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Sex Differences in Self-Report and Behavioral Measures of Disinhibition Predicting Marijuana Use Across Adolescence

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Abstract

Disinhibition has been consistently linked to substance use across development. Recent research suggests, however, that these relations may be influenced by both sex and measurement approach. The current study examined the moderating effect of sex on the association between behavioral and self-report measures of disinhibition and marijuana use across adolescence. Participants were 115 boys and 89 girls initially evaluated at grade 8 using a laboratory behavioral assessment and self-report questionnaires of disinhibitory variables. Marijuana use was measured annually from grades 9 through 12. Results suggest that boys and girls did not differ on either self-reported or behaviorally assessed levels of disinhibition, and that disinhibition measured using both approaches was associated with increases in marijuana use over time. There was a significant interaction between sex and disinhibition, suggesting that boys (but not girls) who self-reported elevations in disinhibition evidenced greater increases in marijuana use. The current findings add to a growing literature supporting the importance of using multiple methods to assess disinhibition and highlight the critical role of biological sex in understanding these relations.

Keywords

Disinhibition; Impulsivity; Marijuana Use; Gender Differences; Adolescents

Adolescence represents a critical developmental period characterized by general increases in risk taking, including the initiation and escalation of substance use. Other than alcohol, marijuana is the most widely used substance during adolescence (Centers for Disease Control and Prevention; CDC, 2013). Recent estimates indicate that marijuana use increases from 30% to 49% between the 9th and 12th grade. By grade 12, approximately 28% of adolescents are current users of marijuana (CDC, 2013). Importantly, high school-aged boys report using marijuana more than same-aged girls (Centers for Disease Control and Prevention [CDC], 2008). Further, males are significantly more likely to maintain higher rates of marijuana use, or increase their use, across the transition from late adolescence to emerging adulthood, while females are more likely to use marijuana rarely or never across this same developmental period (Schulenberg et al., 2005)

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These elevated rates are concerning given that marijuana use during adolescence has been shown to predispose youth to deleterious health outcomes, cognitive impairments, subsequent substance use disorders, and psychiatric disorders (see Hall & Degenhardt, 2013; Lynskey et al, 2003; Semple, McIntosh, Lawrie, 2005). Adolescent-onset persistent cannabis use has also been linked to neuropsychological declines across domains of functioning that remain after cessation (Meier et al., 2012), as well as morphological brain alternations (see Batalla et al., 2013 for a review). Despite these detrimental effects, important gaps remain in our understanding of what constructs predict marijuana use and how these risk factors are associated with differential rates of use for boys and for girls. Specifically, it is unclear if boys evidence higher mean levels of early vulnerabilities to substance use, and/or if these specific risk factors are more strongly associated with marijuana use for boys than girls. Thus, it is critical to identify risk factors contributing to the onset and escalation of cannabis use in youth as well as to understand how these vulnerabilities may bring about the noted sex differences in rates of drug use, in order to develop targeted prevention and early intervention efforts.

Associations between Adolescent Disinhibition and Substance Use

A popular framework that has received extensive support in elucidating the mechanisms underlying substance use is the personality diatheses model which posits that dispositional vulnerabilities may lead to problematic substance use (Krueger et al., 2002; Sher & Trull, 1994; Vanyukov et al., 2003). At the forefront of these personality risk factors is disinhibition, a term that encapsulates overlapping but unique constructs including impulsivity, sensation seeking, and risk taking propensity (Collado, Felton, MacPherson & Lejuez, 2014; Reynolds et al., 2013). A large body of research has linked high scores in each of these three constructs to adolescent substance use broadly, (e.g., Elkins, King, McGue & Iacono, 2006; Aklin, Lejuez, Zvolensky, Kahler & Gwadz, 2005; Lejuez et al. 2007; MacPherson et al. 2010; Hittner & Swickert, 2006), but limited research has examined the relationship between disinhibition and adolescent marijuana use specifically.

Although less is known about the relationship between disinhibition and marijuana use, the general trend shows a positive association. For example, cross-sectional and longitudinal studies demonstrate that adolescents with elevated sensation seeking are more likely to smoke marijuana (e.g., Brook, Zhang & Brook, 2011; Flory et al., 2004; Hampson, Andrews, Barckley, 2008). Research examining the relationship between impulsivity, risk taking, and marijuana use is more limited and has primarily focused on young adult samples. For instance, one recent study using cross-sectional methods found that elevated levels of risk taking propensity were associated with past 18-month marijuana use among 17-20 year-olds (Hanson et al., 2014).

Importantly, there does appear to be a notable sex difference in levels? of disinhibitory factors and their association with substance use (Sharma et al., 2013). For example, with regard to disinhibition and substance use relations, males generally score higher on ratings of disinhibition which leads them to exhibit patterns of problematic alcohol use more so than females (Caspi, Moffitt, Newman & Silva, 1996; Rutledge & Sher, 2001). However, minimal research to date has examined sex differences in disinhibition and marijuana use

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specifically, with two notable exceptions (Hampson et al., 2008; Flory et al., 2004). Both of these studies used only self-report measures and focused on sensation seeking, with results showing that sensation seeking was greater in boys than girls and translated into a higher likelihood of using marijuana in high school.

Self-report and behavioral measures of disinhibition

Extant literature examining the personality diathesis model of the onset of substance use is further complicated by notable discrepancies in findings related to specific measurement approaches. For instance, one study found that while young adult marijuana users are more likely to exhibit greater risk taking propensity in real-world social and health domains relative to non-users, marijuana users and non-users do not differ in laboratory-based analogues of risk taking propensity (Gilman, Calderon, Curran & Evans, 2015). These discrepant findings on risk taking propensity indexed by self-report compared to laboratory tasks align with a recent meta-analytic review that recommends utilizing both methodologies to tap into the unique variance of behavioral versus self-reported disinhibition (Sharma, Markon, & Clark, 2013). Specifically, self-reported measures of personality factors including impulsivity and sensation-seeking were found to constitute distinct facets of a higher-order impulsivity trait, whereas behavioral tasks appear to tap a unique latent disinhibition factor (Sharma et al., 2013). Considering the two approaches in tandem yields an even more complex picture. Researchers have consistently found small or non-significant correlations between self-report measures and behavioral tasks of impulsivity (e.g. Reynolds, Ortengren, Richards, & de Wit, 2006; Reynolds, Penfold, & Patak, 2008; White, Moffitt, Caspi, Bartusch, Needles, & Strouthamer-Lober, 1994; c.f. Meda et al., 2009). Despite the lack of association between measurement approaches, research generally indicates significant relations between substance use and both self-report and behavioral measures of disinhibition (see Sharma et al., 2013 for review). Indeed, associations between drug use and self-report measures of disinhibition range up to .41, and relations between drug use and laboratory tasks of disinhibition range up to .42 (Sharma et al., 2013). However, most of these studies are limited to adult samples and include a wide range of illicit substances.

To our knowledge, only one study has considered sex differences in the relation between adolescent substance use and disinhibition utilizing both self-report and behavioral measures of disinhibition. Using a cross-sectional design, Fields and colleagues (2009), found a significant positive relation between performance on the Connors' Continuous Performance Test-II (CPT-II), a behavioral indicator of impulsivity, and smoking status for boys but not for girls. The authors' findings suggested that male smokers made more mistakes on the CPT-II task (indicating greater impulsivity) than male non-smokers or female participants. Moreover, a significant relation was found between stop reaction time on a Go/Stop task and smoking for both males and females but in the opposite direction, such that slower reaction time was associated with smoking for boys, but faster reaction time was associated with smoking for girls. Whereas sex differences were found for behavioral tasks of disinhibition, there was no support for the moderating role of sex on the relationship between smoking status and a self-report measure of disinhibition (Fields, Collins, Lerass & Reynolds, 2009),

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highlighting the importance of employing multi-method techniques for examining sex differences in disinhibition and substance use relations.

Aims of the Current Study

The current study has three aims: 1) The first aim is to examine sex differences in rates of early self-report and behaviorally-assessed measures of disinhibition. Building on previous work, we created a composite of two self-report measures of disinhibition (e.g. Stuart & Holtzworth-Munroe, 2005) and utilized a behavioral task to identify early (i.e. grade 8) risk factors for the development of marijuana use across the high school years. We hypothesized that boys would evidence greater mean levels of early disinhibition relative to girls. 2) A second aim of the study is to examine the effect of disinhibitory traits, as measured by both laboratory and self-report indices, on the course of marijuana use spanning from early to late adolescence. This study is the first to consider both approaches as independent predictors of increases in marijuana use from 9th through 12th grade. We hypothesized that higher levels of self-report and laboratory-based disinhibition will correspond to greater marijuana use over time. 3) The final aim of the paper is to examine whether the relation between disinhibition and marijuana use over time is different for boys and girls. Following previous work by Hampson et al. (2008) and Flory et al. (2004) on sensation seeking and marijuana use, we hypothesized that the relation between disinhibition and marijuana use over time would be greater for boys than for girls.

Method

Sample and Procedure

Participants were 115 boys and 89 girls in the 8th grade and their parents or guardians recruited from a large metropolitan area to participate in a longitudinal study of the development of risky behaviors across adolescence. Children were between the ages of 12 and 15 at grade 8 (M = 13.12, SD = 0.56) and were 53.9% European-American, 34.3% African-American, 1.0% Latino, 1.5% Asian, 0.5% Native American, and 8.8% mixed ethnicity participants. All procedures were approved by the Institutional Review Board at the University of Maryland. Participants were recruited using fliers and mailings to local area schools, libraries, and community recreation centers. Interested families were screened for proficiency in English and asked to complete annual surveys and behavioral tasks at the University of Maryland. At each data collection point, participants were compensated with prizes worth $15 to $35, including gift cards, games, and movies.

Data for the current study include children in the 8th through 12th grade of the ongoing longitudinal study (see Collado et al., 2014 for further details on study procedures). The study started when participants were approximately 11 - 13 years old. Data were recoded from wave-centered to grade-centered in order to compare children both within and across grade levels. All youth who participated in the first wave of data collection were invited to participate in all following waves (regardless of whether they missed previous data collections). In the current study, there were n=204 participants in grade 8, n=206 participated in grade 9, n=163 in grade 10, n=114 in grade 11, and n=102 in grade 12.

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Measures

Demographics—At each assessment point, parents/guardians completed a demographics form which included questions about age, sex, ethnicity/race, and maternal education. Maternal education was dummy-coded, indicating (1) “some high school,” (2) “high school degree or GED,” (3) “technical or trade school,” (4) “some college,” (5) “associates degree,” and (6) “4-year degree.”

Behavioral Measure of Disinhibition—At the baseline assessment, adolescents completed the Balloon Analogue Risk Task – Youth (BART-Y; Lejuez, et al., 2007; Lejuez, et al., 2002), which is the youth version of an ecologically valid, laboratory-based assessment of risk-taking propensity (see Lejuez et al., 2002 for complete task details) and is considered a gold-standard measure of risk taking (Harrison et al., 2005). Performance on the BART-Y is strongly associated with real world risk behaviors, including substance use, gambling, delinquency, and risky sexual behavior (Aklin, Lejuez, Zvolensky, Kahler, & Gwadz, 2005; Lejuez et al., 2005; Lejuez et al., 2007). The BART-Y was developed to provide a controlled setting in which to model risk taking in the natural environment, where risk taking up to a certain point leads to positive consequences, but further excessive risk taking leads to greater negative consequences that outweigh the positives. The BART-Y measures risk taking propensity specifically as a function of engagement in risk behaviors (i.e. pumping up a computer balloon) to earn financial rewards. The task involves inflating computer balloons with the option to keep pumping for greater rewards but increasing risk of losing these rewards if the balloon explodes. Repeated performance of the risk taking behavior (pumping the balloon) is usually reinforced with monetary gain but sometimes (unpredictably) punished with monetary loss. Participants have the option to stop pumping the balloon (i.e., terminate risk-taking) and instead collect a smaller but guaranteed reward. After each balloon explosion or point collection, the adolescent's exposure to that particular balloon ends and a new balloon appears until 30 balloons (i.e., trials) have been completed. Performance on the BART-Y can be scored using either the total number of adjusted-average pumps or the total number of balloon explosions across the 30 trials, with a greater number of pumps and explosions corresponding to greater risk taking propensity (for more details on scoring, see Lejuez et al., 2002). While these approaches are conceptually and statistically related, recent research utilizing adolescent and young adults samples suggests that the explosions measure may represent a clearer picture of youth risk taking (e.g. DeMartini et al., 2014; Reynolds, Schreiber, Geisel, MacPherson, Ernst & Lejuez, 2013). The average correlation among explosions in the first, second, and third blocks of ten trials in the current study was 0.75, consistent with previous research (Lejuez et al., 2002).

Self-Report Measures of Disinhibition—Youth completed two self-report measures of disinhibition at the baseline assessment. Consistent with previous work (e.g. Stuart & Holtzworth-Munroe, 2005), we created a composite score that combines self-report measures of sensation seeking (Brief Sensation Seeking Scale; BSSS; Hoyle, Stephenson, Palmgreen, Pugzles Lorch, & Donohew, 2002) and impulsivity (Eysenck Impulsiveness Scale; EIS; Eysenck, 1991) in order to capture multiple facets of disinhibition.

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Thus, adolescent sensation seeking was assessed with the BSSS, an eight item measure which asks adolescents to report the extent to which they agree (0=strongly disagree through 4= strongly agree) with statements about themselves, including liking to explore strange places, doing frightening things, and having new and exciting experiences. Scores were calculated as the mean across all items. The BSSS has been shown to have good reliability (α=0.76) and validity among adolescent samples (Hoyle et al., 2002), and evidenced acceptable reliability in the current sample (α=0.71).

Adolescent impulsivity was assessed with the EIS, a 19 item measure which asks children to report (yes/no) if they typically engage in a variety of impulsive behaviors (e.g., not thinking carefully before acting, doing things at the spur of the moment, speaking without thinking). Scores were calculated as the mean of all 19 items, with higher scores indicating greater impulsivity. In previous research, the EIS demonstrated good reliability (α=0.84) and validity community samples (Eysenck, Peasron, Easting, & Allsopp, 1985), and in the current sample also evidenced acceptable reliability (α=0.81).

In order to create the composite score to capture disinhibition across the domains of sensation seeking and impulsivity, we first standardized all scores on the BSSS and the EIS yielding z-scores for each individual on both measures. We then averaged the standardized scores for both measures to create the final composite score, consistent with methods recommended by Stuart and Holtzworth-Munroe (2005).

Marijuana Use—At each assessment point, adolescents reported on their frequency of marijuana use in the previous year since the last assessment point by completing an item from the Youth Risk Behavior Survey (YRBS; CDC 1995). Response options included (0) “zero,” (1) “once,” (2) “a few times,” (3) “1-3 times per month,” (4) “1-3 times per week,” and (5) “almost every day or more.” See Table 1 for rates of marijuana use across all years.

Data Analytic Approach

First, missing data patterns were analyzed using Little's (1988) missing completely at random (MCAR) test. Data were also examined to ensure they met the criteria for univariate normality. In order to assess sex differences in mean levels of disinhibitory factors and marijuana use over time, a series of *t*-tests were conducted.

We utilized a latent growth modeling (LGM) approach to examine the trajectory of youth marijuana use from grades 9 to 12 in M*plus* 6 (Muthén & Muthén, 2010). We used full information maximum likelihood (FIML) estimation methods to handle missing data. FIML provides less biased parameter estimates than procedures such as listwise or pairwise deletion under the missing at random assumption (Little & Rubin, 1987). Thus, we were able to conduct all analyses on the full sample of youth.

LGM allows for the estimation of the means and variances for a latent baseline (*intercept*) and change over time (*slope*) of the marijuana use trajectory. Significant estimates of the means for the intercept and slope factors would suggest that these parameters are significantly different from zero. Significant variances would indicate individual differences around these estimates and would support the inclusion of predictors of these differences.

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Specifically, intercept and slope factors with significant variances would allow us to examine whether these factors varied at baseline and over time as a function of our added predictors.

In order to estimate these models, the regression weights from the latent intercept factor to each manifest variable (at each assessment point) are set to be 1.0. For the slope factor, the first two regression weights (i.e., grades 9 and 10) were set to 0.0 and 1.0, respectively. Regression weights for grades 11 and 12 were allowed to be estimated freely to capture both linear and nonlinear change over time. In order to specify the model, the intercept and slope factors were allowed to covary (Duncan et al., 2006).

To evaluate the fit of our proposed model to the data, we examined several fit indices, including the χ^2 statistic, the Comparative Fit Index (CFI; Bentler, 1990), the Tucker-Lewis Index (TLI, Tucker & Lewis, 1973), the Root Mean Square Error of Approximation (RMSEA; Steiger, 1990), and the Standardized Root Mean-square Residual (SRMR; Bentler, 1995). Good fit was indicated by CFI and TLI values ≥ .90, RMSEA and SRMR values ≤ .08, and nonsignificant chi-square values (Schweizer, 2010). However, since chi-square values are highly sensitive to sample size, the CFI, TLI, RMSEA, and SRMR served as the primary measures of model fit.

We initially examined an unconditional model of the marijuana use trajectory over time to determine whether frequency of marijuana consumed increased over development. We then utilized a model building approach to evaluate whether potential covariates, including child sex, age, race, and maternal education level were associated with marijuana use over time. Covariates that significantly predicted the marijuana use trajectory were retained. Next, we added our disinhibitory factors (self-report and behavioral indices) as predictors of the latent intercept and slope, while controlling for significant demographic covariates. In order to examine sex differences in the relation between our predictors and both the intercept and slope of marijuana use over time, we included an interaction between sex and both the self-report and behavioral disinhibition factors.

Results

Preliminary Analyses

Results from Little's MCAR analyses suggest that the data were missing completely at random, χ^2 (123) = 129.22, p = .333. All skew and kurtosis statistics for key variables appeared to be in the acceptable range, with the exception of the first wave of the marijuana use variable, which was positively skewed. We transformed the data by taking the natural log of each marijuana use value at every wave and then re-assessed the descriptive statistics. The new distributions were within the acceptable bounds for skew and kurtosis (≤ 3.0) and were used throughout the following analyses.

Means and standard deviations of all variables are included in Table 1. Table 1 presents correlations between past year use at grades 9 through 12 and all major independent variables. Ethnicity was dichotomized into European-American (coded as “1”) and “other” (coded as “0”). Of note, ethnicity was significantly correlated with BART-Y explosions

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scores and maternal education level, suggesting that white children evidenced greater risk taking propensity, and parents' of non-white children reported lower levels of educational attainment. Sex was only associated with marijuana use at grades 9 and 10. Sensation seeking, impulsivity, and their composite were associated with marijuana use at grades 11 and 12, while BART-Y explosions scores were significantly correlated with use at grade 12 only. Finally, sensation seeking and impulsivity were significantly correlated with each other, but not with the BART-Y explosions scores.

Contrary to our first hypothesis, *t*-test analyses did not reveal significant sex differences on any measure of disinhibition. Further, sex differences were noted in Grade 9 (t = -2.94, p=. 004) and Grade 10 (t = -2.17, p= =.031) marijuana use, indicating that boys reported significantly greater substance use.

Latent Growth Models: Unconditional Growth Model

Next, we examined a univariate latent growth curve modeling changes in marijuana use over time. The unconditional model fit the data poorly; modification indices suggested the inclusion of a correlation between Grade 10 and 11 residuals (likely reflecting small changes in administration of the measures over time). The addition of this correlation improved the fit of the model significantly and was therefore retained throughout the rest of the analyses. The revised model had excellent fit: $\chi^2_{(df=2)}$ = 1.36, p = 0.51; CFI = 1.00; TLI = 1.00; RMSEA = 0.00 (90%CI = 0.00 – 0.12); SRMR = .03. Both the means of the intercept (M = 0.06, SE = 0.01, p < .001) and the slope (M = 0.06, SE = 0.01, p < .001) were significant, suggesting that baseline marijuana use was different from zero and that marijuana use increased significantly across adolescence. Further, the variances of the intercept (Var. = 0.03, SE = 0.01, p < .001) and the slope (Var. = 0.01, SE = 0.00, p = .019) were also significant, indicating individual differences around these parameters. The correlation between the intercept and slope, however, was not significant.

Conditional Model 1: Demographic Predictors

Utilizing a model-building approach, we next examined a conditional model where we included demographic variables (sex, age, ethnicity, and mother's level of education) as predictors of the marijuana use trajectory. The model continued to fit the data well $\chi^2_{(df=10)}$ = 7.06, p = .720, CFI = 1.00, TLI = 1.00, RMSEA = 0.00 (90%CI = 0.00 – 0.06), SRMR = . 03. Only sex was a significant predictor of the intercept (std. est. = .20, p = .008), suggesting that boys evidence greater levels of marijuana use at baseline. None of the demographic variables were significant predictors of the slope of marijuana use; we therefore chose to retain only sex as a covariate in subsequent models.

Conditional Model 2: Disinhibitory Predictors

Our second hypothesis predicted that both the composite self-report disinhibition factor and the behavioral disinhibition factor (BART-Y) would be significant predictors of both the baseline and slope of marijuana use over time. In order to test this hypothesis, we examined a conditional growth curve model of marijuana use in which we included our self-report disinhibition factor and the number of explosions on the BART-Y as predictors. The model continued to fit the data well: $\chi^2_{(df=8)}$ = 6.38, p = .605, CFI = 1.00, TLI = 1.00, RMSEA =

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0.00 (90%CI = 0.00 – 0.08), SRMR = .04. Sex remained a significant predictor of the intercept (std. est. = 0.25 p = .02). Additionally, both the self-reported disinhibition factor (std. est. = 0.40, p = .001) and the number of explosions on the BART-Y (std. est. = 0.24, p = .036) were significant predictors of the slope of marijuana use[1]. In support of our hypothesis, these findings suggest that children who self-report greater levels of disinhibition and those who evidence increased risk taking on the BART-Y experience greater escalation in marijuana use over time, compared to children with lower levels of disinhibition and lower BART-Y scores.

Conditional Model 3: Interactions with Sex

Our third hypothesis postulated that sex would moderate the relation between both a self-report and a behavioral measure of disinhibition and marijuana use over time. To test this hypothesis, we added an interaction term between sex and both self-reported disinhibition and the BART-Y explosions (see Figure 1). The model fit the data well: $\chi^2_{(df=12)} = 11.51$, p =.803, CFI = 1.00, TLI = 1.00, RMSEA = 0.00 (90%CI = 0.00 – 0.07), SRMR = .04. In partial support of hypothesis 2, the interaction between sex and self-reported disinhibition significantly predicted the slope of marijuana use (see Table 2). Post-hoc simple slope analyses suggest that self-reported disinhibition was associated with increases in marijuana use for boy, but not for girls. No other interactions were significant.

Discussion

The current study examined the role of early disinhibitory personality factors and sex in predicting increased marijuana use across high school. Results of the current study support two important findings. First, and consistent with findings from other studies examining risk for substance use, disinhibitory personality factors were associated with increased use of marijuana from grade 9 to grade 12. Our results also suggest that despite the small correlation between self-report measures and behavioral tasks of disinhibition, both uniquely predicted changes in marijuana use over time. Second, while we did not find differences between boys and girls on mean-levels of disinhibition at grade 8, there was a significant interaction between sex and self-reported disinhibition (including sensation seeking and impulsivity) predicting substance use. Specifically, self-reported disinhibition was associated with increases in marijuana use over time for boys only. These findings are elaborated upon below.

Results from the current study extend the literature that points to the important function of disinhibitory personality factors in predicting substance use among adolescents. Utilizing a longitudinal approach expands on the majority of previous research that has typically only examined cross-sectional relations, and suggests a more nuanced picture of the associations between these constructs. Of note, baseline levels of disinhibition were not associated with marijuana use at Grade 9; however, both self-report and behavioral measures of disinhibition predicted increases in marijuana use across the particularly vulnerable high school years.

[1]We also ran the model using the pumps adjusted average measure from the BART-Y and found that it was not associated with marijuana use either at baseline or over time. Thus, we chose to retain the explosions measure as our primary predictor in subsequent models.

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Findings suggest that while marijuana use increases for all students over time, youth high in disinhibition are at particular risk for engaging in this illicit activity.

These results also underscore the complex role that measurement approach plays in understanding these relations and the importance of utilizing multiple methods for capturing these nuanced relations (e.g. Patrick et al., 2013). Findings from the current study support previous research that suggests that despite the non-significant association between self-report and behavioral measurement approaches, they are likely both tapping unique constructs that play an important role in the development of substance use (e.g. Reynolds et al., 2006). Unfortunately, beyond noting that the two approaches do not typically correlate with one another, there has been little research into validating self-report and behavioral approaches as conceptually distinct factors. To our knowledge, only a small number of studies have factor analyzed multiple self-report and behavioral tasks of disinhibition. Using a sample of adult men, Stuart and Holtzworth-Muroe (2005) found that self-report measures and behavioral tasks form two distinct latent disinhibition constructs, both of which predict construct-relevant behaviors, including substance use. Conversely, Meda and colleagues (2009) examined the factor structure of five self-report and behavioral tasks measuring impulsivity in sample of adults with and without substance use histories. The authors found five distinct factors with the BART loading onto its own, orthogonal, factor. Notably, however, a computer task of disinhibition loaded onto another factor with a self-report measure, suggesting that the BART specifically may be tapping a unique facet of disinhibition.

Our findings also point to important nuances in the relation between sex, self-report and behavioral measures of disinhibition, and changes in marijuana use over time. It is notable that while we did not find a difference between boys' and girls' mean-levels of disinhibition (as measured by self-report or behavioral task), there does appear to be a difference in the strength of relation between self-reported disinhibition and marijuana use. This significant interaction, indicating that the relation between self-reported disinhibtion and changes in marijuana use is stronger for boys and girls, contrasts with the only other study to examine these relations, which found the opposite pattern of association (e.g. Fields et al., 2009). These inconsistencies may reflect different methodological approaches between studies. Specifically, Fields and colleagues (2009) used a slightly older sample of N=100 15-year-olds and a cross-sectional design to examine relations between impulsivity and cigarette smoking behaviors. Our own results found that the relation between disinhibition and marijuana use may unfurl over time, and it could be that sex differences in these relations similarly necessitate a longer time frame to become evident. Differences in findings may also be due to the nature of the specific substance being investigated. Fields et al. (2009) concluded that males who smoke cigarettes may metabolize nicotine differently than females and may experience a boost in concentration during lab-based tasks. Given that at the grade we administered our behavioral task very few children were currently using marijuana, it is unlikely that physiological effects of the drug would play a role in participants' performance. Further, research looking at the pharmacological effect of delta-9-tetrahydrocannobinol (THC) on BART performance found no difference between participants who were and were not administered THC immediately before the behavioral task (Metrik et al., 2012).

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The current results *are* consistent, however, with other research using self-report measures of disinhibition traits and substance use. For instance, Baker and Yardley (2002) examined the relation between self-reported sensation seeking and alcohol use in 420 high school students. They found that elevations in sensation seeking were more related to drinking behaviors for boys than girls. One possible reason that self-reported disinhibition is a stronger predictor of marijuana use for boys than girls is that boys and girls may regard their own disinhibitiory traits as more (or less) consistent with perceived gender norms. Specifically, girls may feel compelled to underreport characteristics and behaviors that are inconsistent with a perceived model of femininity. Societal pressure to live up to a certain idealized female character may therefore confound the relation between impulsivity and substance use. In support of this theory, research suggests that elevated sensation seeking and risk taking propensity are associated with lower femininity scores and less felt gender compatibility among females (Daitzman & Zuckerman, 1980; Saxvik & Joireman, 2004). It would follow, then, that we might see a dampening of the effect of self-reported, but not behaviorally measured, disinhibition on substance use for girls. Conversely, boys may not feel the same pressure to deny impulsive characteristics as they may be more in line with the male societal ideal. Indeed, sensation-seeking and other impulsigenic factors may represent part of perceived “maleness” (Burk, Burkhart & Sikorski, 2004).

Clinical Implications

The results of the current study also suggest some important implications for clinical work. Recent research supports the effectiveness of using personality-targeted interventions to prevent adolescent substance use. Specifically, Conrod and colleagues found that utilizing measures of impulsivity and sensation seeking to identify at-risk youth and enroll them in preventative interventions resulted in significant decrements in substance use compared to children receiving treatment as usual (Conrod et al., 2013). Our results suggest several refinements to current procedures for targeting vulnerable youth. First, clinicians should consider including behavioral indicators of disinhibition alongside self-report measures to target interventions. Tasks such as the BART-Y are inexpensive and easily administered to large groups of youth and may uniquely screen for at-risk children who may not be identified through more traditional paper-and-pencil measurement approaches. Second, clinicians should consider the role that biological sex and gender may play in adolescents' reporting of their disinhibition. Approaches that only use self-report measures may miss at-risk female youth. The use of behavioral tasks may compensate for this and increase the effectiveness of screening procedures for vulnerable girls.

Study Limitations and Future Directions

Although the current research expands our understanding of personality-linked vulnerabilities and substance use across a high-risk developmental period, several limitations to the study suggest avenues for future research. First, this study focused solely on early vulnerability predictors and their influence on marijuana use over time. In the current paper, we did not consider how our predictors themselves may change over time and, concomitantly, how these changes may influence substance use. Instead, we chose to mirror the approach that would be used if youth were being screened for inclusion in a personality-targeted intervention effort; namely, identifying early at-risk adolescents for

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whom substance use has not yet become prevalent or problematic (e.g. Preventure; Conrod et al., 2013). While this approach allows us to inform real-world practices, it does not capture how *changes* in risk factors may influence changes in substance use. Given that levels of risk factors do appear to fluctuate over time (i.e. Collado et al., 2014), it will be important for future research to consider how changing risk influences marijuana use trajectories.

Secondly, we did not include mediators of the relation between disinhibition and substance use. Intervening factors, and specifically interpersonal and environmental variables, may be especially important for understanding the mechanism of action by which disinhibition confers risk for illicit drug use. For instance, Kirisci and colleagues (2009) found that peer deviancy mediated the relation between neurobehavioral disinhibition and substance use in childhood for boys only, but for both boys and girls during adolescence. It will be important for future research to consider intervening variables that may link early personality vulnerabilities to later substance use, and to consider mediated-moderation effects which would allow us to better understand for whom and at what developmental stage particular mediators play a key role in the relationship between disinhibition and substance use trajectories over time.

Thirdly, we used a convenience sample recruited from the surrounding areas using advertisements. Thus, our findings may be limited in their generalizability to other youth in the community. Replication of these findings in other samples, including clinical and community populations, will be important.

Finally, our research highlights a critical need to better understand the influence of sex on the relation between disinhibition and drug use. Given the notable, and inconsistent, pattern of findings, future research should aim to better understand how sex and concomitant gender roles may impact the predictive power of different measurement approaches.

Conclusion

The current study is one of the first to examine the relation between sex, self-report and behavioral measures of disinhibition, and marijuana use over a vulnerable developmental period. Although previous studies have examined the importance of personality-linked constructs in predicting substance use, this research is one of the first to attempt to understand the impact of sex and measurement approach. These findings have clear implications for current intervention and prevention efforts, and highlight the need to re-examine existing models of substance use in youth.

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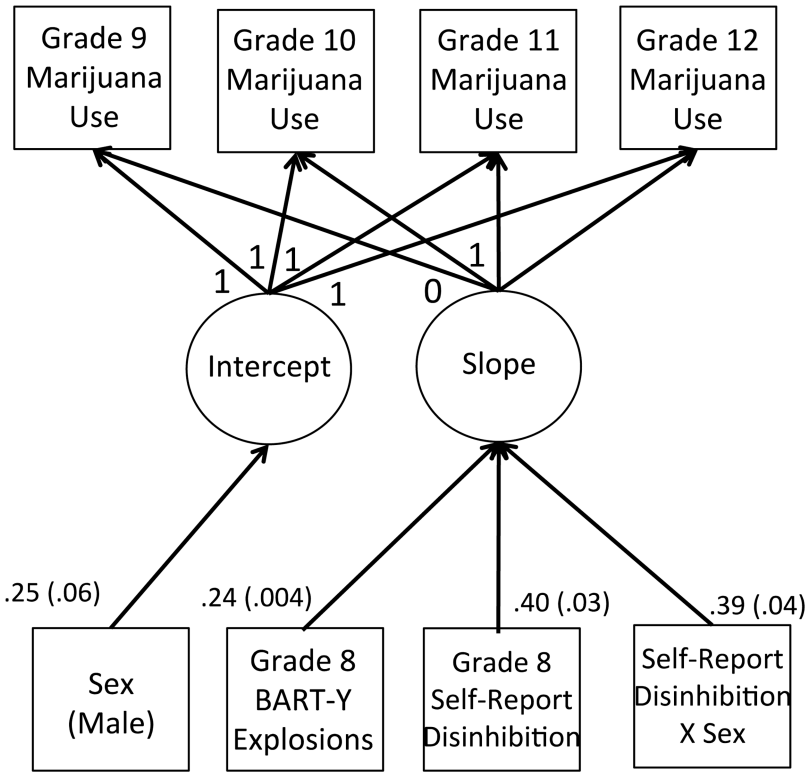

Figure 1.
(Trimmed) latent growth curve model with significant standardized (and unstandardized) estimates.

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Table 1

Means, standard deviations, and correlations between key study variables.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. Grade 9 Marijuana	1.00										
2. Grade 10 Marijuana	0.50**	1.00									
3. Grade 11 Marijuana	0.32**	0.72**	1.00								
4. Grade 12 Marijuana	-0.03	0.44**	0.58**	1.00							
5. Grade 8 BSSS	0.09	0.03	0.18	0.35**	1.00						
6. Grade 8 EIS	0.06	0.13	0.20	0.33**	0.40**	1.00					
7. Grade 8 BART-Y Explosions	0.01	0.04	0.10	0.32**	0.08	0.04	1.00				
8. Ethnicity	-0.15*	0.04	0.08	0.06	0.10	-0.01	0.24**	1.00			
9. Age	0.13	0.17*	0.23*	0.14	0.07	0.05	0.03	-0.10	1.00		
10. Maternal Education	-0.11	-0.05	0.07	-0.01	0.03	-0.07	0.13	0.30**	-0.06	1.00	
11. Sex	0.19**	0.15	0.07	0.05	-0.01	-0.08	0.02	0.04	0.08	-0.05	1.00
M (SD)	0.27 (0.84)	0.54 (1.13)	0.86 (1.30)	0.89 (1.35)	15.14 (5.21)	8.58 (4.36)	10.27 (4.31)	0.49 (0.50)	13.12 (0.56)	5.46 (1.64)	0.56 (.50)

Note. Marijuana use variables are un-transformed for interpretability; BSSS, Brief Sensation Seeking Scale; EIS, Eysenck Impulsivity Scale; White is coded 1 = white, 0 = non-white; Sex is coded 0 = female, 1 = male.

* $p < .05$,

** $p < .01$.

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Table 2

Unstandardized (and Standardized) Parameter Estimates for Final Latent Growth Curve Model.

	Intercept		Slope	
Predictor	**Unstd. Est. (S.E.)**	**Std. Est.**	**Unstd. Est. (S.E.)**	**Std. Est.**
Sex (Male)	.06 (.02)	.25*	.00 (.02)	.02
Gr. 8 BART-Y Explosions	.00 (.00)	.01	.01 (.00)	.24*
Gr. 8 Self-Report Disinhibition	.01 (.00)	.05	.03 (.01)	.40**
BART-Y Explosions x Sex	.00 (.01)	.05	.00 (.00)	.32
Self-Report Disinhibtion × Sex	.01 (.03)	.05	.04 (.02)*	.39*

Note. BART-Y = Balloon Analogue Risk Task-Youth Version;

* $p < .01$,

** $p < .001$.