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Longitudinal Relations Between ADHD Symptoms and Substance Use Across the Transition to College and Evaluation of Promotive and Protective Factors

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LONGITUDINAL RELATIONS BETWEEN ADHD SYMPTOMS AND SUBSTANCE USE ACROSS THE TRANSITION TO COLLEGE AND EVALUATION OF PROMOTIVE AND PROTECTIVE FACTORS

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University

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Abstract

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The prevalence of substance use and related problems increases during adolescence and peaks in young adulthood with substantial increases during the transition from high school to college (Johnston et al., 2018). However, these increases are not universal for all students (White et al., 2006), and there is substantial variation in rates of substance use during the first year of college (Borasri et al., 2007; Frisher et al., 2007). It is important to identify the individual and environmental factors that serve as risk factors for substance use as well as factors that may promote or protect against use during the high school to college transition. This prospective longitudinal investigated the impact of risk, promotive, and protective factors on the substance use outcomes of 150 high school seniors transitioning to college. The prevalence of alcohol and marijuana use substantially increased from high school to the first semester of college. Results indicate that ADHD symptoms at the end of high school predicted residualized change in alcohol and marijuana use during the first semester of college (i.e., controlling for the autoregressive effect of use during college). For alcohol use (but not marijuana), ADHD symptoms continued to predict subsequent use across the first year of college (from fall to spring of the first year).

Promotive models revealed that adaptive social perceptions predicted decreased alcohol and marijuana use, and academic motivation predicted decreased alcohol use, after controlling for the role of ADHD symptoms. Adaptive social perceptions about each substance was protective against future alcohol and marijuana use both before and after the transition to college demonstrated by significant interaction effect with ADHD symptoms, after controlling for the direct risk and promotive effects in the model. These interactions illustrated that adolescents with elevated ADHD symptoms who have high friend disapproval of substances may experience resilience with respect to substance use outcomes. Academic motivation demonstrated promotive (direct) effects for reducing the risk for alcohol use but protective effects were not found. Future research should seek to elucidate more specific mechanisms through which youth and adolescents with elevated ADHD are protected against the high risk for substance use problems.

Longitudinal Relations Between ADHD Symptoms and Substance Use Across the Transition to College and Evaluation of Promotive and Protective Factors

The transition from high school to college is characterized by rapid changes in social context, including increased freedoms, responsibilities, and independence (Arnett, 2000; Newcomb & Bentler, 1987). During the transition, emerging adults are often moving away from home for the first time, forming new social groups, and navigating new sets of demands to independently manage their lives (Arnett, 2005). Some emerging adults thrive in this environment of increased independence, whereas others struggle without the support of parents and teachers to monitor their progress and help them make decisions (Eccles, 2004). Key theorists in emerging adulthood such as Arnett (2005) and Osgood (Osgood, Anderson, & Schafffer, 2005) have argued that increased unstructured socializing, instability, and stress contribute to accelerating substance use during emerging adulthood. In addition, decreases in parental monitoring can lead to increased substance use during this period (Borsari & Carey, 2001).

The prevalence of substance use and related problems increases with age during adolescence and peaks in young adulthood (Johnston, Miech, O'Malley, Bachman, Schulenberg, & Patrick, 2018; CDC, 2015). Epidemiologic studies demonstrate that alcohol and substance use increases substantially during the transition from high school to college (e.g., Johnston, O'Malley, Bachman, & Schulenberg, 2015). Indeed, lifetime prevalence of substance use and misuse rises from 49% among 19 and 20 year-olds to 72% by age 27 (Johnston et al., 2009; Substance Abuse and Mental Health Services Administration, 2009). Further, college students use substances at even higher rates than their non-college-attending peers (Borasri, Murphy, Barnett, 2007; Johnston et al., 2018; White et al., 2005), with nearly half (47%) of all college students meeting criteria for an alcohol or marijuana use disorder at least once in the first three

years of college (Caldiera et al., 2009). Risky substance use among college students is widespread, with 39% of students reporting that they binge drink (Substance Abuse and Mental Health Services Administration, 2012), 38% of students reporting illicit drug use in the past year (Johnston et al., 2015; Kilmer & Geisner, 2013), and one-third reporting having used illicit drugs in the past 30 days (Rigotti, Lee, & Wechsler, 2000; Johnston et al., 2015).

In recent years, substance use patterns have been changing among college student populations. In particular, illicit drug use, especially marijuana, is rising in popularity (Johnston, O'Malley, Bachman & Schulenberg, 2016; Miech, Johnston, O'Malley, Bachman, & Schulenberg, 2016). The most recent data from the from the Monitoring the Future (MTF) project, conducted annually, showed that approximately half (50.4%) of college students report lifetime use of marijuana, 38% report past year use, and 21% report past month use (Johnston et al., 2016; Miech et al., 2016; Schulenberg, Johnston, O'Malley, Bachman, Miech, & Patrick, 2017). These prevalence rates are the highest observed in the MTF project since 1990 for annual and past month use and represent a 5% increase over the past ten years. Further, data from a large study of college students at Virginia Commonwealth University, Spit for Science (Dick et al., 2014), indicate that the majority of risky alcohol use now occurs in the context of other drug use, most commonly marijuana (Cho et al., 2015).

Consequences of Substance Use

Substance use including risky alcohol and marijuana use in college is a serious health concern as it is related to legal consequences, early pregnancy, unwanted sexual encounters, sexually transmitted diseases, violence, unintentional injuries and suicide (e.g., Arria et al, 2013, Hingson, Zha, & Weitzman, 2009; Greenblatt, 1999; Kitzrow, 2003; King, Meehan, Trim, & Chassin, 2006; Peltzer & Pengpid, 2012; Wechsler et al., 2002). Importantly, problematic substance use and associated consequences are also associated with decreased academic

performance, higher rates of academic probation and failure to graduate (Hingson et al., 2009; Kitzrow, 2003; Wechsler, Lee, Kuo & Lee, 2000). In a nationally representative cross-sectional study of college students from 119 colleges, Wechsler and colleagues (2000) found that frequent binge drinkers were eight times more likely to get injured or hurt than non-binge drinkers, 17 times more likely to have missed class, seven times more likely to have engaged in unplanned sexual activity, and eight times more likely to have gotten into trouble with campus or local police. Further, college administrators report substantial increases in the amount of time they spend dealing with substance use and related mental health concerns on campuses (Angelo, 2004; Wechsler et al., 2000; Wechsler et al., 2002). This has prompted public officials to identify substance use behaviors such as heavy drinking by college students as a major public health concern (Task Force of the National Advisory Council on Alcohol Abuse and Alcoholism, 2002).

There is some evidence that first-year students are especially vulnerable to problems associated with substance use (Borsari et al., 2007). For example, freshmen are over-represented in reports of injuries, getting in trouble with the police (Harford, Wechsler, & Muthén, 2003), and alcohol-related emergency room visits (Bergen-Cico, 2000; Wright, Norton, Dake, Pinkston, & Slovis, 1999). Establishing heavy drinking behaviors during the first year of college also has long-term implications as many students begin a pattern of heavy use that continues throughout college and young adulthood (Del Boca et al., 2004). For example, 42% of 18 to 19 year old college students diagnosed with an alcohol use disorder continued to meet criteria at age 25 (Sher & Gotham, 1999).

Limitations of the Study of Substance Use and Misuse in College

Despite this wealth of information, our understanding of substance use and related problems in adolescence, young adulthood and college settings remains limited by the fact that

most data are cross-sectional (e.g., see Borsari et al., 2007; Stone, Becker, Huber, & Catalano, 2012 for reviews). This permits investigating cohort differences as a measure of temporal change, but does not allow for developmental models to be explicitly tested. In particular, we know very little about the trajectory from high school to college, given that few studies have followed students from their senior year across the transition (e.g., Stone et al., 2012; Sher & Rutledge, 2007). The majority of studies assess students after starting college, often using the fall semester as an indicator of the start of college. These studies fail to capture changes in substance use/abuse from high school to college and cannot evaluate whether pre-existing behaviors or factors, present during senior year of high school, predict or protect against substance use in the first year of college. Indeed, one study found pre-college heavy drinking was the strongest predictor of heavy drinking in the first semester of college, suggesting that substance use patterns may be formed prior to the start of college (Sher & Rutledge, 2007). Future longitudinal research, especially starting before students arrive on campus is needed to identify the moderators that are most associated with risky substance use in college.

Substance use Vulnerability is Multifaceted and Heterogeneous

Importantly, increases in substance use behaviors are not universal for all students during the transition to college (White et al., 2006). For example, although most students demonstrate an overall increase in heavy alcohol consumption (e.g., Johnston et al., 2018; SAMHSA, 2009, 2012), there is substantial variation in drinking rates over the course of the first year (Borasri et al., 2007). Further, not all students who use substances in college become addicted or demonstrate continued use over time (Frisher et al., 2007). It is important to identify the individual and environmental factors that serve as risk factors for substance use as well as well as factors that may promote or protect against use from high school to college.

Identifying factors that influence substance use and abuse are important to prevent substance use and related problems. Individuals may use and abuse substances for different reasons (Arnett, 2005; Bond et al., 2007; Borsari et al., 2007; Brook, Brook, Arencibia-Mireles, Richter, & Whiteman, 2001; Heinz et al., 2013), and the development of substance-related problems are often discussed within the context of multiple factors (Dick et al., 2014). Indeed, decades of research have concluded that adolescent and young adult substance use is a complex phenomenon that is best understood as determined by a multitude of factors at different levels of development (i.e., individual, family, social; e.g., Bronfenbrenner, 1979). These developmental pathways and mechanisms are often studied separately as individual covariates; however it is also important to consider the additive and interactive influences on substance use throughout the transition to college.

Externalizing Pathways to Substance Use Problems

The heterogeneity in substance use during college suggests that substance use and associated problems may be more common in certain subgroups. One of the most widely acknowledged pathways recognizes the central role of externalizing behavior in the development of substance use behaviors and problems among adolescents and young adults (Sher, 1993; Zucker, 2006; Zucker, Heitzeg, & Nigg, 2011; Wong et al., 2006). The association between externalizing behaviors and substance use holds for alcohol use and problematic use (Engels, Vermulst, Dubas, Bot, & Gerris, 2005; Maggs, Patrick, Feinstein, 2008; Steinhausen, Eschmann, Heimgartner, & Metzke, 2008; Wiesner, Kim, Capaldi, 2005), as well as marijuana use (e.g., Bor et al., 2010; Brook, Balka, & Whiteman, 1999; Hayatbakhah et al., 2008) and problematic use of substances in general (e.g., Flory, Milich, Lynam, Leukefeld, & Clayton, 2003; Morojele & Brook, 2001; Steinhausen, Eschmann. & Metzke, 2007). The externalizing pathway is characterized by a number of behaviors and traits that represent behavioral disinhibition and

under-control, impulsivity, low self-regulation, antisocial behavior (Dick et al., 2010; Zucker, 2008; Zucker et al., 2011). In addition, there are a variety of personality traits indicative of externalizing behavior that are associated with increased likelihood of harmful substance use, including extraversion, sociability, and impulsivity (Wills, Windle, & Cleary, 1998; Littlefield & Sher, 2010; Cho et al., 2015; Dick et al., 2014; Vassileva et al., 2014; Wong et al., 2006). Other personality traits associated with substance use include sensation seeking (Cho et al., 2015; Cloninger, Sigvardsson, & Bohman, 1988) and poor planning (Clark et al., 2005). In the substance use literature, behavioral under-control or disinhibition is typically defined as a vulnerability of disinhibitory processes that involves the inability or failure to inhibit behavior even in the presence of anticipated or already received negative consequences (Hawkins, Catalano, & Miller, 1992; Zucker, 2006). In terms of characterizing these externalizing traits or behaviors, most researchers posit a hierarchic structural model in which behavioral disinhibition is a higher-order factor superordinate to three lower factors of impulsive sensation-seeking, antisociality, and externalizing symptoms generally (Bogg & Finn, 2010; Wills et al., 2001; Vassileva, Gonzalez, Bechara, & Martin, 2007; Zucker et al., 2011). Interestingly, these traits and characteristics are strongly correlated with ADHD symptoms (e.g., Martel et al., 2009; White, 1999) and could be argued to be the same behaviors just expressed in different language and measures (Molina & Pelham, 2014).

There are several hypotheses regarding the comorbidity of substance use and externalizing behaviors. First, comorbid disorders may share causal factors as suggested by problem behavior theory. For example, it may be that common genetic influences account for the comorbidity between disorders of addiction and externalizing behaviors (Iacono, Malone, & McGue, 2003). Second, externalizing and substance use behaviors may be linked through a lack of peer-competence and social support developed in the context of externalizing behaviors

(Marshal, Molina, & Pelham, 2003; Molina, Marshal, Pelham, & Wirth, 2005; Wilens & Morrison, 2011; Greene, Biederman, Faraone, Sienna, & Garcia-Jetton, 1997; Greene et al., 1999). Third, shared underlying neurocognitive factors may play a role in explaining the association between substance use and externalizing behavior. For example, comorbidity between substance use and externalizing disorders such as ADHD may be due in part to impulsivity (Dick et al., 2010; Krueger et al., 2002), or difficulties with self-control or self-regulation (Baker, Prevatt, & Proctor, 2012; Pahl, Brook, & Lee, 2014). It remains unclear whether externalizing or ADHD behaviors such as disinhibition and impulsivity actually contribute to enhanced risk for substance use problems, or whether these behaviors simply reflect a manifestation of the same predisposition that contributes to substance use and abuse. This underscores the importance of using developmental context to understand the association between externalizing symptoms and substance use.

ADHD as a risk for substance use. ADHD is an externalizing disorder characterized by a persistent pattern of inattention, and/or hyperactivity and impulsivity that interferes with normal functioning and development (American Psychiatric Association, 2013). Inattentive symptoms manifest as wandering off task, lacking persistence, and being disorganized. Hyperactivity includes fidgeting, talking too much, and restlessness or difficulty remaining seated. Impulsivity manifests as difficulty waiting turns, interrupting others, and blurting out. The link between ADHD symptoms and substance use problems encompasses a variety of substances, including alcohol (Biederman, Mick & Faraone, 1998; Molina & Pelham, 2003), tobacco (Biederman et al., 2006; Pomerleau, Downey, Stelson, & Pomerleau, 1995), illicit drugs such as marijuana (Molina & Pelham, 2003; Dennis et al., 2002) as well as polysubstance use and dependence (Arias et al., 2008; Biederman et al., 1995; Carpentier et al., 2010). The association between ADHD and substance use has been demonstrated in both cross-sectional and

prospective longitudinal studies, supporting that ADHD symptoms predict risk of substance dependence onset and escalation of use (Biederman et al., 2006; Lambert & Hartsough, 1998; Mannuza et al., 1991; Molina et al., 2018). This association has also been demonstrated in clinical (e.g., Biederman et al., 1995; Milberger, Biederman, Faraone, Chen, & Jones, 1997; Schubiner et al., 2000) and community-based (Kessler, Chiu, Demler, & Walters, 2005; Szobot et al., 2007) samples.

There is some evidence that substance use risk increases as a function of the severity of ADHD symptoms (e.g., Vitulano et al., 2014; Kollins, McClernon, & Fuemmeler, 2005; Gudjonsson, Sigurdsson, Sigfusdottir, & Young, 2012). For example, in a recent study from the National Epidemiologic Survey on Alcohol and Related Conditions, each additional ADHD symptom before age 18 was associated with a greater lifetime chance of developing substance dependence (Ameringer & Leventhal, 2013). Further, studies with older adolescents and young adults have found that the number of ADHD symptoms is positively associated with symptoms of substance use disorders (Elkins, McGue, & Iacono, 2007; Fuemmeler, Kollins, & McClernon, 2007; Kollins et al., 2005; Rodriguez, Tercyak, & Audrain-McGovern, 2008), alcohol use (Elkins et al., 2007), and marijuana use initiation (Vitulano et al., 2014; Flory et al., 2003).

Cross-sectional studies have also demonstrated that the severity of ADHD symptoms is associated with alcohol use and related problems (Gudjonsson et al., 2012; Kendler, Gardner, & Prescott, 2011). In a large cross-sectional study of adolescents in high school in Iceland (N = 10,987; ages 14-16), ADHD symptoms predicted smoking, alcohol use, and illicit drug use independent of anxiety, depression, and antiestablishment attitudes (Gudjonsson et al., 2012). A study by Kendler and colleagues (2011), demonstrated that ADHD symptoms were significantly related to all downstream variables in the model: neuroticism, sensation seeking, conduct, anxiety, low parental monitoring, peer-deviance, alcohol availability, alcohol use, and alcohol

use disorders. Further, in the context of all the other paths, the path between ADHD and symptoms of alcohol use disorder/abuse was positive (Kendler et al., 2011). Importantly, ADHD symptoms have been found to uniquely predict substance use even after accounting for psychiatric comorbidity including depression and childhood antisocial behaviors (Looby, 2008; Molina & Pelham, 2003).

Several hypotheses have been proposed to explain the link between ADHD and susceptibility to developing substance use problems (see Molina & Pelham, 2014; Glass & Flory, 2010; for reviews). The first hypothesis is related to the behavioral disinhibition that is intrinsic to ADHD, such that when adolescents and young adults with ADHD symptoms are exposed to alcohol, marijuana, and other illicit drugs, they lack self-restraint and are more likely to use substances heavily (Baker, Prevatt, & Proctor, 2012). Several cross-sectional (e.g., Daurio et al., 2018; Lopez, Dauvilliers, Jaussent, Billieux, & Bayard, 2015; Miller, Derefinko, Lynam, Milich, & Fillmore, 2010; Roberts, Peters, Adamas, Lynam, & Milich, 2014; Rooney et al., 2011) and few longitudinal (e.g., Langberg et al., 2014; Pedersen et al., 2016) studies have linked specific components of behavioral disinhibition (e.g., impulsivity, sensation seeking, self-regulation) as an underlying mechanism in the association of ADHD and substance use in adolescence and young adulthood. Another theory is linked to the pervasive impairment often associated with ADHD, such that ADHD often leads to demoralization and failure (i.e., academically, socially, occupationally, etc.), factors commonly associated with substance use in adolescents (Wilens & Morrison, 2011). Recently, longitudinal studies have demonstrated this process of demoralization and low self-efficacy develops over time as a result of poor coping from longstanding academic and social difficulties (e.g., Safren et al., 2004; Eddy et al., 2015), however research is only beginning to emerge that links this poor coping to subsequent alcohol or substance use (e.g., Harty, Gnagy, Pelham, & Molina, 2017). A third hypothesis is that

externalizing disorders such as ADHD, antisocial behavior and substance use disorders may be related to shared genetic risk factors (Iacono, Malone, & McGue, 2003). Some have also suggested the self-medicating hypothesis (e.g., Barkley et al., 2008; Levin et al., 1998; Levin et al., 2006), which suggests that the misuse of alcohol and marijuana by people with ADHD may be an attempt to alleviate the stress and negative feelings that can accompany the disorder (van Emmerik-van Oortmerssen et al., 2012). One of the major concerns about prescribing stimulant medications for youth and adolescents with ADHD is that stimulants may lead to an increased risk of developing substance use problems. However, a recent meta-analysis, which included 15 studies, found that use of stimulants by children and adolescents neither protected against, nor increased risk for substance use later in life (Humphreys, Eng, & Lee, 2013).

ADHD and substance use in the context of college. For college students with ADHD symptoms, poor behavioral inhibition and difficulties with delaying reward comes at a time when developmentally self-regulation is still maturing which creates a "double deficit" (Fleming & McMahon, 2012; Weyandt & DuPaul, 2013). Therefore, college students with ADHD symptoms may be particularly susceptible to substance use and related problems. Studies of college students with ADHD have found associations between ADHD and increased marijuana and alcohol use (Rooney, Chronis-Tuscano, & Yoon, 2012; Upadhyaya & Carpenter, 2008). In a longitudinal study of college students with ADHD (N = 62; $Mage$ = 19.50), Langberg and colleagues (2014) documented significantly increased risks for alcohol use related problems and associated impairment (Langberg, Dvorsky, Kipperman, Molitor, & Eddy, 2014). Specifically, ADHD symptoms and alcohol use measured at the beginning of the school year both significantly predicted overall impairment and adjustment at the end of the school year (rs = .32 - .46). Further, the inability to refrain from pursuing immediately rewarding behaviors in order to work toward long-term goals was particularly important for understanding why college students

with ADHD so often experience negative outcomes. In sum, studies of college students clearly demonstrate that ADHD symptoms are a risk factor for substance use, but whether this impairment has continued or worsened from adolescence is unclear. Research on the prospective longitudinal association between ADHD and substance use over the transition out of high school and into college is needed to directly answer this question.

Heterogeneity of ADHD-related substance use risk. The nature of the association between ADHD symptoms and substance use is complex. Not all adolescents with ADHD symptoms follow a worsening trajectory of impairment (see Howard et al., 2016). Further, not all young adults or adolescents with elevated ADHD symptoms or externalizing characteristics use substances and experience substance use problems. This implies that there are other factors at play that help people to be resilient and buffer this association between ADHD symptoms and substance use.

The few studies that have evaluated ADHD symptoms dimensionally by the three core domains have produced mixed results with some evidence that it depends on the substance use category examined (Ameringer & Leventhal, 2013; Elkins et al., 2007; Fuemmeler et al., 2007; Molina et al., 1999). For example, in a cross-sectional study using a large population-based sample (N = 34,653), Ameringer and Leventhal (2013) found that after adjusting for the overlap between symptom domains, both inattention and hyperactivity/ impulsivity were uniquely associated with alcohol, tobacco and polysubstance dependence, but only hyperactivity/impulsivity uniquely associated with illicit drug dependence. However, other studies have found that inattentive but not hyperactive/impulsive symptoms increase the likelihood of substance use, particularly tobacco use. For example, a recent cross-sectional study using a population-based sample from the National Health and Nutrition Examination Survey (N = 2,517) found that hyperactive/impulsive symptom counts were not independently associated

with any substance use outcome, while a one symptom increase in inattention increased the likelihood of alcohol use by 8-10% (Brinkman, Epstein, Auinger, Tamm, & Froehlich, 2015).

Overall, the mechanisms and longitudinal pathways through which ADHD symptoms increase risk for substance use are insufficiently understood. Given heterogeneity within ADHD, it is hypothesized that distinct associations exist between ADHD symptoms and each substance outcome (see Sibley et al., 2014).

Summary of limitations of studies linking ADHD symptoms and substance use. Despite evidence that an association between ADHD symptoms and substance use exists, several important aspects regarding the nature of this link remain unclear. First, most studies have examined the association between ADHD and substance use from a categorical or dichotomous perspective of ADHD symptomatology (e.g., presence vs. absence of ADHD clinical diagnosis). Nonetheless, the underlying structure of variation in ADHD symptoms may be best characterized on a continuum (Frazier, Youngstrom, & Naugle, 2007; Haslam et al., 2006).

Second, no study to date has evaluated the role of ADHD symptoms as a risk factor for substance use across the transition to college. Specific associations within the context of emerging adults transitioning from high school to college are important because they may provide insight into potential risk and protective mechanisms associated with substance use during this critical developmental period.

Third, our understanding of substance use and related problems during this key developmental transition remains limited by the fact that most data are cross-sectional and focus solely on risk factors. The most recent review identified only four longitudinal studies that evaluated promotive or protective factors against substance use across the transition from adolescence to emerging adulthood, and concluded that the lack of evidence represented a significant gap in the area (Stone et al., 2012). Indeed, very few studies have assessed students

during their senior year in high school and across the transition to college (e.g., Schulenberg et al., 2005; Read, Wood, & Capone, 2005) and most describe "precollege" variables as those assessed in the summer before (e.g., at summer freshman orientation) or retrospectively reported during the fall of students' first year of college after students have already transitioned to college. As such, it is unclear what processes may *reduce* the likelihood that adolescents will engage in substance use during the transition to college (Schoenfelder, Faraone, & Kollins, 2014), especially in the context of high externalizing risk.

Importantly, from a scientific perspective, the issue of substance use in adolescence and during college has been particularly frustrating for several decades because of the lack of conclusive findings about effective solutions (e.g., see Stone et al., 2012; Schulenberg et al., 2001, for discussions). Despite much effort dedicated to prevention and intervention programs, few programs have shown any significant results. One promising way to frame the issue of substance use during the transition to college is to view it from a developmental perspective, an approach that helps us understand what motivates and attenuates risky substance use among students and what types of intervention targets might be most appropriate.

A Resilience Perspective

The present study will utilize a developmental psychopathology framework (e.g., Cicchetti & Toth, 2009; Masten, 2014) to draw attention to relevant promotive/protective processes and to better understand why and how some adolescents manifest positive outcomes across the transition to college in the context of elevated symptoms of ADHD.

Operationalizing resilience. *Resilience* is a broad term that reflects "positive patterns of adaptation in the context of adversity" (Masten & Obradovic, 2006, p. 14). By definition, resilience requires both (1) experiencing risk or adversity, and (2) having positive adjustment outcomes despite risk experiences (Luthar, Cicchetti, & Becker, 2000). Resilience is

conceptualized within a dynamic ecological systems framework, encompassing interactions of many systems across levels, both within and outside the individual (Masten, 2014; Wright, Masten & Narayan, 2013). Resilience and the study of protective factors have increasingly been recognized as central to the promotion of mental health, but efforts to identify protective factors have been complicated by differing views regarding the theoretical and methodological applications of their effect (Farrell, Henry, Mays, Schoeny, 2011; Luthar et al., 2000). Some consider risk and promotive effects as a continuum, with values at one end of a variable indicating risk and values at the other end indicating promotive (Stouthamer-Loeber, Loeber, & Masten, 2004; Schulenberg & Maggs, 2002). Others conceptualize protective factors only as processes that operate in the presence of risk factors, whose effects they serve to attenuate (Hawkins et al., 1992; Rutter, 1987). In this manuscript, the terms "promotive" and "protective" factors or mechanisms are used to represent individual or contextual processes or resources (e.g., peer relationships), which offset the presence of risk. Initially described in the literature broadly as "protective factors," the field has since adopted the terms *promotive effects* (also referred to as "compensatory") to describe main or direct effects and reserves the term *protective effects* to describe interactive processes (i.e., factors that operate by reducing or buffering the effects of a risk) that reduce the likelihood of a negative outcome (i.e., substance use). Promotive factors are beneficial to all individuals, including those at both high and low levels of risk, whereas protective factors are particularly important at high levels of risk for mitigating or reducing the effects of risk on adaptive outcomes (Masten, 2014; Wright, Masten, Narayan, 2013). As such, for the purpose of this manuscript, protective will be defined as an interaction with risk and promotive will be defined as those demonstrating a main effect. Further, the terms buffers and protective effects are used synonymously in this manuscript.

Several tenets from developmental psychopathology provide a guiding framework addressing research questions about resilience in the context of risk. First, the study of resilience places great emphasis on understanding relationships across multiple levels of the social-ecological model (e.g., individual, family, social, community) that contribute to adjustment over time (see Cicchetti & Curtis, 2007; Cicchetti & Toth, 2009; Masten, 2014). Extensive research supports use of this social-ecological framework to understand adolescent and young adult substance use and which characteristics of the individual, as well as those of the family, peer and community domains influence the likelihood of using substances (e.g., Hawkins et al., 1992; Connell, Gilreath, Aklin, & Brex, 2010). Second, this perspective also recognizes the dynamic interactions of influences over time, such that systems often reciprocally influence each other within and across levels of context, often described as *transactional* effects (Sameroff & MacKenzie, 2003). Third, adaptive and maladaptive development occurs through the cumulative consequences of these transactions. The fundamental principles of multifinality, equifinality, continuity, and discontinuity must also be considered within the developmental context of studying resilience (Luthar et al., 2000). For instance, a protective mechanism at play during one stage of development may not have the same function at other stages (Lerner & Castellino, 2002). Indeed, longitudinal studies have identified variables that appear to be protective at one age, but are found to be risk factors at another (e.g., Mikami & Hinshaw, 2006). Further, developmental perspectives emphasize particular transition periods wherein individuals may be especially susceptible to the influence of particular risk or protective factors (Masten, 2014). Finally, developmental psychopathology emphasizes the importance of studying the processes of positive and negative change as well as dynamic pathways to successful as well as maladaptive outcomes (Cicchetti & Toth, 2009; Wright & Masten, 2015). Overall, the resilience perspective emphasizes understanding risk factors increase vulnerability for negative outcomes, as well as

protective factors which serve to buffer an individual from negative outcomes by promoting positive adaptation, even in the context of risk (Luthar et al., 2000).

Findings about protective factors and resilience in the context of ADHD symptoms and substance use can be used to prevent substance use problems by building positive assets and improving contexts that support positive outcomes. However, presently, we know very little about what distinguishes resilient and non-resilient trajectories among young adult college students at risk for substance use and related problems. The study of protective factors and resilience for substance use outcomes remains largely unexplored, as research has historically emphasized risk factors such as symptom severity and comorbid mental health problems. Considerably less attention has been dedicated to clarifying how and what protective factors buffer against or modify the course of substance use behaviors.

Methodological approaches to studying resilience and protective factors. The study of resilience comprises decades of research, which offers several key methodological considerations for studying protective processes. Resilience research has been categorized into two distinct methodological approaches, each encompassing a variety of analytical models: (1) person-focused and (2) variable-focused approaches (Masten, 2014). Variable-focused analyses focus on describing relationships among variables and person-focused analyses focus on the relationships among individuals. Person-focused models examine individual patterns of behavior over time in a group of individuals who share a common risk factor (e.g., Grimm, Ram, & Hamagami, 2011; Murray, Lombardi, & Kosty, 2014). Alternatively, variable-focused approaches employ multivariate statistics to examine predictors and patterns among variables, accounting for potentially influential attributes or processes in the person, their relationships, resources, or interactions with the environment (Wright et al., 2013). Variable-focused approaches also emphasize the statistical power of the full sample and are sensitive to detecting

specific relationships among particular outcome domains and predictors, including synergistic effects. Variable-focused approaches of resilience have primarily been evaluated using (a) compensatory/promotive or main effect models, (b) mediator models, or (c) moderator models. These statistical approaches are well suited for testing the relative contributions of promotive and protective processes for predicting adaptive functioning. Main effects suggest factors that may function as risk or promotive factors. It is also possible to test for mediating effects of risk on particular outcomes via an indirect effect of the mediator.

Most often, investigators test moderating effects, where a potential moderator variable serves to buffer, ameliorate or in some other way protect youth from the full effects of a potential risk factor (Masten, 2014). Statistically, these effects reflect significant interactions of the risk variable with the moderating variable in predicting the outcome of interest. Sometimes the same variable can function as a promotive and protective factor, in which case, a main effect and an interaction effect would be present.

Resilience research over the past decade has increasingly recognized the role of developmental systems in causal explanations of protective processes (Cicchetti & Curtis, 2007; Masten & Tellegen, 2012). That is, rather than simply studying which factors are involved in resilience, investigators are striving to understand *how* such factors may contribute to positive outcomes. Given the push for examining dynamic protective processes and contextual relations, more sophisticated modeling strategies have been used to consider the interactional, reciprocal, and multiple-level models of development (Farrell, 1994; Kaplan, Kim, & Kim, 2009).

Transactional and cascade models refer to snowballing effects across system levels such that promotive effects at one level can spread to influence other levels of functioning (Luthar, Sawyer, & Brown, 2006; Masten & Cicchetti, 2010). For example, cascade models can be used to depict the interrelated and indirect effects of the early childhood promotive factors on

emerging adult adjustment outcomes, as mediated by adolescent processes and promotive trajectories. These models are often constructed using structural equation modeling or path analysis to test more complex patterns of interaction over time using multiple latent constructs or measured variables. Recent models have focused on mediating mechanisms and cascading effects across key developmental periods and incorporate multi-level approaches to studying resilience (Cicchetti & Curtis, 2007). These models allow for testing cross-domain effects of specific domains for both within-time covariance and across-time continuity within domains (e.g., see Obradovic, Burt & Masten, 2010; Masten & Tellegen, 2012). These findings have significantly informed treatment approaches aimed at breaking coercive interactions between parents and their children and promoting adaptive longitudinal outcomes (Patterson et al., 2010).

Findings support that a variety of protective processes across ecological systems should be examined simultaneously and longitudinally to better understand individual differences in developmental pathways and contextual variation. Prospective longitudinal studies are important for studying resilience in order to best capture the individual and context over time (Masten & Tellegen, 2012). Cross-sectional studies are informative for some purposes and may be an important initial step in highlighting constructs of interest and yielding hypotheses about potential processes and relationships. However, understanding pathways, "turning points", and processes related to change requires longitudinal information (Masten, 2014). Importantly, longitudinal studies also permit investigators to observe periods of developmental transition. Longitudinal models capture the capacity for change that exists throughout development and provide valuable insight into the possible processes that may operate to produce stability or change in functioning.

Potential Promotive and Protective Mechanisms for Substance Use during the Transition to College

Resilience and the study of protective factors represent an area that has largely been neglected in the externalizing and ADHD literature. Therefore, the following section includes a discussion of evidence from the developmental literature more broadly, as well as the few studies that have examined promotive and protective factors for substance use outcomes.

The choice of promotive and protective factors examined in this study was guided by the Social Development Model (SDM; Catalano & Hawkins, 1996, 2002; Hawkins et al., 1992; Farrington & Hawkins, 1991). SDM is an integration of several theories including social learning theory (Bandura, 1977), social-cognitive theory (Bandura, 1986; Van Zundert, Nijhof, & Engels, 2009) and social control theory (Hirschi, 1969). SDM emphasizes the role of bonding to prosocial family, school, and peers as a protection against the development of externalizing behaviors and substance use problems. Several elements of social bonding have been shown to be inversely related to substance use, including commitment to schooling (Hawkins et al., 1992; Krohn & Massey, 1980; Newcomb et al., 2002), social support (e.g., Bond et al., 2007), friendship quality (e.g., Catalano et al., 1996; Lansford et al., 2003), and involvement with non-substance using peers (Bates & Labouvie, 1997; Jackson, Sher, & Schulenberg, 2005; Wood et al., 2004). SDM also hypothesizes reciprocal relationships between constructs across development (Catalano et al., 2007). Based on SDM, it is expected that prosocial involvement, skills, and bonding in high school will lead students to seek out individuals that reinforce prosocial behavior and to maintain a developmental course where substance use is less likely to occur (Catalano & Hawkins, 1996). Further, for adolescents at-risk with elevated externalizing symptoms, social environments that facilitate the development of self-regulation ability through positive social reinforcements seem to have a lower risk of developing substance use problems

(Dick et al., 2009; Dodge & Pettit, 2003; Fisher & Stoolmiller, 2008; Fisher, Stoolmiller, Gunnar, & Burraston, 2007; Petras et al., 2008; Philibert et al., 2009).

The theory of Triadic Influence (TTI) is another theoretical framework for studying the promotive and protective influences on health behaviors (Flay, 1999; Flay, Snyder, & Petraitis, 2009) and is often applied to young adult substance use (e.g., Cooke et al., 2016; Connell et al., 2010; Flay, Petraitis, & Hu, 1999). Similar to the SDM (SDM; Catalano & Hawkins, 1996, 2002; Hawkins et al., 1992), the TTI is based upon numerous theories of adolescent substance use (i.e., cognitive-affective, social-learning, conventional commitment/social attachment, intrapersonal). TTI organizes factors of influence based upon domain (i.e., social/interpersonal, culture/environment, attitudinal and individual) as well as level of influence (i.e., contextual, distal/indirect, proximal/direct).

Drawing from these theoretical paradigms I identified factors that consistently have been shown to affect adolescent initiation, frequency or intensity of substance use and associated problems. These influences are summarized below. The current study chose to focus on potential promotive and protective factors from two separate domains: academic motivation from the academic/school domain, and perceptions of friend disapproval of substance use from the interpersonal domain. Academic motivation and social perceptions about disapproval could also be conceptualized as individual/attitudinal factors. Perceived friend disapproval and academic motivation are potential proximal influences on students' alcohol and marijuana use.

Academic functioning. School is particularly important as a social and learning environment, impacting not only academic pathways, but also health and well-being. Individual's academic functioning and behaviors play an important role in shaping adolescents' and young adults' decisions to engage in substance use (Petraitis, Flay, & Miller, 1995). For example, academic engagement and educational achievement have demonstrated promotive

effects against substance use behaviors (e.g., Fothergill & Ensminger, 2006; Oesterle, Hill, Hawkins, & Abbott, 2008; Stone et al., 2012). This is in line with Hirschi's (1969) social control theory, which suggests school success and engagement reflect a commitment to a conventional way of life that inhibits substance use. Dishion et al. (1991) have suggested a similar theory specific to ADHD in which children's behavior and problems in school (e.g., the impulsivity and inattention associated with ADHD) result in school failure, low self-efficacy and decreased motivation, which promotes engagement in substance use (Dishion, Patterson, Stoolmiller, & Skinner, 1991). Therefore, those who demonstrate positive academic functioning and motivation in the context of ADHD symptoms may represent a particularly resilient group with a decreased risk of substance use.

It is important to note that research assessing the association between adolescent grades and young adult substance use outcomes has demonstrated some mixed findings (see Stone et al., 2012; Mallett et al., 2013 for reviews). Some research suggests that a high GPA in high school is associated with increased risk of drinking in young adulthood (McMorris & Uggen, 2000), but this finding may be due to higher alcohol use frequencies among young adults who attend college compared to their non-college attending peers (Slutske, 2005). In contrast, Merline and colleagues (2008) found that high GPA in high school was associated with less heavy drinking at ages 22 and 26. Other researchers have failed to find any association between high school GPA and young adult substance use (Schulenberg, Bachman, O'Malley, & Johnston, 1994). Further, research suggests that at least for alcohol use, prior levels of achievement impact the association between academic achievement and use in college, with alcohol involvement having a smaller impact on those students with lower achievement in high school (Wood et al., 2000).

Academic motivation. Several factors related to adolescents' engagement with school are also important to consider in the context of adolescent substance use (Bond et al., 2007;

Cleveland, Feinberg, Bontempo, & Greenberg, 2008; Petraitis et al., 1998). For example, adolescents reporting greater motivation, commitment, or engagement to school are less likely to engage in substance use (Bond et al., 2007; Bryant, Schulenberg, Bachman, O'Malley, & Johnston, 2000; Bryant & Zimmerman, 2002; Cleveland et al., 2008; Costa et al., 1999; Grunbaum, Del Boca, Wang, & Goldman, 2000; Wang, Matthew, Bellamy, & James, 2005). For example, Guo et al. (2001) found that a positive bond to school in adolescence (age 14 and 16) was associated with decreased risk of alcohol use disorders in young adulthood. Wang et al. (2005) demonstrated that adolescents (ages 11-16) who were more connected to school had a decreased risk for substance use. Similarly, Catalano, Haggerty, Oesterle, Fleming and Hawkins (2004) found that students who were more connected to school in fifth and sixth grade were less likely to start smoking during seventh grade and to smoke during adolescence.

Only three studies have examined the association between academic performance or school attitudes in relation to the risk for ADHD symptoms in predicting substance use (Vitulano et al., 2014; Flory, Malone, & Lamis, 2011; Molina, Pelham, Cheong, Marshal, & Gnagy, 2012). Each of these studies examined these academic factors as mediators between childhood ADHD symptoms and subsequent adolescent substance use outcomes. In a community sample of 754 youth, Flory and colleagues (2011) demonstrated a significant indirect effect via middle school adjustment between childhood ADHD symptoms (i.e., in grade 4) and adolescent cigarette smoking (i.e., in grades 7 and 10), even after controlling for other externalizing problems in childhood. Similarly, Molina et al. (2012) demonstrated a meditational pathway from childhood ADHD to alcohol use frequency through GPA and delinquency, but this pathway was only found in the subgroup with lower parental knowledge of teen's friendships, activities, and whereabouts. Vitulano and colleagues (2014) examined whether fifth grade school bonding mediated the association between childhood ADHD symptoms and risk for early initiation of substance use

using survival analyses with a sample of 126 students with problematic aggression. School bonding did not demonstrate a mediating effect in any of the models, but had a direct promotive effect such that school bonding was associated with lower risk of alcohol use at ninth grade and decreases in the risk of alcohol use initiation from fourth to ninth grade (Vitulano et al., 2014). Interestingly, this effect was not observed for predicting marijuana or tobacco use outcomes. Overall, these studies demonstrate the potential promotive effects of school functioning for decreased risk of adolescent substance use. It is unclear if these associations are present later in adolescence and during the transition to college. Further, it is unclear if prior (i.e., high school) academic functioning and motivation is most relevant or whether the change in these factors over the transition to college is most important for predicting substance use outcomes.

Interpersonal functioning. Social influences are especially salient in adolescence (Masten & Coatswoth, 1998; Spear, 2000; Wang & Eccles, 2012) and may be an important protective factor in the context of externalizing behaviors. Peer relationships in particular are a critical aspect of the social context that can precipitate adolescent substance use (Barrera, Biglan, Ary, & Li, 2001; Van Ryzin, Fosco, & Dishion, 2012; Brook, Brook, Arencibia-Mireles, Richter & Whiteman, 2001). Friendships become increasingly important during adolescence as time spent with family decreases (Larson, Richards, Moneta, Holmbeck, & Duckett, 1996). This is particularly true across the transition to college when many adolescents move out of their parents' homes. Indeed, peers may exert a stronger influence relative to parents on substance use behavior during this developmental period (Monahan, Steinberg, & Cauffman, 2009).

Developmental theory suggests a progressive trajectory, such that youth learn key social skills (e.g., empathy, perspective taking, conflict resolution) in their peer relationships during middle childhood (Pedersen, Vitaro, Barker, & Borge, 2007), and then their display of these social skills contributes to the presence of close and supportive friendships by adolescence

(Buhrmester, 1990). By adolescence and emerging adulthood, the peer microsystem plays a critical role in the socialization process (East, Lerner, Lerner, Soni, & Jacobson, 1992). Peer relationships may provide adolescents with opportunities for intimate disclosure, support, validation, and security (Ladd, 1999). In particular, the development of close friendships and social support from peers are two developmental tasks that gain prominence during adolescence and young adulthood (Hartup, 1992; Hartup, 1996; Henrich, Kupermine, Blatt, & Leadbetter, 2000; Masten & Coatsworth, 1998). The present study seeks to investigate the promotive and protective effects having friendships with individuals who disapprove of risky alcohol use and marijuana use.

Perceived friend disapproval of substance use. Numerous studies have established that peers' substance use behavior is one of the most important predictors of an individual's substance use behavior (e.g., see Stone et al., 2012 for a review). The majority of research in this field has focused on how friends' behavior and perceived social norms may encourage substance use behavior (Lac & Donaldson, 2018; Lau-Barraco & Linden, 2014; Miller et al., 2011). However, a few studies have demonstrated that involvement with non-substance-using peers (e.g., White et al., 2006; Bates & Labouvie, 1997; Jackson et al., 2005; Wood et al., 2004) and perceived peer disapproval (e.g., Prince, Maisto, Rice, & Carey, 2015) have promotive effects against substance use.

The association between perceived friend disapproval and individuals' substance use behavior is in line with SDM and specifically social modeling, whereby an individual may model his or her own behavior after attitudes and behaviors of observed peers (e.g., Read, Wood, Capone, 2005). Social modeling is a type of learning that has demonstrated importance as a passive social influence on the substance use behaviors of college students (Costa et al., 1999; Wood et al., 2001). Further, social modeling is likely to be intensified in relatively novel

contexts (e.g., a first-year student at college) for which the individual has less experience and fewer behavioral scripts (Abelson, 1981). Social Norms Theory (Berkowitz, 2004; Perkins, 2002) builds on the SDM and contends that individuals are influenced by the perceived attitudes (e.g., disapproval or approval) and actions of others, regardless of the accuracy of the perception (Perkins, 2002). Importantly, the broad literature on perceived social norms has often focused on descriptive norms (i.e., an individual's perceptions of their peers' behaviors) and less is known about the injunctive norms (i.e., individual's perceptions of how acceptable or unacceptable their peers find a behavior) as an indicator of positive development for adolescents and college students (see Miller et al., 2013 for a review). However, some support has been found for injunctive norms (also references as "perceived attitudinal norms" in the literature) as efficacious in interventions targeting risky alcohol use in college students (Prince et al., 2015), suggesting they may have untapped potential at least for alcohol use. To date, injunctive norms as typically assessed in the alcohol and substance use literature often use distal reference groups (e.g., peers or typical students; Krieger, Neighbors, Lewis, LaBrie, Foster, & Larimer, 2016; LaBrie et al., 2010; Pedersen et al., 2017), however recent research supports that more proximal reference group members (e.g., close friends) exert greater persuasive force than more distal reference groups on individuals' attitudes and behavior (Lac & Donalson, 2018).

Importantly, little is known about the association of peer relationships in the context of externalizing behaviors such as ADHD symptoms for predicting substance use outcomes. Further, the heterogeneity of interpersonal functioning among adolescents with ADHD is noteworthy and may have potential buffering influences for substance use (Molina & Pelham, 2014). Specifically, whereas some adolescents with ADHD exhibit clinically significant social difficulties (e.g., aggression, rejection; Hoza et al., 2007), others function within the average range socially (Willcutt et al., 2012). Indeed, buffering effects of friendship intimacy and social

competence against ADHD symptoms for predicting later social and academic functioning has been shown in childhood and early adolescent samples (Becker et al., 2013; Dvorsky, et al., 2016). Accordingly, it may be that those adolescents with ADHD symptoms who are able to make positive social connections quickly in college are protected against escalating substance use. Overall, the effects of peer relationships on substance use are complex and may involve several pathways (Wills, Mariani, & Filer, 1996; Catalano et al., 1996; Ellickson et al., 2001; Ensminger et al., 2002), but there is some evidence supporting prosocial friendships as protective factors (Forster, Grigsby, Bunyan, Unger, & Valente, 2015; Griffin, Botyin, Scheier, Epstein, & Doyle, 2002).

Statement of the Problem

In summary, cross-sectional studies have documented the potential importance of promotive and protective processes in substance use in general population samples. However, few firm conclusions can be drawn given the lack of longitudinal research (Stone et al., 2012). Accordingly, it is unclear whether adolescents' functioning in high school or their change in functioning across academic or interpersonal domains during the transition to college is what predicts substance use behavior. Further, there is limited knowledge about how these potential promotive or protective mechanisms may exert effects in the context of ADHD symptoms or interact with ADHD symptoms. Relatedly, most studies examining promotive or protective factors for substance use have examined the effects of predictors separately, and the joint effects of predictors such as moderations or mediations between factors are rarely examined (Stone et al., 2012). Overall, understanding protective factors for positive adjustment may provide a window into processes to be targeted and enhanced in prevention or intervention efforts to promote resilient development across the transition to college.

Current Study

The present longitudinal study evaluates the developmental course of substance use across the transition from high school (T1 = spring semester high school) to college (T2 = fall semester college; T3 = spring semester college) and specific pathways from ADHD symptoms to substance use. Further, this study examines the bidirectional associations between ADHD symptoms and substance use behavior. Finally, this study will explores the impact and timing of promotive and protective influences of academic motivation and adaptive social perceptions (i.e., perceived friendship disapproval of substances), including evaluation of their direct (i.e., promotive effects) as well as their interactive effects as buffers (i.e., protective effects) in the association between ADHD symptoms and substance use outcomes.

Overall, this study addresses several gaps in the extant literature by: (a) considering the domain specific influence of ADHD symptoms on multiple substance use outcomes (alcohol and marijuana), and (b) examining the role of academic motivation and adaptive social perceptions (i.e., perceived friendship disapproval of substances) in these associations over time. Furthermore, the current study uses longitudinal data spanning from high school through the first year of college and include adolescents attending community colleges as well as public and private four-year university institutions.

Aims and Hypotheses

Informed by theoretical frameworks and previous literature, the proposed project has three primary objectives:

I. The first aim is to evaluate whether ADHD symptoms serve as a risk factor for increased alcohol and marijuana use across the transition to college. Importantly, alcohol and marijuana outcomes are examined separately due to the potential for different patterns (Ameringer & Leventhal, 2013 & Sibley et al., 2014).

a. First, I hypothesized that self-report of ADHD symptoms would be positively associated with increased frequency of alcohol and marijuana use across the transition from high school to college.
b. As an exploratory examination, I also explored bidirectional associations. Based on the premise of problem behavior theory, I hypothesized that ADHD symptoms would predict higher frequencies of substance use and that these associations would be reciprocal over time. Thus, I anticipated a synchronous and cyclical association between ADHD symptoms and substance use over time.

II. The second aim is to evaluate whether academic motivation and adaptive social perceptions (i.e., perceived friendship disapproval of substances) influence the association between ADHD symptoms and substance use as time-variant promotive predictors in the autoregressive cross-lagged models. Further, I explored whether initial functioning in high school (T1) or functioning during the fall semester of college (T2) or the residual change from high school to college is promotive for the association between ADHD symptoms and alcohol as well as marijuana use.
    a. First, I hypothesized that academic motivation and adaptive social perceptions would have direct promotive effect against alcohol and marijuana use.
    b. Second, I hypothesized that the direct promotive effects of academic motivation and adaptive social perceptions would increase over the first year of college.

III. The third aim is to examine whether the strength of the associations between ADHD symptoms and substance use behaviors is buffered by academic motivation or adaptive social perceptions. Further, I explored whether initial functioning in high school (T1) or functioning during the fall semester of college (T2) or the residual change from high

school to college is protective for the association between ADHD symptoms and substance use.

a. First, I hypothesized the effect of ADHD symptoms on substance use over time would be buffered by academic motivation. As such, for individuals with high academic motivation, ADHD symptoms would have a limited effect on alcohol and marijuana use.
b. Second, I hypothesized the effect of ADHD symptoms on substance use over time would also be buffered by adaptive social perceptions. As such, for individuals with ratings of friends who highly disapproval of each of the substances, ADHD symptoms would have a limited effect on substance use.
c. Third, I hypothesized that the protective effects of academic motivation and adaptive social perceptions would increase over the first year of college.

Method

Participants

Participants included 150 twelfth grade students who reported plans to enroll in college. Given the focus on the transition to college, participants included students who self-reported either plans to enroll or had already been accepted to a college or university. This included both 2- and 4-year programs. Participant demographics are presented in Table 1. To summarize, participants were two-thirds female (N = 99) and ranged in age from 17 to 19 years of age at T1 (M = 18.25, SD = .33). Ninety-eight participants (65.3%) self-identified as White (n = 98); the remaining participants were either Black (n = 26, 17.3%), Asian (n = 10, 6.7%), Hispanic/Latino (n = 6, 4.0%), Native Hawaiian or Pacific Islander (n = 2, 1.3%), or Multiracial (n = 8, 5.3%). Twenty-six participants (17.3%) reported plans to attend a community college or 2-year associates program and the remaining reported plans to attend a 4-year university (82.7%).

Thirty-six participants (24%) reported plans to attend an out of state program with the remaining (*n* = 114, 76%) attending colleges or universities in Virginia. Although a general school-based sample was recruited for the purposes of this study, sixteen participants (10.7%) self-reported currently taking medication for ADHD which aligns with current prevalence's estimates ranging from 9 to 13% among high school students (Centers for Disease Control and Prevention, 2010; Visser et al., 2014) and 6 to 8% among college students (Pryor, Hurtado, DeAngelo, Blake, & Tran, 2010; Eagan et al., 2014)

Table 1. *Participant Demographic Characteristics*

Variable	Frequency (Percent)	Means ± SD
Age (years)		18.25 ± .33
Sex		
Male	N = 51 (34%)	
Female	N = 99 (66%)	
Race/Ethnicity		
White	N = 98 (65.3%)	
Black	N = 26 (17.3%)	
Hispanic/Latino	N = 6 (4.0%)	
Asian	N = 10 (6.7%)	
Native Hawaiian or Other Pacific Islander	N = 2 (1.3%)	
Biracial or Multiracial	N = 8 (5.3%)	
High School GPA		3.45 ± .48
College Achievement Test		1215.95 ± 232.56
Student Employment Status	N = 76 (50.7%)	
Hours Employed		8.33 ± 10.40
College Type		
2-year college or community college program	N = 26 (17.3%)	
4-year university program	N = 124 (82.7%)	
Out of state college/university	N = 36 (24%)	
In state college/university	N = 114 (76%)	
Housing Status Plans		
Live at home with parents	N = 32 (21.3%)	
Live on campus	N = 118 (78.7%)	
Parent Education Level		
High School or Less	N = 36 (24.0%)	
Some College Education	N = 34 (22.7%)	
Bachelor Degree	N = 66 (44.0%)	
Graduate Degree	N = 14 (9.3%)	
Family Income		65754.10 ± 56852
Did not know/Did not respond	N = 90 (60.0%)	
Below $25,000	N = 21 (14.0%)	
$25,000 – $49,999	N = 9 (6.0%)	
$50,000 - $74,999	N = 7 (4.7%)	
$75,000 - $99,999	N = 6 (4.0%)	
$100,000 - $149,999	N = 12 (8.0%)	
$150,000 and above	N = 5 (3.3%)	

Note. N = 150. GPA = grade point average. College Achievement Test scores are based off of self-report of scores on the Scholastic Aptitude Test (SAT). For employment status reported students who self-reported current part-time employment.

A flow diagram (see Figure 1) has been constructed to track participant flow through the study, as per CONSORT guidelines (Altman et al., 2001). In total, 206 students expressed interest in the study and visited the online survey. Twenty-two were not eligible because they reported no plans to pursue college or because they did not answer the initial screening questions. 128 were over 18 years of age and consented to participate and completed all of the measures. Twenty-two were under 18 and had their parents provide consent before they provided assent and completed all of the measures (see Figure 1 for further details).

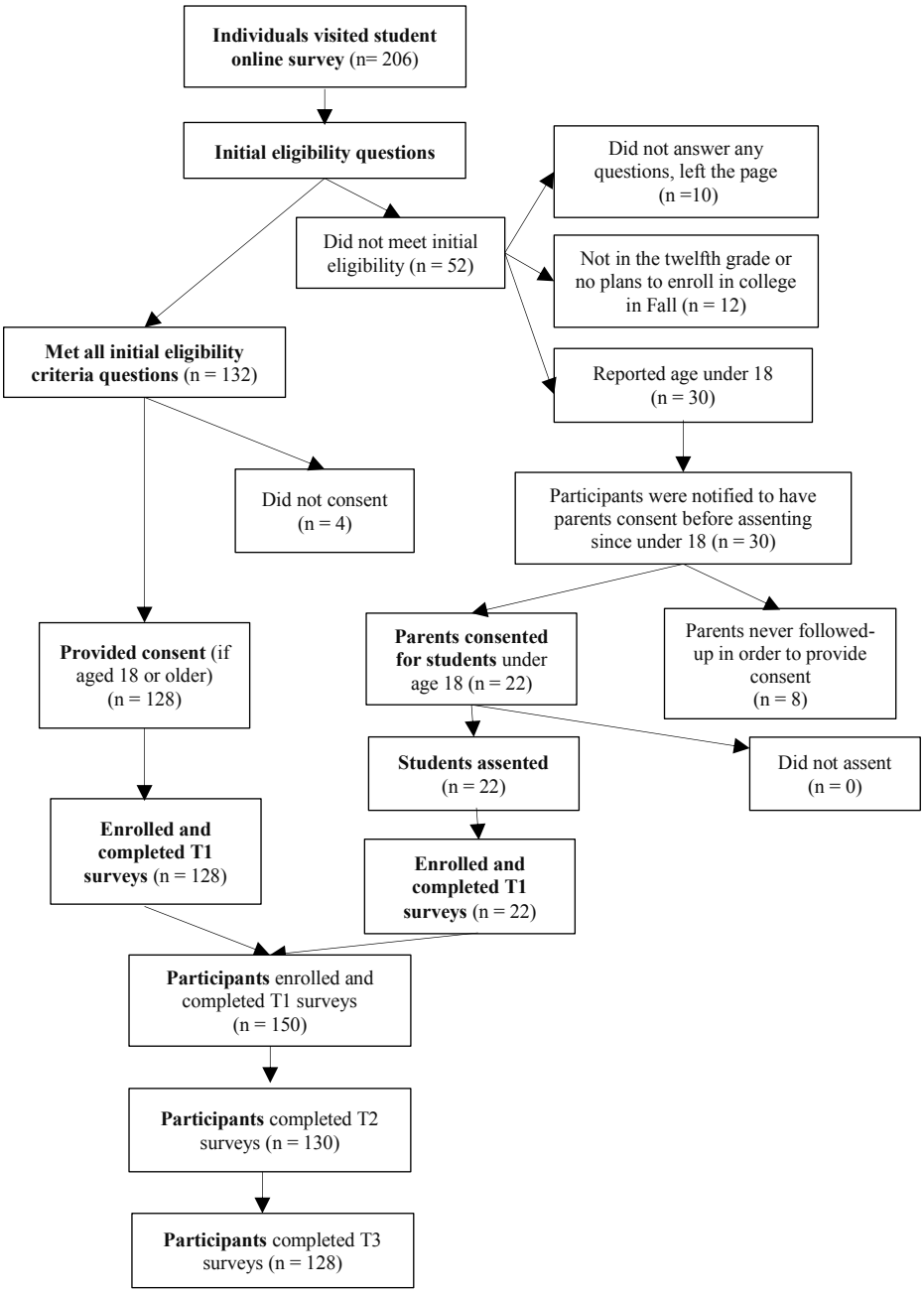


Figure 1. CONSORT Diagram of Participant Recruitment and Data Collection

Procedure

In the proposed longitudinal study, 150 twelfth grade students were recruited and followed for one year, from the spring of their senior year of high school to the spring of their first year of college (see Timeline in Appendix A). A multi-component assessment of substance use and related behaviors, risk mechanisms, and potential promotive or protective factors was administered at three time points. This measurement approach allowed us to evaluate the long-term promotive and protective mechanisms associated with substance use behaviors. Further, this design allowed us to study how risk and protective factors differ for adolescents with elevated symptoms of ADHD.

The study was approved by the university IRB and student participants provided electronic informed assent/consent (depending on age) and their parents/guardians provided electronic consent. Recruitment began in the spring of 2016 and continued through the end of the academic year (i.e., June 2016). Twelfth grade students were recruited from four participating high schools in the Richmond Metropolitan area. Educators were provided with flyers to send home to all families of students in twelfth grade and schools included recruitment information in their regular contacts (e.g., newsletters) with parents. Flyers stated that the study was seeking to examine "how students transition from high school to college." This ensured that all twelfth grade students continuing to college had the opportunity to participate. Recruitment flyers were directed towards parents and adolescents since some adolescents in the study were not yet 18 years old at T1. If the family was interested in participating, parents/guardians and students were instructed to log-onto the online survey to provide informed assent/consent (see Appendix C for Consent Forms) and to complete the measures. Study data were collected and managed using REDCap (Research Electronic Data Capture) tools hosted at Virginia Commonwealth University (Harris et al., 2009).

Participants were compensated $50 for their time and effort in completing the baseline measures, $60 for completing measures at wave 2, and $70 for completing the final measures at wave 3. The study inclusionary criteria included: (a) attendance at the high school where the research was being conducted, and (b) twelfth grade students who reported either acceptance or plans to enroll in college during the fall of 2016 (i.e., including both 2-year or 4-year programs). Students were excluded from participation if they had no plans to attend college in the next year.

Measures

Measures in this study included assessments of demographic information; substance use outcomes including: tobacco, alternative tobacco products, alcohol, and marijuana use, substance use-related problems or impairment; risk factors including ADHD symptoms; and promotive or protective factors including: social academic behaviors and interpersonal factors. These measures were collected at all time points and are described in detail below.

Demographics. Students completed a brief demographics questionnaire at T1. The questionnaire contained items asking about participant age, employment status, race/ethnicity, sex, medication status, university name and type, and current housing arrangements and plans for housing arrangements during college (i.e., living at home with parents, living off-campus, or living on-campus). This questionnaire also had items pertaining to the family income, parent education level, parent marital status, adolescent employment type, hours, and status. An abbreviated version of this form will be administered at T2 and T3 to track any changes in employment or living status, including whether adolescents live at home or transition to living in a dorm or on campus. Participants' sex, housing arrangements, high school grade point average, and university type (i.e., 2-year vs. 4-year college) were examined as potential predictors of substance use outcomes because of their associations with substance use outcomes and their

expected influences on the autoregressive cross-lagged models (e.g., see Hawkins et al., 1992; Stone et al., 2012; for reviews).

Alcohol and marijuana use. Participants reported frequency of alcohol and marijuana use in the past 30 days. For alcohol use, the response categories were, 0, 1-2, 3-5, 6-9, 10-15, 16-20, and more than 21 times. For marijuana us, frequency of use during the past 30-day period was assessed on an 8-point scale ranging from "no use" (0) to "daily use" (7). The questions were based on items from the young adult questionnaire for the Monitoring the Future study (Johnston et al., 2018).

ADHD symptoms. ADHD symptoms were assessed using the self-report of current symptoms version of the *Barkley Adult ADHD Rating Scale-IV* (BAARS-IV; Barkley, 2011). The BAARS-IV includes the 18 *DSM* symptoms of ADHD. Each item was rated using a four-point scale (1 = *never or rarely*, 4 = *very often*). The BAARS-IV scales demonstrate satisfactory internal consistency ($\alpha = .91$ for total ADHD score) and two-week test-retest reliability ($r = .75$ for total ADHD score; Barkley, 2011). It also demonstrates adequate positive and negative predictive power, with positive predictive values ranging from .78-.91 and negative predictive values ranging from .84-.98, in distinguishing between those who meet DSM criteria for ADHD and those who do not. Internal consistencies in the present study at T1 were: Inattention $\alpha = .90$, Hyperactivity $\alpha = .83$, and Impulsivity $\alpha = .86$.

Academic motivation. The Academic Motivation Scale (AMS-C 28) College Version (Vallerand et al., 1992) is a 28-item measure of academic motivation used to determine reasons why students attended college. Its seven-factor structure is based on Deci and Ryan's (1985) self-determination theory. The seven subscales are comprised of (a) three measures of intrinsic motivation: intrinsic motivation to know (IM to know), intrinsic motivation toward accomplishments (IM to accomplish things), and intrinsic motivation to experience stimulation

(IM to experience stimulation); (b) three measures of extrinsic motivation: identified regulation, introjected regulation, and external regulation; and (c) amotivation. Reliability of the AMS-C 28 has been established with measures of internal consistency and test-retest reliability (Vallerand et al., 1992). Although each subscale is measured by only four items, Cronbach's alpha indicated that six of the seven sub-factors had good internal consistency ranging from $\alpha = .83 - .86$, for one sample of 745 students. Test-retest reliability has been reported for all seven subscales, ranging from $r = .71$ to $r = .90$ (Vallerand et al., 1992; Nunnally & Bernstein, 1994). Concurrent and construct validity has been demonstrated with other measures of motivation, motivational antecedents, and motivational consequences (Vallerand et al., 1993). The present study used the sum of the intrinsic motivation scales to represent a global measure of academic motivation (αs from .89 to .90; see Table 2).

Social perceptions of substance use disapproval. Perceived friends' disapproval of alcohol use was the mean of four items adapted from previous studies (e.g., Krieger et al., 2016; Lewis et al., 2010; Neighbors et al., 2008; Wood et al., 2004) assessing whether students believed that their closest friend would disapprove of their drinking across four different drinking situations including drinking daily, drinking ever weekend, drinking and driving, and passing out from drinking. Similarly, friends' disapproval of marijuana use was the mean of four behaviors concerning marijuana use (Neighbors et al., 2008) including: abstaining from marijuana use (reversed scored), trying marijuana once or twice, smoking marijuana occasionally, and smoking marijuana regularly. Injunctive norms for alcohol and marijuana use were assessed by asking students about their perceptions of how much their closest friend disapproved of these behaviors. Students rated each item from 1 (*strongly approve*) to 7 (*strongly disapprove*). Disapproval was averaged across the four drinking and marijuana behaviors to create a score for the perceived attitudes of their closest friends (traditional

injunctive norms; αs from .72 to .87; see Table 2) with higher scores reflecting greater perceived disapproval of risk use. This form is consistent with the most widely used measures of injunctive norms for drinking and substance use (e.g., Keefe, 1994; Lewis et al., 2010; Neighbors et al., 2008).

Data Analyses

Analyses for all study aims were run in *MPlus 8* (Muthén & Muthén, 2017), which has the capability of handling missing data through either multiple imputation or full-information maximum likelihood estimation, includes robust estimation procedures, and provides sandwich estimates to address non-independence due to clustering (e.g., students within schools). Analyses were based on maximum likelihood estimation with robust standard errors (MLR). MLR computes mean-adjusted maximum likelihood estimates for non-normally distributed continuous data (Muthén & Muthén, 2012). With missing data, MLR is used to obtain robust estimates as is recommended for small and medium sample sizes (Yuan & Bentler, 2000; Muthén & Asparouhov, 2002).

Model fit was assessed with the Comparative Fit Index (CFI) and the Root Mean Square Error of Approximation (RMSEA) given that χ^2 is known to be sensitive to sample size (Hong et al., 2007; McDonald & Ho, 2002). Values between 0.90-0.95 or above for the CFI and 0.08 or below for the RMSEA (Bentler, 1995; McArdle & Nesselroade, 2014; Wang & Wang, 2012; Hu & Bentler, 1999; Kline, 2005) indicate that the model adequately fits the data. The CFI is a goodness-of-fit index in a proportion fit metric, whereas the RMSEA is a badness-of-fit index that are not in a proportion metric (West, Taylor, Wu, 2012). The CFI compares the specified model to the null model. The null model assumes zero covariance among the observed variables; thus, the CFI indicates the ratio of improvement from the null to the specified model (Wang & Wang, 2012). The RMSEA assesses the lack of fit of the specified model to the population,

adjusting for the model degrees of freedom. Additionally, the RMSEA provides a 90% confidence interval for the calculated RMSEA value (Wang & Wang, 2012).

Data Preparation

Prior to analysis, means, standard deviations, and 95% confidence intervals (or medians and inter-quartile ranges) were estimated for each continuous variable, while frequencies, proportions, and 95% confidence intervals were computed for each categorical variable. Data were checked for univariate and multivariate outliers, skewness and kurtosis were also evaluated for primary study variables (see Table 2). Data were considered normal if skewness was found to be within the range of +1.5 to -1.5. Linearity was assessed by generating a matrix of scatterplots between variables. Additionally, multicollinearity was assessed by examining bivariate correlations between all study variables. As suggested by Tabachnick and Fiddell (2007), .80 was used as a cutoff to assess for multicollinearity.

Although the focus of this study is at the individual (i.e., adolescent) level, adolescents could be considered to be nested within schools. Specifically, nesting of schools could be examined at the high school or college level such that students clustered from the same school may lead to biased standard errors given that they share an environment and may be exposed to similar contextual influences (e.g., teacher quality, school climate, school composition) which may represent lack of independence of observations (Gilbert, Petscher, Compton, & Schatschneier, 2016; Raudenbush & Bryk, 2002). This study has opted not to incorporate college effects within the models because of the large number of different colleges represented in this sample (n = 51) and small number of students attending any one college (i.e., on average 3). Random effects modeling or intraclass correlations (ICCs) were examined for each outcome to assess clustering effects of high school. ICCs were calculated by estimating the variance between persons divided by the sum of the variance between persons (i.e., high schools) and within

persons (Lee, 2000). Lower ICCs (i.e., .00 to .10) indicate the variance is primarily within students and not between high schools. For each outcome, the ICCs at each wave (.02 to .03) were well within recommended limits (e.g., Cameron & Miller, 2015; Lee, 2000). Therefore, I excluded school as a random effect and opted not to use sandwich estimators to compute adjusted standard errors based on high schools in the final analyses.

Preliminary Analyses

Missing data. Extensive efforts were made to minimize attrition and missing data, and 85% of the initial sample provided data at all three assessments used in the present analyses. There were no missing data at wave 1. Approximately 13% (n = 20) participants were missing data at wave 2 and approximately 15% (n = 22) were missing data at wave 3, with 13% (n = 19) missing data at both wave 2 and 3. Students who missed *any* of the two follow-up waves (n = 23) did not differ from those with complete data at *both* follow-up waves (n = 127) on the total ADHD symptoms, substance use, or the promotive social variables at any wave, as well as baseline demographic variables (all ps > .10). In model estimation, missing data were handled through use of full-information maximum likelihood estimates, which is the default in *MPlu*s for dealing with missing data (Graham, Taylor, Olchowski, & Cumsille, 2006; Wang & Wang, 2012). Maximum likelihood estimation methods can accommodate missing data allowing the analysis to make use of all available data so that any participant with at least one time point can be included in the analysis (Schafer & Graham, 2002). This procedure is more efficient and less biased in comparison to traditional approaches such as listwise or pairwise deletion (Little & Rubin, 1989; Arbuckle, 1996; Collins, Schafer, & Kam, 2001).

Covariates. Previous research has found differences across sex (Jackson, Sher, Cooper & Wood, 2002), academic achievement (Diego, Field, & Sanders, 2003; Luthar, & D'Avanzo, 1999), and living arrangements (i.e., living at home; Stone et al., 2012) in the progression of

substance use across adolescence and young adulthood. Although the exact nature of these specific effects is not always clear as findings are mixed depending upon the outcomes examined (Choquet, Hassler, Morin, Falissard, & Chau, 2008; McArdle et al., 2002; Stone et al., 2012). Further, although there is no literature on university type, it is possible that differences may be observed across students attending 2-year (e.g., community college) and 4-year universities. Thus, this study investigated (1) sex, (2) high school grade point average, (3) living at home, and (4) college type, in the influence the change in substance use outcomes over time. The current state of the literature did not permit the development of a priori hypotheses and these aspects of the analyses are considered exploratory. Preliminary analyses also considered the effect of prescription stimulant use as a covariate. While ADHD treatment with stimulant medication does not have a consistent effect on risk for alcohol or substance use problems (Humphreys et al., 2013; Schoenfelder et al., 2014), medication use is often confounded with ADHD severity (Looby, 2008). Given the low prevalence of students who self-reported taking stimulant medication (ranging from 3.8% to 4%), there was most likely not a sufficient sample to detect effects for this construct as a covariate and it was excluded from analyses.

Primary Analyses

Aim 1: Association of ADHD symptoms to alcohol and marijuana use. To address the first aim, a longitudinal autoregressive cross-lagged model (ARCL; Cole & Maxwell, 2003; Curran & Bollen, 2001) was used to examine the association between ADHD symptoms and substance use. Separate models were examined for alcohol use and marijuana use (see Figure 2). These two models examine how alcohol and marijuana use, respectively, were reciprocally and longitudinally associated with ADHD symptoms across three waves of data spanning one year. In ARCL models, scores at time (t) sufficiently account for score deviation at a previous time (t – 1; Curran & Bollen, 2001; Hong et al., 2007). More precisely, the autoregressive effects (see odd

numbered β in Figure 2) describe the stability of individual differences from one wave to the next; whereas the cross-lagged effects (see even numbered β in Figure 1), examine the effect of one construct on another measured at a later occasion. A feature of the ARCL model is that the cross-lagged effects are estimated controlling for prior level of the construct being predicted (i.e., autoregressive paths). Specifically, the variance in T2 alcohol use that is predicted by T1 ADHD symptoms is the residual variance controlling for previous levels or T1 alcohol use (i.e., the stable portion). Previously referred to as a "residual change model" (Gollob & Reichardt, 1987; Cole & Maxwell, 2003), the ARCL model allows researchers to rule out the possibility that a cross-lagged effect is due simply to the fact that the predictor and outcome were correlated at time 1. In the current models, significant paths from T1 ADHD symptoms → T2 substance or T2 ADHD symptoms → T3 substance established these ADHD symptoms as a risk for either alcohol or marijuana use.

All longitudinal autoregressive cross-lagged models were tested with equality constraints to determine the extent to which within-construct and cross-construct effects are significantly different across time points. A series of hierarchally nested models were examined to determine which path coefficients can or cannot be constrained (i.e., which parameters do or do not differ over time). These models are nested such that equality constraints were placed on each set of parameters one at a time (i.e., first autoregressive paths, then cross-lagged paths) and the more restrictive model (i.e., allowing more degrees of freedom) was compared to the previous unconstrained model. At each step, the model fit was compared with that of the previous step using a chi-square difference test to evaluate whether path constraints result in decremented fit in order to test for stability across time. The unconstrained and constrained models were compared using the Satorra-Bentler Chi-Square (S-B$\Delta\chi^2$) difference test and a comparison of model fit indices. A significant χ^2 difference test indicates that the imposed

constraint leads to decrement in model fit and should be rejected. A non-significant χ^2 difference test indicates that the model with imposed constraint fits the data comparably and more parsimoniously than the unconstrained model (Kelloway, 2015; Mulaik, 2009; Wang & Wang, 2012). Specifically, these procedures followed four steps: (1) the unconstrained model was evaluated to assess baseline fit (i.e., where all path coefficients will be allowed to vary); (2) equality constraints were placed on the autoregressive path coefficients (see odd numbered β in Figure 2); (3) equality constrains were placed on the cross-lagged path coefficients (see even numbered β in Figure 2); and (4) steps 1-3 inform the final model, which includes the autoregressive and cross-lagged paths that were unconstrained and/or constrained across time.

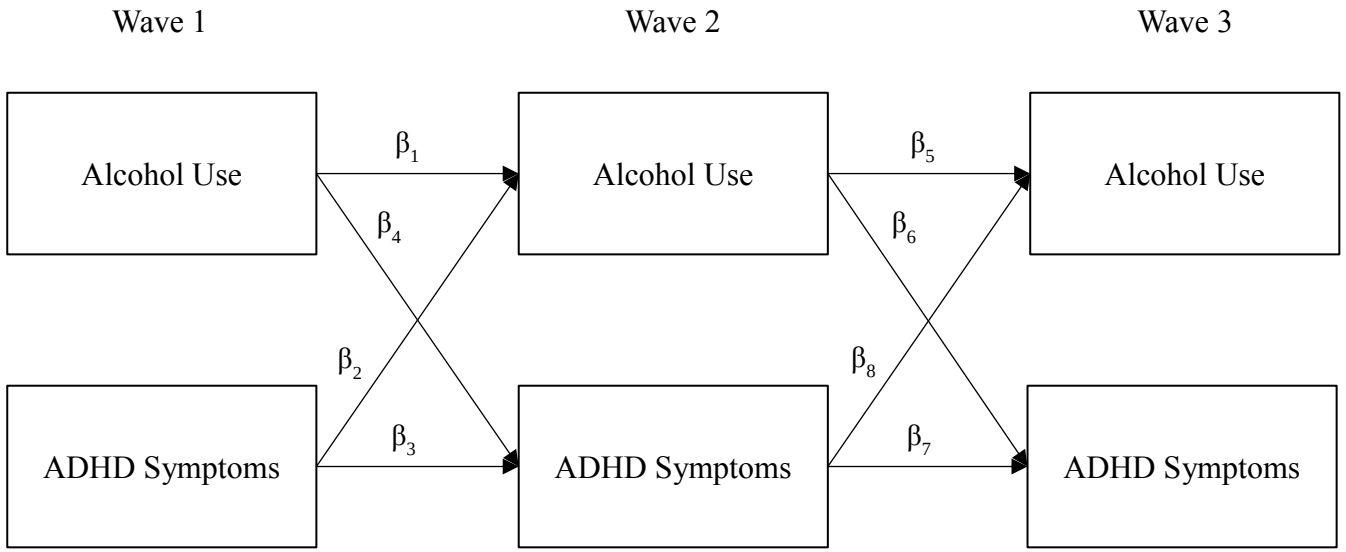


Figure 2. Autoregressive cross-lagged panel model examining the longitudinal associations between ADHD symptoms and alcohol use frequency. The same model was used for ADHD symptoms and marijuana use. Covariates and correlations between measures within each wave were included but not shown in the figure to reduce complexity.

Aim 2: Promotive effects of academic motivation and adaptive social perceptions.

Aim 2 examined the degree to which the strength of academic motivation and perceived friend disapproval promoted positive outcomes or were negatively associated with alcohol and marijuana over the transition from high school to college. Separate models were examined for each potential promotive factor for alcohol and marijuana use (see Figure 3). These models tested how academic motivation or interpersonal factors were reciprocally and longitudinally related to alcohol and marijuana use (as well as ADHD symptoms) by adding each promotive variable separately to the baseline model from Aim 1 with ADHD symptoms and either alcohol or marijuana use. These analyses also included a series of hierarchally nested models for examining equality constraints for the autoregressive and cross-lagged path coefficients as described above. That is, the unconstrained model was compared to constrained model (via autoregressive and cross-lagged path coefficients examined as separate sets) through χ^2 difference tests and a comparison of model fit. Specifically, model constraints were tested for the promotive effects, where promotive path coefficients (see β_{10} and β_{12} in Figure 3) were constrained equal. If the constrained model demonstrated a significant χ^2 difference test or decreased model fit, this indicated significant differences in the strength of association between the promotive variable and substance use outcomes across time.

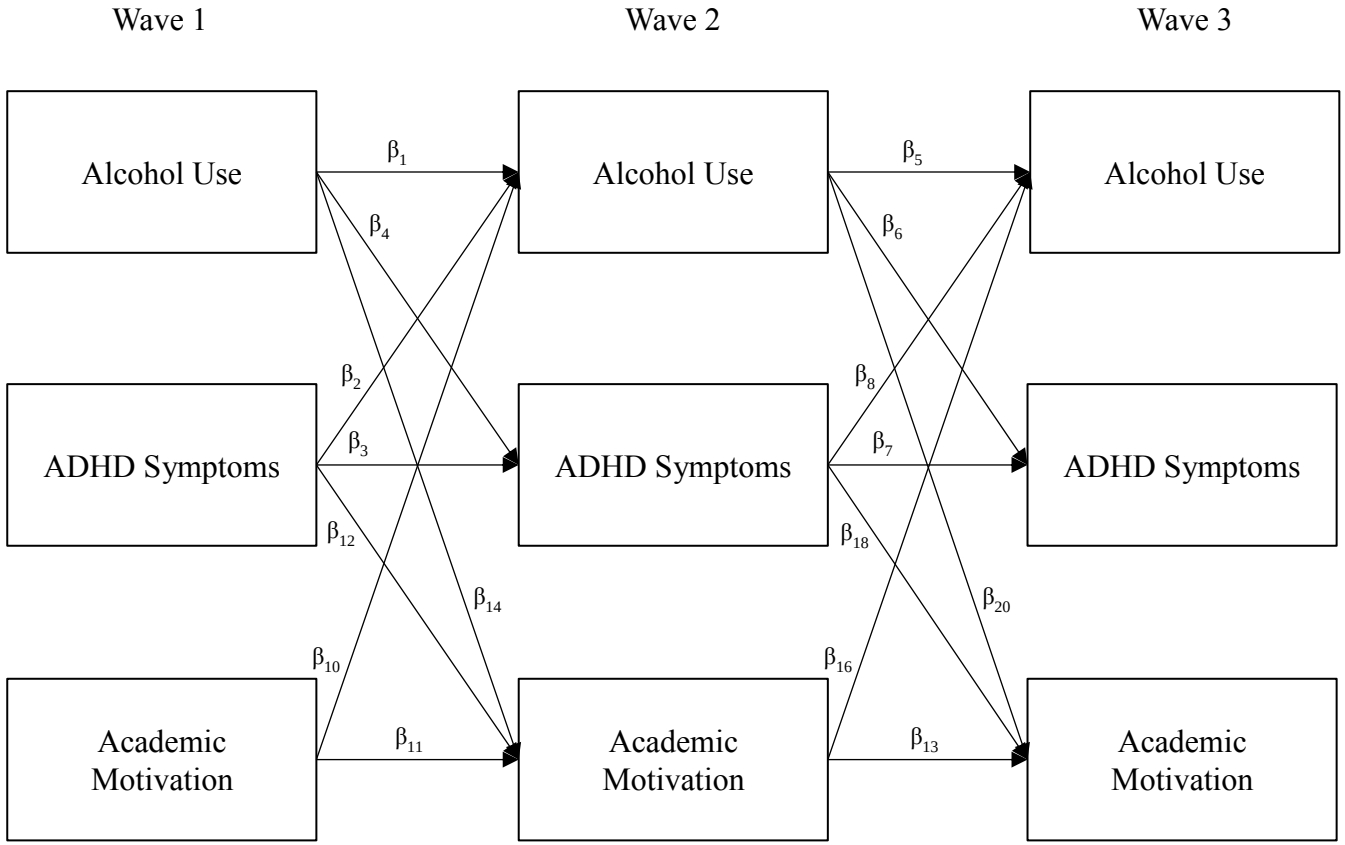


Figure 3. Autoregressive cross-lagged panel model examining the longitudinal associations between ADHD symptoms, academic motivation, and alcohol use frequency. The same model was used for marijuana use, and similarly for the other promotive variables including perceived friend disapproval and friendship quality. Covariates and correlations between measures within each wave were included but not shown in the figure to reduce complexity.

Aim 3: Protective effects against the risk of ADHD symptoms on alcohol and marijuana use. Using the baseline model from Aim 2, the third Aim assessed the potential protective (interactive) effect of academic motivation and perceived friend disapproval with ADHD symptoms for predicting alcohol and marijuana use. Following model-testing recommendations (e.g., Cohen et al., 2003), continuous variables were mean-centered prior to creating interaction terms to reduce multicollinearity and to aid in the interpretation of significant interactions. A predictor variable (i.e., ADHD symptoms), a centered moderator variable (e.g., academic motivation) and a moderator X predictor interaction term (ADHD symptoms X academic motivation) were entered at each of the waves. These variables were used to predict changes in alcohol and marijuana use at each subsequent wave (see Figure 4). These analyses also followed a series of hierarchally nested models for examining equality constraints for (1) the autoregressive (stability) path coefficients and (2) cross-lagged path coefficients and evaluated χ^2 difference tests as well as comparison of model fit indices. Specifically, model constraints were tested for the protective effects, where protective path coefficients (see β_{18} and β_{20} in Figure 4) were constrained equal. If the constrained model demonstrated a significant χ^2 difference test or decreased model fit, this indicated significant differences in the strength of associations between the protective variable and either alcohol or marijuana use across time. In the presence of a significant interaction, subsequent computational tools were used to plot and interpret the findings (Preacher, Curran & Bauer, 2006). Specifically, the simple intercepts and simple slopes for the effects of the predictor on the outcome at specified values of the moderator (i.e., one standard deviation above and below the mean), as well as the region of significance tests were examined. A visual plot of the interaction was produced by imputing the resulting tables into the graphical user interface of SPSS (Bauer & Curran, 2005; Cohen, Cohen, West, & Aiken, 2003).

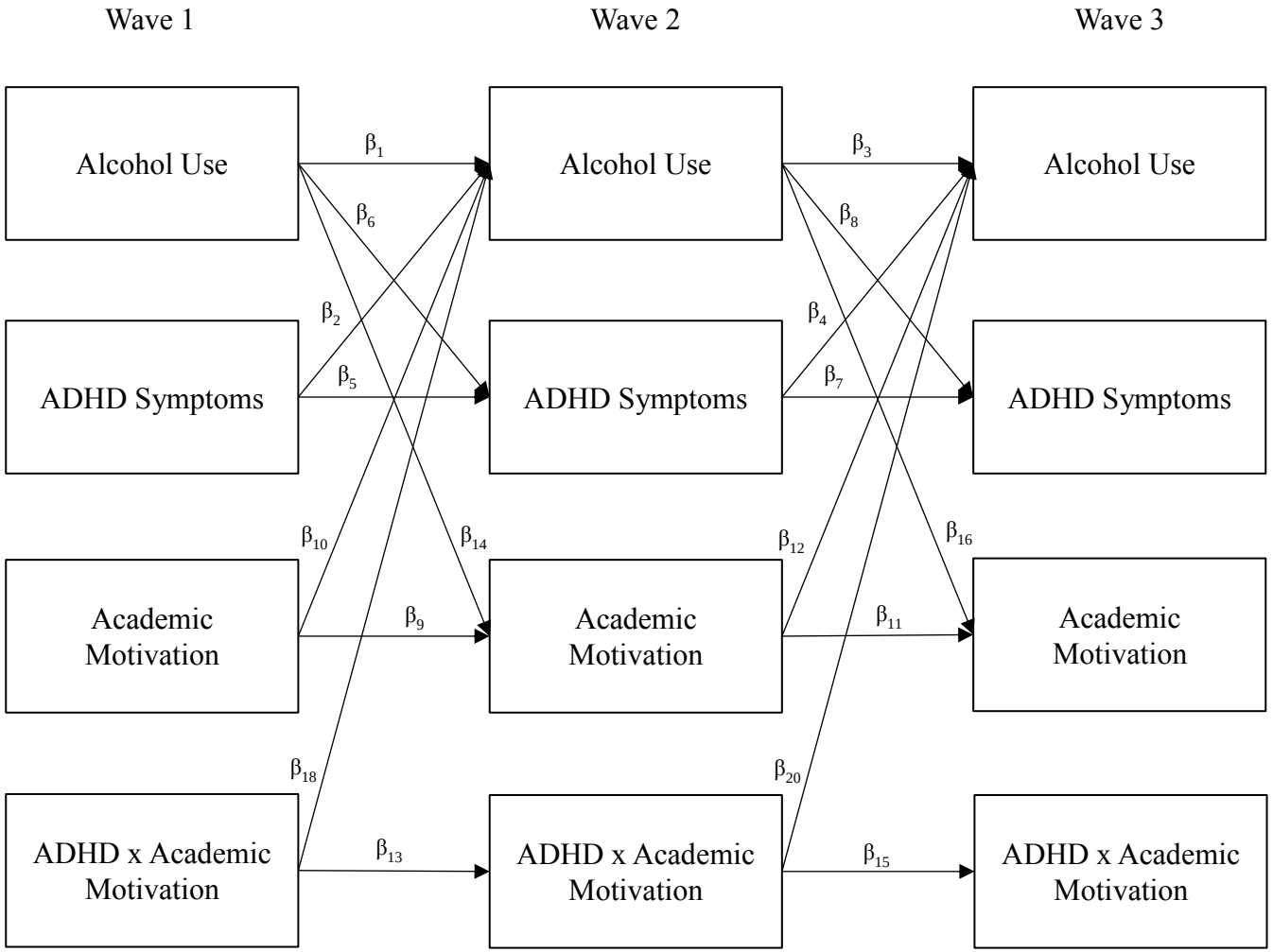


Figure 4. Autoregressive cross-lagged panel model examining the longitudinal association between alcohol use frequency, ADHD symptoms, academic motivation, and the interaction between academic motivation and ADHD symptoms (Academic Motivation X ADHD). The same model was used for marijuana use, and similarly for the other promotive variables including perceived friend disapproval and friendship quality. Covariates and correlations between measures within each wave were included but not shown in the figure to reduce complexity.

Results

Descriptive Statistics

Means, standard deviations, and normality statistics (i.e., skewness and kurtosis) for all primary study variables are presented in Table 2. Participants reported, on average, drinking (*M* =.65, *SD* = .79), between 1-2 times (scale value of 1) at wave 1 in the past 30 days. At waves 2 and 3, participants reported drinking between 3-5 times (*M*s ranging from 1.47 to 1.57; scale value of 2) in the past 30 days. Overall, 43.8% of participants reported using any alcohol in the past month at wave 1, which rose to 62.7% at wave 2 and 69.9% at wave 3, after the transition to college. Further, while 18.9% of participants reported using marijuana in the past month at wave 1, this prevalence increased to 37.3% at wave 2 and continued to rise to 39.9% at wave 3, after the transition to college. On average, participants also reported, using marijuana (*M* =.88, *SD* = 2.18), between 1-2 times (scale value of 1) at wave 1 in the past 30 days. At waves 2 and 3, participants reported using marijuana between 3-5 times (*M*s ranging from 1.59 to 1.77; scale value of 2) in the past 30 days. In terms of initiating use, 73.5% of participants reporting having ever drunk alcohol in high school, which increased to 84.8% at wave 2 and continued to 89.7% at wave 3. In terms of initiating marijuana use, 32.7% of participants reported having ever used marijuana at wave 1, which increased to 47.3% at wave 2 and rose to 54.2% at wave 3.

Table 2 presents the bivariate correlations among alcohol use, marijuana use, ADHD symptoms, and promotive factors (academic motivation, perceived friend disapproval of use), which supported the hypothesized associations. Nearly all of the correlations between alcohol use, marijuana use, ADHD symptoms, and the promotive mechanisms were statistically significant. For example, alcohol and marijuana use were significantly associated with ADHD symptoms and negatively associated with academic motivation and adaptive social perceptions.

Table 2

Descriptive Statistics and Correlations Within Wave for ADHD Symptoms, Promotive Factors, Alcohol, and Marijuana Use

Variable	1	2	3	4	5	6	*M*	*SD*	α	Skew	Kurt
Wave 1											
1. Alcohol Use	--	.390***	.287*	-.082	-.415***	-.342***	.654	.789		1.470	1.321
2. Marijuana Use		--	.269*	-.253**	-.315***	-.432***	.881	2.182		3.077	5.327
3. ADHD Symptoms			--	-.191*	-.093	-.115	11.567	8.954	.901	1.330	2.041
4. Academic Motivation				--	.105	.151*	28.744	6.570	.904	-.626	.687
5. Friend Disapproval of Alcohol						.322***	5.083	.898	.803	-.917	.809
6. Friend Disapproval of Marijuana						--	4.713	.954	.724	-.815	.324
Wave 2											
1. Alcohol Use	--	.384***	.203*	-.190*	-.460***	-.524***	1.466	1.421		.387	1.256
2. Marijuana Use		--	.197*	-.185*	-.221**	-.376***	1.594	1.859		2.015	3.045
3. ADHD Symptoms			--	-.189*	-.090	-.110	11.263	8.087	.903	1.254	2.655
4. Academic Motivation				--	.123	.154*	30.177	6.314	.889	-.625	1.068
5. Friend Disapproval of Alcohol						.205*	4.677	.903	.808	-1.764	1.628
6. Friend Disapproval of Marijuana						--	4.665	.947	.741	-.838	.387
Wave 3											
1. Alcohol Use	--	.310***	.197*	-.202*	-.436***	-.251**	1.556	1.123		-1.894	1.353
2. Marijuana Use		--	.211*	-.289**	-.195*	-.302***	1.766	.982		-.646	.987
3. ADHD Symptoms			--	-.172*	-.205*	-.112	11.504	8.171	.919	.875	1.158
4. Academic Motivation				--	.298**	.191*	29.403	6.788	.897	-.585	.879
5. Friend Disapproval of Alcohol					--	.249**	4.569	.944	.873	.443	.758
6. Friend Disapproval of Marijuana						--	4.496	.985	.844	2.382	5.819

Note. ADHD = Attention-Deficit/Hyperactivity Disorder; Skew = skewness; Kurt = Kurtosis.

Longitudinal Associations between ADHD Symptoms and Substance Use

A series of analyses in *MPlus 8* were conducted to assess associations between ADHD symptoms and alcohol and marijuana use across waves 1 to 3 (see Table 3). An unconstrained model was first fit to the data where all path coefficients were allowed to vary across waves. The model examining alcohol use frequency fit the data well, χ^2 (16) = 26.212, CFI = .951, RMSEA = .085 (90% CI: .045-.127) and the unconstrained model with marijuana use demonstrated very good fit, χ^2 (16) = 22.395, CFI = .970, RMSEA = .063 (90% CI: .000-.110). The unconstrained models predicting alcohol and marijuana use were then compared to each of the constrained models starting with the auto-regressive (i.e., stability within construct) paths and then the cross-lagged paths for ADHD symptoms and the substance use variable were constrained to be equal across waves 1 to 3. Comparisons were made using the Satorra-Bentler scaled chi-square difference test ($SB\Delta\chi^2$) and fit indices (i.e., CFI, RMSEA).

For alcohol use, the autoregressive constrained models (i.e., with path coefficients constrained equal between waves of either ADHD or alcohol use) both resulted in nonsignificant chi-square difference tests, ($SB\Delta\chi^2$ (1) = 1.396, p = .237; and $SB\Delta\chi^2$ (1) = .612, p = .403), and the fit indices remained high despite adding these constraints. This finding suggested stability of ADHD symptoms and alcohol use over time. ADHD symptoms at wave 1 were associated with ADHD symptoms at wave 2 (β = .670, p < .001), and from wave 2 to wave 3 (β = .617, p < .001). Similarly, alcohol use at wave 1 was associated with alcohol use at wave 2 (β = .576, p < .001), and from wave 2 to wave 3 (β = .796, p < .001). The cross-lagged path constraints for ADHD to alcohol use showed a significant decrease in fit as indicated by a significant chi-square difference test, $SB\Delta\chi^2$ (1) = 6.785, p = .009, and decrease in the CFI from .959 to .934. ADHD symptoms were positively associated with alcohol use across waves 1 to 3, but showed variation in the strength of these associations (wave 1 to 2, β = .230; wave 2 to 3, β = .148). Therefore, this

equality constraint was rejected and not carried forward in the next step. Finally, the cross-lagged path constraints for alcohol use to ADHD was supported based on a non-significant chi-square difference test and little change in the fit indices, suggesting constraining these cross-lagged path coefficients did not significantly decrease model fit. Thus based on these findings, in the final model with ADHD symptoms and Alcohol use (see Figure 5), the cross-lagged paths between ADHD to alcohol use across waves were left unconstrained (i.e., freely estimated across waves), and the cross-lagged paths between alcohol use to ADHD as well the autoregressive paths for ADHD and alcohol use were constrained. The final model for alcohol use fit the data well, χ^2 (19) = 26.257, CFI = .960, RMSEA = .071 (90% CI: .018-.115).

All standardized paths for this final model are presented in Figure 5. ADHD symptoms in high school predicted increases in alcohol use from wave 1 to 2 (i.e., from high school to college, β = .230, $p < .001$) and after the transition to college from wave 2 to 3 (β = .148, $p = .013$). Alcohol use did not predict residual changes in ADHD symptoms at any subsequent waves in the model.

A similar process was followed to examine the risk model with marijuana use and ADHD symptoms. Starting with constraining the autoregressive coefficients (i.e., stability paths) between waves of ADHD and marijuana use, this resulted in nonsignificant chi-square difference tests, for both ADHD and marijuana use ($SB\Delta\chi^2$ (1) = 1.433, $p = .231$; and $SB\Delta\chi^2$ (1) = .078, p = .780), and the fit indices remained high despite adding these constraints. This finding suggested stability of ADHD symptoms and marijuana use over time. ADHD symptoms at wave 1 were associated with ADHD symptoms at wave 2 (β = .654, $p < .001$), and from wave 2 to wave 3 (β = .562, $p < .001$). Similarly, marijuana use at wave 1 was associated with marijuana use at wave 2 (β = 756, $p < .001$), and from wave 2 to wave 3 (β = .811, $p < .001$). The cross-lagged path constraints for ADHD to marijuana use showed a significant decrease in fit as indicated by a

significant chi-square difference test, $SB\Delta\chi^2$ (1) = 5.778, p = .016, and decrease in the CFI from .976 to .926. ADHD symptoms were positively associated with marijuana use across waves 1 to 3, but showed variation in the strength of these associations (wave 1 to 2, β = .159, p < .01; wave 2 to 3, β = .040, p = .207). Therefore, this equality constraint was rejected and not carried forward in the next step. Finally, the cross-lagged path constraints for marijuana use to ADHD was supported based on a non-significant chi-square difference test and little change in the fit indices, suggesting constraining these cross-lagged path coefficients did not significantly decrease model fit. Thus based on these findings, in the final model with ADHD symptoms and marijuana use (see Figure 6), the cross-lagged paths between ADHD to marijuana use across waves were left unconstrained (i.e., freely estimated across waves), and the cross-lagged paths between marijuana use to ADHD as well the autoregressive paths for ADHD and marijuana use were constrained. The final model for marijuana use fit the data well, χ^2 (19) = 19.682, CFI = .990, RMSEA = .032 (90% CI: .000-.084).

All standardized paths for this final model are presented in Figure 6. ADHD symptoms in high school predicted increases in marijuana use from wave 1 to 2 (β = .159, p < .05). Interestingly, marijuana use predicted subsequent increases in ADHD symptoms from wave 1 to 2 (i.e., high school to college; β = .115, p < .05), and from wave 2 to 3 (i.e., across the first year of college, β = .142, p < .05).

Table 3. *Comparison of Model Constraints for the Longitudinal Associations Between ADHD symptoms and Alcohol Use or Marijuana Use Frequency*

Alcohol Use and ADHD Symptoms								
Model		χ^2	df	CFI	RMSEA	CI	Satorra-Bentler $\Delta\chi^2$	Decision
Unconstrained		26.212	16	.951	.085	(.045 .127)	--	
Auto-regressive	a) ADHD	25.233	17	.957	.079	(.030, .125)	$\Delta\chi^2$ (1) = 1.396, p = .237	Retain
paths	b) Alc	25.532	18	.959	.074	(.023, .119)	$\Delta\chi^2$ (1) = .612, p = .403	Retain
Cross-lagged	c) ADHD → Alc	33.747	19	.934	.091	(.050, .133)	$\Delta\chi^2$ (1) = 6.785, p = .009	*Reject*
paths	d) Alc → ADHD	26.257	19	.960	.071	(.018, .115)	$\Delta\chi^2$ (1) = .115, p = .735	Retain

Marijuana Use and ADHD Symptoms								
Model		χ^2	df	CFI	RMSEA	CI	Satorra-Bentler $\Delta\chi^2$	Decision
Unconstrained		22.395	16	.970	.063	(.000, .110)	--	
Auto-regressive	a) ADHD	23.686	17	.969	.062	(.000, .108)	$\Delta\chi^2$ (1) = 1.433, p = .231	Retain
paths	b) Marij	22.768	18	.976	.053	(.000, .099)	$\Delta\chi^2$ (1) = .078, p = .780	Retain
Cross-lagged	c) ADHD → Marij	27.675	19	.926	.087	(.023, .148)	$\Delta\chi^2$ (1) = 5.778, p = .016	*Reject*
paths	d) Marij → ADHD	19.682	19	.990	.032	(.000, .084)	$\Delta\chi^2$ (1) = .091, p = .763	Retain

Note. Models presented above are hierarchally nested, that is, constraints that are retained (or rejected) at initial steps are retained (or rejected) for the subsequent models. The first model is the unconstrained (base) model. Model A = Homogeneity constraints to the stability paths of ADHD over time. Model B = Homogeneity constraints to the stability paths of either alcohol or marijuana use over time. Model C = Homogeneity constraints to the cross-lagged paths of ADHD to either alcohol or marijuana use. Model D = Homogeneity constraints to the cross-lagged paths of either alcohol or marijuana use to ADHD. For both alcohol and marijuana, the final models entail constraining the autoregressive paths and the cross-lagged paths of either alcohol or marijuana to ADHD; the path from ADHD to either alcohol or marijuana use is freely estimated across waves in both substance use models. CFI = Comparative Fit Index. RMSEA = Root Mean Square Error of Approximation. Alc = alcohol use frequency. Marij = marijuana use frequency. df = degrees of freedom.

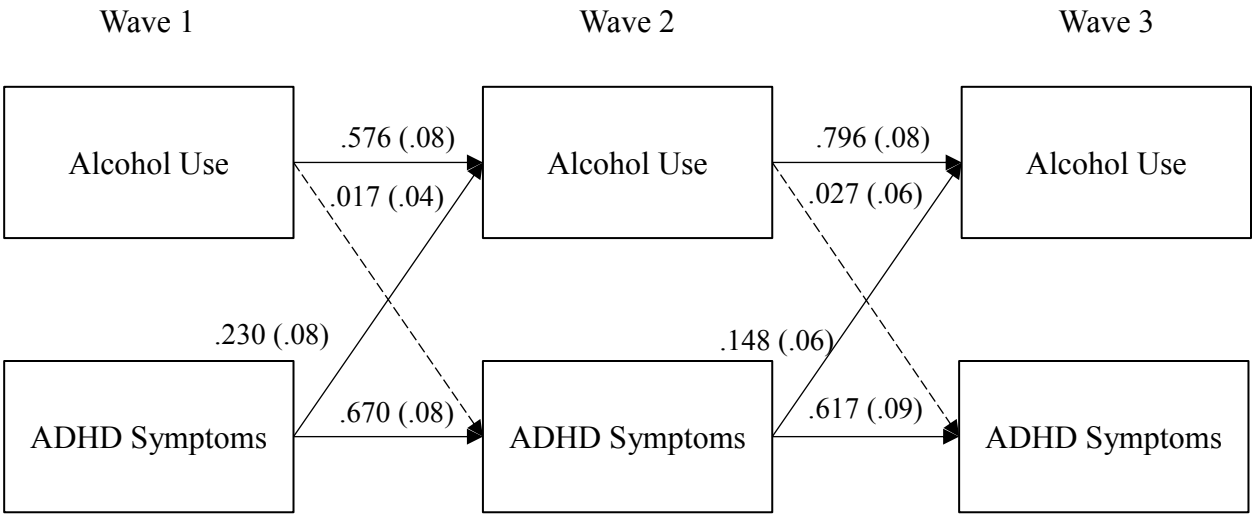


Figure 5. Longitudinal associations between ADHD symptoms and alcohol use. χ^2 (19) = 26.257, p = .035, RMSEA = .071 (90% Confidence Interval: 0.018-0.115), and CFI = .960. Betas (β) are shown and standard errors are in parentheses. Correlations between variables within each wave and covariates were included in the model, but are not shown in the figure to reduce complexity. The dotted lines represent a non-significant path; the solid lines indicate a significant path.

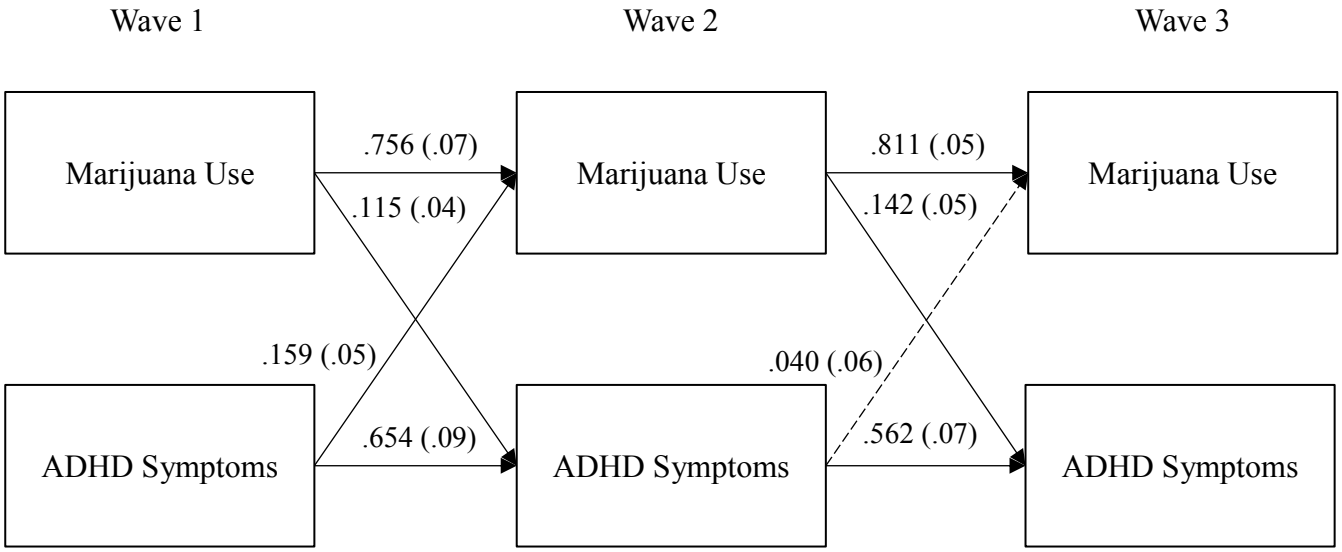


Figure 6. Longitudinal associations between ADHD symptoms and marijuana use. χ^2 (19) = 19.682, p = .291, RMSEA = .032 (90% Confidence Interval: 0.000-0.084), and CFI = .990. Betas (β) are shown and standard errors are in parentheses. Correlations between variables within each wave and covariates were included in the model, but are not shown in the figure to reduce complexity. The dotted lines represent a non-significant path; the solid lines indicate a significant path.

Longitudinal Associations between Substance Use Outcomes, ADHD Symptoms, and Promotive Mechanisms: Academic Motivation and Adaptive Social Perceptions

To examine the potential promotive role of academic motivation and adaptive social perception for predicting alcohol and marijuana use in the context of ADHD symptoms, an autoregressive cross-lagged panel model building on the first aim was fit to the data. First, an unconstrained model was initially run, where all paths were allowed to vary across waves (see summary in Table 4).

Promotive effect of academic motivation. The unconstrained model for academic motivation predicting alcohol use fit the data adequately, χ^2 (31) = 51.946, CFI = .936, RMSEA = .073 (90% CI: .039-.104) as well as for marijuana use, χ^2 (31) = 59.801, CFI = .939, RMSEA = .066 (90% CI: .034-.095). Next, a constrained model was run where all autoregressive paths were constrained to be equal across wave. Comparison of the autoregressive constrained to the fully unconstrained model favored the unconstrained model for the alcohol use model based on the significant chi-square difference test, SB$\Delta\chi^2$ (3) = 10.689, p = 005, and a decrease in CFI from .936 to .913 in the constrained model. Similarly in the model with academic motivation and marijuana use, all autoregressive paths were initially constrained as a set to be equal across wave. Comparison of the autoregressive constrained to the fully unconstrained model also favored the unconstrained model for the marijuana use model based on the significant chi-square difference test, SB$\Delta\chi^2$ (3) = 13.371, p = 005, and a decrease in CFI from .939 to .901 in the constrained model. These results suggested variations in the stability of ADHD symptoms, alcohol/marijuana use, and academic motivation across waves. In both the alcohol and marijuana use models, academic motivation was positively associated from wave 1 to wave 2, (β = .335-.342, p < .001) and positively associated from wave 2 to wave 3 (β = .410-.446, p < .001); however the magnitude of these associations may represent meaningful differences. The

autoregressive model was left unconstrained for all stability paths and was then compared to the following models with cross-lagged paths constrained equal across waves for: (a) ADHD to either alcohol or marijuana use; (b) alcohol or marijuana use to ADHD symptoms; (c) academic motivation to either alcohol or marijuana use. In both the alcohol and marijuana models, comparisons of each constrained model supported holding the equality constraints with the exception of the cross-lagged path constraints from ADHD symptoms to alcohol or marijuana which showed significant decrease in fit as indicated by a significant chi-square difference tests and decrease in the CFI indices for both models (see summary in Table 4). The final model entailed freely estimating all autoregressive paths and the cross-lagged paths from ADHD symptoms to either alcohol or marijuana use while constraining all other cross-lagged path coefficients to be equal across waves. The final model examining academic motivation in the prediction of alcohol use demonstrated adequate fit, χ^2 (33) = 53.729, CFI = .936, RMSEA = .070 (90% CI: .070-.101); and the model predicting marijuana use with the same constraints demonstrated excellent model fit, χ^2 (33) = 56.483, CFI = .952, RMSEA = .057 (90% CI: .020-.087).

All standardized paths for these final models with academic motivation are presented in Figures 7 and 8. After controlling for the effect of ADHD symptoms in predicting alcohol use over time, academic motivation was a significant predictor of decreased alcohol use from wave 1 to wave 2 (β = -.194, p < .05) as well as from wave 2 to wave 3 (β = -.159, p < .05). Interestingly, alcohol use at wave 2 also predicted decreased academic motivation at wave 3 (3 (β = -.164, p < .05). In the model predicting marijuana use, academic motivation did not demonstrate any significant direct effects on subsequent marijuana use at any wave.

Table 4. *Comparison of Model Constraints for Autoregressive Cross-Lagged Models for the Longitudinal Associations Between ADHD symptoms and Alcohol Use or Marijuana Use Frequency and the Promotive Effect of Academic Motivation*

Alcohol Use and ADHD Symptoms								
Model		χ^2	df	CFI	RMSEA	CI	Satorra-Bentler Scaled $\Delta\chi^2$	Decision
Unconstrained Model		51.946	31	.936	.073	(.039 .104)	--	
All auto-regressive paths		63.062	34	.913	.080	(.051, .110)	$\Delta\chi^2$ (3) = 10.689, p = .005	*Reject*
	ADHD → Alc	63.019	32	.907	.086	(.056, .115)	$\Delta\chi^2$ (1) = 13.032, p = .001	*Reject*
Cross-lagged paths	Alc → ADHD	53.050	32	.935	.072	(.038, .103)	$\Delta\chi^2$ (1) = 2.325, p = .127	Retain
	Acad Mot → Alc	53.729	33	.936	.070	(.037, .101)	$\Delta\chi^2$ (1) = .757, p = .384	Retain

Marijuana Use and ADHD Symptoms								
Model		χ^2	df	CFI	RMSEA	CI	Satorra-Bentler Scaled $\Delta\chi^2$	Decision
Unconstrained		59.801	31	.939	.066	(.034, .095)	--	
All auto-regressive paths		78.237	34	.901	.083	(.053, .109)	$\Delta\chi^2$ (3) = 13.371, p = .004	*Reject*
	ADHD → Marij	66.445	32	.924	.073	(.043, .101)	$\Delta\chi^2$ (1) = 8.025, p = .005	*Reject*
Cross-lagged paths	Marij → ADHD	55.607	32	.952	.058	(.021, .088)	$\Delta\chi^2$ (1) = .348, p = .555	Retain
	Acad Mot → Marij	56.483	33	.952	.057	(.020, .087)	$\Delta\chi^2$ (1) = .397, p = .529	Retain

Note. Models presented above are hierarchally nested, that is, constraints that are retained (or rejected) at initial steps are retained (or rejected) for the subsequent models. The first model is the unconstrained (base) model; the second model tests constraints on all of the auto-regressive paths as one set simultaneously, followed sequentially by models testing constraints for each of the cross-lagged paths. CFI = Comparative Fit Index. RMSEA = Root Mean Square Error of Approximation. Alc = alcohol use frequency. Marij = marijuana Acad Mot = Academic Motivation. df = degrees of freedom.

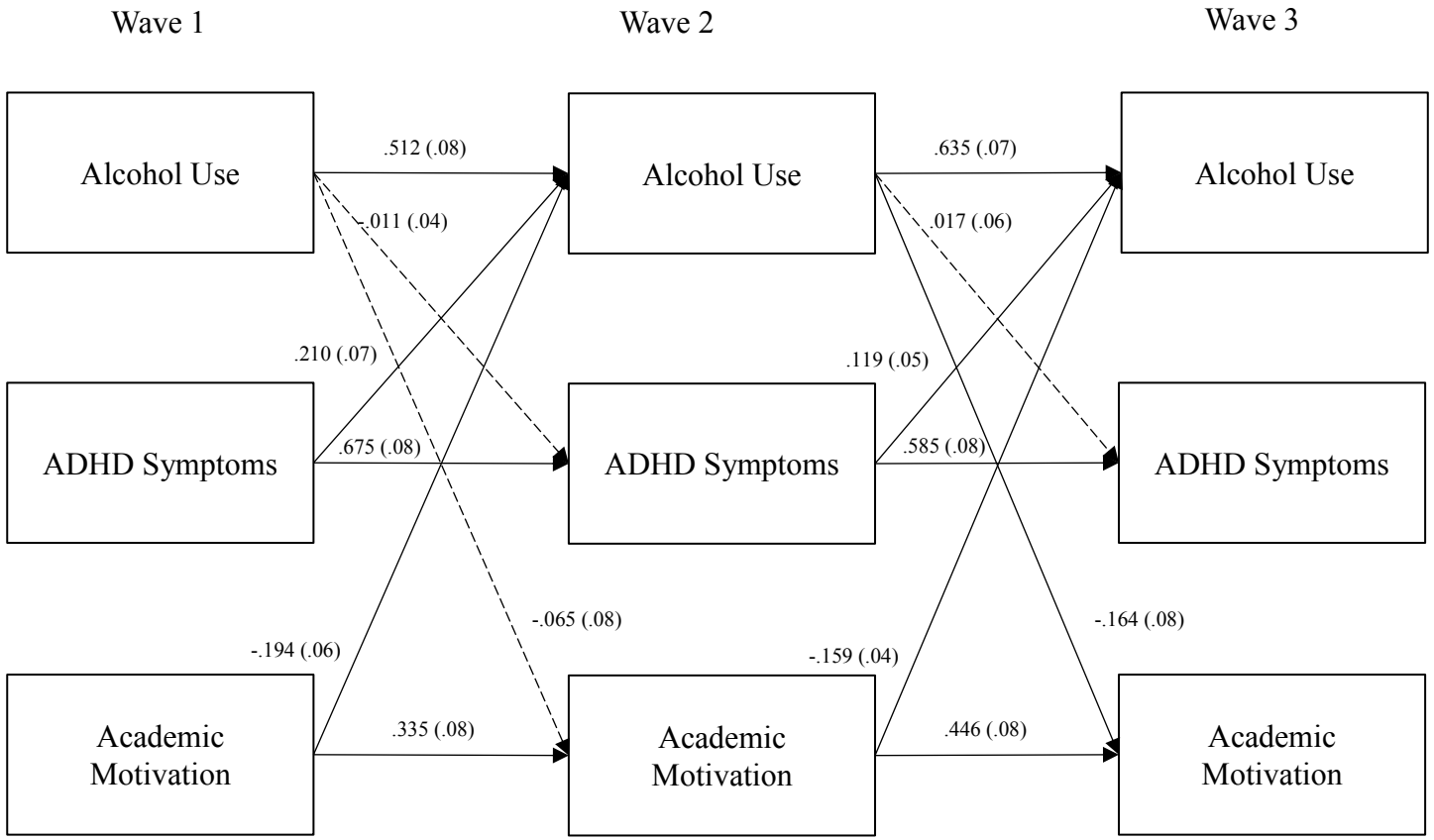


Figure 7. Longitudinal associations between ADHD symptoms and alcohol use and the promotive effect of academic motivation, χ^2 (33) = 53.729, p = .007, RMSEA = .070 (90% Confidence Interval: 0.037-0.101), and CFI = .936. Betas (β) are shown and standard errors are in parentheses. Correlations between variables within each wave and covariates were included in the model, but are not shown in the figure to reduce complexity. The dotted lines represent a non-significant path; the solid lines indicate a significant path.

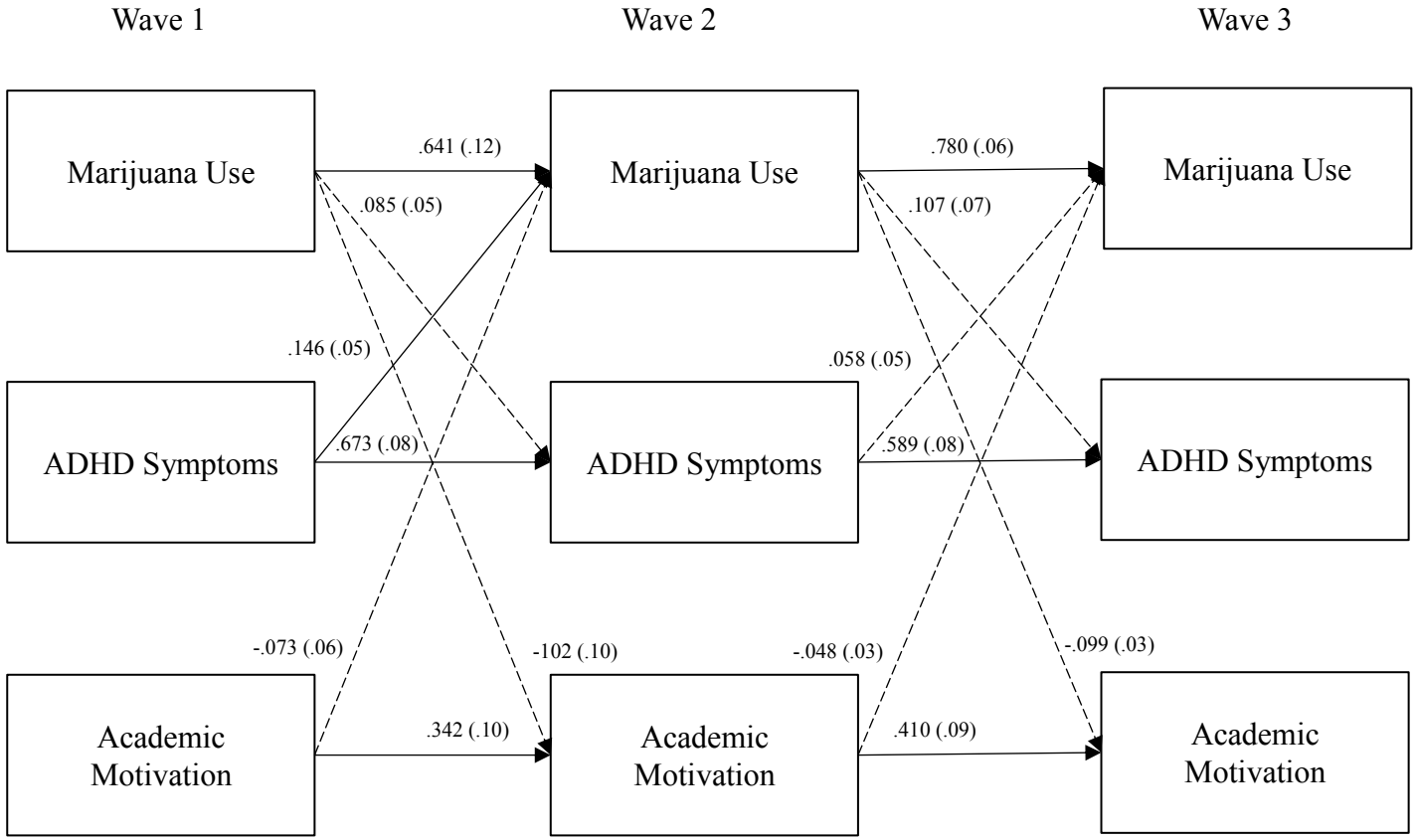


Figure 8. Longitudinal associations between ADHD symptoms and marijuana use and the promotive effect of academic motivation, χ^2 (33) = 56.483, p = .027, RMSEA = .057 (90% Confidence Interval: 0.020-0.087), and CFI = .952. Betas (β) are shown and standard errors are in parentheses. Correlations between variables within each wave and covariates were included in the model, but are not shown in the figure to reduce complexity. The dotted lines represent a non-significant path; the solid lines indicate a significant path.

Promotive effect of perceived friend disapproval. The unconstrained model for perceived friend disapproval of use predicting alcohol use fit the data adequately, χ^2 (31) = 57.498, CFI = .922, RMSEA = .081 (90% CI: .050, .111) as well as for marijuana use, χ^2 (31) = 59.926, CFI = .919, RMSEA = .084 (90% CI: .054, .115; see Table 5). Next, a constrained model was run where all autoregressive paths were constrained to be equal across wave. For alcohol use, the constrained model (i.e., with path coefficients constrained equal between adjacent waves within construct), resulted in a non-significant chi-square difference test, SB$\Delta\chi^2$ (3) = 4.832, p = .185, and the fit indices remained adequate. Similarly, in the marijuana use model, constrained model also resulted in a non-significant chi-square difference test, SB$\Delta\chi^2$ (3) = 5.218, p = .157, and the fit indices remained adequate. In both the alcohol and marijuana use models increased ratings of friend disapproval of use were significantly associated from wave 1 to wave 2, (β = .342-.378, $p < .001$) and positively related from wave 2 to wave 3 (β = .344-.410, $p < .001$). The autoregressive model was constrained for all stability paths and was then compared to the following models with cross-lagged paths constrained equal across waves for: (a) ADHD to either alcohol or marijuana use; (b) alcohol or marijuana use to ADHD symptoms; (c) perceived friend disapproval of either alcohol or marijuana use. In both the alcohol and marijuana models, comparisons of each constrained model supported freeing the equality constraint from ADHD symptoms to either alcohol or marijuana use and retaining the equality constraints for the cross-lagged paths from either alcohol or marijuana to ADHD symptoms over time. For the model predicting alcohol use, the cross-lagged path from friendship disapproval to alcohol use showed a significant decrease in fit as indicated by a significant chi-square difference test, SB$\Delta\chi^2$ (1) = 13.234, p = .001, and decrease in the CFI from .919 to .895. Friend disapproval was negatively associated with alcohol use across waves 1 to 3, but showed variation in the strength of these

associations (wave 1 to 2, β = -.218, $p < .001$; wave 2 to 3, β = -.077, $p = .385$). Therefore, this equality constraint was rejected and not carried forward in the final model. On the other hand, for the model predicting marijuana use, the cross-lagged path from friendship disapproval to alcohol use resulted in a non-significant chi-square difference test, $SB\Delta\chi^2$ (1) = 2.747, $p = .097$, and the fit indices remained adequate, therefore this equality constraint was retained. The final model examining friend disapproval in the prediction of alcohol use demonstrated adequate fit, χ^2 (34) = 62.854, CFI = .919, RMSEA = .078 (90% CI: .048-.107); and the model predicting marijuana use with the same constraints also demonstrated adequate model fit, χ^2 (35) = 61.191, CFI = .928, RMSEA = .073 (90% CI: .042-.102).

All standardized paths for these final models with friend disapproval are presented in Figures 9 and 10. After controlling for the effect of ADHD symptoms in predicting alcohol use over time, friend disapproval was a significant predictor of decreased alcohol use from wave 1 to wave 2 (β = -.218, $p < .001$) but was not significant from wave 2 to wave 3 (β = -.077 $p = .385$). Similarly, in the model predicting marijuana use, friend disapproval was a significant predictor of decreased alcohol use from wave 1 to wave 2 (β = -.150, $p < .01$) but was not significant from wave 2 to wave 3 (β = -.075 $p = .445$).

Table 5. *Comparison of Model Constraints for Autoregressive Cross-Lagged Models for the Longitudinal Associations Between ADHD symptoms and Alcohol Use or Marijuana Use Frequency and the Promotive Effect of Friend Disapproval*

Alcohol Use and ADHD Symptoms								
Model		χ^2	df	CFI	RMSEA	CI	Satorra-Bentler $\Delta\chi^2$	Decision
Unconstrained Model		57.498	31	.922	.081	(.050, .111)	--	
All auto-regressive paths		61.868	33	.918	.079	(.049, .108)	$\Delta\chi^2$ (3) = 4.832, p = .185	Retain
Cross-lagged paths	ADHD → Alc	73.019	34	.890	.090	(.063, .118)	$\Delta\chi^2$ (1) = 9.082, p = .003	*Reject*
	Alc → ADHD	62.854	34	.919	.078	(.048, .107)	$\Delta\chi^2$ (1) = .191, p = .662	Retain
	Friend Disapp → Alc	72.987	35	.895	.087	(.060, .115)	$\Delta\chi^2$ (1) = 13.234, p = .001	*Reject*
Marijuana Use and ADHD Symptoms								
Model		χ^2	df	CFI	RMSEA	CI	Satorra-Bentler $\Delta\chi^2$	Decision
Unconstrained		59.926	31	.919	.084	(.054, .115)	--	
All auto-regressive paths		64.682	33	.914	.083	(.053, .111)	$\Delta\chi^2$ (3) = 5.218, p = .157	Retain
Cross-lagged paths	ADHD → Marij	70.931	34	.900	.088	(.059, .116)	$\Delta\chi^2$ (1) = 8.128, p = .004	*Reject*
	Marij → ADHD	58.374	34	.933	.072	(.040, .101)	$\Delta\chi^2$ (1) = .201, p = .654	Retain
	Friend Disapp → Marij	61.191	35	.928	.073	(.042, .102)	$\Delta\chi^2$ (1) = 2.747, p = .097	Retain

Note. Models presented above are hierarchally nested, that is, constraints that are retained (or rejected) at initial steps are retained (or rejected) for the subsequent models. The first model is the unconstrained (base) model; the second model tests constraints on all of the auto-regressive paths as one set simultaneously, followed sequentially by models testing constraints for each of the cross-lagged paths. CFI = Comparative Fit Index. RMSEA = Root Mean Square Error of Approximation. Alc = alcohol use frequency. Marij = marijuana Friend Disapp = friend disapproval. df = degrees of freedom.

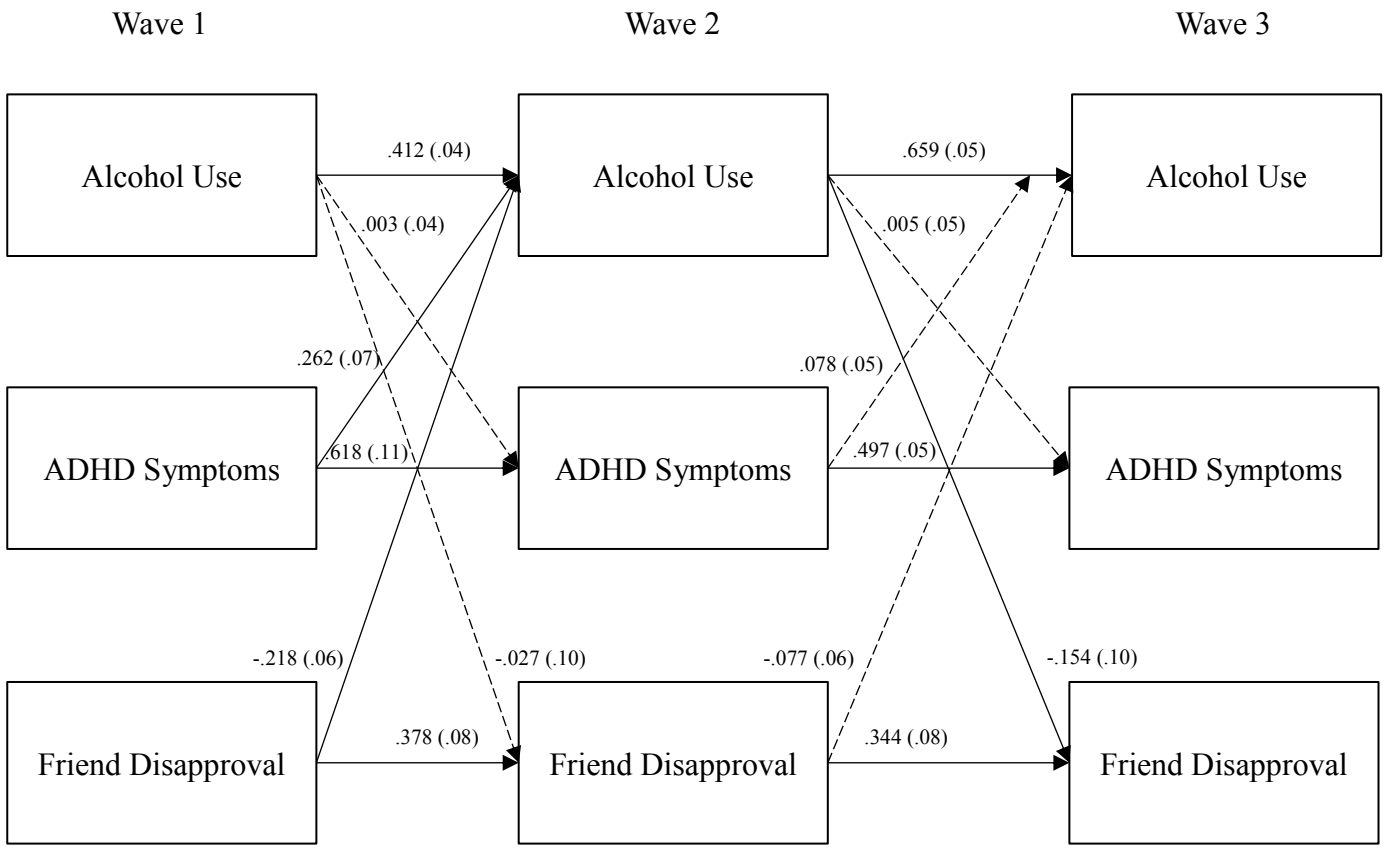


Figure 9. Longitudinal associations between ADHD symptoms and alcohol use and the promotive effect of friend disapproval, χ^2 (34) = 62.854, p = .001, RMSEA = .078 (90% Confidence Interval: 0.048-0.107), and CFI = .919. Betas (β) are shown and standard errors are in parentheses. Correlations between variables within each wave and covariates were included in the model, but are not shown in the figure to reduce complexity. The dotted lines represent a non-significant path; the solid lines indicate a significant path.

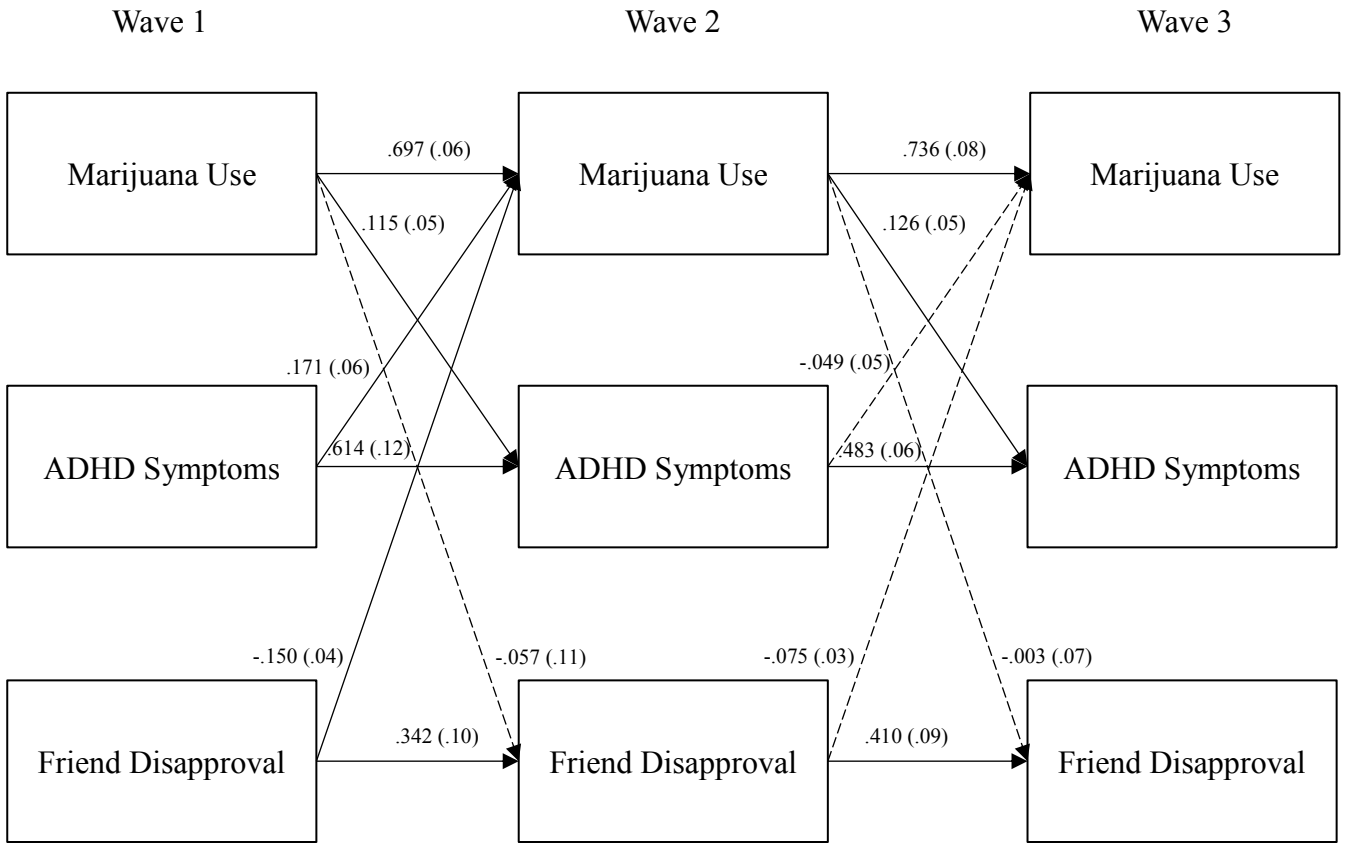


Figure 10. Longitudinal associations between ADHD symptoms and marijuana use and the promotive effect of friend disapproval, χ^2 (35) = 61.191, p = .003, RMSEA = .073 (90% Confidence Interval: 0.042-0.102), and CFI = .928. Betas (β) are shown and standard errors are in parentheses. Correlations between variables within each wave and covariates were included in the model, but are not shown in the figure to reduce complexity. The dotted lines represent a non-significant path; the solid lines indicate a significant path.

Longitudinal Associations between Substance Use Outcomes, ADHD Symptoms, and Protective Mechanisms

To examine the potential protective effects of academic motivation and adaptive social perceptions (i.e., perceived friend disapproval) for buffering against the risk of ADHD symptoms in predicting alcohol and marijuana use, an autoregressive cross-lagged panel model building on the first and second aims was fit to the data. First, an unconstrained model was initially run, where all paths were allowed to vary across waves.

Protective effect of academic motivation. The unconstrained model for academic motivation including the interaction term of ADHD x academic motivation demonstrated poor model fit for both the model of alcohol use, χ^2 (57) = 227.860, CFI = .851, RMSEA = .141 (90% CI: .122-.161) as well as for marijuana use, χ^2 (57) = 185.776, CFI = .882, RMSEA = .128 (90% CI: .108-.148). Given inadequate model fit for the unconstrained model, model constraints were not examined further for academic motivation.

Protective effect of perceived friend disapproval. The unconstrained model for the protective effect of perceived friend disapproval demonstrated excellent model fit in the model predicting alcohol use, χ^2 (57) = 53.205, CFI = .960, RMSEA = .077 (90% CI: .044, .108) as well as for marijuana use, χ^2 (57) = 30.705, CFI = .995, RMSEA = .028 (90% CI: .000, .069). A constrained model was run where all autoregressive paths (i.e., ADHD symptoms, alcohol or marijuana use, friend disapproval, and the interaction term: ADHD x friend disapproval) were constrained to be equal across wave. Comparison of the autoregressive constrained to the fully unconstrained model supported retaining the equality constraints for the autoregressive paths for both the alcohol use and marijuana use models. The autoregressive model was left constrained for all stability paths and was then compared to the following models with cross-lagged paths constrained equal across waves for: (a) ADHD to either alcohol or marijuana use; (b) alcohol or

marijuana use to ADHD symptoms; (c) friend disapproval to either alcohol or marijuana use; (d) interaction term of ADHD x friend disapproval to either alcohol or marijuana use. In both the alcohol and marijuana models, comparisons of each constrained model supported holding the equality constraints with the exception of the cross-lagged path constraints from ADHD symptoms to the marijuana use, based on the significant chi-square difference test, $SB\Delta\chi^2$ (1) = 4.024, p = .045, and a decrease in CFI from .991 to .984 in the constrained model. All other cross-lagged path coefficients were retained in the final model predicting marijuana use. Similarly in the model with friend disapproval and alcohol use, a comparison of the constrained cross-lagged effects were not retained for the path coefficients of: ADHD to alcohol use, alcohol use to ADHD, and for the interaction term "ADHD x Friend Disapproval" in predicting alcohol use demonstrating variability in the strength of these associations across waves. The final model examining the ADHD x friend disapproval interaction in the prediction of alcohol use demonstrated adequate fit, χ^2 (63) = 64.461, CFI = .951, RMSEA = .077 (90% CI: .047-.105); and the final model with ADHD x friend disapproval in predicting marijuana use demonstrated excellent model fit, χ^2 (64) = 35.579, CFI = .999, RMSEA = .010 (90% CI: .000-.059).

All standardized paths for these final models with academic motivation are presented in Figures 11 and 12. After controlling for the direct effects of ADHD symptoms and friend disapproval in predicting alcohol use over time, the interaction between ADHD x friend disapproval was a significant predictor of decreased alcohol use from wave 1 to wave 2 (β = -.186, p < .05) as well as from wave 2 to wave 3 (β = -.179, p < .05). Similarly, in the model predicting marijuana use, interaction between ADHD x friend disapproval was a significant predictor of decreased marijuana use from wave 1 to wave 2 (β = -.213, p < .05) as well as from wave 2 to wave 3 (β = -.164, p < .05); after controlling for the direct effects of ADHD symptoms and friend disapproval.

Table 6. *Comparison of Model Constraints for Autoregressive Cross-Lagged Models for the Longitudinal Associations Between ADHD symptoms and Alcohol Use or Marijuana Use Frequency and the Protective Effect of Friend Disapproval*

Alcohol Use and ADHD Symptoms								
Model		χ^2	df	CFI	RMSEA	CI	Satorra-Bentler $\Delta\chi^2$	Decision
Unconstrained Model		53.205	57	.960	.077	(.044, .108)	--	
All auto-regressive paths		51.963	61	.968	.064	(.029, .095)	$\Delta\chi^2$ (4) = 1.628, p = .804	Retain
	ADHD → Alc	73.019	62	.951	.077	(.048, .106)	$\Delta\chi^2$ (1) = 11.903, p = .001	*Reject*
	Alc → ADHD	57.052	62	.961	.069	(.037, .099)	$\Delta\chi^2$ (1) = 5.834, p = .016	*Reject*
	Friend Disapp → Alc	52.672	62	.968	.062	(.027, .093)	$\Delta\chi^2$ (1) = .108, p = .743	Retain
Cross-lagged paths	ADHD x Friend Disapp → Alc	64.461	63	.951	.077	(.047, .105)	$\Delta\chi^2$ (1) = 25.629, p = .001	*Reject*

Marijuana Use and ADHD Symptoms								
Model		χ^2	df	CFI	RMSEA	CI	Satorra-Bentler $\Delta\chi^2$	Decision
Unconstrained		30.705	57	.995	.028	(.000, .069)	--	
All auto-regressive paths		36.226	61	.991	.029	(.000, .069)	$\Delta\chi^2$ (4) = 5.435, p = .245	Retain
Cross-lagged paths	ADHD → Marij	40.748	62	.984	.039	(.000, .075)	$\Delta\chi^2$ (1) = 4.024, p = .045	*Reject*
	Marij → ADHD	33.240	62	1.000	.007	(.000, .060)	$\Delta\chi^2$ (1) = .107, p = .743	Retain
	Friend Disapp → Marij	33.427	63	1.000	.001	(.000, .057)	$\Delta\chi^2$ (1) = .148, p = .701	Retain
	ADHD x Friend Disapp → Marij	35.579	64	.999	.010	(.000, .059)	$\Delta\chi^2$ (1) = 1.574, p = .210	Retain

Note. Models presented above are hierarchally nested, that is, constraints that are retained (or rejected) at initial steps are retained (or rejected) for the subsequent models. The first model is the unconstrained (base) model; the second model tests constraints on all of the auto-regressive paths as one set simultaneously, followed sequentially by models testing constraints for each of the cross-lagged paths.

CFI = Comparative Fit Index. RMSEA = Root Mean Square Error of Approximation. Alc = alcohol use frequency. Marij = marijuana Friend Disapp = friend disapproval. df = degrees of freedom.

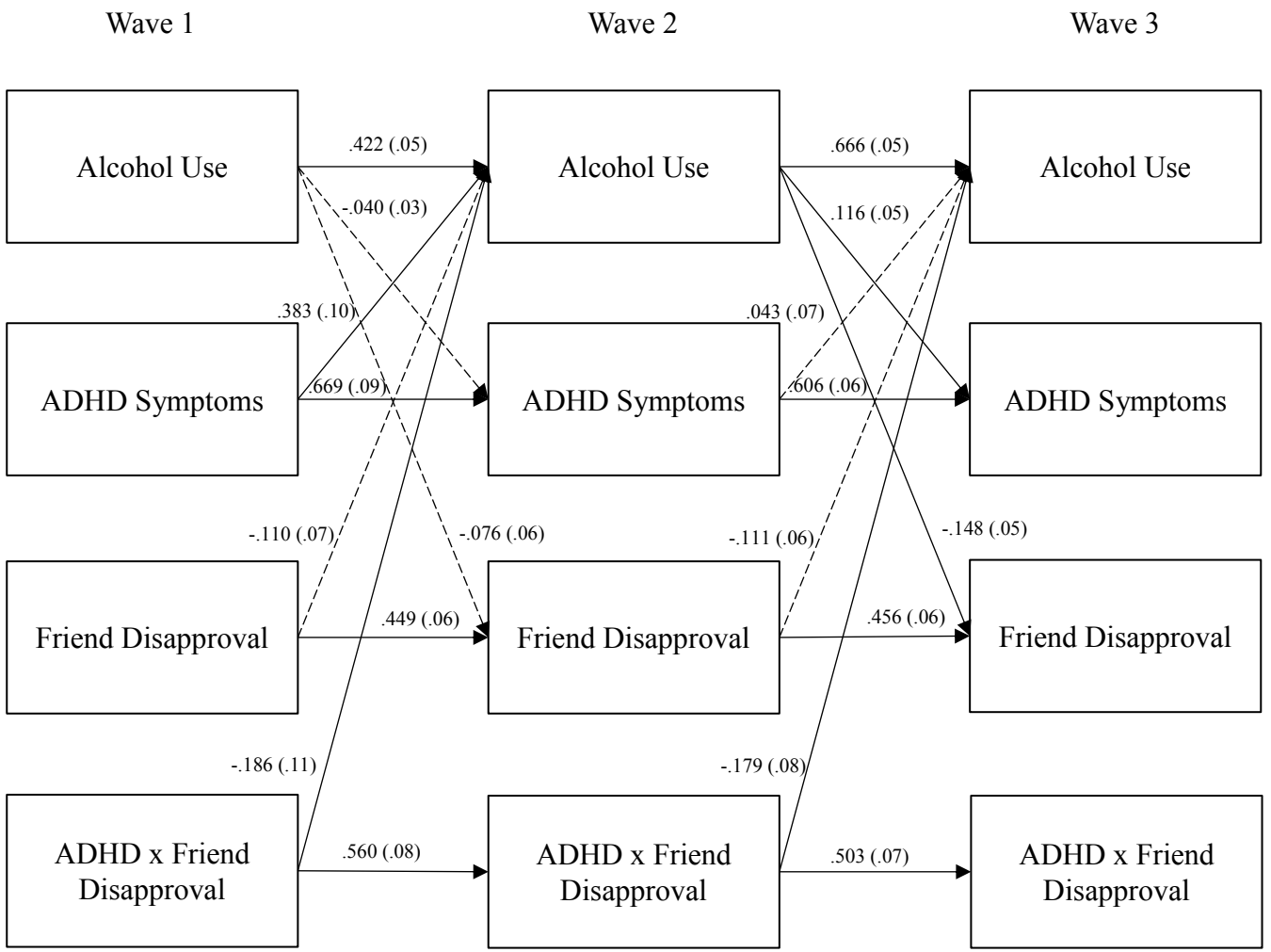


Figure 11. Longitudinal associations between ADHD symptoms and alcohol use and the protective effect of friend disapproval, χ^2 (63) = 64.461, p = .001, RMSEA = .077 (90% Confidence Interval: 0.047-0.105), and CFI = .951. Betas (β) are shown and standard errors are in parentheses. Correlations between variables within each wave and covariates were included in the model, but are not shown in the figure to reduce complexity. The dotted lines represent a non-significant path; the solid lines indicate a significant path.

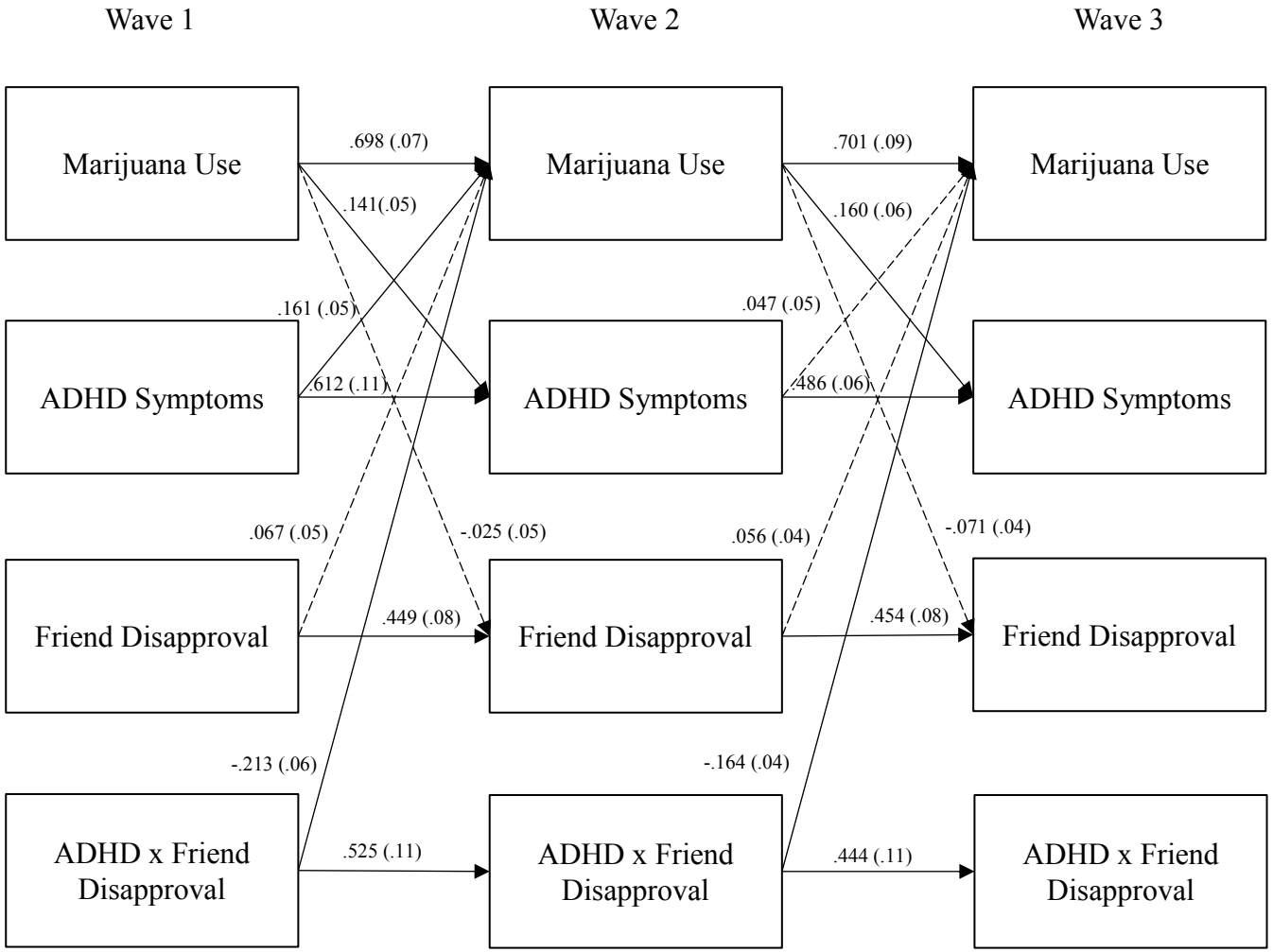


Figure 12. Longitudinal associations between ADHD symptoms and marijuana use and the protective effect of friend disapproval, χ^2 (64) = 35.579, p = .441, RMSEA = .010 (90% Confidence Interval: 0.000-0.059), and CFI = .999. Betas (β) are shown and standard errors are in parentheses. Correlations between variables within each wave and covariates were included in the model, but are not shown in the figure to reduce complexity. The dotted lines represent a non-significant path; the solid lines indicate a significant path.

A visual plot of the significant interactions (see Figures 13 and 14) demonstrates that the association between ADHD symptoms and alcohol as well as marijuana use for high school students transitioning to college was buffered for those with high adaptive social perceptions (i.e., strong disapproval about substance use from friends; +1 SD), but for students with low disapproval about substances from friends, ADHD symptoms were more strongly associated with both alcohol and marijuana use. Figure 14A demonstrates the interaction effect of friend disapproval with ADHD demonstrates a significant effect on decreased marijuana use given that the simple slopes were significant at -/+ 1SD, meaning they were significant from zero. In the remaining figures, friend disapproval perceptions appears to demonstrate a "positive-stabilizing" (Luthar, Cicchetti, Becker, 2000) effect whereby the simple slope for those with high friend disapproval (i.e., +1 SD) is not significant from zero, but the simple slopes for those with low friend disapproval is significant in predicting increased alcohol and marijuana use.

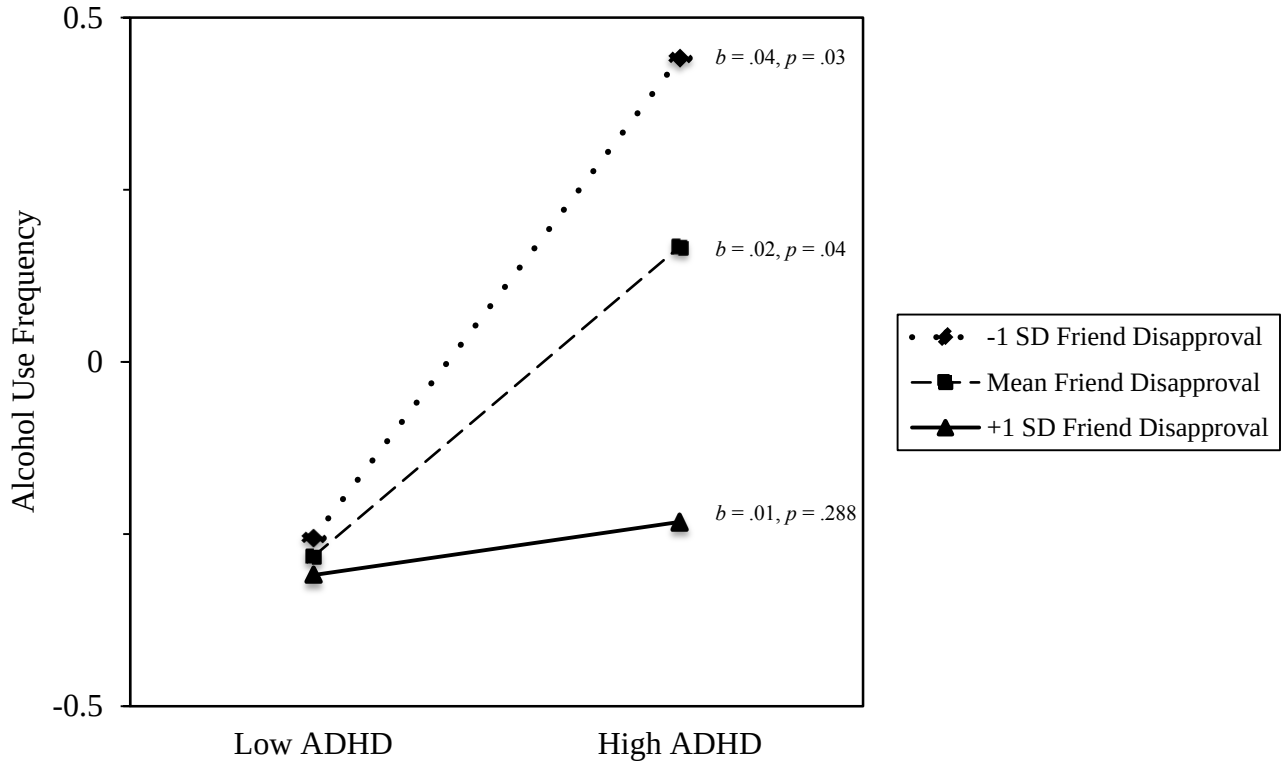


Figure 13A. Significant interaction (ADHD x friend disapproval of alcohol use) on alcohol use frequency at Waves 1-2.

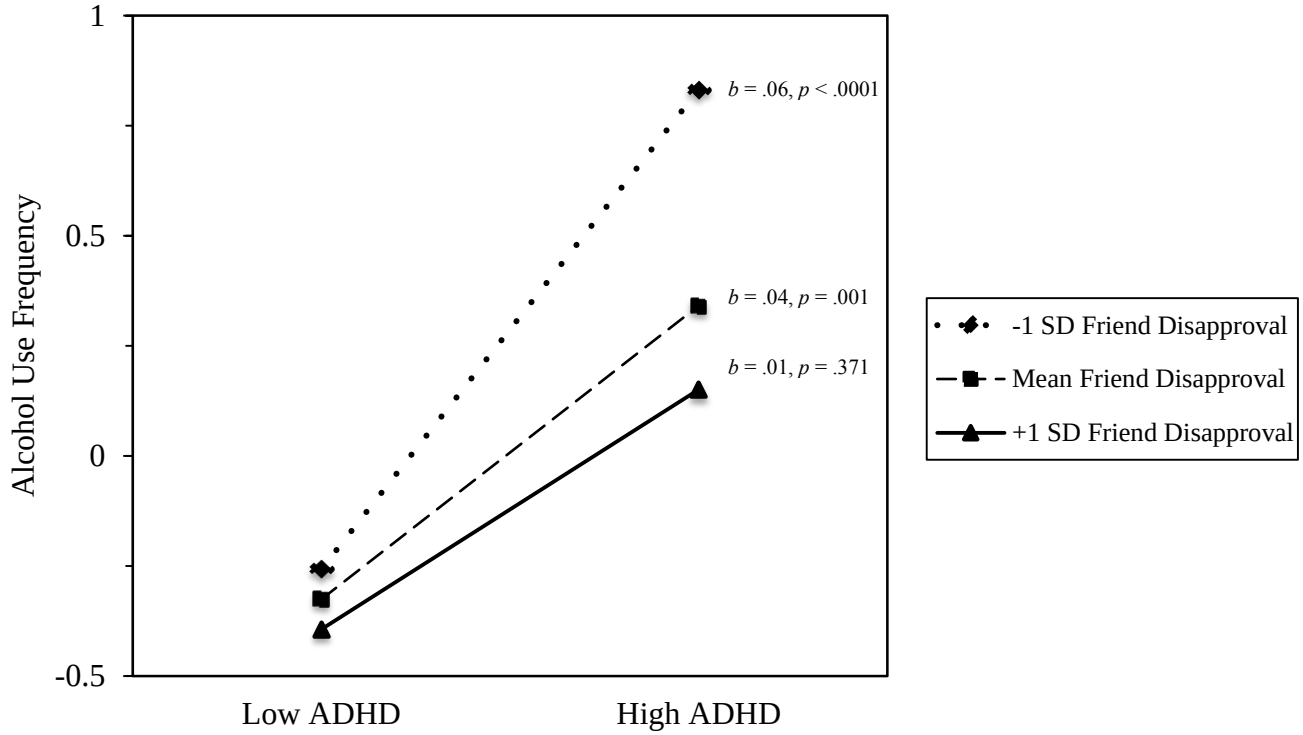
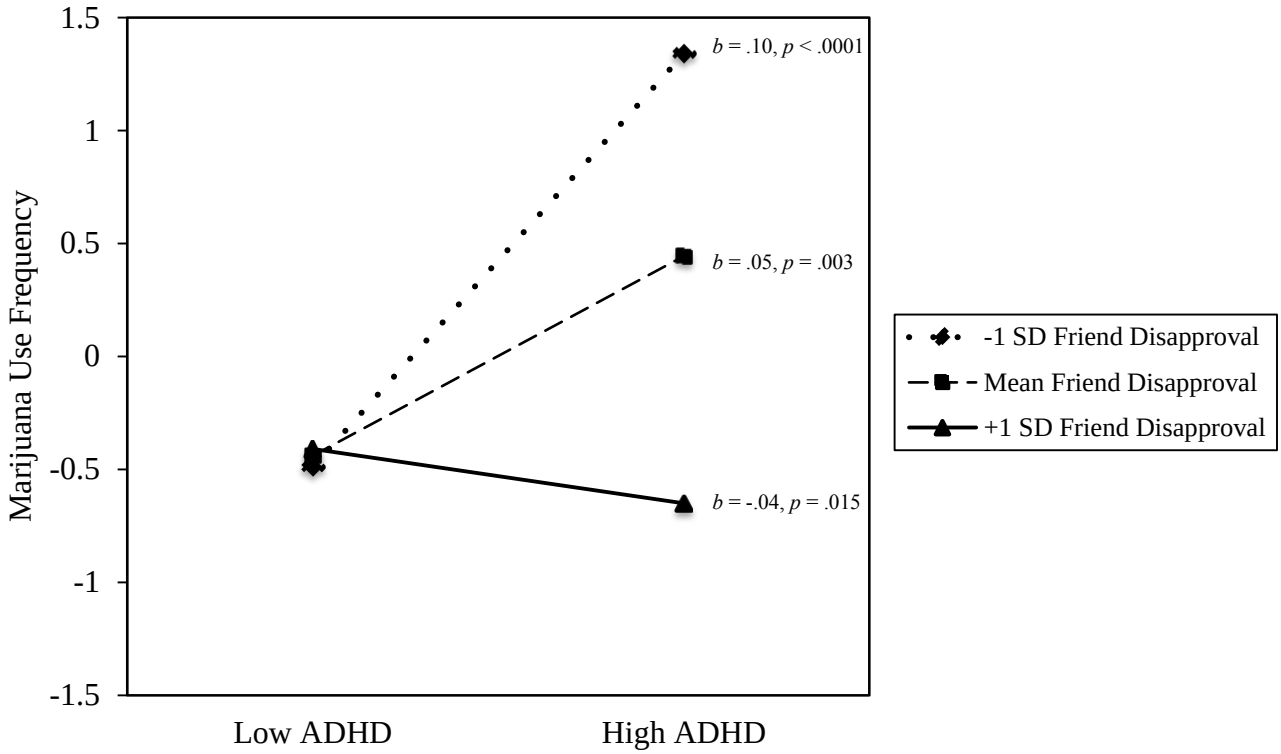


Figure 13B. Significant interaction (ADHD x friend disapproval of alcohol use) on alcohol use frequency at Waves 2-3.



F*igure 14A*. Significant interaction (ADHD x friend disapproval of marijuana use) on marijuana use frequency at Waves 1-2.

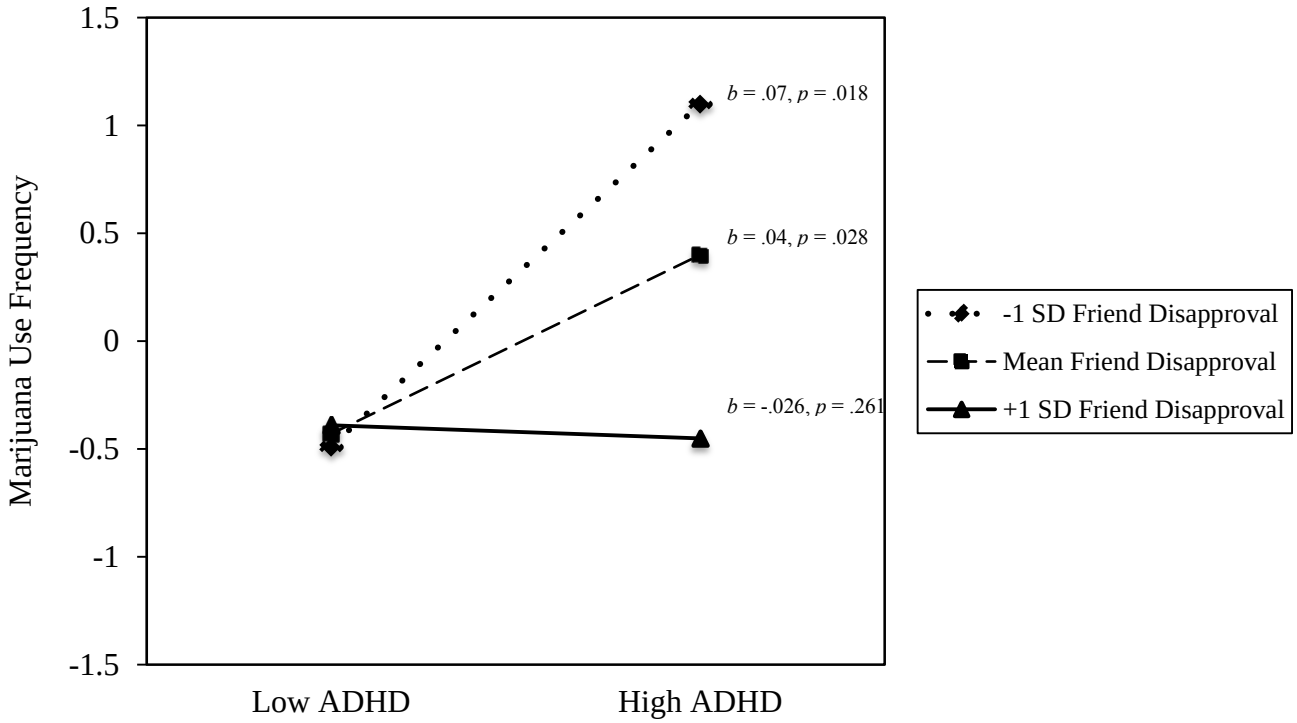


Figure 14B. Significant interaction (ADHD x friend disapproval of marijuana use) on marijuana use frequency at Waves 2-3.

Discussion

The substantial increase in alcohol and substance use during the transition from high school to college (Arria et al., 2017; Johnston et al., 2015; O'Brien et al., 2018) and associated adverse outcomes, such as blacking out, missing class or work, having unprotected or unplanned sexual intercourse, academic probation, or legal consequences (Hingson et al., 2009; King et al., 2006; McCabe et al., 2006), underscores the need to identify risk and protective processes associated with this transition. Indeed, in the present sample, frequency of past month alcohol and marijuana use increased substantially from the end of high school (wave 1) to the first semester of college (wave 2). Whereas 43.8% of the students reported any past month use during high school, this rose to 62.7% during the first semester of college. Further, the prevalence of students reporting any marijuana use in the past month doubled from high school (18.9%) to the first semester of college (37.3%).

Symptoms of ADHD are known risk factors for substance use (e.g., Flory, Malone, & Lamis, 2011; Vitulano et al., 2014; Pedersen et al., 2014), but there has been no longitudinal research evaluating associations between ADHD symptoms and alcohol and marijuana use specifically across the transition to college. The present study is the first to longitudinally evaluate to the association between ADHD symptoms and alcohol and marijuana use during the transition from high school to college. Further, this study explored the role that promotive and protective mechanisms may play in understanding whether even in the context of ADHD, some individuals do not demonstrate increased substance use during this key developmental transition. Findings suggest that a longitudinal association exists with ADHD symptoms at the end of high school predicting residualized change in alcohol and marijuana use during the first semester of college (i.e., controlling for the autoregressive effect of use during college). For alcohol use (but

not marijuana), ADHD symptoms continued to predict subsequent use across the first year of college (from fall to spring of first year).

Promotive models revealed that adaptive social perceptions predicted decreased alcohol and marijuana use, and academic motivation predicted decreased alcohol use, after controlling for the role of ADHD symptoms. Adaptive social perceptions about each substance (i.e., perceiving friend's disapproval of using that substance) was protective against future alcohol and marijuana use both before and after the transition to college demonstrated by significant interaction effect (ADHD X friend disapproval) after controlling for the direct risk and promotive effects in the model. These findings are discussed in more detail below.

ADHD Symptoms as a Risk for Alcohol and Marijuana Use

Hypotheses regarding the longitudinal associations between ADHD symptoms and alcohol and marijuana use were largely supported. ADHD symptoms predicted increases in subsequent alcohol use from Wave 1 to 2 (i.e., high school to fall of first year of college) and from Wave 2 to 3 (i.e., fall to spring of first year of college). ADHD symptoms also predicted increases in subsequent marijuana use from Wave 1 to 2, but not from Wave 2 to 3 (i.e., after the transition to college). Interestingly, a reciprocal association was found in the model with marijuana use, such that marijuana use also predicted increased ADHD symptoms from Wave 1 to 2 and from Wave 2 to 3. Overall these results suggest that ADHD symptoms are important risk processes that are associated with increased marijuana use before the transition and increased alcohol use both before and after the transition to college. These findings are also consistent with research documenting the risk of ADHD symptoms for predicting concurrent alcohol and marijuana use among adolescents and young adults (e.g., Gudjonsson et al., 2012; Murphy & Flory, 2017). The current study extends extant literature by demonstrating that ADHD symptoms severity was not only concurrently associated with alcohol and marijuana use,

but increased use was also longitudinally predicted by prior ADHD symptom severity over the course of the last year of high school to the end of the first year of college.

While ADHD symptoms are known to be associated with increased long-term risk for alcohol and marijuana use problems, research on the underlying pathways linking these constructs is only just emerging. The current study addressed an important gap in the literature by examining specific promotive and protective factors that may buffer the association between ADHD symptoms and later alcohol and marijuana use. Specifically, the present study found support for two promotive mechanisms, adaptive social perceptions and academic motivation.

Effect of Academic Motivation

The promotive effect of academic motivation for decreased alcohol use is consistent with social development theories that highlight the importance of prosocial bonding and with evidence that engagement in school (Bond et al., 2007; Newcomb et al., 2002; Hawkins et al., 1992) and academic achievement (Connell et al., 2010; Grunbaum et al., 2000; Sher & Rutledge, 2007) is negatively associated with substance use. Academic motivation may be conceptualized as one aspect of "school bonding" which has received strong theoretical and empirical support as an important causal element in healthy youth development and the prevention of substance use (Catalano et al., 2004; Cleveland et al., 2008)

The lack of promotive effect of academic motivation for marijuana use may have been due to the relatively small sample size, as prior prospective research in general college samples suggests that the association between academic engagement or motivation and marijuana use frequency is modest (Bond et al., 2007; Connell et al., 2010; Diego et al., 2003; Phillips et al., 2015). However, other studies have also found academic engagement or achievement to be promotive against the risk for alcohol use but not marijuana use in adolescent high school (e.g., Cleveland et al., 2008; Grunbaum et al., 2000; Wills, Vaccaro, & McNamara, 1992) and college

student samples (e.g., Sher & Rutledge, 2007; Wood, Sher, & McGowan, 2000) even after controlling for the effect of other risks. Some research has suggested that the impact of academic engagement on marijuana and alcohol use during college is moderated by prior levels of academic achievement in high school, with motivation having a larger impact on those students with a history of high achievement (Connell et al., 2010; Wood et al., 2000; White et al., 2006). Finally, there is emerging evidence for what has been called a "marijuana amotivational syndrome" such that marijuana use (but not alcohol or tobacco use) longitudinally predicts decreased initiative, self-efficacy, and task persistence among for college students (Lac & Luk, 2018; Volkow et al., 2016).

Effect of Adaptive Social Perceptions

The promotive effect of perceptions of friend disapproval for substance use is in line with prior evidence supporting the importance of social normative beliefs (e.g., Lac & Donaldson, 2018; Lee et al., 2007; Neighbors et al., 2008; Pedersen et al., 2017; Rinker & Neighbors, 2014) and involvement with non-substance using peers (e.g., Jessor et al., 2006; Napper et al., 2016; Van Ryzin et al., 2012) for promoting decreased alcohol and marijuana use for high school and college students. Specifically, findings fit with college student research showing that perceived injunctive norms (i.e., friend disapproval) are powerful predictors of problem drinking, perhaps even more so than perceived descriptive norms (LaBrie et al., 2010; Lee et al., 2007; Pedersen et al., 2017). Indeed, there is strong support for the increasing influence of friendships and social context for substance use during the adolescent period (Borsari & Carey, 2001; Brook et al., 2001; Monahan et al., 2009). In line with social developmental theories, in the present study, higher levels of friend disapproval of marijuana or alcohol use predicted decreased individual use from high school to college. Specifically, these findings support Social Development Model (Catalano & Hawkins, 1996; 2002) and the Theory of Triadic Influence (Flay et al., 1999;

Petraitis et al., 1998) and indicate social perceptions of friends disapproving substances place adolescents on a prosocial pathway that includes less alcohol and marijuana use.

The reciprocal association between alcohol use and subsequent adaptive social perceptions as well as academic motivation is consistent with developmental socialization theories (e.g., Catalano & Hawkins, 2002; Hirschi, 1969) which highlight the relation between bonding to prosocial peers and school as protective against the development of problem behavior such as externalizing and substance use problems (Dishion et al., 1991). Together, these theories suggest that individuals with externalizing behaviors, such as those with ADHD, often experience school adjustment problems and rejection by conventional or prosocial peers. As a result, many of these individuals then begin to identify with unconventional or deviant peers and become increasingly involved in deviant activities including substance use. Further, the reciprocal association between academic motivation and alcohol use during the first year of college is consistent with several recent studies demonstrating the adverse academic consequences of alcohol use during college (Bolin et al., 2017; Meda et al., 2017; Suerken et al., 2016; Wilhite et al., 2017). Specifically, skipping class has been identified as a key mediator in the association of alcohol and substance use with academic failure, delayed graduation, and dropping out of college (Arria et al., 2015; Wilhite et al., 2017).

Finally, one of the most novel contributions of the present study is the finding that adaptive social perceptions, or perceived friend disapproval of substance use, moderated the association between ADHD symptoms and alcohol (Figure 11) as well as marijuana use (Figure 12) both before and after the transition to college. Further, these associations held after controlling for prior levels of use, gender, living status, college type, and prior grade point average. Analyses examining the conditional effects of ADHD symptoms on alcohol and marijuana use (Figures 13 and 14) demonstrated that ADHD symptoms were less associated with

alcohol use when perceived friend disapproval was high, demonstrating a "protective stabilizing" effect (Luthar et al., 2000). Specifically, in the presence of high ADHD symptoms, those with high perceptions of friend disapproval demonstrated lower alcohol and marijuana use compared to those with high ADHD symptoms and low friend disapproval. However, friend disapproval did not differentially impact alcohol or marijuana use for those with low ADHD symptoms in either model, such that those with low ADHD symptoms exhibited similar rates of alcohol and marijuana use in relation to the sample mean. It is important to note that given this is general population sample, those in the high ADHD symptoms group plotted for interpretation in the figures do not necessarily represent clinical levels of ADHD.

Limitations

These findings should be interpreted in the context of several methodological limitations that may affect the generalizability of findings. First, the relatively small sample size may have limited our ability to detect smaller effects and reduced our power to find significant interaction effects. Overall, the sample size was modest at best and the ARCL models should be replicated with larger samples. Additionally, the present study could not account for nesting of schools/classrooms, which is recommended for use with larger sample sizes and with a large number of clusters (> 50 are present). Given that the sample was collected across a limited amount of high schools, nesting was not accounted for in the models. The implication of using non-nested models is that one may miss some variance attributable to key variables (promotive factors and substance use) that could be due to school or classroom effects. Further, high school recruitment was limited to schools in central Virginia, and future research should extend the scope of examination to additional schools and students across varying contexts.

The present study also did not account for the heavily skewed and zero-inflated nature of the adolescent alcohol and marijuana use frequency count outcomes, which has been noted as a

challenge by addiction researchers (e.g., Atkins, Baldwin, Zheng, Gallop, & Neighbors, 2013). Specifically, the combination of count outcomes that are often strongly skewed with a high preponderance of zeroes can produce non-normality in the residuals. Muthén and Muthén (2010) have suggested modeling this skewness with a two-part semi-continuous growth model to simultaneously address two forms of this variable: a binary version (e.g., any use relative to no use) and a categorical indicator of severity of use for those using. Others researchers have recommended using generalized estimated equations within a multilevel modeling framework (Zeger, Liang, & Albert, 1988) to allow for the estimation of zero-inflated and hurdle count models, which may better estimate the response generation process for these variables while also accounting for the effects of clustering within individual for repeated time.

Similarly, although the full range of ADHD symptoms was represented in the present sample, these results may not generalize to adolescents and emerging adults with a clinical diagnosis of ADHD. While this is a limitation, the use of continuous ADHD symptoms allowed for greater symptom variability and the inclusion of subclinical ADHD symptom levels, which adds important contributions to the literature on alcohol and marijuana use risk among college students and ADHD symptoms. It would be informative for future work to use structured clinical interviews to compare the risk and promotive processes for adolescents with clinical diagnoses of ADHD relative to their typically developing peers. Additionally, although more individuals with ADHD are matriculating to college than in the past (Wolf, 2001), many young adults with ADHD or elevated symptoms may not attend college. It is important for future work to examine risk and promotive processes for young adults who do not attend college (e.g., those that enter the workforce directly after high school) as well as other adults with ADHD who are at increased risk for alcohol use and substance use disorders (Lee et al., 2011; Lau-Barraco, et al., 2016).

Similar to most prior studies of ADHD and substance use, the present study evaluated ADHD symptoms together, as a total score and did not examine separate symptom dimensions (i.e., inattention, hyperactivity, impulsivity). There is growing evidence that the three symptom domains may differentially predict alcohol and substance use (e.g., Ameringer & Leventhal, 2013; Sibley et al., 2014). Further, given that hyperactivity-impulsivity symptoms present differently during late adolescence and adulthood relative to childhood (Barkley et al., 2008), associations with substance involvement may also change. Some have suggested that while hyperactivity-impulsivity may be association with initiation, inattention symptoms may be more related to marijuana problems by young adulthood (Bidwell, et al., 2014; Zohsel et al., 2016). Overall, the evidence to date is evidence mixed, and the relevance of the symptom cluster tends to vary depending on the substance outcome examined. Future research could examine each of the ADHD dimensions separately and their association with substance use outcomes. For instance, there is emerging research suggesting that specific facets of impulsivity (i.e., urgency, lack of planning, lack of perseverance, sensation-seeking, and positive urgency (UPPS; Coskunpinar, Dir, & Cyders, 2013) may be linked to both ADHD and alcohol use problems for adults (Pedersen et al., 2016).

The use of single items to assess alcohol and marijuana use might also be considered a limitation. However, many studies in addiction science (e.g., see Stone et al., 2012 for a review), and in the ADHD literature (e.g., Gudjonsson et al., 2012; Molina & Pelham, 2003; Vitulano et al., 2014) examine substance use with single items (e.g., ever used marijuana, age at first use) as outcomes. Further, substance use outcomes examined in the present study included frequency of alcohol and marijuana use over the past 30 days and did not account for alcohol or marijuana related problems (e.g., binge drinking, dependency, dangerous use). This is a limitation given that at least for alcohol, youth with ADHD may not consume at higher frequencies (Janusis &

Weyandt, 2010), but still experience greater likelihood of impairment and problems associated with use (Molina et al., 2013; Molina et al., 2007; Rooney, Chronis-Tuscano, Yoon, 2012). It is possible that the promotive and protective mechanisms for predicting substance use problems and associated impairment may be unique from those that predict frequency of use. In addition, students' ratings of past 30 day use in this study relied on self-report which may be biased. Future research should consider alternative methods of assessment, including ecological momentary assessments using frequently repeated measurements to potentially capture more accurate estimates and day-to-day variability. For example, a recent study by Phillips and colleagues (2018) demonstrated that some college students report using marijuana in the moment for social facilitation purposes, whereas daily users had more variability in terms of the social context of their use. Future work should also extend these findings to additional waves of data collected throughout college and earlier waves during high school in order to better understand the reciprocal nature of these associations.

Finally, although the sample used in the present study was ethnically diverse and representative of college students across 2- and 4-year institutions, there were not sufficient numbers of each demographic subgroup to evaluate whether demographic characteristics moderated the observed relations. It is plausible that associations could be stronger in certain groups and weaker in others. For example, the association between academic motivation promoting decreased marijuana and alcohol use may be stronger for those with a stable history of high academic achievement (i.e., high GPA in high school). Instead, covariates were examined as continuous predictors in the ARCL models. Future work should identify whether there are differences (i.e., by sex, race, achievement) in the association between ADHD symptoms, adaptive social perceptions, and academic motivation in predicting marijuana and alcohol use by examining multi-group analyses to compare the structural coefficients (i.e., structural invariance)

by group. Specifically, future work with larger samples that permit dividing the sample by sub-groups could evaluate whether the model fits equally well for important subgroups (e.g., males and females).

Despite these limitations, this study makes an important contribution to the understanding of the reciprocal, dynamic interplay, between ADHD symptoms, academic motivation, and adaptive social perceptions in predicting alcohol and marijuana use across the transition to college. Although the present study cannot indicate causal associations between constructs, the longitudinal transactional design provides information about the possible direction of effects from high school to college. The general pattern of significant and nonsignificant results can provide useful insight for model building and guidance for intervention timing.

Future Directions

The precise mechanisms that contribute to the promotive and protective effect of academic motivation and adaptive social perceptions for the association between ADHD symptoms and alcohol and marijuana use outcomes remain untested. As implied above, there may be additional mediating mechanisms that account for the association between academic motivation and adaptive social perceptions in predicting decreased alcohol and marijuana use. Future studies could benefit from clarifying the processes through which academic motivation and adaptive social perceptions serve as promotive effects and/or buffers against ADHD and substance use. Possibilities include school adjustment, engagement in prosocial activities, as well as emotional or cognitive factors that might encourage increased self-efficacy, self-worth, or decreased symptoms of depression or anxiety. Future research should consider students' range of expectations and motivations about college in general. For instance, future work might explore students' various goals or motivations for attending college. Students who attend college with the goal of gaining admission to law or medical school may have different expectations and

motivations compared to students who are going to college in order to move out of their parents home or students who have minimal expectations or are ambivalent about attending college.

Given the significant effect of perceived friend disapproval of risky alcohol and marijuana use on students' own use, it is important that future work identify what facets, characteristics, or behaviors are present among students' friends who disapprove of substances. Social injunctive norms regarding disapproval are conceptually multifaceted and complex (Neighbors et al., 2008), however we know very little about how these social perceptions are formed and what specific social processes are involved with peers that makes them disapproving of substances. It is unclear whether college students directly tell their friends they disapprove of use, or alternatively whether this may be implied through their actions, responses to observing others using, whether they also have friends who use substances, or other individual qualities (e.g., being extraverted, using humor when talking about substances). In order to develop effective intervention strategies targeting social norm perceptions and the social context of substance use, it is important that future research enhance our understanding of these processes of disapproval.

It is important to note that by not including these possible intermediate variables in the present analysis, we do not know the relative role of academic motivation or adaptive social beliefs in the context of other potential contributors. For example, future research could further clarify the effect of adaptive social perceptions and academic motivation by evaluating their impact after accounting for deviant peer involvement and other externalizing problems (e.g., conduct problems), which have been linked to both ADHD symptomology and involvement in substance use (Flory & Lynam, 2003; Pingault et al., 2013). Of note, many studies examining the role of ADHD in predicting substance use outcomes in young adults have demonstrated an effect of ADHD symptoms, even when accounting for effects of conduct problems (e.g., Elkins,

Saunders, Malone, Keyes, McGue, & Iacono, 2018; Flory et al., 2011; Glass & Flory, 2012; Van Eck et al., 2014; Zohsel et al., 2016). Similarly, the present study did not include other types of social experiences that could provide a richer understanding of the processes that influence social perceptions and academic motivation. For example, information regarding peer interactions, quality of friendships, and/or the behaviors and characteristics of the friends who are disapproving might be particularly useful who understanding the qualities of friends who disapprove of risky alcohol and marijuana use. The contribution of various aspects of peer relationships to the development of social perceptions of disapproval of substances, their interactive effects, and underlying social processes are an important area for future research (Wang & Eccles, 2012).

The developmental models presented here hinge on the assumption that variables such as academic motivation and adaptive social perceptions carry the same meaning and the same scale over all time points and over all individuals. This is the idea of longitudinal measurement invariance (Meredith & Horn, 2001; Millsap & Cham, 2012; Liu et al., 2017). Importantly, the same scale can measure a different construct at different points in development, especially given the significant transitions that occur during the period of adolescence. It is important for future longitudinal models examining academic motivation, social perceptions and other risk and promotive mechanisms to examine longitudinal measurement invariance of these constructs across development. For example, the same scale of academic motivation can carry different meaning to high school students relative to college students. If longitudinal measurement invariance does not hold, then the observed changes may reflect differences in what is being measured rather than in the level of the construct of interest. Without an investigation of longitudinal measurement invariance, it is difficult to understand the degree to which changes

over time in the observed risk or promotive variables can be attributed to true changes in these constructs.

Another potential direction for future research would be the use of person-focused analytic approaches as variable-focused approaches may overlook important subgroups. For example, there may be students with low ADHD symptoms but poor or maladaptive social perceptions as well as students with high ADHD symptoms but adaptive social perceptions. Failure to consider these heterogeneous groups impedes our understanding of developmental processes and limits the ability to design targeted interventions for specific groups of students. One limitation of the ARCL models examined here is the focus on individual differences (interindividual variability) rather than within-individual change (intraindividual variability). Specifically it is worth noting that in the ARCL model, although the model parameters are affected by intraindividual change (e.g., the magnitude of the autoregressive coefficient is affected by individual-level change), the parameters of the ARCL model are not sensitive to the type of individual-level change. Future work with person-focused approaches would provide a better understanding of various developmental processes and the diverse patterns of risk and promotion/adjustment and synergy among these constructs. As such, future work examining changes in mechanisms of risk and promotion for substance use in emerging adults could incorporate methods for examining intraindividual change.

There has been growing attention around stimulant medication use in college (see Benson et al., 2015 for a meta-analytic review) with studies reporting as many as 43% of college students have misused stimulant medication (i.e., used prescription stimulant medication without a prescription or used more than prescribed) in their lifetime (Advokat et al., 2008; Weyandt et al., 2013). Although stimulant medication use did not demonstrate an effect in any of the models, stimulant misuse was not specifically measured in the present study. It is important for future

work examining ADHD and substance use to explore the role of stimulant medication use/misuse both as a covariate and key outcome. Although many studies have demonstrated a clear association between symptoms of ADHD and stimulant medication misuse (Benson et al., 2015), there evidence is mixed evidence for the impact on substance use. Some studies suggest that stimulant medication in itself does not increase risk for substance use disorders (Humphreys et al., 2013) and may even reduce substance use (Schoenfelder et al., 2014). Other longitudinal work has also demonstrated that prescription simulant use for ADHD does not serve as a risk or protective factor (i.e., is neither associated with increased or decreased risk) for substance use and associated problems (Molina et al., 2013). However, this null effect could be confounded by the fact that stimulant medications are highly effective at reducing ADHD symptomatology (Findling & Dogin, 1998) and can positively impact functioning, but those taking medications long-term into emerging adulthood may also represent a higher risk group of individuals with ADHD (Barkley, 2006). Benson and colleagues (2015) hypothesized that the general propensity for substance use problems related to ADHD symptoms is the driving link between ADHD and stimulant medication misuse among college students. Although the association of ADHD symptoms/diagnosis to greater misuse of stimulant medications may not be unique to stimulant medications, future research should certainly assess for ADHD medication use as a covariate as well as stimulant misuse as a potential substance use outcome.

Implications

The present study findings have important implications for the timing and targets of intervention programs designed to reduce the problem of heavy drinking and marijuana use in college. Overall, findings from the present study suggest that interventions targeting problematic drinking and marijuana use may benefit from implementation prior to college entry. For example, interventions may need to be implemented during the senior year of high school, after

college admission or at freshman orientations. Some support for precollege interventions has been demonstrated at least for alcohol use prevention implemented during the summer following high school graduation but before college entrance (Turrisi, Jaccard, Taki, Dunnam, & Grimes, 2001). Additional research is needed to determine the optimal timing of alcohol and marijuana use interventions.

Adolescence is a key developmental period for youth to construct an identity as academically committed and socially integrated (Skinner et al., 2009; Wang & Eccles, 2013). The present findings highlight two potential targets of intervention programs: academic motivation and social normative perceptions or perceived friend disapproval/approval about substance use. Further the association between ADHD symptoms and alcohol and marijuana use across this key transition suggests that targeting the core deficits of ADHD (e.g., behavioral inhibition, impulsivity, self-regulation) either separately, or concurrently with alcohol and marijuana use, might enhance intervention efforts.

Interventions that improve social perceptions may protect against the risk for substance use in adolescents with ADHD symptoms. Peer programs that promote dyadic friendships with prosocial non-substance using peers may be an important place to start. Interventions that address maladaptive social perceptions may also prove beneficial for the treatment of social vulnerability that often accompanies ADHD. Specifically, the importance of high school injunctive social norm perceptions (i.e., perceived friend disapproval) as a unique predictor of first-semester alcohol and marijuana use frequency suggests that individuals who have friends or associate with peers who disapprove of alcohol and marijuana use in high school may seek out similar peers in college. Interventions could target this self-selection effect by focusing on incoming students who affiliated with deviant or substance using peers in high school and by focusing on the social environments into which students may self-select (e.g., social

organizations). For example, the creation of prosocial social environments such as freshman academic groups (Tinto & Goodsell, 1994) in which first-year students are clustered in social groups and residence halls based on their majors and/or academic interests might reduce the potential of selecting substance using peer groups. Such academic interest groups may simultaneously stimulate academic motivation and engagement as well as increase the likelihood of students engaging in prosocial behaviors (i.e., as an alternative to drinking or using marijuana). For example, implementing campus activities that encourage social bonding during times that might conflict with when students may choose to drink alcohol or smoke marijuana (e.g., late-night student organization activities). Another strategy for interventions could be to challenge maladaptive social perceptions by directly targeting students' alcohol and beliefs and expectancies (Pedersen et al., 2016). As described above, it is important that future work identify what facets, characteristics, or behaviors are present among students' friends who disapprove of substances. In order to develop effective intervention strategies targeting social norm perceptions and the social context of substance use, it is important that future research enhance our understanding of these processes of disapproval.

Finally, the promotive effect of academic motivation on alcohol use suggests that interventions could target students' motivation for college, and in particular, motivation toward long-term (i.e., rather than immediate) rewards that are common to the demands and tasks present in college (e.g., papers, projects, exams). Specifically, targeting students' motivation and engagement in long-term academic tasks is especially important in the context of college where there are many immediately available alternative (and perhaps ultimately maladaptive) rewards and distractions such as heavy alcohol use. Academic motivation shapes adolescents' everyday experiences in school, both academically and socially. Therefore, early education focused

college-based interventions for low-motivated or less engaged students could be effective in decreasing substance use and preventing adolescents from developing problematic use.

Conclusions

To better understand, predict, and improve adolescent and young adult trajectories of ADHD and substance use risk, it is important to continue studying the role of promotive and protective processes. Findings from the present study suggest that adolescents with elevated ADHD symptoms who have high friend disapproval of substances may experience resilience with respect to substance use outcomes. This finding is critical given that alcohol and marijuana use tends to peak during the transition to college and young adults with ADHD have demonstrated significantly increased risk for alcohol and substance use related problems. Academic motivation demonstrated promotive (direct) effects for reducing the risk for alcohol use but protective effects were not found. The results from this study will hopefully be used to inform prevention and intervention programs designed to limit the significant increase in alcohol and marijuana use witnessed across the transition to college. Future research should seek to elucidate more specific mechanisms through which youth and adolescents with elevated ADHD symptoms are protected against the high risk for substance use problems.

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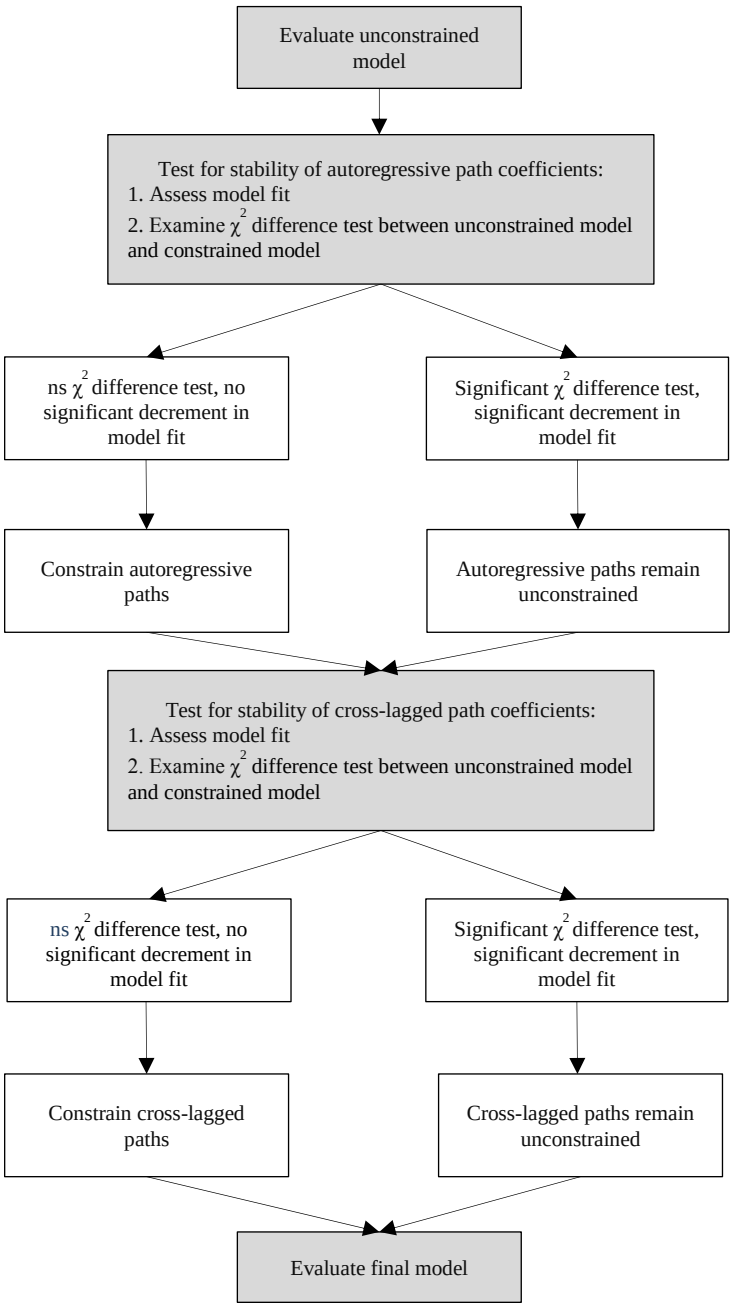
Appendix A: Study Timeline

Prior to Study	April May	June July Aug	Sept	Oct	Dec Jan	Feb	March	April
Prepare REDCap surveys and prepare for recruitment	Recruit participants, obtain parent and adolescent consent T1 data collection (online ratings)	Data management and analysis of T1 data	Prepare REDCap for T2 data collection	T2 online ratings	Data management and analysis of T2 data	Prepare REDCap for T3 data collection	T3 online ratings Finalize data analysis	Data analysis, dissemination, grant prep

Appendix B: Data Analysis Procedures for Cross-lagged Models



Note. It is important to consider in this hierarchy that the models must be nested to test equality constraints. For example, if paths were to remain unconstrained from Step 2, then Step 3 would be compared to Step 1 (unconstrained model) and not Step 2.

Appendix C: Consent and Assent Forms

RESEARCH SUBJECT INFORMATION AND ADOLESCENT CONSENT FORM

TITLE: Predictors of Functioning During the Transition from High School to College
VCU IRB NO.: HM20006492

Thank you for your interest in this research project being conducted by researchers at Virginia Commonwealth University (VCU). Research is an important part of all universities. This project is an opportunity for high school students continuing to college in the next year to be involved in the research process. One of things that researchers here at VCU are interested in is what factors contribute to a successful and positive transition to college for individuals with and without ADHD. For some individuals, this period can be a high-risk time for the development of problems associated with tobacco use, alcohol use, other substance use, as well as emotional health. We want to understand what factors might contribute to these outcomes, so that we can ultimately use this information to improve the quality of life for students transitioning to college. You are being asked to participate in this study because you are planning to attend college in the fall. This project is voluntary and you can decide if you want to take part.

What will I be asked to do?

- The attached survey will take approximately 60-90 minutes for you to complete and contains questions about your emotional, physical and behavioral health including questions about tobacco and substance use. You will be asked about interpersonal relationships and social interactions with your peers and family. This information will be de-identified; your name as well as other identifiable information will not be connected with these data.
- Your participation will entail completing this online survey three separate times over the course of the next year. If you decide to participate, you will complete the first survey now, and in the future you will be contacted again for two follow-up surveys in the Fall and Spring of the next year. You will have the opportunity to decline to participate at that time.
- You may skip any question that you do not want to answer. If you want to skip a question, please select 'I choose not to answer'. You may choose not to answer the questions, or you may choose to complete the questions over the phone. There is no penalty for not completing the survey.
- We will request your permission to contact your parent(s)/guardian(s) and they will also need to complete a brief online survey. The primary purpose of this brief survey for parents is to ask about your current behavior and behavior during childhood.

RISKS AND DISCOMFORTS

There are no more than minimal risks involved in this survey. One potential risk is that you could become bored or uncomfortable after being asked questions during a survey about behavior or emotional struggles. You can choose not to answer any question or stop a survey or take a break at any time. If you become upset for any reason during a survey, a member of our research staff will be glad to talk with you and to provide referrals. Another potential risk is that confidentiality could be breached. However, as described in more detail below, all research data will be coded by ID numbers and stored in a locked research area. Once you complete the survey, or if you leave the survey before finishing, make sure to close your web browser so that others cannot see your information.

BENEFITS TO YOU AND OTHERS

You may not get any direct benefit from this study, but the information we learn from this study may help us understand why some individuals are more likely than others to develop problems associated with tobacco, alcohol and other substance and emotional health after transitioning to college. We hope to use this information to improve the services available to college students.

COSTS
There are no costs for completing the survey and you will be paid $50 for completion of the initial survey questions.

PAYMENT INFORMATION
You will receive $50 for your completion of this first survey. Following the survey you will be instructed on how to collect your $50. In the future, you will be contacted again for two follow-up surveys in the Fall and Spring of the next year. You will have the opportunity to decline to participate at that time. If you decide to participate and complete these follow-up surveys, you will receive $60 (during the Fall) and $70 (during the Spring) for completion of surveys.

ALTERNATIVES
If you do not want to answer these questions via the secure website, you have the option of calling Melissa Dvorsky at (804) 828-5517 to complete the survey over the phone. You also have the option of not participating in this study.

CONFIDENTIALITY
All responses to this survey will be kept strictly confidential. Your information will only be available to study investigators and research staff who are provided with a password to access a secure server where the responses are stored. Your data will be identified by ID numbers and birthdates, not names, and stored separately from research data in a locked research area. All personal identifying information will be kept in a password-protected file and this file will be deleted at the end of the study. Study data will not be shared with your parent or school/university. We will not tell anyone the answers you give us; however, information from the study and the consent form may be looked at or copied for research or legal purposes by Virginia Commonwealth University. Personal information about you might be shared with or copied by authorized officials of the Department of Health and Human Services or other federal regulatory bodies. In addition, to help us protect your privacy, a Certificate of Confidentiality issued by the National Institutes of Health is being requested to protect all of the information collected in this study. With this Certificate, the researchers cannot be forced to disclose information that may identify you, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below. The Certificate cannot be used to resist a demand for information from personnel of the United States Government that is used for auditing or evaluation of federally funded projects. You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. If an insurer, employer, or other person obtains your written consent to receive research information, then the researchers may not use the Certificate to withhold that information. Additional details about the protections and limitations associated with a Certificate of Confidentiality can be found at http://grants.nih.gov/grants/policy/coc/.

VOLUNTARY PARTIICPATION AND WITHDRAWAL
You do not have to participate in this study. Your participation in this research is completely

voluntary. Your school and/or university will not know if you participate, nor what your responses to any of the questions are.

You need to provide a response to all items on the survey to receive the compensation. You will have an option 'I choose not to answer' for all questions on the survey. There is no penalty for not completing the survey.

You may choose not to answer any of the questions and you may withdraw your consent and discontinue participation at any time or by selecting 'No, I do not want to participate in this study' from the options below. Additionally, you can withdraw your consent at any time by contacting the Principal Investigator at 804-828-5517. Once you complete the survey, or if you leave the survey before finishing, make sure to close your web browser so that others cannot see your information.

Your participation in this study may be stopped at any time by the study staff or the sponsor without your consent. The reasons might include:

- the study staff thinks it necessary for your health or safety;
- you have not followed study instructions;
- the sponsor has stopped the study; or
- administrative reasons require your withdrawal.

QUESTIONS

If you have any questions, complainants, or concerns about your participation in this research, please contact:

Melissa Dvorsky (Study PI) at 804-828-5517
or
Dr. Joshua Langberg (Study PI) at 804-828-6273

The researcher/study staff named above is the best person(s) to call for questions about your participation in this study.

If you have any general questions about your rights as a participant in this or any other research, you may contact:

Office of Research
Virginia Commonwealth University
800 East Leigh Street, Suite 3000
P.O. Box 980568
Richmond, VA 23298
Telephone: (804) 827-2157

Please call this number if you cannot reach the research team or wish to talk to someone else. General information about participation in research studies can also be found at http://www.research.vcu.edu/irb/volunteers.htm.

By participating in research project survey, you acknowledge that:

- Your answers will be recorded.
- You will be contacted again in the future for follow-up surveys. You will have the

opportunity to decline to participate at that time.
- Coded data (i.e., de-identified data that is not connected to your name or any other identifying information about you) may be shared with other researchers.

Please indicate your preference for taking part in the survey:

☐ Yes, I understand this and agree to participate in this research project. (Link to take them to the survey)

☐ I want to think about it more before making a decision about participation. Please exit by closing your browser. (Do not click 'previous page', 'next page', or 'save and return later.')

☐ No, I do not want to participate in the study. (Link to take them to the withdrawal text)

[Text for RedCap withdraw survey:]
We are sorry that you are not interested in participating in this research project at this time. If you change your mind and decide that you do want to participate in the project, please contact the Principal Investigator at 804-828-5517 and we will reissue an invitation to participate.

RESEARCH SUBJECT INFORMATION AND ADOLESCENT ASSENT FORM

TITLE: Predictors of Functioning During the Transition from High School to College
VCU IRB NO.: HM20006492

Thank you for your interest in this research project being conducted by researchers at Virginia Commonwealth University (VCU). Research is an important part of all universities. This project is an opportunity for high school students continuing to college in the next year to be involved in the research process. One of things that researchers here at VCU are interested in is what factors contribute to a successful and positive transition to college for individuals with and without ADHD. For some individuals, this period can be a high-risk time for the development of problems associated with tobacco use, alcohol use, other substance use, as well as emotional health. We want to understand what factors might contribute to these outcomes, so that we can ultimately use this information to improve the quality of life for students transitioning to college. You are being asked to participate in this study because you are planning to attend college in the fall. This project is voluntary and you can decide if you want to take part.

What will I be asked to do?

- The attached survey will take approximately 60-90 minutes for you to complete and contains questions about your emotional, physical and behavioral health including questions about tobacco and substance use. You will be asked about interpersonal relationships and social interactions with your peers and family. Your parent will be asked to complete a brief survey for parents about your current behavior and behavior during childhood. This information will be de-identified; your name as well as other identifiable information will not be connected with these data.
- Your participation will entail completing this online survey three separate times over the course of the next year. You will receive $50 for your completion of this first survey. Following the survey you will be instructed on how to collect your $50. In the future, you will be contacted again for two follow-up surveys in the Fall and Spring of the next year. You will have the opportunity to decline to participate at that time. If you decide to participate and complete these follow-up surveys, you will receive $60 (during the Fall) and $70 (during the Spring) for completion of surveys.
- You may skip any question that you do not want to answer. If you want to skip a question, please select 'I choose not to answer'. You may choose not to answer the questions, or you may choose to complete the questions over the phone. There is no penalty for not completing the survey.

Are there any risks/benefits to participation?

There are no more than minimal risks involved in this survey. One potential risk is that you could become bored or uncomfortable after being asked questions during a survey about behavior or emotional struggles. You can choose not to answer any question or stop a survey or take a break at any time. If you become upset for any reason during a survey, a member of our research staff will be glad to talk with you and to provide referrals. Another potential risk is that confidentiality could be breached. However, as described in more detail below, all research data will be coded by ID numbers and stored in a locked research area. Once you complete the survey, or if you leave the survey before finishing, make sure to close your web browser so that others cannot see your information.

You may not get any direct benefit from this study, but the information we learn from this study may help us understand why some individuals are more likely than others to develop problems associated with tobacco, alcohol and other substance and emotional health after transitioning to college. We hope to use this information to improve the services available to college students.

There are no costs for completing the survey and you will be paid $50 for completion of the initial survey questions.

What will you do with the information?
All responses to this survey will be kept strictly confidential. Your information will only be available to study investigators and research staff who are provided with a password to access a secure server where the responses are stored. Your data will be identified by ID numbers and birthdates, not names, and stored separately from research data in a locked research area. All personal identifying information will be kept in a password-protected file and this file will be deleted at the end of the study. Study data will not be shared with your parent or school/university. We will not tell anyone the answers you give us; however, information from the study and the consent form may be looked at or copied for research or legal purposes by Virginia Commonwealth University. Personal information about you might be shared with or copied by authorized officials of the Department of Health and Human Services or other federal regulatory bodies. n addition, to help us protect your privacy, a Certificate of Confidentiality issued by the National Institutes of Health is being requested to protect all of the information collected in this study. With this Certificate, the researchers cannot be forced to disclose information that may identify you, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below. The Certificate cannot be used to resist a demand for information from personnel of the United States Government that is used for auditing or evaluation of federally funded projects. You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. If an insurer, employer, or other person obtains your written consent to receive research information, then the researchers may not use the Certificate to withhold that information. Additional details about the protections and limitations associated with a Certificate of Confidentiality can be found at http://grants.nih.gov/grants/policy/coc/.

Do I have to be in this study?
You do not have to participate in this study. Your participation in this research is completely voluntary. Your school and/or university will not know if you participate, nor what your responses to any of the questions are.

You need to provide a response to all items on the survey to receive the compensation. You will have an option 'I choose not to answer' for all questions on the survey. There is no penalty for not completing the survey.

You may choose not to answer any of the questions and you may withdraw your consent and discontinue participation at any time or by selecting 'No, I do not want to participate in this study' from the options below. Additionally, you can withdraw your consent at any time by contacting the Principal Investigator at 804-828-5517. Once you complete the survey, or if you leave the survey

before finishing, make sure to close your web browser so that others cannot see your information.

If you do not want to answer these questions via the secure website, you have the option of calling Melissa Dvorsky at (804) 828-5517 to complete the survey over the phone. You have the option of not participating in this study.

QUESTIONS
If you have any questions, complainants, or concerns about your participation in this research, please contact:

Melissa Dvorsky (Study PI) at 804-828-5517
or
Dr. Joshua Langberg (Study PI) at 804-828-6273

The researcher/study staff named above is the best person(s) to call for questions about your participation in this study.

If you have any general questions about your rights as a participant in this or any other research, you may contact:

Office of Research
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Please call this number if you cannot reach the research team or wish to talk to someone else. General information about participation in research studies can also be found at http://www.research.vcu.edu/irb/volunteers.htm.

By participating in research project survey, you acknowledge that:

- Your answers will be recorded.
- You will be contacted again in the future for follow-up surveys. You will have the opportunity to decline to participate at that time.
- Coded data (i.e., de-identified data that is not connected to your name or any other identifying information about you) may be shared with other researchers.

Please indicate your preference for taking part in the survey:

☐ Yes, I understand this and agree to participate in this research project. (Link to take them to the survey)

☐ I want to think about it more before making a decision about participation. Please exit by closing your browser. (Do not click 'previous page', 'next page', or 'save and return later.')

☐ No, I do not want to participate in the study. (Link to take them to the withdrawal text)

[Text for RedCap withdraw survey:]

We are sorry that you are not interested in participating in this research project at this time. If you change your mind and decide that you do want to participate in the project, please contact the Principal Investigator at 804-828-5517 and we will reissue an invitation to participate.

RESEARCH SUBJECT INFORMATION AND PARENT CONSENT FORM

TITLE: Predictors of Functioning During the Transition from High School to College
VCU IRB NO.: HM20006492

Thank you for your interest in this research project being conducted by researchers at Virginia Commonwealth University (VCU). Research is an important part of all universities. One of things that researchers here at VCU are interested in is what factors contribute to a successful and positive transition to college for adolescents with and without ADHD. In particular, we are interested in learning about factors that might protect adolescents from using tobacco and other substances in college. The results of this project will be used to improve programs for youth and families preparing to transition to college. You and your child are being asked to participate in this study because your child is planning to attend college in the fall. This project is voluntary and you and your child can decide if you want to take part.

The purpose of this survey is to gather information about your child's current behavior and behavior during childhood. Researchers on this project are interested in certain characteristics of high school students continuing to college that may predict a successful transition and the survey you are about to complete helps identify those characteristics.

What will you be asked to do?
In this study you will be asked to complete this one-time survey for parents. The survey will take approximately 15-20 minutes for you to complete on a secure website and contains questions about your child's emotional and behavioral health, as well as about your family. It covers topics including family demographics and functioning; and your child's emotional and behavioral health including depression, anxiety, attention problems, and behavioral problems. This information will be de-identified; you and your child's names as well as other identifiable information will not be connected with these data.

You may skip any question that you do not want to answer. If you want to skip a question, please select 'I choose not to answer'. You may choose not to answer the questions, or you may choose to complete the questions over the phone. There is no penalty for not completing the survey.

We will also be asking you for alternate points of contacts your child. If your child is eligible to participate based upon your survey responses we will e-mail you within one business day to let you know. That e-mail will contain a link that will allow your child to complete the study surveys.

What will your child be asked to do?
If your child is eligible, we will ask him/her to complete surveys through a secure website three times over the course of one year. These questionnaires will take approximately 60-90 minutes to complete each time. The surveys contain questions about your child's positive and negative experiences and behavior including questions about tobacco and substance use. Your child also will be asked about interpersonal relationships and interactions. Your child will also be asked questions about his/her relationship with you and family environment. Your child's participation will not impact current standing in school or acceptance to other schools/universities.

By completing the survey you are providing consent for the research investigators to view the answers to the survey you have provided. If your child is eligible and chooses to participate, he/she

will also be asked to read a similar on-line consent document and given a choice about participation.

RISKS AND DISCOMFORTS
There are no more than minimal risks involved in this survey. One potential risk is that you or your child could become uncomfortable or upset after being asked questions during a survey about behavior or emotional struggles. For example, you and your child may be asked questions about symptoms of depression or anxiety. You or your child can choose not to answer any question or stop a survey or take a break at any time. If you or your child becomes upset for any reason during a survey, a member of our research staff will be glad to talk with you or your child about it and to provide referrals. Another potential risk is that confidentiality could be breached. However, as described in more detail below, all research data will be coded by ID numbers and stored in a locked research area. Once you complete the survey, or if you leave the survey before finishing, make sure to close your web browser so that others cannot see your information.

BENEFITS TO YOU AND OTHERS
Your child may not get any direct benefit from this study, but the information we learn from people in this study may help us why some individuals are more likely than others to develop problems associated with tobacco, alcohol and other substance and emotional health.

COSTS
There are no costs for completing the survey and you will not be paid for answering questions since it is only to see whether your child qualifies to take part in the study.

PAYMENT FOR PARTICIPATION
Your child will receive $50 for completing the first survey. After the first survey, your child will be asked to participate in two additional surveys in the Fall and Spring of the next year. Your child will also receive $60 (during the Fall) and $70 (during the Spring) for completion of surveys.

ALTERNATIVES
If you do not want to answer these questions via the secure website, you have the option of calling Melissa Dvorsky at (804) 828-5517 to complete the survey over the phone. You also have the option of not participating in this study.

CONFIDENTIALITY
All responses to this survey will be kept strictly confidential. Your information will only be available to study investigators and research staff who are provided with a password to access a secure server where the responses are stored. You and your child's data will be identified by ID numbers and birthdates, not names, and stored separately from research data in a locked research area. All personal identifying information will be kept in a password-protected file and this file will be deleted at the end of the study. Study data will not be shared with your child's school or university. We will not tell anyone the answers you give us and research data provided by your child will not be shared with you; however, information from the study and the consent form may be looked at or copied for research or legal purposes by Virginia Commonwealth University. Personal information about you might be shared with or copied by authorized officials of the Department of Health and Human Services or other federal regulatory bodies. Further, what we find from this study may be presented at meetings or published in papers, but you and your child's name will not ever be used in these presentations or papers. In addition, to help us protect your privacy, a Certificate of Confidentiality issued by the National Institutes of Health is being requested to

protect all of the information collected in this study. With this Certificate, the researchers cannot be forced to disclose information that may identify you, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below. The Certificate cannot be used to resist a demand for information from personnel of the United States Government that is used for auditing or evaluation of federally funded projects. You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. If an insurer, employer, or other person obtains your written consent to receive research information, then the researchers may not use the Certificate to withhold that information. Additional details about the protections and limitations associated with a Certificate of Confidentiality can be found at http://grants.nih.gov/grants/policy/coc/.

VOLUNTARY PARTICIPATION AND WITHDRAWAL

You do not have to participate in this study. You and your child's participation in this research are completely voluntary. You will have an option 'I choose not to answer' for all questions on the survey. If you choose to participate, you may withdraw your consent and discontinue participation at any time without any penalty. Additionally, you can withdraw your consent at any time by contacting the Principal Investigator at 804-828-5517.

Your participation in this study may be stopped at any time by the study staff or the sponsor without your consent. The reasons might include:

- the study staff thinks it necessary for your health or safety;
- you have not followed study instructions;
- the sponsor has stopped the study; or
- administrative reasons require your withdrawal.

QUESTIONS

If you have any questions, complainants, or concerns about you or your child's participation in this research, please contact:

Melissa Dvorsky (Study Coordinator) at 804-828-5517
or
Dr. Joshua Langberg (Study PI) at 804-828-6273

The researcher/study staff named above is the best person(s) to call for questions about your participation in this study.

If you have any general questions about your rights as a participant in this or any other research, you may contact:

Office of Research
Virginia Commonwealth University
800 East Leigh Street, Suite 3000
P.O. Box 980568
Richmond, VA 23298
Telephone: (804) 827-2157

Please call this number if you cannot reach the research team or wish to talk to someone else. General information about participation in research studies can also be found at http://www.research.vcu.edu/irb/volunteers.htm.

By participating in research project survey for parents, you acknowledge that:

- You and your child's answers will be recorded.
- Your child will be contacted again in the future for follow-up surveys. Your child will have the opportunity to decline to participate at that time.
- Coded data (i.e., de-identified data that is not connected to your name or any other identifying information about you) may be shared with other researchers.

Please indicate your preference for taking part in the survey:

☐ Yes, I understand this and agree to participate in this research project. (Link to the survey)

☐ I want to think about it more before making a decision about participation. Please exit by closing your browser. (Do not click 'previous page', 'next page', or 'save and return later.')

☐ No, I do not want to participate in the study. (Link to take them to the withdrawal text)

[Text for RedCap withdraw survey]: We are sorry that you are not interested in participating in this research project at this time. If you change your mind and decide that you do want to participate in the project, please contact the Principal Investigator at 804-828-5517 and we will reissue an invitation to participate.

Vita

Melissa Renée Dvorsky was born on May 9, 1988, in Columbus, Ohio and is a current U.S. citizen. She graduated from Hilliard Davidson High School, Hilliard, Ohio in 2006. She received her Bachelor of Arts in Psychology from Ohio University, Athens, Ohio in June, 2010 and subsequently worked as a full-time research coordinator at the University of South Carolina for two years. She began the doctoral program in clinical child psychology at Virginia Commonwealth University (VCU), Richmond, Virginia in August, 2012. She received a Master of Science in Psychology from VCU in August, 2014. After completing her clinical internship at the Cincinnati Children's Hospital and Medical Center, Melissa will graduate with her doctorate in Clinical Psychology from VCU.