and somatic complaints (e.g., headaches, without medical cause) subscales. Responses were based on a 3-point scale ( $0 = Not\ True$ ;  $1 = Somewhat\ or\ Sometimes\ True$ ;  $2 = Very\ or\ Often\ True$ ) based on their child's behavior within the past 6 months. This scale has adequate predictive (r = .45 with a clinical diagnosis of depression) and discriminative validity (i.e., correctly classified 80% of referred and nonreferred children) as well as strong internal consistency ( $\alpha = .90$ , test–retest: r = .91; Achenbach, 1991). Items were summed for analyses. Internal consistency of the measure in the current sample was good ( $\alpha = .85$ ).

Aggressive behavior. Caregivers reported on the aggressive behavior subscale of the CBCL (Achenbach, 1991). The scale consists of 20 items of externalizing behaviors (e.g., gets in many fights). Responses were based on a 3-point scale ( $0 = Not\ True$ ;  $1 = Somewhat\ or\ Sometimes\ True$ ;  $2 = Very\ or\ Often\ True$ ) based on their child's behavior within the past 6 months. This measure has adequate diagnostic sensitivity (r = .50 with a clinical diagnosis of oppositional defiant disorder, discriminant validity (correctly classified 80% of referred and nonreferred children) and very good reliability ( $\alpha = .94$ , test–retest: r = .90; Achenbach, 1991). Items were summed for analyses. Internal consistency in the current sample was very good ( $\alpha = .88$ ).

# **Data Analyses**

Survival analyses were estimated in MPlus to examine risk for initiation of each substance (tobacco, alcohol, and marijuana use). Age of initiation was defined as the age each participant first reported lifetime use of a substance. If a child reported lifetime use at the first assessment, they were considered to have initiated substance use in or prior to fourth grade. In the rare circumstance (<7%) in which contradictory information was reported (e.g., responding with a *yes* in response to lifetime use in an earlier year and a *no* response in later years), the age at which the child first reported use was assumed to be the actual age of initiation.

Robust maximum likelihood estimation with Monte Carlo integration was used (Muthen & Muthen, 2004). Full information maximum likelihood robust estimate (FIMLRE) was used to accommodate missing data. FIMLRE uses all available data to calculate parameter estimates and does not exclude missing data (Kline, 2010). FIMLRE has been found to be less biased and more efficient than other strategies, such as pairwise and listwise dele-

tion, to accommodate missing data (Arbuckle, 1996). FIMLRE is also robust to non-normality of data. Furthermore, our analyses used simultaneous estimation in predicting unique variances and covariances of variables (i.e., controlling for partial correlations).

Hazard probabilities, the probability that substance use initiation will occur at a particular grade for a particular individual for whom initiation had not previously occurred, was modeled. Linear, quadratic, and cubic effects of age across each substance were first evaluated. The linear (-5, -4, -3, -2, -1, 0), quadratic (25, 16, 9, 4, 1, 0), and cubic (-125, -64, -27, -8, -1, 0) contrasts were coded in such a way that the intercept was set at ninth grade. Variances of the intercept and slopes were fixed at 0 in accordance with a traditional survival model. The proposed mediators were included in the model to determine if peer rejection, school bonding, and internalizing problems accounted for the relation between ADHD symptoms and risk for initiation.

Tests of indirect effects (MacKinnon et al., 2004) were not available for the current model due to the use of Monte Carlo integration and the evaluation of 3-chain mediational paths. Therefore, we relied on previous simulation studies that suggest that when all chains of an indirect path are significant, the indirect effects are likely significant (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). All data were analyzed continuously and thus none of the analyses were group by ADHD. For significant mediation pathways, in order to depict risk over time for substance use, hazard probabilities were plotted at varying levels of ADHD symptoms: high (+1 SD, approximately 7.58 on ADHD scale) and low values (-1 SD, less than 1 on ADHD scale).

# **Results**

## **Descriptive Statistics**

The lifetime prevalence of having ever used a substance was low in the fourth grade (<10% tobacco and alcohol use, <2% marijuana use). However, by the ninth grade, lifetime prevalence of substance use for this high-risk sample was quite significant: 42% for tobacco use, 57% for alcohol use, and 32% for marijuana use. These rates are higher than observed in a nationally representative sample, as the Monitoring the Future national survey overlaps with current sample eighth grade data on tobacco use: 28% versus 39% ( $\chi^2 = 6.81$ , p = .01), alcohol use: 44% versus 51%  $(\chi^2 = 2.07, p = .15)$ , and marijuana use: 16% versus 27% ( $\chi^2 =$ 10.38, p = .001; Johnston, O'Malley, Bachman, & Schulenberg, 2011). Higher prevalence rates are attributed to the high-risk nature of the sample. Correlations, means, standard deviations and ranges of study variables are displayed in Table 1. Although these variables are interrelated with shared variance (r = .23 to .60), they are unique constructs (all < 36% shared variance) adequately contributing unique variance. It is important to note, however, that the correlations with initiation of substances at ninth grade do not have implications for survival findings related to the slopes and hazard probability associations.

# **Survival Analyses**

**Tobacco.** As seen in Figure 2a, and reported elsewhere (Fite et al., 2008), initiation of tobacco use hazard probabilities followed a linear trend, such that risk for the initiation of tobacco use

Table 1 Correlations, Means, Standard Deviations, and Ranges of Study Variables

Variable	M	SD	Range	Skewness	Kurtosis	1	2	3	4	5	6	7	8
1. ADHD symptoms Grade 4	4.10	3.48	0-20	1.50	3.21	_							
2. Aggressive behavior Grade 4	9.41	6.09	1-28	0.86	0.33	.60**	_						
3. Peer rejection Grade 5	0.47	1.92	-4.8 - 3.1	-0.35	-0.67	.23*	.24*	_					
4. School bonding Grade 5	7.70	1.37	4–9	-0.81	-0.29	03	08	19					
5. Internalizing problems Grade 6	5.85	5.41	0-24	1.11	1.00	.38**	.38**	.30*	.02	_			
6. Tobacco use Grade 9	0.42	0.50	0-1	_	_	.22*	.22*	.12	07	.09			
7. Alcohol use Grade 9	0.57	0.50	0-1	_	_	02	.13	.12	17	.07	.31**		
8. Marijuana use Grade 9	0.32	0.47	0-1	_	_	02	.13	.11	19	.01	.49**	.40**	_

<sup>\*</sup> p < .05. \*\* p < .001.

increased as participants aged from fourth to ninth grade (M = 0.15, p = .05). The addition of quadratic ( $\chi^2(1) = 0.04$ , p = .84) and cubic ( $\chi^2(1) = 0.01$ , p = .92) trends did not improve the model fit. ADHD symptoms, aggression, race, and gender as well as potential mediators (peer rejection, school bonding, and internalizing problems) were then included in the model. Internalizing problems were positively associated with initiation of tobacco use at ninth grade (B = 0.14, p = .01) and the linear slope of tobacco use initiation (B = 0.05, p = .02), such that higher levels of internalizing problems were associated with tobacco use initiation at ninth grade (intercept) and increases in the risk of tobacco use initiation from fourth to ninth grade (slope). Although ADHD was not directly associated with risk for initiation of tobacco use,

ADHD symptoms were indirectly associated with risk for tobacco use initiation through internalizing problems, such that a higher number of ADHD symptoms were related to more internalizing problems (B = 0.48, p = .001), which in turn was associated with increased risk of initiation of tobacco use (B = 0.14, p = .01). Further, ADHD symptoms were also positively associated with risk for tobacco use initiation through a complex mediational pathway, such that a high level of ADHD symptoms were a marginally significant predictor of high levels of peer rejection (B = 0.17, p = .06), which in turn predicted high levels of internalizing problems and subsequent increases in tobacco use (B = 0.14, D = .01). Predicted risk trajectories for initiation of tobacco use at high and low levels of ADHD symptoms through

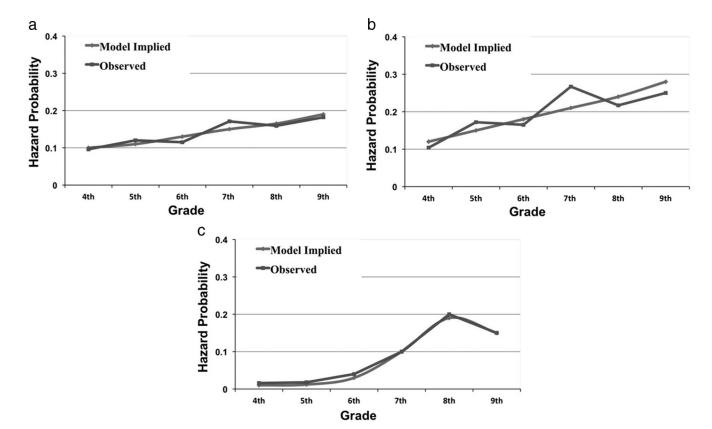


Figure 2. Observed and model implied hazard probabilities. a. Tobacco, b. alcohol, and c. marijuana hazard models.

the effect of both peer rejection and internalizing problems as well as internalizing problems only are plotted in Figures 3 and 4, respectively. Hazard ratios indicate that starting in seventh grade, there is increased risk for tobacco use initiation that seems associated with ADHD symptoms and the identified mediators. This risk continues to increase during the eighth and ninth grades. In contrast, ADHD symptoms were not associated with school bonding, and school bonding was not associated with either internalizing problems (B = 0.26, p = .40) or initiation of tobacco use (B = -0.03, p = .91), suggesting that school bonding does not play a role in proposed developmental pathways.

Alcohol. Initiation of alcohol use hazard probabilities followed a linear trend, such that risk for the initiation of alcohol use increased as participants aged from fourth to ninth grade (M =0.20, p = .005; see Figure 2b). The addition of quadratic ( $\chi^2(1) =$ 1.09, p = .30) and cubic ( $\chi^2(1) = 0.02$ , p = .88) trends did not improve the model fit. ADHD symptoms, aggression, race, and gender as well as potential mediators (peer rejection, school bonding, and internalizing problems), were then included in the model. Consistent with correlations, ADHD symptoms were not directly associated with risk for initiation of alcohol use. However, school bonding was negatively associated with initiation of alcohol use at ninth grade (B = -0.39, p = .04) and the linear slope of alcohol use initiation (B = -0.11, p = .05), such that higher levels of school bonding were associated with lower risk of alcohol use initiation at ninth grade and decreases in the risk of alcohol use initiation from fourth to ninth grade. Race was a marginally significant predictor of initiation of alcohol use at ninth grade (B = -1.64, p = .08), such that White youth were more likely to initiate alcohol use than minority youth. All other variables were unrelated to the risk of alcohol use initiation (ps = .29-.88) and the linear slope of alcohol use initiation (ps = .29-.89).

**Marijuana.** Initiation of marijuana use hazard probabilities followed a marginally significant cubic pattern (linear M = -0.98, p = .15, quadratic M = -0.81, p = .05, cubic M = -0.10, p = .07; see Figure 2c). The addition of a quadratic trend (from a linear trend) did not improve the model fit ( $\chi^2(1) = 2.05$ , p = .15), but the addition of a cubic trend produced a marginally statistically significant improvement in the model fit ( $\chi^2(1) = 3.40$ , p = .06). Risk for initiation of marijuana use increased slowly from fourth grade to sixth grade, increased rapidly from sixth to eighth grade, then slightly decreased from eighth to ninth grade. Findings sug-

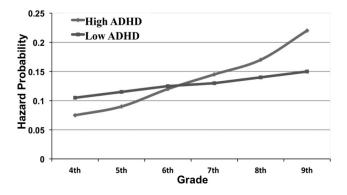


Figure 3. Risk for tobacco use initiation from fourth grade to ninth grade through internalizing symptoms.

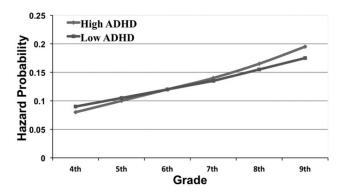


Figure 4. Risk for tobacco use initiation from fourth grade to ninth grade through peer rejection and internalizing symptoms.

gest that children are most at risk for initiation of marijuana use in eighth grade. ADHD symptoms, aggression, race, and gender as well as potential mediators (peer rejection, school bonding, and internalizing problems), were then included in the model. All variables were unrelated to risk for initiation of marijuana use at ninth grade (ps = .17-.97). ADHD was, however, associated with the cubic slope of marijuana use initiation (B = 0.06, p = .002), such that a high number of ADHD symptoms were associated with a strong cubic trend (e.g., a more rapid acceleration of risk for initiation) once also controlling for the variance of potential mediator variables. Predicted risk trajectories for initiation of marijuana use at high and low levels of ADHD symptoms are illustrated in Figure 5. Hazard ratios indicate that starting in the sixth grade, there is increased risk for marijuana use initiation that seems associated with ADHD symptoms, except for the eighth grade when lower levels of ADHD seem to indicate the greater risk. Aggression was also associated with the cubic slope of marijuana use initiation (B = -0.03, p = .006), such that low levels of aggression were associated with a stronger cubic trend.

# Discussion

The current study examined development from childhood ADHD symptoms to risk for early initiation of tobacco, alcohol, and marijuana use. Risk of early initiation of substance use was examined from fourth to ninth grade as ratios of those who used a substance for the first time in that grade relative to children who had not previously used that substance. As previously reported (Fite et al., 2008), timing of initiation of substance use from fourth to ninth grade follows a linear trend for tobacco and alcohol use while marijuana use follows a cubic trend. ADHD symptoms appear to be associated with ninth grade tobacco use initiation and risk for tobacco use initiation over time through two mediational pathways. ADHD symptoms seemed to positively predict both peer rejection and internalizing symptoms, 1 and 2 years later, respectively. Peer rejection was then also associated with internalizing symptoms. Thus, it appears that ADHD symptoms in fourth

 $<sup>^{1}</sup>$  Given the sample was predominantly African American, statistical analyses also were conducted on only African American participants (N = 99). As the pattern of findings remained consistent, results are reported on the full sample.

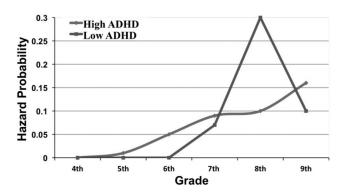


Figure 5. Risk for marijuana use initiation from fourth grade to ninth grade at high and low levels of ADHD symptoms.

grade may follow a path to peer rejection in fifth grade and then to internalizing problems, such as depression and anxiety in sixth grade.

Social problems seem to be a significant impairment in children with ADHD as they struggle to form individual friendships and often are ostracized by their classmates (Hoza, 2007). ADHD symptoms appear to result in future internalizing problems both directly and indirectly through peer rejection. Although related constructs, it appears that peer rejection, but not school bonding, is implicating in the current study's complex associations. The experience of being rejected in social situations puts a great deal of stress on a child and can lead to internalizing symptoms without well-developed coping skills (Prinstein & Aikins, 2004). Additionally, compared with children without ADHD, children with ADHD display less self-regulation of affect by exhibiting more behavioral responses of sadness, anger, and guilt (Braaten & Rosen, 2000), which likely results in subsequent internalizing problems. Findings suggest that peer rejection and internalizing problems play an important role in the development of early tobacco use initiation in children with a high number of ADHD symptoms. Social adversity and vulnerability for experiencing negative emotion may put individuals with ADHD symptoms at risk for tobacco use as they seek alternative methods to cope with stressful events (Braaten & Rosen, 2000).

The current findings on tobacco use are generally consistent with literature suggesting that children with ADHD are more likely to smoke at an earlier age, even after controlling for confounding variables of SES, IQ, and psychiatric comorbidity (Milberger et al., 1997). Interestingly, each additional reported symptom of ADHD was associated with a younger age of onset of smoking in regular smokers (Kollins, McClernon, & Fuemmler, 2005). Early initiation of tobacco use is a notable concern because it is often a gateway to future drug and alcohol use disorders (Kandel & Logan, 1984). Further, the gateway hypothesis is particularly robust for youth with ADHD, as ADHD smokers are significantly more likely to subsequently use drugs and alcohol as well as develop comorbid substance use disorders compared with individuals with ADHD who do not smoke (Biederman et al., 2006). Thus, effective interventions are needed to disrupt the detrimental path to early tobacco use in children with increased ADHD symptoms.

ADHD symptoms also seem to be associated with the risk for early initiation of marijuana. Although not directly correlated with initiation of use at ninth grade, starting in the sixth grade, ADHD symptoms appear to increase the risk for marijuana use in each year except for the eighth grade. Our findings are generally consistent with prior literature suggesting ADHD is associated with an earlier onset of psychoactive substance use disorder (most commonly marijuana; Wilens, Biederman, & Mick, 1998) as well as marijuana use and dependence symptoms (Flory et al., 2003). The ADHD risk for early marijuana use found in our study is particularly concerning as the recovery time in substance use treatment is more than twice as long in individuals with ADHD compared with those without ADHD (Wilens et al., 1998). However, it appears that the path to early marijuana use is different from tobacco use. Although significant mediators seem to play a role in the tobacco models, these academic, social, and emotional factors did not appear to influence the development of marijuana use from ADHD symptoms. Further, it is unclear why ADHD symptoms may have a different effect on marijuana initiation in the eighth grade. Thus, more work is needed to identify mediating factors in the link between ADHD symptoms and timing of onset for marijuana use.

The nonsignificant findings between ADHD symptoms and initiation of alcohol use was unexpected; however, this may be partially supported by the literature that suggests stronger evidence for early adolescent tobacco use in individuals with ADHD (e.g., Pomerleau et al., 2003) than other substances. Although our study appears to identify potential developmental links between ADHD symptoms and tobacco use by ninth grade, it may not have captured alcohol use that develops later on, particularly due to the gateway hypothesis (Biederman et al., 2006). Additionally, aggression was also unexpectedly not associated with initiation of tobacco or alcohol use. The long duration in time from baseline aggression to ninth grade substance use may account for these null findings. We also chose to recruit an aggressive sample, and as such there was more limited variability in aggressive behavior that would have been critical to detect typical effects. Additionally, due to the strong overlap between ADHD and aggression, the variance accounted for by ADHD likely attenuated the previously established association between aggression and substance use.

Further, school bonding may or may not represent an influential factor in the developmental pathway from ADHD symptoms to risk for early substance use initiation. It may be that the timing of assessing school bonding was too early to detect the effects of academic challenges of children exhibiting ADHD symptoms, which may not be evident until coursework becomes more stimulating in middle school. Teacher report of school bonding or academic performance may also have been a more valid assessment of this academic variable. The school bonding measure also yielded weaker reliabilities than expected, which may have attenuated results, thus making it more difficult to detect potential effects. Thus, further research is warranted before null effects of school bonding in the context of ADHD development are concluded.

## **Implications for Intervention**

The current study yields findings that may be useful in informing existing nonpharmacological interventions and constructing new, more effective behavioral interventions. If left untreated, ADHD symptoms may spiral into a pathway toward early initia-

tion of substances, particularly marijuana, and tobacco use. When children with ADHD mature, they have a greater than 50% chance of developing a substance use disorder if left untreated that is two times the risk of adults who received treatment for ADHD (Biederman, 1995). The increased prevalence of substance use appears to be predominantly among individuals with comorbid conduct or antisocial disorders, but can also be found in individuals who are undertreated for their symptoms as a means of self-medication (Harty, Ivanov, Newcorn, & Halperin, 2011). Nicotine may be especially useful as a means of self-medication, as it has been found to improve attention in adults with ADHD (Conners et al., 1996). Indeed, controversy exists regarding the effects of psychostimulant treatment on substance use in adolescents with ADHD. A meta-analysis of six longitudinal studies investigating substance use disorders during adolescence or adulthood among youth with ADHD found a nearly twofold reduction in substance use in those who received stimulants compared with those who did not (Wilens, Faraone, Biederman, & Gunawardene, 2003). However, some evidence suggests stimulant treatment increases future substance use (Lambert & Hartsough, 1998), including nicotine (Rush et al., 2005). This highlights the need for effective nonpharmacological interventions for children with ADHD and mitigation of developmental risk factors to reduce the possibility of substance

Additionally, interventions that improve social skills and promote social competence may protect against the risk for peer rejection in children with ADHD symptoms. Peer programs that promote dyadic friendships and help children develop at least one strong friendship have been useful for ADHD children with social impairments and may be an effective intervention (Hoza, Mrug, Pelham, Greiner, & Gnagy, 2003). Lastly, psychological interventions that address socioemotional issues in addition to attentional problems may prove beneficial for the treatment of stress and emotional vulnerability that often accompanies individuals with ADHD. Even at subclinical levels, ADHD symptoms are associated with mood disturbances and also with the urge to smoke cigarettes and engage in other unhealthy behaviors (Whalen, Jamner, Henker, Delfino, & Lozano, 2002). If left untreated, children with ADHD may develop a dual diagnosis of a mood or anxiety disorder. Children with combined ADHD and depression exhibit more severe impairment in academic and social functioning than children with only ADHD (Blackman, Ostrander, & Herman, 2005). The emergence of internalizing symptoms may lead many teenagers to turning to tobacco and potentially other substances to cope with their negative emotions, as suggested by the current findings.

## **Limitations and Conclusion**

This study has several methodological limitations that may affect the generalizability of findings. The sample contained children that were high in aggression and thus there may be limited range to control for the effects of aggression or may only generalize to a more aggressive subset of ADHD children. The sample was also predominantly African American, and thus the findings may not generalize to other racial/ethnic populations. The sample also included children only through ninth grade, which may not have captured associations with substance use that began during or following sophomore year. Parental assessment of internalizing

symptoms was used, and in the interest of reliability, it would have been useful to have adolescent self-report ratings of internalizing symptoms.

The relatively small sample size may have also limited our ability to detect smaller effects. However, it is believed that the person-by-time observations are most important when considering power for growth models (e.g., Muthen & Curran, 1997). The current study has over 500 person-by-time observations, providing adequate power to detect effects. Additionally, we could not account for the nesting of schools/classrooms, which is recommended for use with larger sample sizes and with a large number of clusters (>50 are present). The implication of using non-nested models is that you may miss some variance attributable to outcome variables (mediators and substance use) that could be due to school or classroom effects.

Further, our assessment of ADHD symptoms was from a behavioral parent checklist (CBCL). It may have been more informative to have used structured clinical interviews yielding separate symptom dimensions (i.e., inattention and hyperactivity/impulsivity) and more accurate clinical diagnoses (Reich, 2000). ADHD symptom dimensions seem to be differentially associated with substance use, social factors and internalizing symptoms. Specifically, hyperactivity/impulsivity has uniquely predicted initiation of substance use, and the effects of inattention symptoms on substance use (except for nicotine) are nullified when controlling for both the other symptom dimension and conduct disorder (Elkins et al., 2007). Furthermore, although ADHD is associated peer problems overall, inattentive symptoms appear to contribute to greater difficulty attending and actively participating in social interactions, whereas hyperactivity/impulsivity symptoms contribute to overt peer rejection as they are perceived as more aggressive, demonstrating more overtly negative social behaviors (Mc-Quade & Hoza, 2008). Finally, inattention symptoms seem to be more influential in predicting lower academic achievement (Merrell & Tymms, 2001).

In sum, the development of ADHD into adolescence seems to follow a path to early initiation of tobacco use through peer rejection and internalizing problems. Although much attention has been given to academic underachievement of individuals with ADHD, the social impairment and emotional problems that accompany ADHD appear to be another important area of concern. If socioemotional difficulties are not addressed in children with ADHD, they are likely to become a precursor to early cigarette smoking or other tobacco use and can become a gateway to more serious substance use as well as have implications for medical problems (e.g., heart and lung disease). Future studies should avoid neglecting the impact of peers and internalizing symptoms, as the current findings suggest these variables contribute to increased risk for tobacco use in children with ADHD, a rapidly growing public health concern. Children exhibiting ADHD symptoms seem to become affected by their cognitive and social impairment, and ADHD symptoms should be examined with other sociometric variables in larger samples with a wider age range. Findings also suggest that ADHD symptoms are linked to increased risk for early marijuana use initiation; however, the mechanisms contributing to this link are currently unknown. Research examining potential underlying mechanisms (e.g., delinquent peer affiliations) of substance use in youth with ADHD requires further investigation to identify intervention strategies.

## References

- Achenbach, T. M. (1991). *Manual for the child behavior checklist/4–18* and 1991 profile. Burlington, VT: University of Vermont Department of Psychiatry.
- American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Washington, DC: American Psychiatric Association.
- Arbuckle, J. L. (Ed.). (1996). Full information estimation in the presence of incomplete data. Mahwah, NJ: Erlbaum, Inc.
- Arslan, C., Dilmac, B., & Hamarta, E. (2009). Coping with stress and trait anxiety in terms of locus of control: A study with Turkish university students. Social Behavior and Personality, 37, 791–800. doi:10.2224/ sbp.2009.37.6.791
- Audrain-McGovern, J., Rodriguez, D., & Kassel, J. D. (2009). Adolescent smoking and depression: Evidence for self-medication and peer smoking mediation. *Addiction*, 104, 1743–1756. doi:10.1111/j.1360-0443.2009 .02617.x
- Bagwell, C. L., Molina, B. S. G., Pelham, W. E., Jr., & Hoza, B. (2001). Attention-deficit hyperactivity disorder and problems in peer relations: Predictions from childhood to adolescence. *Journal of the American Academy of Child & Adolescent Psychiatry*, 40, 1285–1292. doi:10.1097/00004583-200111000-00008
- Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. Psychological Bulletin 121, 65–94. doi:10.1037/0033-2909.121.1.65
- Barkley, R. A. (2006). Attention deficit hyperactivity disorder: A handbook for diagnosis and treatment. (3rd ed. Vol. 1). New York, NY: Guilford Press.
- Barlow, D. H., Allen, L. B., & Choate, M. L. (2004). Towards a unified treatment for emotional disorders. *Behavior Therapy*, 35, 205–230. doi:10.1016/S0005-7894(04)80036-4
- Biederman, J., Faraone, S., Mick, E., Moore, P., & Lelon, E. (1996). Child behavior checklist findings further support comorbidity between ADHD and major depression in a referred sample. *Journal of the American Academy of Child and Adolescent Psychiatry*, 35, 734–742. doi:10.1097/ 00004583-199606000-00013
- Biederman, J., Mick, E., & Faraone, S. V. (2000). Age-dependent decline of symptoms of attention deficit hyperactivity disorder: Impact of remission definition and symptom type. *The American Journal of Psychi*atry, 157, 816–818. doi:10.1176/appi.ajp.157.5.816
- Biederman, J., Wilens, T., Mick, E., Milberger, S., Spencer, T. J., & Faraone, S. V. (1995). Psychoactive substance use disorders in adults with attention deficit hyperactivity disorder (ADHD): effects of ADHD and psychiatric comorbidity. *The American Journal of Psychiatry*, 152, 1652–1658.
- Biederman, J., Monuteaux, M. C., Mick, E., Wilens, T. E., Fontanella, J. A., Poetzl, K. M., . . . Faraone, S. V. (2006). Is cigarette smoking a gateway to alcohol and illicit drug use disorders? A study of youths with and without attention deficit hyperactivity disorder. *Biological Psychiatry*, 59, 258–264. doi:10.1016/j.biopsych.2005.07.009
- Blackman, G. L., Ostrander, R., & Herman, K. C. (2005). Children with ADHD and depression: A multisource, multimethod assessment of clinical, social, and academic functioning. *Journal of Attention Disorders*. 8, 195–207. doi:10.1177/1087054705278777
- Braaten, E. B., & Rosen, L. A. (2000). Self-regulation of affect in attention deficit-hyperactivity disorder (ADHD) and non-ADHD boys: Differences in empathic responding. *Journal of Consulting and Clinical Psychology*, 68, 313–321. doi:10.1037/0022-006X.68.2.313
- Brook, D. W., Brook, J. S., Zhang, C., & Koppel, J. (2010). Association between attention- deficit/hyperactivity disorder in adolescence and substance use disorders in adulthood. *Archives of Pediatric Adolescent Medicine*, 164, 930–934. doi:10.1001/archpediatrics.2010.180
- Bryant, A., Schulenberg, J., O'Malley, P. M., Bachman, J. G., & Johnston, J. D. (2003). How academic achievement, attitudes, and behaviors relate

- to the course of substance use during adolescence: A six-year multi-wave national longitudinal study. *Journal of Research on Adolescence*, *13*, 361–397. doi:10.1111/1532-7795.1303005
- Campbell, S. B., Pierce, E. W., Moore, G., Marakovitz, S., & Newby, K. (1996). Boys' externalizing problems at elementary school age: Pathways from early behavior problems, maternal control, and family stress. *Development and Psychopathology*, 8, 701–719. doi:10.1017/S0954579400007379
- Coie, J. D., Dodge, K. A., & Coppotelli, H. (1982). Dimensions and types of social status: A cross-age perspective. *Developmental Psychology*, 18, 557–570. doi:10.1037/0012-1649.18.4.557
- Conners, C. K., Levin, E. D., Sparrow, E., Hinton, S. Ernhardt, D., Meck, W. H., . . . March, J. (1996). Nicotine and attention in adult ADHD. Psychopharmacological Bulletin, 32, 67–73.
- De Sanctis, V. A., Trampush, J. W., Harty, S. C., Marks, D. J. Newcorn, J. H., Miller, C. J., . . . Halperin, J. M. (2008). Childhood maltreatment and conduct disorder: Independent predictors of adolescent substance use disorders in youth with attention deficit/hyperactivity disorder. *Journal of Clinical Child and Adolescent Psychology*, 37, 785–793. doi: 10.1080/15374410802359650
- Diamantopoulou, S., Rydell, A., Thorell, L. B., & Bohlin, G. (2007). Impact of executive functioning and symptoms of attention deficit hyperactivity disorder on children's peer relations and school performance. *Developmental Neuropsychology*, 32, 521–542. doi:10.1080/ 87565640701360981
- Dishion, T. J., Patterson, G. R., Stoolmiller, M., & Skinner, M. L. (1991). Family, school, and behavioral antecedents to early adolescent involvement with antisocial peers. *Developmental Psychology*, 27, 172–180. doi:10.1037/0012-1649.27.1.172
- Doyle, A., Ostrander, R., Skare, S., Crosby, R. D., & August, G. J. (1997).
  Convergent and criterion-related validity of the Behavior Assessment
  System for Children-Parent Rating Scale. *Journal of Clinical Child Psychology*, 26, 276–284. doi:10.1207/s15374424jccp2603\_6
- Drabick, D. A. G., Gadow, K. D., & Sprafkin, J. (2006). Co-occurrence of conduct disorder and depression in a clinic-based sample of boys with ADHD. *Journal of Child Psychology and Psychiatry*, 47, 766–774. doi:10.1111/j.1469-7610.2006.01625.x
- Elkins, I. J., McGue, M., & Iacono, W. G. (2007). Prospective effects of attention- deficit/hyperactivity disorder, conduct disorder, and sex on adolescent substance use and abuse. Archives of General Psychiatry, 64, 1145–1152. doi:10.1001/archpsyc.64.10.1145
- Ferguson, J. H. (2000). National institutes of health consensus development conference statement: Diagnosis and treatment of attention-deficit/hyperactivity disorder (ADHD). *Journal of the American Academy of Child and Adolescent Psychiatry*, 39, 182–193. doi:10.1097/00004583-200002000-00018
- Fergusson, D. M., Woodward, L. J., & Horwood, L. (1999). Childhood peer relationship problems and young people's involvement with deviant peers in adolescence. *Journal of Abnormal Child Psychology*, 27, 357– 369. doi:10.1023/A:1021923917494
- Fischer, M., Barkley, R. A., Smallish, L., & Fletcher, K. (2002). Young adult follow-up of hyperactive children: Self-reported psychiatric disorders, comorbidity, and the role of childhood conduct problems and teen CD. *Journal of Abnormal Child Psychology*, 30, 463–475. doi:10.1023/ A:1019864813776
- Fite, P. J., Colder, C. R., Lochman, J. E., & Wells, K. C. (2007). Pathways from proactive and reactive aggression to substance use. *Psychology of Addictive Behaviors*, 21, 355–364. doi:10.1037/0893-164X.21.3.355
- Fite, P. J., Colder, C. R., Lochman, J. E., & Wells, K. C. (2008). The relation between childhood proactive and reactive aggression and substance use initiation. *Journal of Abnormal Child Psychology*, 36, 261– 271. doi:10.1007/s10802-007-9175-7
- Flory, K., Milich, R., Lynam, D. R., Leukefeld, C., & Clayton, R. (2003).
  Relation between childhood disruptive behavior disorders and substance use and dependence symptoms in young adulthood: Individuals with

- symptoms of attention-deficit/hyperactivity disorder and conduct disorder are uniquely at risk. *Psychology of Addictive Behaviors, 17*, 151–158.
- Flory, K., Malone, P. S., & Lamis, D. A. (2011). Childhood ADHD symptoms and risk for cigarette smoking during adolescence: School adjustment as a potential mediator. *Psychology of Addictive Behaviors*, 25, 320–329. doi:10.1037/a0022633
- Garber, J., & Horowitz, J. L. (2002). Depression in children. In I. H. Gotlib & C. H. Hammen (Eds.), *Handbook of depression* (pp. 510–540). New York, NY: Guilford Press.
- Harty, S. C., Ivanov, I. Newcorn, J. H., & Halperin, J. M. (2011). The impact of conduct disorder and stimulant medication on later substance use in an ethnically diverse sample of individuals with attention-deficit/ hyperactivity disorder in childhood. *Journal of Child and Adolescent Psychopharmacology*, 21, 331–339. doi:10.1089/cap.2010.0074
- Hawkins, J., Catalano, R. F., & Miller, J. Y. (1992). Risk and protective factors for alcohol and other drug problems in adolescence and early adulthood: Implications for substance abuse prevention. *Psychological Bulletin*, 112, 64–105. doi:10.1037/0033-2909.112.1.64
- Hirschi, T. (1969). Causes of delinquency. Berkeley: University of California Press.
- Hoffman, B. R., Sussman, S., Unger, J. B., & Valente, T. W. (2006). Peer influences on adolescent cigarette smoking: A theoretical review of the literature. Substance Use & Misuse, 41, 103–155. doi:10.1080/10826080500368892
- Hollingshead, A. B. (1975). Four factor index of social status. New Haven, CT: Yale University.
- Hoza, B. (2007). Peer functioning in children with ADHD. Journal of Pediatric Psychology, 32, 655–663. doi:10.1093/jpepsy/jsm024
- Hoza, B., Mrug, S., Gerdes, A. C., Hinshaw, S. P., Bukowski, W. M., Gold, J. A., . . . Arnold, L. E. (2005). What aspects of peer relationships are impaired in children with attention-deficit/hyperactivity disorder? *Journal of Consulting and Clinical Psychology*, 73, 411–423. doi:10.1037/0022-006X.73.3.411
- Hoza, B., Mrug, S., Pelham, W. E., Greiner, A. R., & Gnagy, E. M. (2003).
  A friendship intervention for children with attention deficit hyperactivity disorder: preliminary findings. *Journal of Attention Disorders*, 6, 87–98. doi:10.1177/108705470300600301
- Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2009). Monitoring the future: National results on adolescent drug use: Overview of key findings, 2008. Bethesda, MD: National Institute on Drug Abuse. doi:10.1037/e560352009-001
- Kandel, D. B., & Logan, J. A. (1984). Drug use from adolescent to young adulthood: I. periods of risk for initiation, continued use, and discontinuation. *American Journal of Public Health*, 74, 660–666. doi:10.2105/ AJPH.74.7.660
- Kandel, D. B., Raveis, V. H., & Davies, M. (1991). Suicidal ideation in adolescence: Depression, substance use, and other risk factors. *Journal* of Youth and Adolescence, 20, 289–309. doi:10.1007/BF01537613
- Kendall, P. C., Kortlander, E., Chansky, T. E., & Brady, E. U. (1992). Comorbidity of anxiety and depression in youth: Treatment implications. *Journal of Consulting and Clinical Psychology*, 60, 869–880. doi:10.1037/0022-006X.60.6.869
- Kessler, R. C., Berglund, P., Demler, O., Jin, R., & Walters, E. E. (2005). Lifetime prevalence and age-of-onset distributions of *DSM-IV* disorders in the National Comorbidity Survey Replication. *Archives of General Psychiatry*, 62, 593–602. doi:10.1001/archpsyc.62.6.593
- Khantzian, E. J. (1985). The self-medication hypothesis of addictive disorders: Focus on heroin and cocaine dependence. *The American Journal of Psychiatry*, 142, 1259–1264.
- Kline, R. B. (2010). Principles and practice of structural equation modeling (3rd ed.). New York, NY: Guilford Press.
- Kollins, S. H., McClernon, F., & Fuemmeler, B. F. (2005). Association between smoking and attention-deficit/hyperactivity disorder symptoms

- in a population-based sample of young adults. Archives of General Psychiatry, 62, 1142–1147. doi:10.1001/archpsyc.62.10.1142
- Kupersmidt, J. B., & Coie, J. D. (1990). Preadolescent peer status, aggression, and school adjustment as predictors of externalizing problems in adolescence. *Child Development*, 61, 1350–1362. doi:10.2307/1130747
- Lambert, N. M., & Hartsough, C. S. (1998). Prospective study of tobacco smoking and substance dependencies among samples of ADHD and non-ADHD participants. *Journal of Learning Disabilities*, 31, 533–544. doi:10.1177/002221949803100603
- Langberg, J. M., Molina, B. S. G., Arnold, L. E., Epstein, J. N., Altaye, M., Hinshaw, S. P., . . . Hechtman, L. (2011). Patterns and predictors of adolescent academic achievement and performance in a sample of children with attention-deficit/hyperactivity disorder. *Journal of Clinical Child & Adolescent Psychology*, 40, 519–531. doi:10.1080/15374416 .2011.581620
- Lewinsohn, P. M., Clarke, G. N., Seeley, J. R., & Rohde, P. (1994). Major depression in community adolescents: Age at onset, episode duration, and time to recurrence. *Journal of the American Academy of Child & Adolescent Psychiatry*, 33, 809–818. doi:10.1097/00004583-199407000-00006
- Lewinsohn, P. M., Gotlib, I. H., & Seeley, J. R. (1995). Adolescent psychopathology: IV. Specificity of psychosocial risk factors for depression and substance abuse in older adolescents. *Journal of the American Academy of Child & Adolescent Psychiatry*, 34, 1221–1229. doi:10.1097/00004583-199509000-00021
- Linn, R. T., & Hodge, G. K. (1982). Locus of control in childhood hyperactivity. *Journal of Consulting and Clinical Psychology*, 50, 592– 593. doi:10.1037/0022-006X.50.4.592
- Lochman, J. E., & Wells, K. C. (2002). The Coping Power program at the middle-school transition: Universal and indicated prevention effects. *Psychology of Addictive Behaviors*, 16, S40–S54. doi:10.1037/0893-164X.16.4S.S40
- Lochman, J. E., & Wells, K. C. (2003). Effectiveness study of Coping Power and classroom intervention with aggressive children: Outcomes at a one-year follow-up. *Behavior Therapy*, 34, 493–515. doi:10.1016/ S0005-7894(03)80032-1
- Lochman, J. E., & Wells, K. C. (2004). The Coping power program for preadolescent aggressive boys and their parents: Outcome effects at the 1-year follow-up. *Journal of Consulting and Clinical Psychology*, 72, 571–578. doi:10.1037/0022-006X.72.4.571
- Lochman, J. E., Wells, K. C., & Murray, M. (2007). The Coping Power program: Preventive intervention at the middle school transition. In P. Tolan, J. Szapocznik, & S. Sambrano (Eds.), Preventing youth substance abuse: Science-based programs for children and adolescents (pp. 185– 210). Washington, DC: American Psychological Association. doi: 10.1037/11488-008
- Loe, I. M., & Feldman, H. M. (2007). Academic and educational outcomes of children with ADHD. Ambulatory Pediatrics, 7, 82–90.
- Loukas, A., Suzuki, R., & Horton, K. D. (2006). Examining school connectedness as a mediator of school climate effects. *Journal of Research on Adolescence*, 16, 491–502. doi:10.1111/j.1532-7795.2006.00504.x
- Lynskey, M. T., & Hall, W. (2001). Attention deficit hyperactivity disorder and substance use disorders: Is there a causal link? *Addiction*, *96*, 815–822. doi:10.1046/j.1360-0443.2001.9668153.x
- MacKinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G., & Sheets, V. (2002). A comparison of methods to test mediation and other intervening variable effects. *Psychological Methods*, 7, 83–104.
- MacKinnon, D. P., Lockwood, C. M., & Williams, J. (2004). Confidence limits for the indirect effect: Distribution of the product and resampling methods. *Multivariate Behavioral Research*, 39, 99–128.
- Marmorstein, N. R., Iacono, W. G., & Malone, S. M. (2010). Longitudinal associations between depression and substance dependence from adolescence through early adulthood. *Drug and Alcohol Dependence*, 107, 154–160. doi:10.1016/j.drugalcdep.2009.10.002

- McCauley, E., Mitchell, J. R., Burke, P., & Moss, S. (1988). Cognitive attributes of depression in children and adolescents. *Journal of Consult*ing and Clinical Psychology, 56, 903–908. doi:10.1037/0022-006X.56 .6.903
- McQuade, J. D., & Hoza, B. (2008). Peer problems in attention deficit hyperactivity disorder: Current status and future directions. *Developmental Disabilities Research Reviews*, 14, 320–324. doi:10.1002/ddrr.35
- Merrell, C., & Tymms, P. B. (2001). Inattention, hyperactivity and impulsiveness: Their impact on academic achievement and progress. *British Journal* of Educational Psychology, 71, 43–56. doi:10.1348/000709901158389
- Milberger, S., Biederman, J., Faraone, S. V., Chen, L., & Jones, J. (1997).
  ADHD is associated with early initiation of cigarette smoking in children and adolescents. *Journal of the American Academy of Child and Adolescent Psychiatry*, 36, 37–44. doi:10.1097/00004583-199701000-00015
- Molina, B. S. G., Hinshaw, S. P., Swanson, J. M., Arnold, L. E., Vitiello, B., Jensen, P. S., . . . The MTA Cooperative Group. (2009). The MTA at 8 years: Prospective follow-up of children treated for combined-type ADHD in a multisite study. *Journal of the American Academy of Child & Adolescent Psychiatry*, 48, 484–500. doi:10.1097/CHI .0b013e31819c23d0
- Molina, B. S. G., & Pelham, W. E. (2003). Childhood predictors of adolescent substance use in a longitudinal study of children with ADHD. *Journal of Abnormal Psychology*, 112, 497–507. doi:10.1037/0021-843X.112.3.497
- Muthen, B. O., & Curran, P. J. (1997). General longitudinal modeling of individual differences in experimental designs: A latent variable framework for analysis and power estimation. *Psychological Methods*, 2, 371–402. doi:10.1037/1082-989X.2.4.371
- Muthen, L. K., & Muthen, B. O. (2004). Mplus: The comprehensive modeling program for applied researchers (3rd ed.). Los Angeles, CA: Muthen & Muthen.
- Newcomb, M. D., & Harlow, L. L. (1986). Life events and substance use among adolescents: Mediating effects of perceived loss of control and meaninglessness in life. *Journal of Personality and Social Psychology*, 51, 564–577. doi:10.1037/0022-3514.51.3.564
- Newes-Adeyi, G., Chen, C. M., Williams, G. D., & Fader, V. B. (2005). Surveillance report 74: Trends in underage drinking in the United States 1991–2003. Rockville, MD: NIAAA, Division of Epidemiology and Prevention Research, Alcohol Epidemiologic Data System.
- Ollendick, T. H., Weist, M. D., Borden, M. C., & Geene, R. W. (1992). Sociometric status and academic, behavioral, and psychological adjustment: A five-year longitudinal study. *Journal of Consulting and Clinical Psychology*, 60, 80–87. doi:10.1037/0022-006X.60.1.80
- Ostrander, R., & Herman, K. C. (2006). Potential cognitive, parenting, and developmental mediators of the relationship between ADHD and depression. *Journal of Consulting and Clinical Psychology*, 74, 89–98. doi:10.1037/0022-006X.74.1.89
- Pentz, M. A., Dwyer, J. H., MacKinnon, D. P., Flay, B. R., Hansen, W. B., Wang, E. Y., & Johnson, C. A. (1989). A multicommunity trial for primary prevention of adolescent drug abuse: Effects on drug use prevalence. *Journal of the American Medical Association*, 261, 3259–3266. doi:10.1001/jama.1989.03420220073030
- Pitkänen, T., Lyyra, A.-L., & Pulkkinen, L. (2005). Age of onset of drinking and the use of alcohol in adulthood: A follow-up study from age 8–42 for females and males. *Addiction*, *100*, 652–661. doi:10.1111/j.1360-0443.2005.01053.x

- Pomerleau, C. S., Downey, K. K., Snedecora, S. M., Mehringera, A. M., Marksa, J. L., & Pomerleau, O. F. (2003). Smoking patterns and abstinence effects in smokers with no ADHD, childhood ADHD, and adult ADHD symptomatology. *Addictive Behaviors*, 28, 1149–1157. doi:10.1016/S0306-4603(02)00223-X
- Prinstein, M., & Aikins, J. (2004). Cognitive moderators of the longitudinal association between peer rejection and adolescent depressive symptoms. *Journal of Abnormal Child Psychology*, 32, 147–158. doi:10.1023/B: JACP.0000019767.55592.63
- Reich, W. (2000). Diagnostic Interview for Children and Adolescents (DICA). Journal of the American Academy of Child & Adolescent Psychiatry, 39, 59–66. doi:10.1097/00004583-200001000-00017
- Rush, C. R., Higgins, S. T., Vansickel, A. R., Stoops, W. W., Lile, J. A., & Glaser, P. E. (2005). Methylphenidate increases cigarette smoking. *Psychopharmacology*, 181, 781–789. doi:10.1007/s00213-005-0021-8
- Steingard, R., Biederman, J., Doyle, A., & Sprich-Buckminster, S. (1992).
  Psychiatric comorbidity in attention deficit disorder: Impact on the interpretation of Child Behavior Checklist results. *Journal of the American Academy of Child and Adolescent Psychiatry*, 31, 449–454. doi: 10.1097/00004583-199205000-00010
- Terry, R., & Coie, J. D. (1991). A comparison of methods for defining sociometric status among children. *Developmental Psychology*, 27, 867– 880. doi:10.1037/0012-1649.27.5.867
- The National Survey on Drug Use and Health Report (NSDUH). (2004). Alcohol dependence or abuse and age at first use. Retrieved October 22, 2004 from www.drugabusestatistics.samhsa.gov
- Thompson, L. L., Riggs, P. D., Mikulich, S. K., & Crowley, T. J. (1996).
  Contribution of ADHD symptoms to substance problems and delinquency in conduct-disordered adolescents. *Journal of Abnormal Child Psychology*, 24, 325–347. doi:10.1007/BF01441634
- Timmermans, M., Van Lier, P. A. C., & Koot, H. M. (2008). Which forms of child/adolescent externalizing behaviors account for late adolescent risky sexual behavior and substance use? *Journal of Child Psychology* and Psychiatry, 49, 386–394. doi:10.1111/j.1469-7610.2007.01842.x
- Vile Junod, R. E., DuPaul, G. J., Jitendra, A. K., Volpe, R. J., & Cleary, K. S. (2006). Classroom observations of students with and without ADHD: Differences across types of engagement. *Journal of School Psychology*, 44, 87–104. doi:10.1016/j.jsp.2005.12.004
- Waschbusch, D. A. (2002). A meta-analytic examination of comorbid hyperactive-impulsive-attention problems and conduct problems. *Psychological Bulletin*, 128, 118–150. doi:10.1037/0033-2909.128.1.118
- Whalen, C. K., Jamner, L. D., Henker, B., Delfino, R. J., & Lozano, J. M. (2002). The ADHD Spectrum and everyday life: Experience sampling of adolescent moods, activities, smoking, and drinking. *Child Develop*ment, 73, 209–227. doi:10.1111/1467-8624.00401
- Wilens, T. E., Biederman, J., & Mick, E. (1998). Does ADHD affect the course of substance abuse? Findings from a sample of adults with and without ADHD. *The American Journal on Addictions*, 7, 156–163. doi:10.1111/j.1521-0391.1998.tb00330.x
- Wilens, T. E., Faraone, F. V., Biederman, J., & Gunawardene, S. (2003). Does stimulant therapy of attention-deficit/hyperactivity disorder beget later substance abuse? A meta-analytic review of the literature. *Pediatrics*, 111, 179–185. doi:10.1542/peds.111.1.179

Received April 8, 2013
Revision received January 23, 2014
Accepted February 11, 2014