Developmental Trajectories of ADHD Symptoms to Adolescent Substance Use: What Influence Do Peer, Family and Neighborhood Factors Have?

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Dedication

To my family, especially my father and mother for their overwhelming support and belief in me through all of my academic endeavors.

Acknowledgements

What a long strange trip it has been. I am grateful for the mentorship and professional guidance of Paula Fite, who took a chance in giving me this wonderful opportunity many years ago. I appreciate your patience and thoughtful teaching of research methods and statistical analysis. I would also like to acknowledge Derek Hopko for his continued mentorship and sharing his knowledge in research methods and scale development. This project would also not have been possible without the gracious provision of data and resources from John Lochman at The University of Alabama and Karen Wells at Duke University.

Abstract

Attention-Deficit/Hyperactivity Disorder (ADHD) has been consistently linked to risk for early substance use. However, the potential mediating mechanisms and moderators of this association remain unclear. The current study examined peer rejection, school bonding and internalizing problems as potential mediators of the association between childhood ADHD symptoms and adolescent substance use in a longitudinal study following children from fourth to ninth grade. Results suggest 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 did not follow developmental pathways to overall frequency of substance use or initiation of alcohol or marijuana use. Neighborhood problems, family activities and parenting styles did not moderate the developmental pathways from ADHD symptoms to substance use frequency. Results identify important development factors in children with ADHD symptoms that highlight the need for primary prevention and psychological interventions that target these factors and thus minimize substance use during adolescence.

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Section 1: Introduction

One of the most common behavioral disorders in children and adolescents is Attention-Deficit/Hyperactivity Disorder (ADHD), with prevalence rates between 3-7% (APA, 2000). ADHD is associated with significant functional impairment, including peer difficulties (Hoza et al., 2005) academic underachievement (Loe & Feldman, 2007), internalizing problems (Ostrander & Herman, 2006) and deficient rule-governed behavior (Barkley, 2006). One of the most concerning issues associated with ADHD is the risk for substance use during adolescence (Molina & Pelham, 2003), which often persists into adulthood and often progresses into substance use disorders (Biederman et al., 1995). While the link between ADHD and substance use has been established, there is little research on developmental pathways explaining increased risk of substance use. Further study of potential mediating mechanisms and moderators of this association is needed to better understand the trajectory of ADHD and develop and refine 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 (Flory, Malone & Lamis, 2011; Raggi & Chronis, 2006; Diamantopoulous, Henricsson & Rydell, 2005; Hawkins, Catalano & Miller, 1992). Another potential mediator is internalizing problems, based on the high comorbidity rates of ADHD symptoms, depression, anxiety and substance use disorders (e.g., Jensen et al. 2001).

Ecological systems are believed to interact with individual biological differences to influence child development (Bronfenbrenner & Ceci, 1994). Thus, the developmental progression from ADHD symptoms to adolescent substance use may partially depend on contextual factors, such as family dynamics, neighborhood characteristics, and preferred activities. These variables may exacerbate or buffer pathways to substance use outcomes (e.g.,

Bauman & Ennett, 1996; Fauth, Roth, & Brooks-Gunn, 2007). Therefore, these environmental factors seem better suited to moderate the pathways from ADHD symptoms to substance use rather than causal mechanisms accounting for these relations. Peer relations and school attitudes, however, may be causal mechanisms from ADHD symptoms to substance use. Although peer relations and school attitudes could also be conceptualized as moderators, within a conventional social institution model (Hawkins, Catalano, & Miller, 1992), these variables are conceptualized as direct causal mechanisms of substance use. It is important to examine the impact of these factors on the pathways that put children with ADHD at risk for substance use, as these factors may have implications for primary prevention and intervention. Accordingly, the current study had two aims: (a) to examine the potential developmental trajectories from ADHD symptoms to substance use (tobacco, alcohol and marijuana) through school bonding attitudes, peer rejection, and internalizing problems, and (b) to examine parenting behaviors, family activities, and neighborhood quality as potential moderators of these pathways.

Attention-Deficit/Hyperactivity Disorder

ADHD is characterized by symptoms of poor sustained attention, deficient impulse control, and excessive activity (Barkley, 2006). While the direct causes of ADHD symptoms are unknown, substantial empirical support for neurological and genetic models exists (Barkley, 2006). Neuropsychological studies reveal core deficits on tests targeting executive functioning within the frontal lobe, suggesting a disinhibition of behavioral responses in areas such as working memory, planning, verbal fluency, perseveration, and motor sequencing (Biederman et al., 2004). Neuroimaging research reveals that due to executive functions deficits, ADHD is a disorder of disinhibition, with brain abnormalities observed in the prefrontal cortex and other brain structures (Castellanos et al., 1996; for a review see Seidman, Valera & Makris, 2005).

Genetic research shows that 57% of parents with ADHD have offspring with the disorder (Biederman et al., 1995) and twin studies estimate the heritability to be between 0.6 and 0.9 (Todd, 2000). Other psychosocial theories propose that overstimulation from parents and parental psychopathology may cause ADHD (e.g., Carlson, Jacobvitz & Stroufe, 1995), but there is little evidence to support these psychosocial risk factors other than over-intrusive/controlling parenting (Ford, Goodman & Melzer, 2004; Shanahan, Copeland, Costello & Angold, 2008).

Children with ADHD symptoms are at risk for significant life impairment in social skills, oppositional and antisocial behavior, and academic performance (Molina et al., 2009). ADHD has also been linked to academic underachievement, poor school bonding/engagement, retention, suspension and expulsion (DuPaul & Stoner, 2003; Frick et al., 1991; Barkley, Fischer, Edelbrock, & Smallish, 1990). Consequently, individuals with ADHD are less likely to graduate from high school, obtain full-time employment, and generally have lower incomes (Biederman & Faraone, 2006). ADHD is also related to problems in peer relationships, evidenced by fewer close friendships and greater peer rejection (Diamantopoulous et al., 2005; Bagwell et al., 2001; Hoza et al., 2007). Further, ADHD commonly co-exists with other disruptive behavior disorders and often with internalizing disorders such as depression and anxiety (Kessler, Chiu, Demler & Walters, 2005). In fact, the lifetime prevalence of depression in youth with ADHD is between 26-45% (Biederman et al., 1996; Fischer et al., 2002). Thus, prior research identifies numerous social, academic, and psychological problems associated with ADHD symptoms.

ADHD and Substance Use

ADHD has also been linked to risk for early initiation of substance use and subsequent substance use disorders (Biederman et al., 1995; Chilchoat & Brelau, 1999; 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 conduct problems that include substance use (Waschbusch, 2002). Due to overlap with such behavioral problems, there is debate as to whether the risk for substance use in ADHD is primarily accounted for by other diagnoses, particularly conduct disorder. While evidence is mixed (Lynskey & Hall, 2001; Thompson, Riggs, Mikulich, & Crowley, 1996), ADHD symptoms account for significant incremental variance in predicting some forms of drug use and drug related activities beyond that accounted for by conduct disorder, including tobacco, alcohol, marijuana and hard drug use (Winters, Fahnhorst & Botzet, 2007; Barkley, Fischer, Smallish & Fletcher, 2004; Flory, Milich, Lynam, Keukefeld & Clayton, 2003).

Barkley (1997) posits poor self-control as the unifying feature of ADHD, resulting from underdeveloped neural networks required for acquisition of inhibitory skills. Poor self-control is also a predictor of adolescent substance use, and good self-control can serve as a resilience factor for those at risk (Wills & Dishion, 2004; Tarter et al., 2003). Conversely, neuropsychological impairment in executive functions, manifested in symptoms such as inattention and impulsivity, may lead to antisocial behaviors that include substance use (Moffitt, 1993). Therefore, it seems that ADHD symptoms are a risk factor for the development of early substance use at least in part because both problems involve poor self-control.

School Bonding Attitudes as a Potential Mediator

Children with ADHD possess intellectual deficits of approximately 10 points on intelligence tests and up to 30 standard score points on various achievement tests (Barkley, 2006; Faraone, Biederman, Mennin, Russell &Tsuang, 1998). Children with ADHD are also likely to experience poorer academic performance and peer and teacher conflict (Evans, Axelrod &

Langberg, 2004; Zentall, 1993). Along with conflict in school, students with ADHD demonstrate less academic engagement compared to 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). This may be explained by a failure to adhere to societal conventions, suggesting that less commitment to school-related activities may be related to aberrant behavior that includes substance use (Hawkins et al., 1992). That is, an individual who is uninvested in following social norms and rules due to chronic underachievement (and associated internalizing problems) may lack the confidence and motivation to engage in prosocial behaviors and be more vulnerable to substance use. Thus, ADHD symptoms may result in poor school bonding (attitude/commitment towards school), which in turn may be associated with increased risk of substance use.

Peer Rejection as a Potential Mediator

As noted above, impairment in social skills is another prominent feature associated with ADHD (Molina et al., 2009). Given the disruptive and distractible behaviors of ADHD, children with ADHD often struggle to form friendships and experience significant peer rejection (Hoza, 2007; Bagwell, Molina, Pelham & Hoza, 2001). 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). Peer rejection, peer isolation and low social competence are risk factors for substance use (Lochman, Wells & Murray, 2007; Coie, Dodge & Kupersmidt, 1990; Hawkins et al., 1992). As with poorer school bonding and likely contributing to diminished identification with school settings, peer rejection is linked to maladaptive behaviors such as substance use (Hawkins et al., 1992). More specifically, rejection by peers may result in a lack of investment in conventional relationships (teachers, parents, prosocial children) due to low social

competence (Lochman et al., 2007). Thus, peer rejection has been found to mediate children's early behavioral difficulties and later drug abuse and may partially account for the link between ADHD symptoms and substance use (Lochman et al., 2007). .

Internalizing problems as a Potential Mediator

While an association between ADHD symptoms and internalizing problems (i.e., depression, anxiety, somatic problems) has been established, the mechanisms that account for this link are not as clear. 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). In 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 (Ostrander & Herman, 2006; McCauley, Mitchell, Burke, & Moss, 1988; Arslan, Dilma, & Hamarta, 2009). More specifically, depressed and anxious children and adolescents tend to exhibit a cognitive style that attributes positive events to external, unstable, and specific factors, with effective interventions targeting this cognitive style (McCauley et al., 1988; Garber & Horowitz, 2002). This attributional style is consistent with children presenting with ADHD (Ostrander & Herman, 2006), suggesting a unifying link between the two conditions.

Moreover, as children with ADHD are likely to be rejected by peers (Hoza, 2007) and fail to bond to school (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 depressive symptoms (Loukas, Suzuki & Horton, 2006; Murray & Greenberg, 2000). Children who experience decreased bonding to schools may feel little sense of belonging, thus putting them at risk for depression (Shochet, Dadds, Ham & Montague, 2006). In addition, peer rejection is also connected to internalizing symptoms (Hankin, Mermelstein & Roesch, 2007; Hammen, Shih, Altman & Brennan, 2003; Ladd, 2006; Prinstein & Aikens, 2004; Coie, Lochman, Terry, & Hyman, 1992). Accordingly, peer rejection and lack of bonding and acceptance into conventional social institutions (i.e., social networks and school) that children with ADHD symptoms experience may result in internalizing problems (Prinstein & Aikens, 2004; Ostrander & Herman, 2006; Drabick et al., 2006).

Internalizing problems are directly linked to substance use (e.g., 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 internalizing problems (e.g., Arnett, 2005; 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, Rodriguez & Kassel, 2009; Kandel, Raveis & Davies, 1991). Adolescents who feel depressed or anxious may not have the coping resources to effectively reduce stress and may 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 substance use as a coping mechanism. Note that while the relation between internalizing problems and

substance use may be reciprocal (i.e., the effects of substances causing depression/anxiety; Hallfors, Waller, Bauer, Ford & Halpern, 2005; 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 ADHD symptoms and substance use.

Neighborhood, Parenting, Family Activities and Substance Use

From a bio-ecological perspective, familial and community contexts represent microsystems or environments that interact with biological factors during child development (Bronfenbrenner & Ceci, 1994; Loeber & Wikstrom, 1993; Steinberg & Avenevoli, 2000). These environmental factors may also contribute to the developmental progression of ADHD. Neighborhood quality (i.e., resources, support, and problems) may be an important variable to examine on adolescent substance use because substance use is often concentrated in urban communities (Carroll, 1993). Adolescents who live in disadvantaged (lower socioeconomic) neighborhoods are more likely to exhibit problem behavior, including substance use due to a lack of organization and control in the neighborhood (Barker, Trentacosta, Salekin, 2011; Elliot et al., 1996; Lynam, 2000). Stressful neighborhoods are also associated with depressive symptoms, possibly increasing vulnerability to substance use to cope with internalizing problems (Callahan, Scaramella, Laird & Sohr-Preston, 2011; Latkin & Curry, 2003).

Family dynamics is another variable that research suggests may influence the developmental progression of ADHD to substance use. Parental involvement is an important aspect of adolescent development because it protects against substance use by promoting school success (Pilgram, Schulenberg, O'Malley, Bachman & Johnston, 2006). Parents of high-risk adolescents who are highly involved and engage in good parental monitoring has been shown to be inversely associated with early adolescent substance use (Dishion, Nelson & Kavanagh,

2006). On the other hand, parents who engage in harsh discipline practices are more likely to have children who engage in externalizing behaviors that may lead to later substance use, particularly if they have poor self-regulation as observed in ADHD (Erath & El-Sheikh, 2009; Bates & Pettit, 2007). In addition, adaptive family activities may protect against risk of substance use because they promote family cohesion and are incompatible with (problematic) behavioral alternatives, and may increase school investment and achievement (Crosnoe & Trinitapoli, 2008; Felix-Ortiz & Newcomb, 1992; Hornberger, Zabriskie & Freeman, 2010; Jessor, Van Den Bos, Vanderryn, Costa & Turbin, 1995). Such contexts may mitigate the risk of substance use associated with the developmental pathways from ADHD symptoms.

In summary, the trajectory of ADHD symptoms may depend on particular familial and community variables that serve as protective factors for at-risk youth. Considering their role in reducing substance use and problem behavior in adolescents, it is reasonable to believe that neighborhood quality, parental involvement, and positive parenting and family activities may buffer developmental pathways from ADHD to substance use. Thus, it was hypothesized that these environmental variables would be moderators of ADHD symptoms and related areas of impairment.

The Current Study

The current longitudinal study attempts to identify specific pathways from fourth-grade ADHD symptoms to ninth-grade frequency and onset of substance use (from fifth- through ninth-grade). Both frequency and onset are important components of early substance use to consider, as both are associated with later substance use and substance use-related problems (Pitkanen, Lyyra & Pulkkinen, 2005; Hoffman, Sussman, Unger & Valente, 2006). Substance

use outcomes of tobacco, alcohol and other drug use were examined separately due to different timing of initiation and patterns of use (Kandel & Logan, 1984).

Existing research shows that poor school bonding, peer rejection and internalizing problems are associated with symptoms of ADHD (Barkley, 2006) and are risk factors for adolescent substance use (Hawkins et al., 1992), thus making them potential mediators of the link between symptoms of ADHD and substance use. Accordingly, multiple mediated pathways were hypothesized. More specifically, ADHD symptoms were expected to result in both peer rejection and poor school bonding, which in turn were expected to predict substance use both directly and indirectly, through internalizing problems. ADHD symptoms were also expected to directly predict internalizing problems, which in turn would predict substance use. Finally, family activities, parental involvement, positive parenting and neighborhood quality (resources, social support, and problems) were expected to moderate the hypothesized pathways. More specifically, pathways were expected to show weaker associations in the context of healthier environments (i.e., frequent family activities, strong parental involvement, positive parenting and higher quality neighborhoods).

The proposed pathways were examined in a high-risk sample of aggressive youth for two reasons. The first is due to the low base-rate of ADHD symptoms in non-clinical samples (Biederman, Mick & Faraone, 2000). Therefore, the current sample was more likely to present with ADHD symptoms and other developmental risk factors described above. Second, aggressive behavior is a risk factor and developmental precursor for substance use (Timmermans, Van Lier & Koot, 2008), allowing us to further understand developmental pathways to early substance use. To control for the effects of aggression in this sample, aggression was included as a covariate of substance use.

Section 2: Methods

Participants.

The current study included participants from an intervention study designed to evaluate the effectiveness of the Coping Power program for childhood aggression (Lochman & Wells, 2002, 2004). Participants were recruited from 17 elementary schools in Durham, North Carolina. Children were initially screened for aggression for inclusion into the study. 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. Sixty-five percent of these children's parents agreed to participate, creating a sample of 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 examined, to avoid confounding the study 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% Caucasian, 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%), while 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. The study

maintained an 86% retention rate over 6 years. Attrition of the study was as follows, year 1: N=126 (100%), year 2: N=111 (88%), year 3: N=108 (86%), year 4: N=101 (80%), year 5: N=100 (79%), year 6: N=108 (86%).

Procedure

Active informed consent was obtained from primary caregivers, and assent was obtained from children prior to every 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 at least a Bachelor's degree and were trained extensively. Interview training consisted of practicing reading interviews with other interviewers and role-playing mock interviews with experienced interviewers. 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. Caregivers were compensated $40 and children were compensated $10 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, and all symptoms may not be evident until this time (APA, 2000). Also, developmental research suggests many children grow out of "normal" behavior problems by elementary school, and thus many behaviors become significant only after children begin school (Campbell, Pierce, Moore, Marakovitz, & Newby, 1996). Further, elementary school is an appropriate setting to examine peer relations because children interact with the same classroom 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 (Lewinsohn et al., 1994; Kendall, Kortlander, Chansky & Brady, 1992) and thus internalizing problems were collected in the sixth-grade. Substance use research suggests frequency of use (number of days in the past month of alcohol, cigarettes, or marijuana) tends to increase drastically around the eighth and ninth grades (20-34%: from eighth to tenth grade) (Chassin & Hussong, 2009; Johnston, O'Malley, Bachman & Schulenberg, 2009). Therefore, the current study predicted substance use at ninth grade while controlling for substance use at eighth grade to capture increases in the early stages of substance use, unique to the effects of predictor variables. Further, the average age an individual first tries a substance is 14 (Newes-Adeyi, 2005), and initiating prior to 15 puts individuals at increased risk for alcohol dependence over the lifetime (NSDUH, 2004). Thus, we examined pathways from ADHD symptoms to early initiation of substance use.

Measures.

Substance use. Both the onset and frequency of substance use was assessed by children's report on the Center for Substance Abuse Prevention (CSAP) Student Survey. The 26-item survey was adapted from the California Student Survey (Pentz et al., 1989). Six items were used in the current study assessing tobacco, alcohol and marijuana frequency of use and timing of initiation. Initiation of each substance was examined using lifetime substance use items administered at each grade. A sample item is "Have you EVER had a drink of alcohol?" Items were coded as yes (1) or no (0) for analyses. Frequency was assessed using a 6-point scale to indicate the frequency of substance use within the past 30 days (0 = *never*; 1 = *1 or 2 days in the past month*; 2 = *3 to 5 days in the past month*; 3 = *6 to 9 days in the past month*; 4 = *10 to 19*

days in the past month; 5 = *20 to 31 days in the past month*). A sample item is "On how many days did you use marijuana in the last month (30 days)?" Since associations were similar across substances, frequency items were combined to create a composite measure of mean substance use to simplify presentation of results.

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 was found to be valid (correlated with a clinical diagnosis of ADHD, $r = .60$) and reliable ($\alpha = .84$, test-retest: $r = .93$) (Achenbach, 1991). The subscale also shows good diagnostic discrimination of ADHD in psychiatric samples (Biederman et al., 1993; Steingard, Biederman, Doyle & Sprich-Buckminster, 1992) and in a school sample (Doyle, Ostrander, Skare, Crosby & August, 1997). Items were summed and used for analyses. Internal consistency of the measure in the current sample was adequate ($\alpha = .79$).

Peer rejection. Peer rejection was assessed using a peer nomination system of classroom sociometrics at fifth grade. Children indicated the three peers they liked the most and the three peers they liked the least within their classroom. Peer nominations were standardized within each classroom. Then each individual's "liked least" score was subtracted from his or her "liked most" score to determine a social preference score (Coie, Dodge, & Coppetelli, 1982). Scores were then recoded, such that high values indicate high levels of peer rejection. This is a widely used measure and found to be a good method for discriminating between sociometric groups

(Terry & Coie, 199; Fite, Colder, Lochman, & Wells, 2007). This sociometric measure has good convergent validity, as it correlates moderately with other methods used to assess 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. This measure contains 9 items, including "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.

Internalizing problems. Caregivers reported on child internalizing behavior at 6th 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 in the past six months. This scale has adequate predictive validity (correlated with a clinical diagnosis of depression, r = .45, discriminated significantly between referred and nonreferred children, 80% correctly classified) and reliability (α = .90, test-retest: r = .91; Achenbach, 1991). Items were summed for analyses. Internal consistency of the measure in the current sample was good (α = .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 in the past six months. This measure has adequate diagnostic sensitivity (correlated with a clinical diagnosis of oppositional defiant disorder, r = .50, discriminated significantly between referred and

nonreferred children, 80% correctly classified) and reliability (α = .94, test-retest: *r* = .90; Achenbach, 1991). Items were summed for analyses. Internal consistency of the measure in the current sample was good (α = .88).

Parenting. Parenting processes were assessed using an abbreviated form of the Alabama Parenting Questionnaire (APQ; Shelton, Frick & Wooton, 1996). For this study, parents reported on the 5-item Appropriate Parenting scale and the 6-item Harsh Parenting scale. A sample Appropriate Parenting item was "You calmly explain to your child why his/her behavior was wrong when he/she misbehaves." A sample Harsh Parenting item was "You slap your child when he/she has done something wrong." Item responses were given on a 5-point likert scale (1 = *never,* 5 = *always*). The measure has shown adequate construct validity in prior research (Colder, Lochman & Wells, 1997). These scales had low internal consistency at all time points (α = .41 - .57), which is likely a product of the inclusion of only 5 and 6 items for the scales. However, despite these low internal consistencies, the measure has shown adequate construct validity in prior research as conduct problems are negatively related to appropriate parenting (*r* = -.18) and positively related to harsh parenting (*r* = .24) (Dadds, Maujean & Fraser, 2003).

Neighborhood quality. The three variables use to assess neighborhood quality were the amount of community support, social resources, and community problems. These were obtained from the subscales of the Chicago Youth Development Study (CYDS)-Neighborhood Questionnaire (Tolan, Gorman-Smith, Huesmann, & Zelli, 1997), which was completed by caregivers. The CYDS is a 46-item scale that asks respondents to assess their community on a 5-point likert scale (1 = *strongly agree* to 5 = *strongly disagree*). The community support scale includes items regarding the level of belonging one feels in their neighborhood and whether one feels a sense of loyalty to other members of the community. The community resources scale

includes items such as involvement in neighborhood organizations that deal with issues or problems and willingness to work with others to improve the neighborhood. The community problems scale contains items such as perceived rates of drug activity, homelessness, gangs, and burglary. Higher scores indicate poor community support, low resources, and more community problems. All the scales had high internal consistency in the current sample (α = .87 - .91) with the resources scale slightly lower but adequate (α = .68 - .76).

Family activities. Caregivers were assessed on family activities by indicating if they engaged in 28 activities – over what time period?. This measure has been used previously in studies at the Oregon Social Learning Center (Capaldi, 1991). Caregivers responded with either *yes* (1) or *no* (0) to each item and mean scores were computed for analyses.

Section 3: Data Analytic Plan

Lifetime Prevalence

Comparisons between the current sample and a national survey (Monitoring the Future; Johnston, O'Malley, Bachman, Schulenberg & 2011) of 8th grade lifetime prevalence rates were examined. Chi-square tests with Yates correction were used due to the large values in the national survey sample.

Path Models

Frequency of substance use hypotheses were examined using structural equation models that were estimated using AMOS. To account for non-normality in the distribution of the substance use variable, robust maximum likelihood estimation was used. This estimation method uses maximum likelihood parameter estimates with standard errors that are robust to non-normality (Muthen & Muthen, 2004). Full information estimation (FIE) was used with the proposed data-analytic strategy to accommodate missing data. FIE uses all available data to calculate parameter estimates and does not exclude missing data (Kline, 2010). FIE has been found to be less biased and more efficient than other strategies, such as pairwise and listwise deletion, to accommodate missing data (Arbuckle, 1996). Based on guidelines from Hu and Bentler (1999) and common guidelines in the structural equation modeling literature, good model fit was evaluated using the following cutoff criteria: $\chi^2/df < 2$, Comparative Fit Index (CFI) > .95, and Root Means Square Error of Approximation (RMSEA) < .08.

Mediational paths were evaluated using Meeker's Test for indirect effects. This method has been found to provide a more accurate balance between Type I and Type II errors than other methods used to test indirect effects such as Sobel's method (MacKinnon, Lockwood, &

Williams, 2004). Using Meeker's table of upper and lower values, 95% confidence intervals (CIs) were used to test the significance of the indicated indirect effects.

Survival Analysis

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. Robust maximum likelihood estimation with Monte Carlo integration was used (Muthen and Muthen, 2004). Again, FIE was used to accommodate missing data. 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 for the individual substances 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. Next, symptoms of ADHD were added as a predictor. Finally, the proposed mediated pathways were added to 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).

Potential Moderators

A multiple group model approach was then employed to determine if mediated pathways were invariant across levels of the moderators for both the path and survival analysis models. Median splits were used to dichotomize moderating variables (Kline, 2010). Each moderator was evaluated separately in its own series of models.

The multiple group model approach is an iterative approach that is conducted in several steps. First, paths of the model are free to vary across levels of the moderator. Next, models in which paths are constrained to be equal across levels of the moderator are estimated. A χ^2 diff test is then consulted to determine if constraining paths to be equal across levels of the moderator results in a significant decrement in the model chi-square. Constraints that result in a significant decrement in the model chi-square indicate significant moderation.

Section 4: Results

Descriptive Statistics

With regard to substance use, 25% of ninth graders reported substance use (tobacco, alcohol and/or marijuana) in the past 30 days (16% tobacco use, 11% alcohol use, and 12% marijuana use). 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% vs. 39% ($\chi^2 = 6.81$, $p = 0.01$), alcohol use: 44% vs. 51% ($\chi^2 = 2.07$, $p = 0.15$), and marijuana use: 16% vs. 27% ($\chi^2 = 10.38$, $p = 0.001$) (Johnston, O'Malley, Bachman, Schulenberg & 2011). Higher prevalence rates are attributed to the high-risk nature of the sample.

Correlations, means and standard deviations of study variables are reported in Table 1. Contrary to expectations, ADHD symptoms were not related to ninth grade frequency of use of tobacco, alcohol, or marijuana. ADHD symptoms were related to ninth grade tobacco use initiation ($r = .22$, $p = .02$), but not alcohol or marijuana initiation. Consistent with previous research, ADHD problems were strongly positively correlated with aggressive behavior (Connor et al., 2003). Also as expected, ADHD problems were positively correlated with peer rejection, internalizing problems, and harsh parenting (Ostrander & Herman, 2006; Hoza et al., 2005; Bates & Pettit, 2007). Aggressive behavior was positively correlated with internalizing problems, poor neighborhood quality and harsh parenting. Internalizing problems were positively correlated with peer rejection and, unexpectedly, appropriate parenting. Additionally, family

activities were positively correlated with appropriate parenting and negatively correlated with harsh parenting and tobacco use. Harsh parenting was also related to higher frequency of substance use. Finally, minority status was related to lower frequency of alcohol use and poorer neighborhood quality.

Path Model

Structural equation modeling was used to examine the developmental trajectory of ADHD symptoms as predictors of school bonding, peer rejection, internalizing problems and substance use, while controlling baseline levels of aggression and substance use one year prior to outcome. Due to the strong overlap between ADHD symptoms and aggressive behavior (36% shared variance), aggressive behavior was a covariate. Gender and race were also included as covariates originally, however, preliminary analyses suggested that gender and race were not significant predictors of substance use. Therefore, race and gender were not considered in the final model. As seen in Figure 1, 26 parameters were estimated in the model, resulting in nine degrees of freedom. The model in which frequency of any substance was evaluated provided a modest fit to the data ($\chi^2(9) = 17.3$, $\chi^2/df = 1.92$, CFI = .932, RMSEA = .086). It is important to note that three separate models for each substance (i.e., tobacco, alcohol and marijuana) were first evaluated, but due to similarities in results for models (i.e., no associations between each substance and all study variables) only one model, with a mean substance use variable evaluated, is reported.

Results suggested that ADHD symptoms positively predicted grade 5 peer rejection and grade 6 internalizing symptoms, such that high levels of ADHD symptoms predicted high levels of rejection and internalizing symptoms. Peer rejection also positively predicted internalizing symptoms, such that high levels of rejection were associated with higher levels of internalizing

symptoms. However, no study variables predicted ninth grade substance use other than substance use at eighth grade. Using Meeker's table of upper and lower values, confidence intervals (CIs) were used to test the significance of the indicated indirect effects. The test of indirect effects suggested that peer rejection did not account for the relation between ADHD symptoms and internalizing symptoms (B = 0.091, 95% CI [-.04, .21]).

Moderation of Path Model

The multiple group model was then estimated to determine if the pathways from ADHD symptoms to substance use frequency were invariant across high and low levels of the potential moderators. Neighborhood was tested first as a moderator by dividing the sample using a median split into two groups, high neighborhood problems and low neighborhood problems. The unconstrained model was compared to the fully constrained model, and the χ^2 diff test indicated the constrained model did not cause a significant decrement in the model fit ($\Delta\chi^2(11) = 6.4$, $p >$ .05). Thus, paths were determined to be invariant across high and low neighborhood problems. Family activities were then tested using the same method (high and low activities); however, the χ^2 diff test indicated the constrained model did not cause a significant decrement in the model fit ($\Delta\chi^2(11) = 7.6$, $p >$ .05). Thus family activities did not moderate the path model. Next, appropriate parenting was tested as a moderator and the χ^2 diff test indicated the constrained model did not cause a significant decrement in the model fit ($\Delta\chi^2(11) = 7.6$, $p >$ .05). Thus appropriate parenting did not moderate the path model. Last, harsh parenting was tested as a moderator, and the χ^2 diff test indicated the constrained model did not cause a significant decrement in the model fit ($\Delta\chi^2(11) = 17.9$, $p >$ .05). Thus harsh parenting also did not moderate the path model.

Survival Analysis

Tobacco. Initiation of tobacco use hazard probabilities followed a linear trend, such that risk for the initiation of tobacco use increased as participants aged from fourth to ninth grade (M=0.15, p=0.05). The addition of quadratic ($\chi^2(1)$ =0.04, p=0.84) and cubic ($\chi^2(1)$=0.01, p=0.92) trends did not improve the model fit. Covariates of ADHD symptoms, race, and gender were then added to the linear model. No significant associations were found for ADHD symptoms, race, and gender and ninth grade tobacco use initiation (*ps* =0.13 to 0.45) or the linear slope of tobacco use initiation (*ps*= 0.52 to 0.59).

Peer rejection, school bonding, internalizing problems, and aggression were then added to the model. Internalizing problems were positively associated with initiation of tobacco use at ninth grade (B=.14, p=0.01) and the linear slope of tobacco use initiation (B=.05, p=0.02), 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). 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=.48, p<0.001), which in turn was associated with increased risk of initiation of tobacco use. 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 marginal predictor of high levels of peer rejection (B=.17, p=0.06), which subsequently predicted high levels of internalizing problems (B=0.65, p=0.04) and subsequent increases in tobacco use. Predicted risk trajectories for initiation of tobacco use at high and low levels of ADHD symptoms through the effect of both peer rejection and internalizing problems as well as internalizing problems only are plotted in Figure 2a and 2b, 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.

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=0.005). The addition of quadratic ($\chi^2(1)$=1.09, p=0.30) and cubic ($\chi^2(1)$=0.02, p=0.88) trends did not improve the model fit. Covariates of ADHD symptoms, race, and gender were then added to the linear model. No significant associations were found for ADHD symptoms, race, and gender with ninth grade alcohol use initiation (ps =0.11 to 0.77) or the linear slope of alcohol use initiation (ps= 0.31 to 0.49).

Peer rejection, school bonding, internalizing problems and aggression were then added to the model. School bonding was negatively associated with initiation of alcohol use at ninth grade (B=-0.39, p=0.04) and the linear slope of alcohol use initiation (B=-0.11, p=0.05), 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=0.08), such that Caucasian youth were more likely to initiate alcohol use than minority youth. All other variables were unrelated to the risk of alcohol use initiation (ps=0.29 to 0.88) and the linear slope of alcohol use initiation (ps=0.29 to 0.89).

Marijuana. Initiation of marijuana use hazard probabilities followed a marginally significant cubic pattern (linear M= -0.98, p= 0.15, quadratic M= -0.81, p= 0.05, cubic M= -0.10, p= 0.07). The addition of a quadratic trend (from a linear trend) did not improve the model fit ($\chi^2(1)$=2.05, p=0.15), but the addition of a cubic trend produced a marginally significant

improvement in the model fit ($\chi^2(1)=3.40$, $p=0.06$). 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 suggest that children are most at risk for initiation of marijuana use in eighth grade. Covariates of ADHD, gender, and race were added to the model. ADHD, gender and race were unrelated to risk for initiation of marijuana use (*ps*= 0.26 to 0.90).

Peer rejection, school bonding, internalizing problems and aggression were then added to the model. All variables were unrelated to risk for initiation of marijuana use at ninth grade (*ps*= 0.17 to 0.97). ADHD was however, associated with the cubic slope of marijuana use initiation ($B=0.06$, $p=0.002$), 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. Aggression was also associated with the cubic slope of marijuana use initiation ($B=-0.03$, $p=0.006$), such that low levels of aggression were associated with a stronger cubic trend.

Moderation of Survival Model

Multiple group models were then estimated in order to determine if the pathways from ADHD symptoms to substance use initiation and slope of substance use initiation over time were invariant across high and low levels of the potential moderators. Each survival model (tobacco, alcohol and marijuana) was divided into two groups for every potential moderator, high and low levels of neighborhood problems, family activities, appropriate parenting and harsh parenting. However, due to model complexity and a limited sample size when separated into groups, the models were unable to converge.

Section 5: Discussion

ADHD to Substance Use Frequency

The current study first examined pathways from ADHD symptoms to substance use frequency. We found that ADHD symptoms in childhood were unrelated to overall substance use frequency in adolescence. This may have occurred due to the developmental period of our sample ending in ninth grade, when many children with ADHD symptoms may have engaged in substance use later in high school. Further, the length of time between assessments (fourth to ninth grade) may have been too long to detect effects. While the study did not yield significant substance use frequency findings (a main objective of the study), other developmental impairments of ADHD with psychosocial variables and substance use initiation were identified.

ADHD symptoms positively predicted peer rejection and internalizing symptoms, one and two years later, respectively. Peer rejection was also associated with internalizing symptoms. Thus, it appears that ADHD symptoms in fourth grade follow a path to peer rejection in fifth grade and then to internalizing problems, such as depression and anxiety in sixth grade. Social problems are a significant impairment in children with ADHD as they struggle to form individual friendships and tend to be ostracized by their classmates (Hoza, 2007). Further, ADHD may lead to future internalizing problems either directly or indirectly through peer rejection. 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 (Hankin, Mermelstein & Roesch, 2007). Compared to 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). Additionally, ADHD symptoms were linked directly to internalizing problems, suggesting there may be other unmeasured developmental influences.

ADHD and Initiation of Substance 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. While ADHD symptoms were not linked to initiation of tobacco use in the first survival model, this association was present through mediator variables when introduced in the second model. ADHD symptoms were associated with ninth grade tobacco use initiation and risk for tobacco use initiation over time through mediation. Mediators included a simple path through internalizing problems and a more complex path through peer rejection and internalizing problems. The fact that significant associations only occur through mediation suggests the likelihood of a suppression effect, which may be due to the extended time between assessments (i.e., fourth to ninth grade; MacKinnon, Krull & Lockwood, 2000). 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 a risk for tobacco use as they seek alternative methods to cope with stressful events (Braaten & Rosen, 2000; Hankin, Mermelstein & Roesch, 2007).

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 (Collins, 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 to 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.

The nonsignificant findings between ADHD symptoms and initiation of both alcohol use and marijuana use were 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. While our study identified developmental links between ADHD symptoms and tobacco use by ninth grade, it may not have captured alcohol and marijuana use that develops later on, particularly due to the gateway hypothesis (Biederman et al., 2006). Additionally, the age range of the sample may not have detected large enough frequencies of alcohol and marijuana use in the early initiators and the low variability may have contributed to a lack of significant findings with these substances. Further, school bonding did not represent an influential factor in the development of substance use in children with ADHD symptoms. It may be that the timing of assessing school bonding was too early to detect the effects of academic struggles of children with ADHD symptoms, which may not be evident until coursework becomes more challenging in middle school.

When evaluating the development of ADHD symptoms to substance use by different environmental moderators there did not seem to be an impact of neighborhood, family activities or parenting. In other words, the associations between ADHD symptoms and psychosocial impairments did not vary across the quality of neighborhoods, the amount of family activities or

difference in the use of appropriate and harsh parenting styles. Some have suggested that the neighborhood context may have the greatest influence on older adolescents' internalizing and externalizing behavior (Leventhal & Brooks-Gunn, 2000).

Implications for Intervention

The current study yields findings that would be useful in refining existing interventions and constructing new, more effective interventions. If left untreated, ADHD symptoms are likely to spiral into a pathway towards early initiation of substances, particular tobacco use. When ADHD children grow up, 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 their ADHD (Biederman, 1995). During childhood, it may be useful to focus on interventions that target inattention symptoms, as adolescent inattention is associated with twice the risk for co-occuring tobacco use, even when controlling for conduct disorder (Burke, Loeber & Lahey, 2001). Further, while symptoms of hyperactivity tend to decrease with age, inattention seems to persist into adolescence (Hart et al., 1995) and may cause adolescents to turn to cigarettes to self-medicate instead of seeking appropriate treatments.

Finally, although appropriate and harsh parenting did not moderate associations in the current study, other parental behavior, such as involvement or monitoring may be protective against certain developmental risks associated with ADHD symptoms. Parents that create opportunities for organized activities may keep ADHD symptoms from progressing into social and emotional difficulties and tobacco use. Participation in after-school activities, such as attending a Boys and Girls Club, is associated with numerous positive adjustment outcomes, including less truancy and cigarette use (Anderson-Butcher, Newsome & Ferrari, 2003).

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 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 though ninth grade, which may not have captured associations with substance use that began during or following sophomore year. Further, our assessment of ADHD symptoms was from a behavioral parent checklist (CBCL). Individualized structured clinical interviews may have yielded more accurate clinical diagnoses and potentially may have affected results (Reich, 2000; Hodges, 1993).

In sum, the developmental trajectory of ADHD seems to follow a path to early initiation of tobacco use through peer rejection and internalizing problems. While much attention has been paid to the 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 other health 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 with 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.

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Appendix

Table 1. *Correlations, Means, Standard Deviations*

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. ADHD Symptoms Grade 4	4.10	3.48	-														
2. Aggressive Behavior	9.41	6.09	.60***	-													
Grade 4																	
3. Peer Rejection Grade 5	0.47	1.92	.23*	.24*	-												
4. School Bonding Grade 5	7.70	1.37	-.03	-.08	-.19	-											
5. Internalizing Problems	5.85	5.41	.38***	.38***	.30*	.02	-										
Grade 6																	
6. Tobacco Use Freq Grade 9	.23	.63	.09	.22	.20	-.16	.13	-									
7. Alcohol Use Freq Grade 9	.17	.58	.00	-.02	-.17	.01	-.08	.17	-								
8. Marijuana Use Freq Grade 9	.32	1.03	.03	.07	.06	-.11	.03	.27**	.67***	-							
9. Substance Use (*M)* Freq	.24	.54	.07	.16	.12	-.14	.07	.75***	.68***	.81***	-						
Grade 9																	
10. Poor Neighborhood Quality	1.98	0.41	.17	.35***	.15	-.04	.14	.02	-.18	.05	.00	-					
11. Family Activities	.60	.13	.18	-.01	.13	.03	.04	-.27*	-.14	-.17	-.27*	-.18	-				
12. Appropriate Parenting	2.77	0.40	.19	.15	.19	-.09	.25*	-.11	-.12	-.09	-.13	.17	.46***	-			
13. Harsh Parenting	1.99	0.43	.25*	.29**	.17	-.07	.11	.31	.09	.12	.25*	.14	-.34**	-.05	-		
14. Gender	.66	.48	-.04	.01	-.19	.14	.02	.16	-.06	-.11	.02	-.15	.00	.08	.00	-	
15. Race	.79	.41	-.14	-.05	-.07	.05	.08	.08	.33***	.12	.19*	-.36***	-.15	-.06	-.12	.15	-

M = mean, SD = standard deviation, Freq = Frequency, Gender (1 = Male, 0 = Female), Race (1 = Caucasian, 0 = minority status); *p<0.05, **p<0.01, ***p<0.001

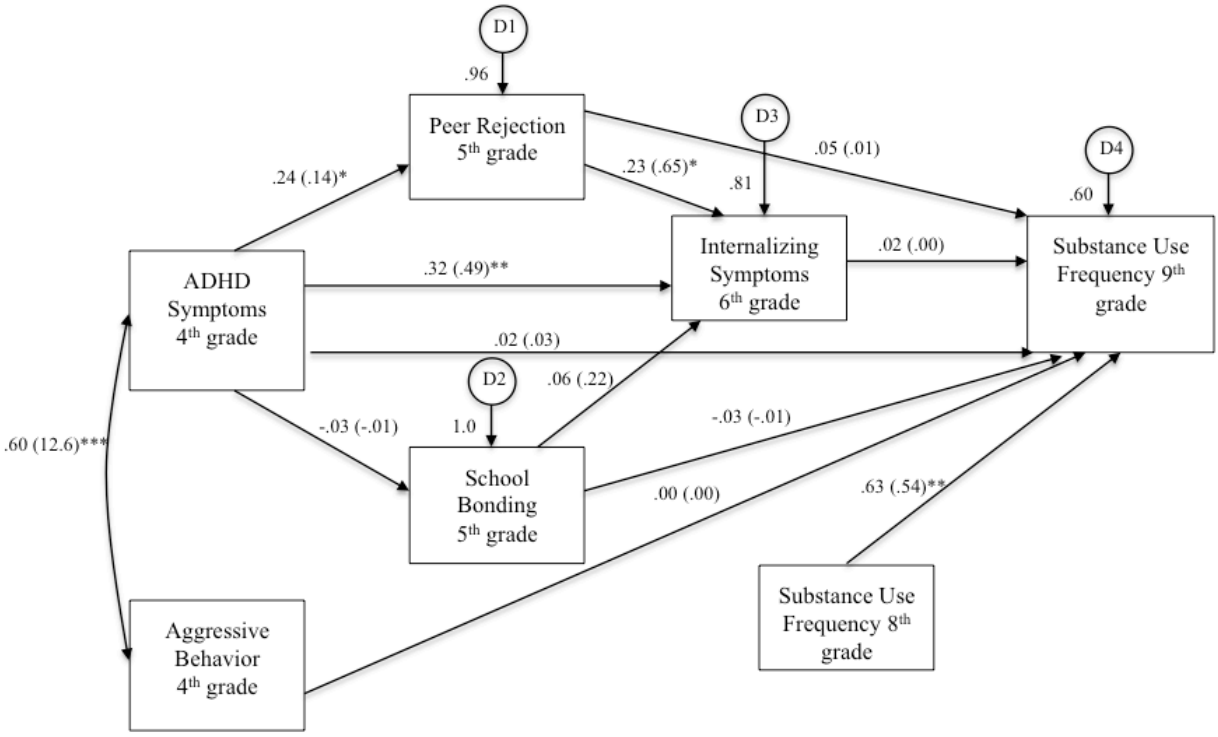

Figure 1. Developmental trajectories from childhood ADHD symptoms to adolescent substance use path model. N = 126. Standardized and unstandardized (in parentheses) estimates are reported. Estimates for the disturbances (D1-D2) are proportions of unexplained variance. * $p < .05$, ** $p < .01$, *** $p < .001$.

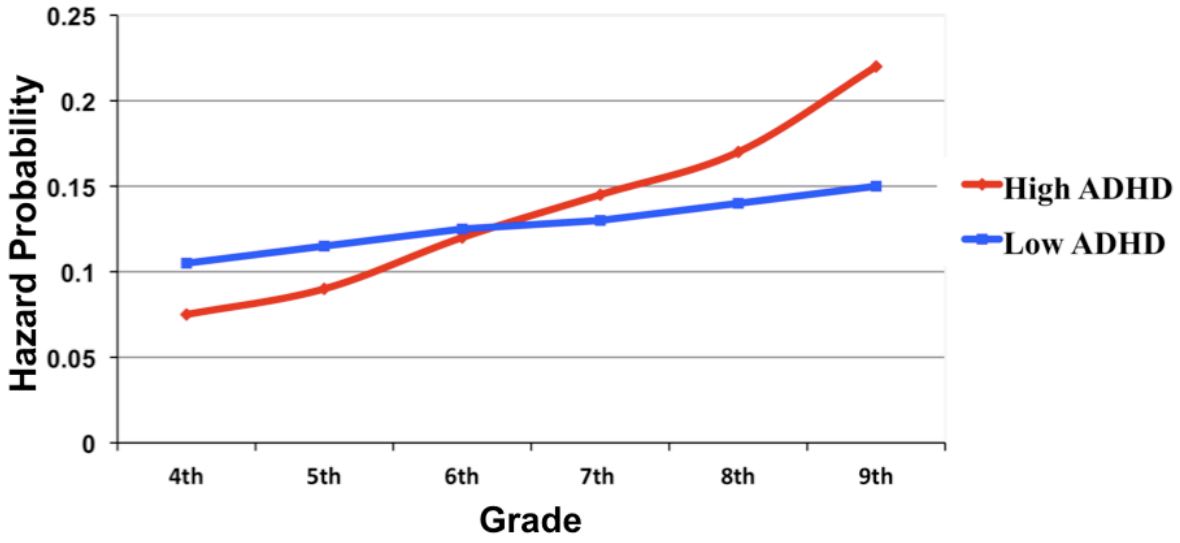

Figure 2a. Risk for tobacco use initiation from fourth grade to ninth grade through internalizing symptoms.

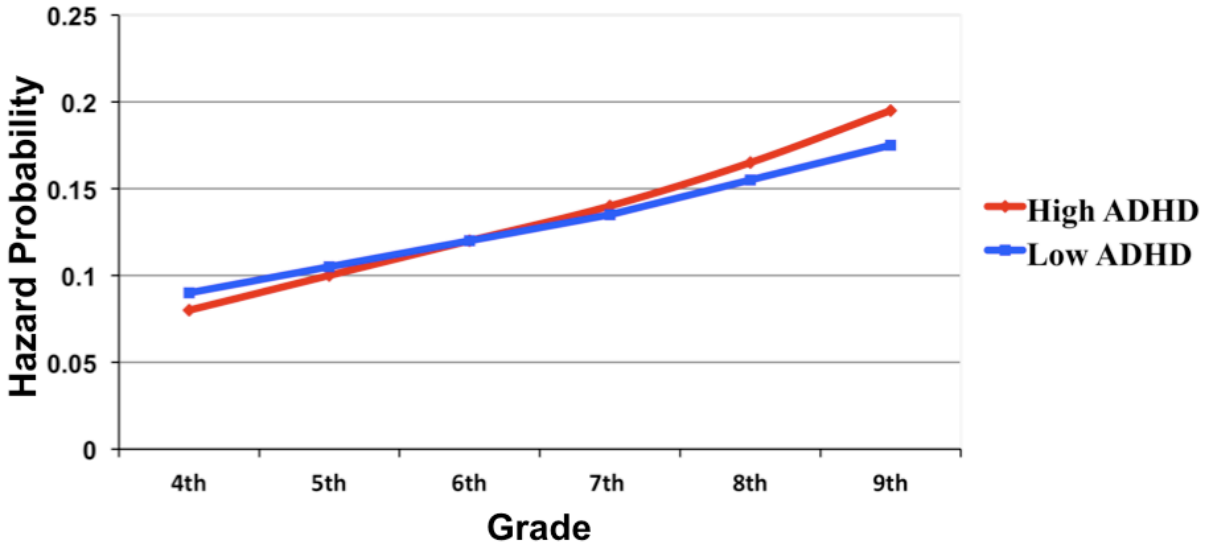

Figure 2b. Risk for tobacco use initiation from fourth grade to ninth grade through peer rejection and internalizing symptoms.

Vita

Michael L. Vitulano received his B.A. in Psychology in May of 2006 from Wesleyan University. In the fall of 2008, he began his doctoral studies in Clinical Psychology at The University of Tennessee, Knoxville. In the spring of 2010, he successfully earned an M.A. in Psychology at The University of Tennessee. Currently, Michael's primary research interests surround protective environmental factors, such as parenting, neighborhood and organized activities, as they relate to the development of ADHD and potential negative outcomes. Furthermore, he has interests in applied statistics in child behavior.