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Changes in Sensation Seeking and Risk-taking Propensity Predict Increases in Alcohol Use among Early Adolescents

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Abstract

Background—Conceptual models implicating disinhibitory traits often are applied to understanding emergent alcohol use, but, little is known of how inter-individual changes in these constructs relate to increases in alcohol use in early adolescence. The current study utilized behavioral and self-report instruments to capture the disinhibitory-based constructs of sensation seeking and risk taking propensity to examine if increases in these constructs over time related to increases in early adolescent alcohol use.

Methods—Participants included a community sample of 257 early adolescents (aged 9-12) who completed a self-report measure of sensation seeking, a behavioral task assessing risk taking propensity, and a self-report of past year alcohol use, at three annual assessment waves.

Results—Both sensation seeking and risk taking propensity demonstrated significant increases over time, with additional evidence that change in the behavioral measure of risk taking propensity was not due to practice effects. Greater sensation seeking and greater risk taking propensity demonstrated concurrent relationships with past year alcohol use at each assessment wave. Prospective analyses indicated that after accounting for initial levels of alcohol use, sensation seeking, and risk taking propensity at the first assessment wave, larger increases in both constructs predicted greater odds of alcohol use at subsequent assessment waves.

Conclusions—Results indicate the role of individual changes in disinhibitory traits in initial alcohol use in early adolescents. Specifically, findings suggest it is not simply initial levels of sensation seeking and risk taking propensity that contribute to subsequent alcohol use but in particular increases in each of these constructs that predict greater odds of use. Future work should continue to assess the development of sensation seeking and risk taking propensity in early adolescence and target these constructs in interventions as a potential means to reduce adolescent alcohol use.

Keywords

early adolescence; alcohol use; sensation seeking; risk taking propensity

Early Adolescents Early adolescence represents a critical developmental period during which there is a rapid increase in initiation of alcohol use. Specifically, rates of alcohol use have been shown to double between fourth and sixth grades (Windle et al., 2008) and earlier onset of initial alcohol use often signals future impairments in social functioning and physical and mental health (Jones et al., 2004; McGue & Iacono, 2005; Friedman, Terras &

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Zhu, 2004). To better understand emergent alcohol use, conceptual models have implicated the disinhibitory trait of impulsivity as a key variable of interest (e.g., Chassin, Flora, & King, 2004; Flory, Lynam, Milich, Leukefeld, & Clayton, 2004). Beyond impulsivity, there are other overlapping but conceptually and empirically distinct disinhibitory traits (e.g., Lejuez, Aklin, Bornoalova, & Moolchan, 2005; Meda et al., 2009; Whiteside & Lynam, 2001), including sensation seeking and risk-taking propensity, that also have shown a relationship with emergent alcohol use (e.g., Sher, Bartholow, & Wood, 2000; Zuckerman & Kuhlman, 2000). However, little is known of how *individual change* in, and particularly increases in, sensation seeking and risk-taking propensity relates to increases in alcohol use in early adolescence. This is critical as there is an identified need to move beyond treating sensation seeking and risk-taking propensity purely as static risk factors and rather towards measuring these variables as dynamic constructs to improve our understanding of the increases seen in alcohol use during early adolescence¹.

Arguably the most researched disinhibitory trait in its relationship to alcohol use is sensation seeking (Hittner & Swickert, 2006), with this construct defined as the tendency to seek out novel and highly stimulating experiences and a willingness to take risks to attain these experiences (Zuckerman, 1979). Multiple cross-sectional studies among youth indicate that sensation seeking is associated with early alcohol onset and use frequency (e.g., Donohew et al., 1990; 1999; Earleywine & Finn, 1991). Beyond cross-sectional relationships, initial levels of sensation seeking have also been associated prospectively with alcohol use trajectories that include more rapid escalation in consumption and persistence of use beyond early adolescence into later adolescence and early adulthood (Bates et al., 1994; Bennett et al., 1999; Crawford et al., 2003). Specifically, initial levels of sensation seeking assessed at baseline in early adolescence have been found to discriminate early-onset from later-onset and non-substance using youth (Flory et al., 2004) and predict initial use in ninth grade and increase in alcohol use across high school (Crawford et al., 2003). Moreover, greater sensation seeking corresponded with higher rates of alcohol use across a national sample of youth ages 14 to 22 (Romer & Hennessy, 2007). Data specific to novelty seeking aspects of sensation seeking drawn from Cloninger's tridimensional model of personality also predicted problematic alcohol use in young adulthood when assessed in early adolescence (Cloninger et al., 1988) and exhibited a univariate prospective relationship with presence of an alcohol use disorder in older adolescents (Sher et al., 2000).

Compared to sensation seeking, research aimed at understanding alcohol use among youth has been less focused on risk taking propensity, defined as a behavioral tendency to take risks in response to cues for potential reward in spite of some probability for undesirable results (Fowles, 1980; Lejuez et al., 2002; Zuckerman, 1983). Both sensation seeking and risk taking propensity are relevant to the engagement in risk taking behavior, but the core feature of risk taking propensity is the willingness to take risks given the balance of potential positive and negative consequences; it does not require that such risk engagement is motivated by arousal or novelty seeking as is the case for sensation seeking. Brief self-report measures of 'risk taking' at baseline assessment have contributed to the prediction of more severe latent trajectories of alcohol use over time from early adolescence (Colder et al., 2002) and have moderated the effects of social factors on increases in early adolescent alcohol use over time (Henry et al., 2005). As a complement to this approach, behavioral laboratory-based measures have been developed to measure risk taking but with a more

¹It is important to acknowledge that consideration of sensation seeking and risk taking propensity as disinhibitory-based traits does not necessarily overlap with the literature indicating disinhibition is a much-studied dimension of the multidimensional construct of impulsivity. Rather, we have referred to sensation seeking and risk taking propensity as "disinhibitory-based traits" in line with a well-developed literature using disinhibition as an umbrella term for these constructs (e.g., Chassin et al., 2004; Iacono, Mallone, & McGue, 2008; Johnson, Hicks, McGue, & Iacono, 2007).

specific focus on risk taking propensity. Cross sectional data from these behavioral assessments has indicated the link between risk taking propensity and alcohol use with samples ranging from adolescents at the transition period from early to middle adolescence through young adults (Lejuez et al., 2002; Lejuez et al., 2007).

Despite promising research suggesting a link between these disinhibitory-based constructs and early alcohol use, little is known regarding the developmental changes in these constructs and how such changes relate to increases in alcohol use in early adolescence. In contrast to traditional perspectives that personality traits are relatively stable and unchanging over the course of one's life (e.g., McCrae et al., 2000), some more recent views have taken the stance that personality traits evidence substantial individual as well as mean-level change over the course of human development (e.g., Lenzenweger & Willett, 2007; Roberts, Walton, & Viechtbauer, 2006). However, the vast majority of prospective studies with sensation seeking have not included multiple assessments of sensation seeking over time, particularly during the formative period of early adolescence. Crawford and colleagues (2003) examined individual latent growth curves in sensation seeking from middle school to high school but did not find any relationship between increases in sensation seeking and increases in alcohol use; however, the lack of findings is difficult to interpret given self-reported sensation seeking was only assessed with two items resulting in potentially inadequate coverage of the construct. This general lack of attention to repeated measurements of personality constructs is critical as there is an identified need to move beyond treating traits such as sensation seeking and risk taking propensity purely as static risk factors and rather towards dynamic measurement of these constructs over time to improve our understanding of the increases seen in alcohol use during early adolescence.

Considering the available literature, few studies have examined sensation seeking or risk taking propensity as dynamic, individual-level traits through early adolescence in their relation to alcohol use. This is an important limitation as longitudinal studies (e.g., Johnson, Hicks, McGue, & Iacono, 2007) have demonstrated personality traits are constructs that exhibit mean-level shifts along developmental trajectories (Roberts & Caspi, 2003; Roberts, Walton, & Viechtbauer, 2006) as opposed to being stable and time-invariant. Moreover, there are individual differences in these trends over time reflecting deviations from such overall mean-level patterns (e.g., Crone, Bullens, Van Der Plan, Kijkuit, & Zelazo, 2008; Johnson et al., 2007;). Thus, individual-level alterations in sensation seeking and risk taking propensity may correspond with greater increases in risk behavior involvement. Providing initial support for the potential normative changes seen in disinhibition in early adolescence, Steinberg et al. (2008) identified distinct neural underpinnings and trajectories of sensation seeking over the course of adolescence. Although based on cross-sectional analyses across cohorts of individuals, they demonstrated that sensation seeking increased steadily from age 10 to 15, in line with the time period of increases in alcohol use in early adolescence (Windle et al., 2008). However, individual variation in these overall increases in sensation seeking was not investigated. Clearly, prospective research is needed to examine individual changes in disinhibitory-based traits as they relate to early adolescent alcohol use.

Understanding how individual changes in sensation seeking and risk taking propensity starting in early adolescence may relate to alcohol use patterns, specifically increased use in early adolescence, may further our understanding of how variability in personality changes may fuel escalation in alcohol use during this time period. Such an understanding could potentially guide future clinical work that could address changes in personality as well as alcohol use behaviors, at the level of prevention, assessment, and early intervention (Conrod et al., 2008; Littlefield et al., 2009). The current study represents an initial effort to determine the nature of the relationship between sensation seeking, risk taking propensity and alcohol use over a three year period when use of alcohol is just beginning to emerge.

The current study expands on limitations of previous research in two important ways. First, the study recruited a sample at the beginning of early adolescence before alcohol use peaks and assessed them annually into mid-adolescence. Second, the study utilized a combination of behavioral and self-report instruments to capture the lower order disinhibitory-based constructs of sensation seeking and risk taking propensity to examine how these constructs may change over time and how these changes relate to alcohol use.

To our knowledge, this is the first study to examine individual changes in self-reported sensation seeking and behavioral assessment of risk taking propensity over time and how these changes correlate with alcohol use involvement from early to mid-adolescence. Specifically, we hypothesized that baseline risk taking propensity and sensation seeking will, above and beyond baseline alcohol use, be associated with increased odds in alcohol use at subsequent time points. Second, we examined if individual changes in risk taking propensity and in sensation seeking were associated with changes in odds of alcohol use in the same time period. Specifically, we hypothesized that greater increases in risk taking propensity and in sensation seeking would be associated with increases in alcohol use controlling for the baseline level of alcohol use, risk taking propensity, and sensation seeking. The inclusion of both sensation seeking and risk taking propensity is notable given the magnitude of the relationship between the two constructs in prior studies has been modest (Lejuez et al., 2002, 2007; Stephenson et al., 2003), supporting theoretical argument that these are related but distinct constructs (Lejuez et al., 2005). Thus the simultaneous incorporation of sensation seeking and risk taking propensity may allow for a more complex and complete picture of disinhibitory-based traits than using either measure alone.

Materials and Method

Subjects

This study employed data from a sample of early adolescents ($n = 277$), ages 9 to 12 at initial enrollment, participating in a larger prospective study of behavioral, environmental, and genetic mechanisms of risk for HIV-related risk behaviors in youth. Follow-up assessments were conducted at yearly intervals for 3 consecutive years and are ongoing with additional assessments planned. Permission to conduct research was obtained from the University of Maryland Institutional Review Board (IRB). Participants were a convenience sample of youth and their parents recruited in the greater metropolitan Washington D.C. area via media outreach and mailings with area schools, libraries, and Boys and Girls Clubs. Recruitment lasted approximately two years and was open to all youth in the 5th and 6th grades who were proficient in English; no other exclusion criteria were used. Interested families who met inclusion criteria were invited to come to the University of Maryland campus accessible by public transportation. Upon arrival at the baseline assessment session, a more detailed description of the study procedures was provided and the primary caregiver and youth signed informed consent/assent. The youth and caregiver were then accompanied to separate rooms to complete the assessments. Standardized specific instructions were given separately to the caregiver and youth. These procedures were repeated at all interview points.

Participants included in the present analyses were youth who completed both the baseline and at least one of the two subsequent annual follow-up assessments (Waves 1, 2, and 3 respectively; ± 2 months from the annual scheduled appointment at each assessment). Participants were excluded from the present analyses for missing both Waves 2 and 3 of data ($n=20$). Follow-up rates were 89.1% and 86.9% for Waves 2 and 3, respectively. Participants lost to attrition included those who could not be located, or did not respond to phone or letter inquiries. Excluded participants did not differ significantly on gender, age, ethnicity, sensation seeking, or risk taking propensity (all p 's $>.10$). The resultant sample of

257 youth included participants who at study enrollment were on average 11.0 years of age ($SD = .8$), 44.4% female, 48.8% non-Hispanic White, 35.5% African-American, 3.1% Latino, 1.2% Asian-American, and 11.4% of mixed or other ethnicity.

Measures

Demographics—The parent/guardian completed a basic demographics form for personal information, as well as information about the child. The form included age, gender, race, education level of mother and father, and annual family income. The annual family income variable was collapsed into quartiles (0-48,000, 48,001-85,000, 85,001-120,000, 120,001+).

Self-reported Sensation Seeking—The Brief Sensation Seeking Scale (BSSS; Hoyle et al., 2002) was used to assess sensation seeking. The BSSS is an 8-item self-report measure designed specifically for use with youth populations. Example items include, “I would love to have new and exciting experiences, even if they are illegal.” Participants are asked to rate each item according to the extent to which it accurately describes their experience using a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). The BSSS has been found associated with well-established measures of other aspects of disinhibition and is predictive of risky behaviors (Hoyle et al. 2002; Stephenson, Hoyle, Palmgreen, & Slater, 2003). Items were summed to create a total score. Internal consistency within this sample of youth was adequate at Wave 1 ($\alpha = .69$), Wave 2 ($\alpha = .77$), and Wave 3 ($\alpha = .75$).

Risk Taking Propensity: Balloon Analogue Risk Task- Youth (BART-Y; Lejuez et al., 2007)—In the BART-Y, the youth inflates a computer-generated balloon. Each pump is worth one point, but if the balloon is pumped past its explosion point, then all points accrued for that balloon are lost. The probability that any particular balloon will explode is 1/128 for the first pump, 1/127 for the second pump, and so on until the 128th pump at which point the probability is 1/1. According to this algorithm, explosion values form a normal distribution around 64 pumps (Lejuez et al., 2002). The task can be analyzed separately for the first, middle, and last 10 blocks of balloons. To allow a meaningful and unbiased comparison across these blocks, the average breakpoint was set in each case also to mirror the overall average breakpoint of 64. These blocks have been used in previous work to examine changes in risk taking propensity as a function of continued exposure to the task. As in all previous BART studies completed by our group, the key measure was the adjusted average which equals the average number of pumps on balloons that did not explode (see Lejuez et al., 2002 and 2007 for more computational detail on the adjusted average and Pleskac, Wallsten, Wang, & Lejuez, 2009 for a theoretical discussion of the limitations of using the unadjusted average score). Given its role as a primary variable in the current study, the adjusted average is referred to herein as risk taking propensity.

During the task, participants had the opportunity to stop pumping the balloon at any time prior to an explosion and allocate the accrued points to a permanent prize meter. After a balloon exploded or points were allocated to the permanent prize meter, a new balloon appeared. After completion of 30 balloon trials, the position of the prize meter determined the final prize (small, medium, large, bonus). Standardized instructions were given to each participant prior to beginning the task. Further, participants were informed that “It is your choice to determine how much to pump up the balloon, but be aware that at some point the balloon will explode” and that “the explosion point varies across each of the 30 balloons, ranging from the first pump to enough pumps to make the balloon fill the entire computer screen.” Participants were given no further information about the probability underlying the explosion point for each balloon. Participants completed the BART-Y at each wave of assessment.

Alcohol Use—We used a modified version of the Youth Risk Behavior Surveillance System (Centers for Disease Control and Prevention, 2001) assessing past year engagement in alcohol use at each assessment wave. Response options were “zero”, “once”, “a few times”, “1-3 times per month”, “1-3 times per week”, and “almost everyday or more.” Frequencies of each response option above “zero” were low, with endorsement of no other response option rising above 20%. Specifically, reports of “zero” use were 73.2%, 64.9%, and 53.8% at Waves 1, 2, and 3 respectively. Therefore due to the item distributions and the variable interval between response options, a dichotomous scale was constructed to identify whether the child had engaged in alcohol use a few times or more (1) or zero times (0) in the past year.

Analysis Plan

We first examined concurrent zero-order correlations between alcohol use, sensation seeking, risk taking propensity and potential covariates (age and gender) at each assessment wave and prospectively across assessment waves. We also conducted paired *t*-tests to determine whether there were significant increases in risk taking propensity and sensation seeking across follow-up waves.

To investigate how individual changes in sensation seeking and risk taking propensity corresponded with changes in alcohol use, repeated measures analyses for binomial outcomes were conducted using generalized estimating equations (GEEs) with alcohol use at Wave 2 and 3 assessments as the outcome variable. Analyses were conducted in SPSS v.15 with a binomial distribution, logit link function, and an independent correlation matrix specified. Gender and age were considered for inclusion as covariates given their relationship with changes in alcohol use (c.f., Barnes et al., 1997). Additionally, Wave 1 alcohol use, Wave 1 sensation seeking, and Wave 1 risk taking propensity were included as main effects, along with the linear effect of time. To examine change in sensation seeking and in risk taking propensity as correlates of alcohol use over time, risk taking propensity was included in the model as a time-varying difference score, reflecting the difference between risk taking propensity at a given follow-up (either Wave 2 or Wave 3) and baseline risk taking propensity. Controlling for Wave 1 risk taking propensity and including the time-varying risk taking propensity difference score addresses whether changes in risk taking propensity over time are associated with concurrent alcohol use above and beyond the effects of initial levels (Wave 1) of risk taking propensity. An equivalent time-varying sensation seeking difference score also was included in the GEE models. Change scores can be unreliable because they assume a linear, one-to-one association between a variable assessed at two time points (Cohen, 1988). However, controlling for the baseline assessment (i.e., partialling out baseline sensation seeking or baseline risk taking propensity) in the model removes variability in the change score associated with the baseline value and therefore corrects the unreliability of the change score (Cohen, 1988). We initially conducted the above GEE analyses separately for risk-taking propensity and for sensation seeking, and then conducted a full model including both disinhibitory-based constructs.

Results

Sample Description

The current sample was 44.4% female, 48.8% non-Hispanic White, 35.5% African-American, 3.1% Latino, 1.2% Asian-American, and 11.4% of mixed or other ethnicity with a median household income of \$82,750. Average age of the sample was (M(SD)) 11.01 (.81), 12.07 (.90), and 13.00 (.88) at Waves 1, 2, and 3 respectively.

Descriptive Statistics and Intercorrelations among Predictors

The skewness values for all variables were less than or equal to 1.1, thus no transformations were required. There were no gender differences on any constructs of interest (p 's $>.07$) at each assessment wave. Paired sample t -tests did not indicate a significant increase in mean sensation seeking from Wave 1 to Wave 2 ($t(245) = 1.06, p = .29$), although there was a significant increase from Wave 2 to Wave 3 ($t(227) = 3.57, p < .001$).

To examine normative changes in the disinhibitory-based constructs, paired samples t -tests were conducted and indicated a significant increase in mean risk taking propensity from Wave 1 to Wave 2 ($t(232) = 5.47, p < .001$), and from Wave 2 to Wave 3 ($t(215) = 4.31, p < .001$). Given risk taking propensity is assessed with the BART-Y, a behavioral measure, it is important to consider whether this increase may be accounted for by practice effects on the task across waves; to determine whether such an explanation is plausible, one can examine practice effects within each session to the effect of time. As in previous work (Lejuez et al., 2002; 2007) within session practice effects were examined by comparing blocks of 10 balloons, all of which as discussed in the method section are pre-set to have the same average explosion point of 64. As shown in Figure 1, the number of pumps across blocks within each wave showed a quadratic effect, which was significant in repeated measure ANOVAs conducted in each Wave ($F(1, 244) = 14.38; F(1, 238) = 9.79$, and $F(1, 218) = 23.79; p$'s $\leq .002$ in all three Waves respectively). Risk taking propensity score was higher in the first block of 10 balloons as compared to the last block of 10 balloons at Wave 1 ($t(244) = 2.33, p = .02$) and Wave 3 ($t(234) = 2.09, p = .04$), and this difference approached significance at Wave 2 ($t(238) = 1.83, p = .07$). This decrease from the first block within each administration of the task is consistent with previous adolescent research using the BART-Y (Lejuez et al., 2005; 2007). Across Waves, this pattern re-emerged, but was shifted higher at each subsequent Wave.

Zero order correlations among the independent variables were examined and are presented in Tables 1. At Wave 1, the only significant association was between older age and risk taking propensity ($r = .12$). At Wave 2, older age was significantly associated with sensation seeking ($r = .25$). At Wave 3, older age was also significantly associated with sensation seeking ($r = .19$). However, at Wave 3 sensation seeking and risk taking propensity also were significantly correlated ($r = .14$).

In Table 1, we also present correlations for the disinhibitory-based variables across the three waves of data collection. Relationships within these constructs were relatively robust over time with correlations ranging from r 's = .44 to .64 for sensation seeking and from r 's = .39 to .67 for risk taking propensity. Moreover, the magnitude of relationships increased across waves of assessment such that Waves 2 and 3 exhibited the strongest correlations for both sensation seeking and risk taking propensity. Finally, the relationships between sensation seeking and risk taking propensity, both within and across waves of assessment, were small (r 's = .01 to .14).

Concurrent Associations of Alcohol Use with Sensation Seeking and Risk Taking Propensity

Concurrent zero order correlations were also examined between predictors and alcohol use within each time point. Rates of past year alcohol use were 27.6%, 35.1%, and 44.5% for Waves 1, 2, and 3 respectively. At Wave 1, alcohol use in the past year was significantly correlated with sensation seeking ($r_{pb} = .17, p = .01$) although not risk taking propensity ($r_{pb} = .06$). At Wave 2, however, alcohol use in the past year was again significantly correlated with sensation seeking ($r_{pb} = .25, p = .001$) and also with risk taking propensity ($r_{pb} = .14, p = .03$). Finally, at Wave 3, past year alcohol use was again significantly correlated with

sensation seeking ($r_{pb} = .29, p = .001$) and also with risk taking propensity ($r_{pb} = .18, p = .006$). Thus, correlations between the disinhibition predictors and alcohol use generally increased in robustness across each wave. Gender and age were unrelated to alcohol use at any time point and thus were not included as covariates in the GEE models presented next.

GEE Model of Alcohol Use Over Time

Two separate repeated measures analyses for binomial outcomes were conducted using GEEs for the dependent variable of percentage used alcohol (yes vs. no) at Waves 2 and 3, with predictors including Wave 1 alcohol use and then (a) Wave 1 risk taking propensity and the time-varying change in risk taking propensity in the first model and (b) Wave 1 sensation seeking and the time-varying change in sensation seeking in the second model. Results of the GEE analyses for both models are presented in Table 2. For the first model, Wave 1 alcohol use ($B = 1.65, SE = .28, OR = 5.21, p = .0001$), the effect of time ($B = .41, SE = .18, OR = 1.51, p = .02$) and time varying change in risk taking propensity ($B = .02, SE = .01, OR = 1.02, p = .035$) were significantly associated with greater odds of alcohol use at Waves 2 and 3. For the second model, again Wave 1 alcohol use ($B = 1.54, SE = .27, OR = 4.66, p = .0001$) and the effect of time ($B = .36, SE = .17, OR = 1.43, p = .04$) were significantly associated with greater odds of alcohol use at Waves 2 and 3. In addition, both higher sensation seeking at Wave 1 ($B = .09, SE = .02, OR = 1.09, p = .0001$) and the time-varying change in sensation seeking ($B = .10, SE = .02, OR = 1.11, p = .001$) were associated with greater odds of alcohol use over time.

A full GEE model for the dependent variable of percentage used alcohol use at Waves 2 and 3 was then conducted with predictors including Wave 1 alcohol use, Wave 1 risk taking propensity, Wave 1 sensation seeking, and the time-varying change in risk taking propensity and the time-varying change in sensation seeking. Results of the GEE analyses are presented in Table 3. Wave 1 alcohol use ($B = 1.55, SE = .28, OR = 4.71, p = .001$) and higher sensation seeking at Wave 1 ($B = .42, SE = .13, OR = 1.52, p = .001$) were significantly associated with a greater odds of alcohol use at Waves 2 and 3. Additionally, the time varying change in risk taking propensity ($B = .25, SE = .13, OR = 1.28, p = .05$) and the time varying change in sensation seeking ($B = .43, SE = .13, OR = 1.54, p = .001$) were also significantly associated with greater odds of alcohol use at Waves 2 and 3. To interpret these odds ratios, for each increase of one standard deviation in change in the time varying risk taking propensity, the odds of alcohol use over time increase by 1.28; for each increase of one standard deviation in change in the time varying sensation seeking, the odds of alcohol use over time increase by 1.54. There was not a significant linear effect of time (indicating no significant increase in alcohol use between Wave 2 and Wave 3) or of Wave 1 risk taking propensity. Thus, it was not only sensation seeking at the first assessment wave, but also greater increases in the change in risk taking propensity and in sensation seeking from the initial assessment that was associated with an overall greater odds of having consumed alcohol during the subsequent two years of the follow-up period. Finally, following procedures outlined by Chinn (2000) we computed effect sizes from the model derived odds ratios for the time-varying effects. Based on these procedures, derived effect sizes were $d = .14$ for the time-varying effect of risk taking propensity difference scores variable and $d = .24$ for the time-varying effect of sensation seeking difference scores variable indicating small effects for both.

Discussion

The current study was the first to our knowledge to examine how changes in sensation seeking and risk-taking propensity over time correspond prospectively to initial stages of alcohol use in early adolescents. Moreover, this is the first study to examine stability and change using a behavioral assessment of risk taking propensity. There were a number of key

findings. Although sensation seeking and risk taking propensity exhibited nominal relationships with each another (e.g., Wave 1 sensation seeking with Wave 1 risk taking propensity) supporting the notion that there is limited overlap between these constructs, associations within each construct over time (e.g., Wave 1 sensation seeking with Wave 2 sensation seeking, Wave 2 risk taking propensity with Wave 3 risk taking propensity) were relatively robust. Moreover, both constructs significantly increased over time, although paired sample tests suggested the mean-level change in sensation seeking may have been localized in the second to third waves of assessment. Further, additional evidence suggests the normative change in risk taking propensity was not due to practice effects. In examining alcohol use, greater sensation seeking and greater risk taking propensity demonstrated concurrent relationships with past year alcohol use at the majority of time points. Finally our models indicated that event after accounting for initial levels of alcohol use, sensation seeking, and risk taking propensity, greater increases in intra-individual differences in each construct predicted greater odds of alcohol use at subsequent assessment points. In other words, individuals who exhibited larger increases in change in sensation seeking and in risk taking propensity across time were more likely to use alcohol across early adolescence.

This observed inter-individual change in disinhibitory-based traits predicting alcohol use in early adolescence is in line with the extant literature in older adolescence and young adulthood demonstrating a relationship with individual-level personality change and changes in alcohol use. A recent study in a young adult sample (Littlefield et al., 2009) examined how both mean-level and individual-level changes in self-reported personality factors (impulsivity, neuroticism, and extraversion) correspond with the “maturing out” process of reductions in problematic alcohol use in older adolescence. Although often a focal point in the literature (Caspi et al., 2005), transitions in life roles (e.g., marriage) were not sufficient to explain why problematic alcohol use and personality changed over time in this study. Rather, Littlefield and colleagues (2009) demonstrated that the relationship between changes in personality traits and decreased alcohol involvement over time (ages 18 to 35) was not accounted for by life role status, and rather that personality change may itself be a mechanism in the “maturing out effect” of decreased alcohol use into middle adulthood.

Our finding that sensation seeking increases from Wave 2 to Wave 3 is consistent with prior research demonstrating that overall levels of sensation seeking increase throughout adolescence (Crawford et al., 2003; Steinberg et al., 2008; Stephenson et al., 2003; Zuckerman, 1994). Similar results were identified for risk taking propensity, with an interesting pattern that could be identified as a result of the behavioral measurement used to assess the construct. Specifically, risk taking propensity increased from Wave 1 through 3, but showed no such increase within each Wave, with data actually indicating a significant decrease in risk taking propensity from the first and last blocks of the task within Waves 1 and 3. This pattern simultaneously indicates an interesting increase in the construct across years and argues against practice effects as the explanation for this increase. It is unclear why BART-Y scores decreased within each Wave, both in the current study and in previous research with youth (Lejuez et al., 2005; 2007). One possibility is that the youth “explore” in the initial balloons and reduce their pumps as they experience explosions, with this pattern repeating following the one year period between assessments. Unfortunately, this hypothesis would be best tested with a modified version of the task specifically designed for that purpose. The need for a modified task lies in the fact that in the current version, some exploded balloons will be followed by balloons with a low set point for exploding limiting the range of pumps that could be made and thereby precluding the opportunity to examine immediate effects of explosions. Although future work will be necessary to determine the role of developmental and environmental factors for this increase, at the present time the results do at least suggest that a meaningful increase in risk taking propensity may be evident across years through early adolescence.

Results of the current study add to the empirical literature in a number of ways. First, by utilizing an earlier developmental period, evidence was obtained for the role of individual personality change in initial alcohol use similar to individual and developmental shifts in specific personality constructs that can contribute to ‘maturing out’ of problematic alcohol use in early adulthood. These findings contribute to a larger perspective on how individual-level change in personality traits can relate to both initiation and desistance of alcohol use. Adolescence is a period that evidences substantial personality change, perhaps in part due to neurobiological changes and pubertal development during this time, but there is also expected variability in the magnitude of such changes (Dahl, 2004). Further, the current study extends prior work by utilizing a combination of behavioral and self-report measurements of disinhibition. Coupling self-report assessment with behavioral measurement is thought to increase accuracy of assessment given the notable limitations in solely relying on self-report to measure personality in early adolescence (e.g., social desirability biases, or inaccuracies due to one’s inability to report on behavior due to lack of awareness or recall). In addition, the study has moved beyond cross-sectional approaches and provides initial evidence that it is not simply initial levels of sensation seeking and risk taking propensity that contribute to subsequent alcohol use but in particular individual differences in the increases in each of these constructs that are associated with greater odds of alcohol use. These results provide additional support indicating the importance of attending to and assessing development of disinhibitory-based traits in early adolescence as unique correlates of progression of alcohol use. Also significant to note is the observed importance of assessing multiple constructs under the umbrella of disinhibition, as sensation seeking and risk taking propensity were generally unrelated to each other and moreover, changes in both incrementally added to the prediction of alcohol use. This further supports the notion of disinhibition as a multidimensional construct. Thus, those youth exhibiting greater increases in sensation seeking and risk taking propensity over time may be particularly at risk for rapidly escalating alcohol use into middle and older adolescence.

The present research has several limitations. First, although the study design is prospective, with only 3 waves of data there is a relatively limited follow-up period and future research is needed to examine trajectories of disinhibition and alcohol use from early adolescence into young adulthood. Second, we relied on self-report of alcohol use. Assessment of alcohol use using indices other than self-report may have been difficult with children in this sample, as the volume of substance use in this age group was infrequent enough to make biological tests of substance use insensitive to detections of early-onset usage (Allen, Litten, Anton, & Cross, 1994; Allen & Litten, 2001). Related, the measure of alcohol use was limited to a single item inquiring about past year use and rates of use were relatively low. This measure does not allow for an understanding of frequency of use or alcohol-related problems and such indices should be included in future studies of disinhibition change in relation to early adolescent use. Third, our assessment was mismatched on construct and measurement type as we used a self-report measure of sensation seeking and a behavioral measure of risk taking propensity. We would have preferred to measure both constructs with behavioral and self-report indices but the measures available to do so that truly capture the constructs at hand are limited. Indeed, currently there is no behavioral task providing a pure assessment of sensation seeking, with the closest available measures (e.g., Stoplight task, Steinberg et al., 2008) arguably tapping a combination of sensation seeking and other disinhibitory processes such as inhibitory control. Similarly, there do not exist self-report measures targeting a propensity to take risks that aren’t comprised of questions focused on actual risk behaviors, or that are not better characterized as impulsivity and sensation seeking. Also a limitation in measurement, we did not include a measure of impulsivity in our Wave 1 assessment as has been done previously in the adolescent alcohol literature (e.g., Chassin et al., 2004). This was not an oversight but instead an a priori decision to restrict the number of measures thereby limiting participant burden given the age of these children at the

beginning of the study, with this decision further driven by our previous cross-sectional work with adolescents and young adults (Aklin, Lejuez, Zvoleknsky, Kahler, & Gwadz, 2005; Lejuez et al., 2002, 2007) where impulsivity did not provide incremental validity in real world risk taking behavior including alcohol use above and beyond sensation seeking and risk taking propensity (BART). Although this decision was based on sound empirical data, it nevertheless is a limitation in that it prevents direct comparison with several other related studies using this construct. Fourth, although our sample was sociodemographically diverse, it was a convenience community-based sample which could limit the generalizability of the findings to other youth. Finally, as this study was a first step in understanding change in disinhibition in relation to alcohol use in early adolescence, we examined a limited number of covariates. Future research would benefit from investigation of other theoretically important characteristics (e.g., parental monitoring, negative life events, substance use expectancies, neighborhood risk) that may exert general and/or specific effects on alcohol use engagement. Finally, although we believe the significant findings here are meaningful and set the stage for further exploration as alcohol use continues to increase into middle adolescence, the modest effects in the current work should be acknowledged.

Keeping in mind the aforementioned limitations, these results highlight the importance of attending to and adequately assessing dynamic individual-level changes in disinhibitory-related traits in early adolescence as unique predictors of onset and progression of alcohol use. A number of future directions are indicated including the examination of potential bidirectional relationships between changes in sensation seeking and risk taking propensity with changes in alcohol use over time. For example, it could be that alcohol use behavior, particularly in the early adolescent years, may contribute to greater increases in sensation seeking and risk taking propensity. Given the emerging, albeit circumscribed, body of evidence indicating that alcohol use may impact frontal, limbic, and striatal structures in the brain associated with reward processing in adolescents (c.f., Clark, Thatcher, & Tapert, 2008), there is a need to better understand the influence of early alcohol use on the modulation of potential individual differences in developmental changes in sensation seeking and risk taking propensity.

Finally, results of the study also have potential clinical implications, specifically in providing further rationale for the development of interventions for sensation seeking and risk taking propensity as a means to reduce alcohol use. For example, Conrod, Castellanos, and Mackie (2008) recently developed a personality-targeted intervention to delay the growth of adolescent drinking. A randomized control trial showed a group difference in the growth of alcohol use between baseline and 6-months follow-up, with the control group showing a greater increase in drinking than the intervention group. The intervention was particularly effective in preventing the growth of binge drinking in those students with a high sensation seeking personality. This is a unique example of targeting personality variables among youth to reduce problematic alcohol use and calls for the development of more novel personality interventions, especially for non-clinical samples. Moreover, integration of behavioral measures such as measuring risk taking propensity at baseline and over the course of prevention/early interventions could identify youth at risk for early alcohol use that is known to be associated with long term negative outcomes, doing so in a less transparent manner than possible with the exclusive use of self report strategies.

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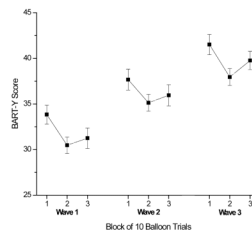


Figure 1. Comparison of blocks of 10 balloons within each administration of the BART-Y at all assessment waves.

Table 1
Zero-order correlations between Sensation Seeking and Risk Taking Propensity

RT Propensity	RT Propensity			Sensation Seeking			Age ^f	Gender
	Wave 1	Wave 2	Wave 3	Wave 1	Wave 3	Wave 1		
Wave 1	—						.12 *	.02
Wave 2	.49 **	—					.08	.06
Wave 3	.39 **	.67 **	—				.08	-.003
Sensation Seeking								
Wave 1	.10	.01	.01	—			.06	.09
Wave 2	.06	.06	.07	.53 **	—		.25 **	.08
Wave 3	.13	.12	.14 *	.44 **	.64 **	—	.19 *	.12
<i>M</i>	31.26	35.96	39.09	13.11	13.32	14.65	—	—
<i>SD</i>	14.20	15.20	13.87	5.26	5.65	5.61	—	—

* Note: * $p < .05$;

** $p < .01$.

^f Correlations between age and disinhibition constructs are concurrent within each wave. Thus age at Wave 1 is correlated with risk taking propensity assessed at Wave 1, etc.

Table 2

Generalized Estimation Equations Analyses Predicting Past Year Alcohol Use at Waves 2 and 3

Variable	OR	95%CI	p
Time	1.36	0.95, 1.94	0.09
Wave 1 alcohol use	4.71	2.70, 8.23	0.001
Wave 1 RT propensity	1.26	0.95, 1.67	0.108
Wave 1 sensation seeking	1.52	1.18, 1.98	0.001
Change in RTP	1.28	1.00, 1.67	0.05
Change in SSS	1.54	1.19, 1.99	0.001

OR, odds ratio; CI, confidence interval; change in RTP, time-varying risk taking propensity change score variable; change in SSS, time-varying sensation seeking change score variable. ORs <1 indicate reduced odds of alcohol use; ORs >1 indicate increased odds of alcohol use. All continuous variables were centered.