Collegiate Heavy Drinking Prospectively Predicts Change in Sensation Seeking and Impulsivity

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Abstract

Recent models of alcohol use in youth and young adulthood have incorporated personality change and maturation as causal factors underlying variability in developmental changes in heavy drinking. Whereas these models assume that personality affects alcohol use, the current prospective study tested the converse relation. That is, we tested whether, after accounting for the effect of traits on drinking, collegiate heavy drinking in turn predicted individual differences in change in alcohol-related aspects of personality. We also examined whether affiliation with heavy-drinking peers better accounted for this relation. Following a cohort of recent high school graduates ($N = 1,434$) through the college years, we found evidence for transactional relations between heavy drinking and changes in impulsivity and sensation seeking. Both traits predicted increases in heavy drinking, but more importantly, heavy drinking predicted increases in sensation seeking and impulsivity. In final models, social influences did not underlie the effect of heavy drinking on increases in sensation seeking and impulsivity. The results of this investigation suggest that collegiate heavy drinking may negatively and pervasively impact a wide range of behaviors because of its effect on personality change.

Keywords

Alcohol; College Students; Sensation Seeking; Impulsivity; Personality Change

The facets often grouped under the term *behavioral undercontrol* are the strongest personality predictors of alcohol use and abuse (Sher, Bartholow, & Wood, 2000; Sher & Trull, 1994). In addition to drinking, these traits reliably predict a variety of other negative outcomes, including poorer academic performance (Duckworth & Seligman, 2005) and greater likelihood of risky behaviors such as illicit drug abuse (Sher et al., 2000), unprotected sex (Hoyle, Fejfar, & Miller, 2000), and gambling (Slutske, Caspi, Moffitt, & Poulton, 2005). Whereas there is a substantial body of evidence suggesting that the individual differences comprising behavioral undercontrol are risk factors for alcohol use and related behaviors, the converse may also be true: alcohol use may influence the development and maturation of these traits. During the college years in particular, when adolescents increase their drinking to the highest mean levels across the lifespan and personality continues to mature (Bachman, Wadsworth, O'Malley, & Johnston, 1997; Caspi, Roberts, & Shiner, 2005), alcohol use may be most likely to influence personality change. In the current investigation, we tested the hypothesis that heavy drinking in college predicts change in alcohol-related aspects of personality.

Recent evidence demonstrates that there is both continuity and change in personality across the lifespan (Roberts & DelVecchio, 2000; Roberts, Walton, & Viechtbauer, 2006). One aspect of personality continuity—or the lack thereof—is rank-order stability, which quantifies the degree to which between-person individual differences on a given trait remain stable across time. In a meta-analytic review, Roberts and DelVecchio (2000) demonstrated that whereas personality is relatively stable and is increasingly so with age, there is also a non-trivial amount of instability from childhood through young adulthood. During the college years, the average stability correlation was approximately $r = .50$, indicating that roughly 25% of the variance in personality was explained by prior measurements of personality.

Another aspect is mean-level change, which captures the normative trends of maturation in personality across development. Relative to the mid-to-late 20s, there is little change in Big Five dimensions on average during the college years, although mean levels of both Openness to Experience and the Extraversion domain of social dominance increase from 18–22 (Roberts, Walton, & Viechtbauer, 2006). Whereas Roberts and colleagues (2006) have demonstrated how personality typically develops across the lifespan, research exploring the ways in which individuals deviate from these patterns has only begun to emerge in the past half-decade (e.g., Donnellan, Conger, & Burzette, 2007; Neyer & Lehnart, 2007; Vaidya, Gray, Haig, Mroczek, & Watson, 2008). Studies of individual differences in personality change can detect individuals who depart from mean-level trends, and more importantly, these studies can identify variables that predict differences in personality change trajectories (Roberts & Mroczek, 2008). The current investigation aims to determine whether collegiate heavy drinking, in particular, influences deviation from typical patterns of personality development.

Alcohol Use and Individual Differences in Personality Change

In two of the few longitudinal studies of alcohol use and personality change, Littlefield and colleagues (2009, 2010) demonstrated that individuals' trajectories of change in impulsivity and neuroticism from college through age 35 were associated with trajectories of alcohol involvement. That is, as individuals matured in regards to personality across young adulthood, they also decreased their alcohol involvement. One possible explanation for these findings is that drinking is influenced by and yoked to changing personality (e.g., Littlefield et al., 2010). Changes in alcohol use would therefore be a function of personality maturation or the lack thereof. Given the evidence supporting traits as predictors of alcohol use and misuse, this account makes some theoretical sense. A limitation of these correlated-change analyses, however, is that they cannot establish the temporal precedence of either variable (Cheong, MacKinnon, & Khoo, 2003). That is, establishing that change in drinking correlates with change in personality does not provide evidence for the direction of the effect. An alternative interpretation of these findings is that a transactional relation underlies the correlation between personality and alcohol use: as personality influences drinking, so too may drinking influence change in personality.

To our knowledge, only one study has explicitly tested transactional relations between substance use and personality change. Roberts and Bogg (2004) used data from the Mills Longitudinal study of women at three assessments to test the relation between health behaviors and the Conscientiousness facet of social responsibility (i.e., dutifulness and sociability). Whereas age-21 social responsibility predicted lower levels of marijuana consumption at age 43, marijuana consumption at age 43 also predicted decreases in social responsibility from age 43 to age 52. Thus, some substance use may predict differential change in at least some traits.

The Correspansive Principle

Reflecting the emerging evidence for transactional relations between differential personality change and life experiences (e.g., Roberts & Bogg, 2004; Scollon & Diener, 2006), Caspi and colleagues (2005) propose that "the most likely effect of life experience on personality development is to deepen the characteristics that lead people to those experiences in the first place (p. 470)." That is, according to this *correspansive principle*, the same traits which predict specific behavioral or social-environmental outcomes should also be influenced by those experiences, whereas other traits should be unaffected. Thus, the facets of behavioral undercontrol that predict college alcohol use should in turn be affected by the degree to which students engage in heavy drinking.

Two such traits are sensation seeking, a tendency to seek and enjoy novelty and risk, and impulsivity, a tendency to act on impulses without considering consequences. A meta-analysis of 61 studies demonstrated that high sensation seekers reliably consume more alcohol (Hittner & Swickert, 2006). Impulsivity is also associated with alcohol use, although some studies suggest that it may be more strongly related to the negative consequences of drinking than to drinking itself (Dawe, Gullo, & Loxton, 2004; Magid, MacLean, & Colder, 2007; Smith et al., 2007). Some personality theories (e.g., Cloninger, Przybeck, & Svrakic, 1991) have treated impulsivity and sensation seeking as a single construct, but recent factor-analytic (Smith et al., 2007; Whiteside & Lynam, 2001) and developmental (Harden & Tucker-Drob, in press; Steinberg et al., 2008) studies demonstrate that they are distinct.

The presence of individual differences in intra-individual change in sensation seeking and impulsivity is central to the proposition that alcohol use may influence change in these traits. Whereas neither may change substantially at the mean level during the college years (Roberts, Walton, & Viechtbauer, 2006; Steinberg et al., 2008), there is increasing evidence indicative of individual differences in collegiate personality change. From adolescence to young adulthood, all Big Five dimensions demonstrate individual differences in change (Vaidya et al., 2008), and trajectories of change in both sensation seeking and impulsivity during adolescence and young adulthood vary significantly across individuals (Harden & Tucker-Drob, in press). In sum, there appear to be individual differences in the maturation of sensation seeking and impulsivity during the college years.

If only those traits that predict alcohol use are in turn affected by alcohol use, then traits that are not directly related, such as autonomy, should not change as a result of drinking. Autonomy is defined as preference for interpersonal independence (Hirschfeld et al., 1977); it is most closely associated with the Big Five dimensions of Neuroticism (inversely) and Openness to Experience (van der Zee, Thijs, & Schakel, 2002). More autonomous individuals are affected less by the evaluations of others. As a consequence, autonomy may moderate the influence of peer alcohol use on one's own drinking (Knee & Neighbors, 2002; Neighbors, Lewis, Bergstrom, & Larimer, 2006). In contrast to autonomy's role as a moderator, however, there appears to be little evidence for a main-effect relation between autonomy and alcohol use. Although some studies have found a small inverse association between autonomy and drinking (Chawla, Neighbors, Logan, Lewis, & Fossos, 2009), the bulk of the evidence suggests a weak and non-significant relation among both adolescents (Chassin, Pitts, & DeLucia, 1999) and college students (Knee & Neighbors, 2002; Neighbors, Lewis et al., 2006). The correspansive principle would therefore predict that autonomy would not be affected by collegiate drinking.

According to the correspansive principle, socialization shapes the transactional relations between traits and life experiences (Caspi et al., 2005). Indeed, a variety of social-environment factors have been identified as contributors to differential personality change (Neyer & Lehnart, 2007; Roberts & Bogg, 2004; Roberts, Walton, Bogg, & Caspi, 2006;

Scollon & Diener, 2006; Vaidya, Gray, Haig, & Watson, 2002). It is therefore important to test the possibility that an alcohol effect on personality change may be a product of the social nature of collegiate drinking. College students' beliefs about how much their peers drink, referred to as descriptive drinking norms, represent a major social foundation for collegiate heavy drinking (Baer, Stacy, & Larimer, 1991). Indeed, the most proximal norms, such as those for same-gendered social group members, may be the best predictors of drinking in college (Neighbors, Lee, Lewis, Fossos, & Larimer, 2007; Read, Wood, & Capone, 2005; Stappenbeck, Quinn, Wetherill, & Fromme, in press). Thus, rather than representing a meaningful relation, associations between heavy drinking and change in personality might rather be spurious, reflecting a true association between affiliation with heavier drinking peers and personality change. Ruling out the confounding influence of interaction with heavy-drinking peers, however, would suggest that drinking affects personality change for reasons beyond this social influence. One alternative possibility is that the pharmacological effects of alcohol influence personality change. In animal models, for example, adolescent alcohol exposure produces changes in the functioning of the nucleus accumbens (e.g., Philpot, Wecker, & Kirstein, 2009; Szumlinski et al., 2007), a key component of the mesolimbic dopamine system thought to underlie sensation seeking (Steinberg, 2008).

The Present Research

In the current investigation, we followed a cohort of undergraduates from the summer prior to matriculation through senior year of college to test whether alcohol use predicted change in alcohol-relevant personality traits across the college years. We also tested whether the social nature of collegiate drinking accounted for the alcohol-personality change relation. After a preliminary examination of rank order stability and mean-level change in personality, we tested the following specific hypotheses: (1) Sensation seeking and impulsivity will predict heavier drinking whereas the more weakly associated trait of autonomy will not; (2) Collegiate heavy drinking will, in turn, predict increases in the alcohol-relevant traits of sensation seeking and impulsivity but not autonomy; and (3) Heavy drinking will continue to predict increases in sensation seeking and impulsivity when accounting for the confounding effects of affiliation with heavy-drinking peers, operationalized as social group descriptive drinking norms.

Method

Participants and Procedures

Participants were students in a longitudinal study of alcohol use and other behavioral risks from high school through college. First-time college students between the ages of 17 and 19 in the entering class of 2004 at a large, public university in the southwest ($N = 6,391$) were recruited in the summer prior to matriculation. Seventy-six percent of invited students ($N = 4,832$) expressed interest in participating and met the final inclusion criterion of being unmarried. Of the interested students, 3,046 were randomly assigned to complete a high school survey and 2 subsequent assessments per academic year for 3 years, in addition to one survey in the 4th year, corresponding to their senior year.[1] These students were given access to a secure website, on which they provided informed consent and completed a survey assessing the final semester of high school ($N = 2,247$; 74% of the randomized sample). The present study is based on this sample. For a more detailed description of participant recruitment and other study procedures, see Corbin, Vaughan, and Fromme (2008) and Hatzenbuehler, Corbin, and Fromme (2008).

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[1]Of the remaining participants, 976 were assigned to complete surveys prior to starting college and again in the fourth year, and 810 were assigned to complete a survey in the fourth year only.

Following the high school survey, each subsequent survey was administered online three weeks prior to the end of the semester, assessing behaviors for the preceding three months. In addition to measures of alcohol use and other risky behaviors, the high school survey, the senior fall survey, and each spring survey included measures of descriptive drinking norms. The high school and senior fall surveys also included assessments of personality traits, including impulsivity, sensation seeking, and autonomy. Participants' survey responses were collected and stored by DatStat (Seattle, Washington). Participants received $30 for completion of the high school survey, $20 for the first three fall college surveys, $25 for the spring college surveys, and $40 for the senior fall survey.

In the current investigation, we included participants who completed the high school survey, the sophomore spring survey, and the senior fall survey. Although heavy drinking and social group descriptive drinking norms were also assessed in the freshman- and junior-year spring surveys, we selected the sophomore spring survey for inclusion as the middle assessment because it most closely approximated the midpoint of the college years.2 Of the 2,247 participants who completed the high school survey, 80% (*n* = 1,790) completed the sophomore spring, and 68% (*n* = 1,539) completed the senior fall survey. A total of 1,434 participants (64% of the consented sample) completed all three assessments and were therefore included in this study. This sample (64% female; 54% White, 21% Asian-American, 14% Hispanic or Latino, 4% African-American, and 7% multiethnic or other ethnicities) was demographically similar to the undergraduate population of the university.

Measures

Personality—Participants completed measures of sensation seeking and impulsivity taken from the Zuckerman-Kuhlman Personality Questionnaire (Zuckerman, Kuhlman, Joireman, Teta, & Kraft, 1993). Respondents endorse the 11 sensation seeking and 8 impulsivity items on a dichotomous scale where 0 = *false* and 1 = *true*. The sensation seeking and impulsivity scales include items such as "I like doing things just for the thrill of it" and "I very seldom spend much time on the details of planning ahead," respectively. In the current sample, both the sensation seeking (αs = .73 – .79) and impulsivity (αs = .71 – .75) scales demonstrated adequate internal consistency. No item on either scale referred to alcohol or other substance use.

We assessed trait-level autonomy with the Assertion of Autonomy subscale of the Interpersonal Dependency Inventory (Hirschfeld et al., 1977). Participants endorsed 14 items on a 4-point Likert scale, ranging from 1 = *not characteristic of me* to 4 = *very characteristic of me*. The Assertion of Autonomy subscale includes items such as "I rely only on myself" and "I prefer to be by myself." The Assertion of Autonomy subscale has demonstrated inverse associations with measures of social support (Shahar, 2008). In the current sample, it demonstrated adequate internal consistency, αs = .81 – .86.

Heavy drinking—We used a latent variable approach to the measurement of heavy drinking, with three well-validated measures of alcohol use as indicators. Participants reported how frequently in the past three months they binge drank (i.e., four or more standard drinks for women and five or more standard drinks for men; Wechsler & Isaac, 1992). Participants also reported the number of times that they became subjectively "drunk (not just a little high) on alcohol" in the past three months (Jackson, Sher, Gotham, & Wood,

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2Although the results are not reported in this article, we replicated our analyses using data from the freshman-spring and junior-spring assessments in place of the sophomore-spring assessment. In models using junior-spring data, heavy drinking predicted change in sensation seeking and impulsivity, whereas social group norms did not. In freshman-spring models, we found less support for the predicted relations, likely reflecting the longer (2.5 years) gap between assessments. The results of these analyses are available from the first author upon request.

2001; Midanik, 1999). Finally, participants completed the Daily Drinking Questionnaire (DDQ; Collins, Parks, & Marlatt, 1985). The DDQ asks participants to indicate the number of standard drinks (defined as 12 oz of beer, 5 oz of wine, or 1 shot of liquor straight or in a mixed drink) they consumed on each day of a typical week in the past three months. From responses to the DDQ, we calculated the total number of drinks typically consumed per week. Similar approaches to the measurement of heavy drinking have been used in research among college students (Fromme, Corbin, & Kruse, 2008) and have been recommended for use in genomic studies (Agrawal et al., 2009). Internal consistency among the alcohol use measures in this study was excellent at all assessments, αs = .89 – .90.

Social group descriptive drinking norms—We assessed perceived social group descriptive drinking norms using a modified version of the Drinking Norms Rating Form (DNRF; Baer et al., 1991). In a format similar to that of the DDQ, the DNRF asks participants to estimate the number of standard drinks same-gendered members of their social group (i.e., "the principal group of friends with whom you interacted and spent time") consumed on each day of a typical week during the past three months. Because in the context of drinking 'typical' peers are often construed as male, same-gendered descriptive norms exert greater influence on alcohol use than do gender-neutral norms, particularly for women (Lewis & Neighbors, 2004). From responses to the DNRF, we calculated the perceived total number of drinks consumed per week by same-gendered social group members.

Statistical Analyses

After preliminary analyses regarding participant attrition and mean-level change and stability in study variables, data were analyzed in three steps. First, we tested for measurement invariance in personality and heavy drinking over time. Measurement invariance captures the degree to which a measurement model of a particular construct remains equivalent across time (Meredith, Horn, Collins, & Sayer, 2001). As such, longitudinal measurement invariance is central to assessing intra-individual change across time. Because sensation seeking, impulsivity, and autonomy were measured using single scales, we parceled each scale to create a latent score, which improves reliability and permits evaluation of measurement invariance without requiring the estimation of an item-level measurement model (Hagtvet & Nasser, 2004; Little, Cunningham, Shahar, & Widaman, 2002). Parcels were created by randomly assigning scale items to three parcels each for each trait, with item scores summed within parcels.

Second, we estimated bivariate latent difference score (LDS; Ferrer & McArdle, 2003; McArdle & Nesselroade, 2003) models to test transactional relations between changes in heavy drinking and impulsivity, sensation seeking, and autonomy (Hypotheses 1 and 2). LDS models are structured such that change from one time-point to the next in a given variable is specified as a latent variable. For example, sensation seeking at time t is defined as the sum of two factors: stability from sensation seeking at time $t − 1$ and the latent difference score. LDS models accomplish the goals of longitudinal data analysis (i.e., estimating both intra-individual change across time and inter-individual differences in change) when scores are available for only two time-points (e.g., personality in the current study). The bivariate LDS models tested for transactional relations between heavy drinking and personality. We modeled relations between heavy drinking and each personality trait separately in the interest of maintaining consistency with prior studies of personality change, facilitating model convergence, and maximizing interpretability.

Third, we tested whether the effects of affiliation with heavy-drinking peers would also predict individual differences in trait change and whether heavy drinking would predict

increases in traits over and beyond social influence (Hypothesis 3). These analyses were conducted to determine whether trait change reflected an effect of drinking itself rather than the social influences that underlie drinking. In order to test this hypothesis, we first estimated LDS models similar to those described above but with perceived social group descriptive drinking norms as observed variables in place of the latent heavy drinking variables. Finally, we constructed full models including traits, heavy drinking, and social norms to examine whether personal drinking continued to predict trait change over and beyond social influences on drinking.

Because the χ^2 test of overall goodness-of-fit may be erroneously significant when sample sizes are large, we used multiple indices to determine how well each model fit the data (Kline, 2005). In addition to the χ^2 test, we examined the root mean square error of approximation (RMSEA), which indicates reasonable fit with values less than .08 and good fit with values less than .05 (Browne & Cudeck, 1993), the Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI), which indicate good fit with values greater than .90 (Hu & Bentler, 1999), and the standardized root mean square residual (SRMR) which indicates adequate fit with values less than .10 (Kline, 2005). Although participants were only included in the current analysis if they completed surveys at all three assessments, missing data for specific measures was still observed. An advantage of structural equation modeling in MPlus is the use of full-information maximum likelihood estimation, which can effectively handle this non-systematic missing data (Kline, 2005). We log-transformed social group descriptive drinking norms and the heavy drinking indicators (i.e., typical weekly drinking, binge drinking, and subjective intoxication) to adjust for non-normality. Finally, we controlled for gender by regressing personality, heavy drinking, and social norms at the high school assessment onto an exogenous gender variable.

Results

Participant Attrition

Participants excluded from the current analyses ($n = 813$) were more likely to be male, $\chi^2(1) = 31.48$, $p < .001$, and multiethnic or other ethnicities, $\chi^2(7) = 22.58$, $p = .002$, than were included participants. At the high school survey, excluded participants were more sensation seeking, $t(2,128) = 4.20$, $p < .001$, $d = .19$, impulsive, $t(2,147) = 4.64$, $p < .001$, $d = .21$, and autonomous, $t(2,228) = 2.45$, $p = .01$, $d = .11$. They also consumed more standard drinks in a typical week, $t(2,240) = 4.74$, $p < .001$, $d = .20$, endorsed more frequent subjective intoxication, $t(2,238) = 3.05$, $p = .002$, $d = .13$, and binge drinking, $t(2,238) = 3.87$, $p < .001$, $d = .17$, and perceived same-gendered members of their social group to drink more heavily, $t(2,227) = 5.37$, $p < .001$, $d = .23$.

Rank-Order Stability and Mean-Level Change

Correlations among study variables at all assessments are shown in Table 1. As indicated by the bivariate correlations, impulsivity, sensation seeking, and autonomy demonstrated moderate-to large-stability effects across the college years. In addition, social group descriptive drinking norms and all three indicators of heavy drinking displayed moderate-to-large stability. That is, across the four years of college, participants were relatively rank-order stable in personality, drinking, and social group drinking norms.

Table 2 shows the means and standard deviations for traits, heavy drinking, and social group descriptive drinking norms across all three assessments. At the mean level, there was no significant change in sensation seeking, $t(1,289) = 1.20$, $p = .23$, $d = -0.03$, impulsivity, $t(1,310) = 1.71$, $p = .09$, $d = -0.05$, or autonomy, $t(1,386) = 1.52$, $p = .13$, $d = -0.04$, across the college years. Thus, the normative pattern of development in all three traits was one of

no change. In contrast, participants experienced steady increases in both personal drinking and perceived social group drinking across the same time period. From high school to senior year of college, participants reported drinking significantly more heavily on all indices of heavy drinking, including typical weekly drinking, $t(1,428) = 18.76$, $p < .001$, $d = 0.51$, binge drinking, $t(1,427) = 11.92$, $p < .001$, $d = 0.36$, and frequency of subjective intoxication, $t(1,425) = 11.57$, $p < .001$, $d = 0.35$. Across the same period, social group descriptive drinking norms also increased moderately, $t(1,403) = 15.67$, $p < .001$, $d = 0.48$.

Measurement Invariance

In order to test measurement invariance across time, we compared a series of separate models for heavy drinking and personality in which parameters were increasingly constrained to equivalence across time-points (Allemand, Zimprich, & Martin, 2008). We began by estimating measurement models for heavy drinking and the three parceled personality variables in which all parameters were free to vary across time. We then compared these models to models in which factor loadings were constrained to be equal (i.e., weak measurement invariance), followed by models with additional equivalence constraints on the indicator intercepts (i.e., strong measurement invariance) and finally residual variances (i.e., strict measurement invariance). Following the recommendations of Meade and colleagues (2008), we tested whether increasing levels of constraint worsened model fit using the CFI and McDonald's noncentrality index (NCI), in addition to the χ^2 difference test. CFI differences greater than .002 and NCI differences varying as a function of the number of items and factors were used to determine significant changes in fit between models with successively constrained parameters (Meade et al., 2008). By these criteria, sensation seeking and autonomy demonstrated strict measurement invariance, impulsivity demonstrated strong measurement invariance, and heavy drinking demonstrated weak measurement invariance.[3] See Table 3 for measurement invariance model comparisons.

Transactional Relations between Heavy Drinking and Alcohol-Related Traits

The first set of bivariate LDS models tested whether differences in heavy drinking predicted individual differences in change on each trait. The models included the latent heavy drinking variable at all three assessments and personality at high school and college senior year (see Figures 1 and 2 for the sensation seeking and impulsivity models, respectively). For each personality trait, we compared transactional models, in which personality predicted change in drinking and heavy drinking predicted personality change, to alternative models with no path between heavy drinking and subsequent personality change. These alternative models served as a rigorous test of the hypothesized transactional relations.

The transactional sensation seeking model fit the data better than did the more conservative alternative model, $\chi^2(107) = 606.14$, $p < .001$, CFI = .97, TLI = .96, RMSEA = .06 [90% CI: .05, .06], SRMR = .03, $\Delta\chi^2(1) = 17.35$, $p < .001$. Although as reported above there was no mean-level change in sensation seeking, there were significant individual differences in sensation seeking change across the college years. See Table 4. Most importantly, collegiate heavy drinking predicted greater increases in sensation seeking.[4] Similarly, higher sensation seeking in high school also predicted greater increases in heavy drinking, albeit to a lesser

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[3]To determine whether potentially limited measurement invariance in heavy drinking across time influenced the results, the final LDS models were also run assuming strict measurement invariance (i.e., factor loadings, indicator intercepts, and residual variances associated with heavy drinking were constrained to be equal across assessment periods), with results identical to those presented here.
[4]We also explored the possibility that initial levels of heavy drinking in high school—rather than collegiate drinking—predicted personality change. In models identical to those reported here but also including paths from high school drinking to personality change, drinking in college continued to predict change in personality, whereas we found little evidence for the influence of high school drinking on personality change.

extent. Additionally, higher levels of sensation seeking in high school predicted decreases in sensation seeking across the college years. The same was true of heavy drinking.

The transactional impulsivity model fit the data better than did the alternative model, $\chi^2(104) = 454.48$, $p < .001$, CFI = .98, TLI = .97, RMSEA = .05 [.04, .05], SRMR = .03, $\Delta\chi^2(1) = 17.76$, $p < .001$, and there were significant individual differences in change in impulsivity. We again found evidence for a transactional relation between drinking and impulsivity, along with stability within both variables. Whereas higher impulsivity in high school predicted greater increases in heavy drinking, heavier drinking in college in turn predicted greater increases in impulsivity. Additionally, students with higher levels of impulsivity in high school decreased more in impulsivity across the college years.

In contrast to the above models, the transactional autonomy model, $\chi^2(107) = 670.71$, $p < .001$, CFI = .97, TLI = .96, RMSEA = .06 [.06, .07], SRMR = .04, $\Delta\chi^2(1) = 0.39$, $p = .53$, did not fit the data significantly better than did the alternative model, $\chi^2(108) = 670.80$, $p < .001$, CFI = .97, TLI = .96, RMSEA = .06 [.06, .07], SRMR = .04. That is, although change in autonomy varied across individuals, heavy drinking did not predict individual differences in autonomy change. High school autonomy, in contrast, significantly and inversely predicted change in heavy drinking during the sophomore year, indicating that individuals higher on autonomy increased less in heavy drinking, $\beta = -0.08$, $p = .01$.

Social Group Descriptive Drinking Norms Do Not Better Account for the Effect of Heavy Drinking on Personality Change

In order to determine whether the effect of heavy drinking on change in sensation seeking and impulsivity was better explained by social group descriptive drinking norms, we first tested whether social group norms predicted personality change. We estimated LDS models similar to those above but with the observed social group norms variable in place of heavy drinking. In these models, we retained paths predicting change in social norms from personality on the basis of prior research suggesting that college students select into social groups partially as a function of personality (Park, Sher, Wood, & Krull, 2009).

The sensation seeking model fit the data well, $\chi^2(37) = 285.18$, $p < .001$, CFI = .93, TLI = .92, RMSEA = .07 [.06, .08], SRMR = .04. High school sensation seeking predicted increases in social group norms ($\beta = .07$, $p = .01$), which in turn predicted increases in sensation seeking, $\beta = .12$, $p < .01$. The impulsivity model also fit the data well, $\chi^2(34) = 162.83$, $p < .001$, CFI = .96, TLI = .95, RMSEA = .05 [.04, .06], SRMR = .04. Whereas high school impulsivity did not predict change in sophomore year social group norms ($\beta = .03$, $p = .21$), sophomore year social group norms predicted increases in impulsivity, $\beta = .06$, $p = .05$.

Finally, because heavy drinking and social group norms each predicted increases in sensation seeking and impulsivity, we estimated a third set of LDS models including both drinking and norms as predictors of change in these traits. As shown in Figures 3 and 4 (for sensation seeking and impulsivity, respectively), in these models we additionally permitted transactional relations between social norms and drinking (e.g., Neighbors, Dillard, Lewis, Bergstrom, & Neil, 2006). The sensation seeking model fit the data well, $\chi^2(144) = 821.46$, $p < .001$, CFI = .96, TLI = .96, RMSEA = .06 [.05, .06], SRMR = .03. Social norms did not predict change in sensation seeking controlling for heavy drinking. Heavy drinking, however predicted greater increases in sensation seeking across the college years, and the effect of heavy drinking on increases in sensation seeking decreased only 13% (from $\beta = 0.15$ to $\beta = 0.13$) when accounting for social norms. In addition, from high school to sophomore year, both sensation seeking and social group norms predicted greater increases in heavy drinking, but sensation seeking did not predict change in social group norms.

The model for impulsivity also fit the data well, $\chi^2(141) = 676.67$, $p < .001$, CFI = .97, TLI = .96, RMSEA = .05 [.05, .06], SRMR = .03. Heavy drinking again predicted greater increases in impulsivity after accounting for social group norms. Indeed, this association appeared somewhat larger than it had when not accounting for social group norms (i.e., in Figure 2). Additionally, social group norms predicted greater increases in heavy drinking from high school to sophomore year, whereas impulsivity did not predict change in either heavy drinking or social group norms.

Discussion

We found evidence for transactional relations between heavy drinking and change in sensation seeking and impulsivity. Both traits were significantly correlated with heavy drinking prior to college matriculation and predicted increases in heavy drinking across the first two years of college. Most importantly, however, there were individual differences in personality change, and heavy drinking was a significant predictor of that change. Specifically, whereas at the mean level there was no change in either trait, heavier drinking in college predicted increases in both traits. As expected, heavy drinking did not predict change in the more weakly and inconsistently related trait of autonomy. Whereas social group descriptive drinking norms separately predicted change in both sensation seeking and impulsivity, in a final set of models including both norms and drinking, only heavy drinking predicted increases in alcohol-related traits across the college years. Thus, a major social-environmental influence did not underlie the effect of heavy drinking on changes in sensation seeking and impulsivity.

Notably, although autonomy was not associated with heavy drinking at either the high school or college senior fall surveys, greater autonomy in high school predicted less heavy drinking in the spring of sophomore year. Although this effect was small in size, it nevertheless contrasts with previous null findings (Chassin et al., 1999). Research into the role of autonomy in alcohol use has typically examined autonomy as a moderator of peer influences (e.g., Knee & Neighbors, 2002). It is possible that, in contrast with previous studies, the present investigation had sufficient power to detect a small but meaningful main-effect association between lower autonomy and heavy collegiate drinking (e.g., Chawla et al., 2009). Further research is warranted to determine whether autonomy, in addition to buffering the effect of peers, is directly protective against drinking as well.

Prior research has treated sensation seeking and impulsivity as stable—or recently, less-stable—risk factors for heavy drinking. The present findings indicate that transactional relations underlie this association, at least during college when drinking rates are at their highest levels across the lifespan (Bachman et al., 1997). Indeed, in this investigation, heavy drinking prospectively influenced change in sensation seeking to a greater degree than sensation seeking prospectively influenced change in heavy drinking. Further, when accounting for social group descriptive norms, impulsivity did not significantly predict increases in heavy drinking from high school to the sophomore year of college, whereas heavy drinking predicted change in impulsivity. In sum, prior findings that traits and alcohol use demonstrate cross-sectional associations and correlated change appear to result from a transactional relation.

If the present findings are robust across replications, the transactional nature of drinking-personality relations may have broad implications for models of heavy drinking in youth. Steinberg (2008), for example, proposed that the typical adolescent increase in sensation seeking, coinciding with still-high levels of impulsivity, explains the increase in risk-taking during that developmental period. A challenge for this theory, however, is that whereas decreases in both sensation seeking and impulsivity are typical after mid-adolescence

(Steinberg et al., 2008), mean levels of substance use and other problem behaviors, including risky sex, continue to increase into the college years (Fromme et al., 2008). The results of this investigation provide a potential explanation. Following the normative adolescent increase in sensation seeking, those individuals who initiate heavy drinking may get caught in a spiral of mutually reinforcing increases in both traits and drinking. Thus, some individuals may continue to increase their drinking—and their levels of sensation seeking or impulsivity—in spite of the typical patterns of personality maturation.

The current findings are consistent with Caspi and colleagues' (2005) corresponsive principle of personality development in that the same traits identified as predictors of drinking were in turn influenced by heavier drinking. That the effect of drinking on change in sensation seeking and impulsivity was independent of a major social correlate of collegiate alcohol use, however, is inconsistent with the principle's proposed mechanism. Caspi and colleagues (2005) argued that individuals select into social environments on the basis of their traits and experience subsequent increases in those traits as a function of socialization. In contrast, although we cannot rule out the possibility that other, unexamined social-environmental factors explain the alcohol effect on trait change, our results suggest that aspects of heavy drinking beyond social influences produce increases in sensation seeking and impulsivity.

If social factors do not better explain these findings, we see two possible mechanisms through which heavy drinking may affect sensation seeking and impulsivity. First, the self-perceptions upon which most self-report measures of personality rely may be influenced by personal drinking but not peer drinking. That is, engaging in heavy drinking may indicate to college students that they yield to temptations or that they prefer novel and exciting behaviors. A far more alarming possibility, however, is that alcohol exerts a pharmacological effect on the neurological systems thought to underlie these traits (Casey, Getz, & Galvan, 2008; Steinberg, 2008). Although the present investigation cannot offer evidence for or against this proposed mechanism, we note that cross-sectional studies have demonstrated that adolescents with substance use disorders display deficits in neuropsychological functions, including attention (Tapert & Brown, 2000) and executive function (Giancola, Shoal, & Mezzich, 2001). Moreover, preliminary evidence suggests that hangover symptoms may predict worsened attention performance, at least among adolescent boys (Squeglia, Spadoni, Infante, Myers, & Tapert, 2009). More research is therefore needed to determine whether drinking-induced personality change may be a function of the pharmacological effects of alcohol.

Limitations

Whereas the present four-year longitudinal design is well-suited to detect differential trait change, the chief limitation of this investigation is that personality traits were only assessed at two time points. This research design prevents us from including other statistical approaches in our analyses (e.g., Biesanz, West, & Kwok, 2003; McArdle & Nesselroade, 2003) and specifically does not allow us to include sophomore-year personality measurements in our autoregressive models. This limitation raises the possibility that the effect of drinking on personality may have resulted from unmeasured increases in traits—which, in turn, increased drinking—from high school to sophomore year. This alternative interpretation is unlikely for two reasons. First, the rank-order stability of traits in this study was comparable to the mean stability estimate found in Roberts and DelVecchio's (2000) meta-analysis, suggesting that we did not underestimate trait stability by omitting a sophomore-year assessment. Second, in addition to the hypothesized paths, we included in our analyses correlations among change scores. We are therefore confident that the association between sophomore-year drinking and increases in impulsivity and sensation

seeking through senior year reflected the prediction of change by heavy drinking over and beyond correlated change.

Because this study included a limited number of personality traits, autonomy was the only less-alcohol-related personality facet included in the current analyses. We cannot rule out the possibility that other traits thought to be unrelated to alcohol use (e.g., facets of Openness; Hampson, Goldberg, Vogt, & Dubanoski, 2006) may change as a result of collegiate drinking. Similarly, although both sensation seeking and impulsivity are theoretically and empirically strong candidates for our hypotheses, these results cannot be generalized to other trait-level correlates of heavy drinking (e.g., facets of Neuroticism; Littlefield et al., 2009). Further, recent factor analytic studies have demonstrated that dispositional impulsivity is better conceptualized as four distinct traits other than sensation seeking: lack of planning, lack of perseverance, and positive and negative urgency (Cyders & Smith, 2008; Smith et al., 2007; Whiteside & Lynam, 2001). Because the measure of impulsivity used in this study predates those investigations, we were unable to distinguish among these facets in the present research.

Finally, college students drink more heavily than their non-college peers, and alcohol use is most common and most heavy during the college years (Bachman et al., 2002; Bachman et al., 1997). College students are therefore an ideal population in which to identify the effects of drinking on personality change. The college sample does, however, limit the extent to which we can generalize the current findings to other populations. Moreover, the sample included in our analyses was biased relative to the full sample as a result of the attrition of 36% of the sample. Our attrition rate was comparable to other larger-scale longitudinal studies of alcohol use among college students (Goudriaan, Slutske, Krull, & Sher, 2009; Park et al., 2009), although we note that smaller studies of college students have shown stronger retention (e.g., retention rates of approximately 85%; Littlefield et al., 2009; Walls, Fairlie, & Wood, 2009). In the current investigation, biased retention may have reduced variance in study variables, resulting in attenuation of path coefficients due to range restriction. The effect sizes reported for associations among personality traits and heavy drinking may therefore represent lower-bound estimates of the true magnitudes of the transactional relations.

Conclusions

In demonstrating that heavy drinking predicts individual differences in the maturation of sensation seeking and impulsivity, this investigation identified a new consequence of collegiate alcohol use. Prior research has identified some short- and longer-term consequences of collegiate drinking, even among those who will eventually mature out of heavy drinking (Jackson et al., 2001; O'Neill, Parra, & Sher, 2001). The current study suggests that, in addition, heavy drinking in college may exert a broad, negative influence on behavior because of its effect on personality change. Drinking heavily in college may not only lead to event-level consequences of intoxication such as overslept classes, fights with friends, and failures to use protection in sexual encounters (Neal & Fromme, 2007). It may more generally increase propensities to prefer risky activities to safe ones and short-term rewards to long-term benefits, thereby contributing to more pervasive negative outcomes.

Although the magnitude of the effect of heavy drinking on differential trait change was not large, any personality change is likely to have clinically meaningful ramifications across a wide range of behaviors. Mroczek and Spiro (2007) demonstrated that increases in trait-level neuroticism, for example, predicted mortality in older adults. Further, decreases in neuroticism may contribute to the positive outcomes of some depression treatments (Tang et al., 2009). Given the substantial evidence that absolute levels of sensation seeking and impulsivity predict many clinically meaningful outcomes, it stands to reason that increases

in these traits may result in even greater negative outcomes. In addition to the ample evidence demonstrating the efficacy of brief interventions to reduce alcohol use among college students (Larimer & Cronce, 2007), impulsivity and sensation seeking have emerged as the focus of several recently developed interventions aimed at preventing substance abuse and other outcomes (Conrod, Castellanos-Ryan, & Strang, 2010; Conrod, Castellanos, & Mackie, 2008; Duckworth, Grant, Loew, Oettingen, & Gollwitzer, in press). Our findings suggest that targeting both drinking and these traits may prevent college students and other youth from the mutually reinforcing effects of increasing drinking and more problematic personality change. Intervening early may help prevent the escalation and expansion of negative outcomes.

Acknowledgments

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Figure 1.
Transactional relations between heavy drinking and sensation seeking across the college years. Values are standardized regression and correlation coefficients. Bolded lines indicate paths of interest. Italicized coefficients reflect constraints imposed on the model. Wksum = typical weekly drinking. Binge = binge drinking. Intox = subjective intoxication. P1–3 = sensation seeking parcels. Δ = latent difference score. * $p < .05$.

Figure 2.
Transactional relations between heavy drinking and impulsivity across the college years. Values are standardized regression and correlation coefficients. Bolded lines indicate paths of interest. Italicized coefficients reflect constraints imposed on the model. Wksum = typical weekly drinking. Binge = binge drinking. Intox = subjective intoxication. P1–3 = impulsivity parcels. Δ = latent difference score. * $p < .05$.
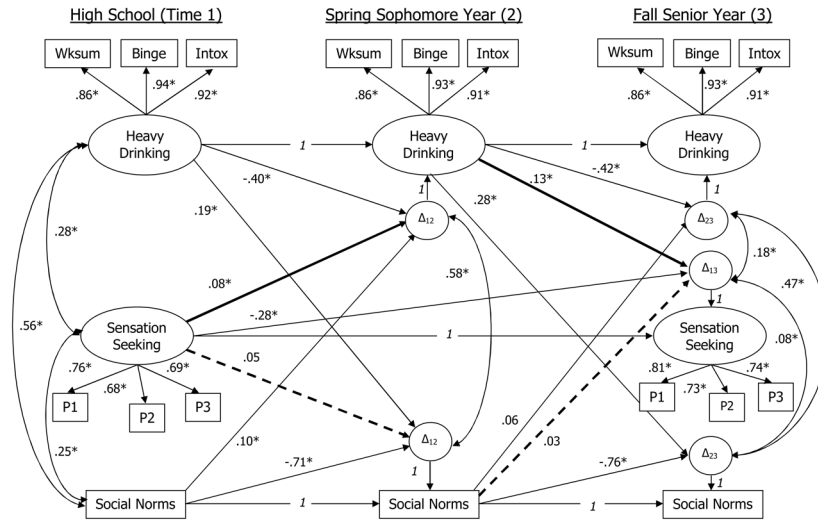
Figure 3.
Transactional relations between heavy drinking and sensation seeking over and beyond
social group descriptive drinking norms. Values are standardized regression and correlation
coefficients. Bolded lines indicate paths of interest. Dashed lines indicate comparison paths
for social norms. Italicized coefficients reflect constraints imposed on the model. Wksum =
typical weekly drinking. Binge = binge drinking. Intox = subjective intoxication. P1–3 =
sensation seeking parcels. Δ = latent difference score. * $p < .05$.
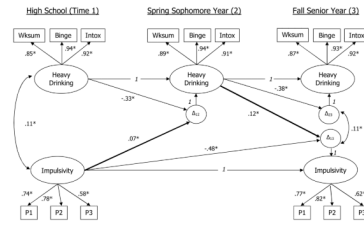
Figure 4.
Heavy drinking predicts change in impulsivity over and beyond social group descriptive drinking norms. Values are standardized regression and correlation coefficients. Bolded lines indicate paths of interest. Dashed lines indicate comparison paths for social norms. Italicized coefficients reflect constraints imposed on the model. Wksum = typical weekly drinking. Binge = binge drinking. Intox = subjective intoxication. P1–3 = impulsivity parcels. Δ = latent difference score. * $p < .05$.
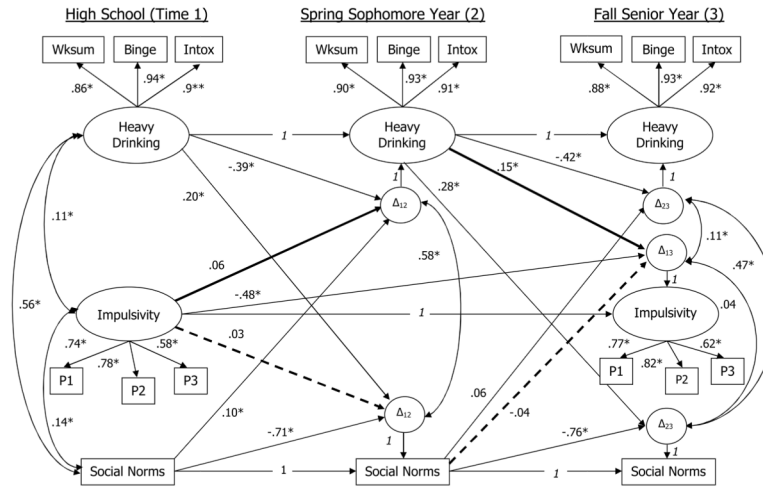
Table 1

Bivariate Correlations among Personality Traits, Heavy Drinking, and Social Norms

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Impulsivity																	
1. High school	-																
2. College senior	.39*	-															
Sensation seeking																	
3. High school	.49*	.30*	-														
4. College senior	.31*	.56*	.53*	-													
Autonomy																	
5. High school	.11*	.08*	.11*	.10*	-												
6. College senior	.12*	.11*	.09*	.11*	.52*	-											
Typical weekly drinking																	
7. High school	.10*	.15*	.20*	.16*	.07*	.04	-										
8. College sophomore	.11*	.17*	.19*	.22*	-.02	.01	.51*	-									
9. College senior	.11*	.24*	.18*	.28*	-.04	.01	.47*	.63*	-								
Binge drinking																	
10. High school	.05	.13*	.14*	.13*	.02	-.02	.74*	.42*	.40*	-							
11. College sophomore	.09*	.14*	.14*	.17*	-.05	-.01	.48*	.76*	.55*	.44*	-						
12. College senior	.09*	.18*	.12*	.21*	-.05	-.01	.40*	.55*	.79*	.35*	.60*	-					
Subjective intoxication																	
13. High school	.04	.11*	.14*	.10*	-.01	-.04	.72*	.40*	.38*	.82*	.44*	.34*	-				
14. College sophomore	.06*	.11*	.14*	.18*	-.08*	-.05	.46*	.72*	.54*	.40*	.81*	.57*	.45*	-			
15. College senior	.08*	.18*	.11*	.19*	-.07*	-.01	.36*	.52*	.70*	.32*	.58*	.78*	.35*	.63*	-		
Social group norms																	
16. High school	.12*	.19*	.19*	.16*	.07*	.07*	.57*	.35*	.33*	.41*	.31*	.25*	.38*	.28*	.23*	-	
17. College sophomore	.08*	.15*	.17*	.19*	-.01	.03	.43*	.73*	.54*	.36*	.58*	.44*	.35*	.57*	.43*	.37*	-
18. College senior	.10*	.18*	.16*	.24*	-.02	.04	.42*	.59*	.76*	.35*	.53*	.65*	.33*	.49*	.58*	.35*	.60*

*
$p < .05$.

Table 2

Summary Statistics for Personality, Heavy Drinking, and Social Norms

Variable	Observed Range	High School Mean (*SD*)	College Sophomore Mean (*SD*)	College Senior Mean (*SD*)
Personality traits				
Sensation seeking	0–11	5.40_a (2.69)	-	5.27_a (3.05)
Impulsivity	0–8	1.92_a (1.92)	-	1.80_a (1.98)
Autonomy	14–53	26.86_a (6.37)	-	26.52_a (7.23)
Heavy drinking				
Standard drinks consumed in a typical week	0–95	2.52_b (5.50)	4.92_b (8.25)	6.44_c (8.84)
Frequency of binge drinking	0–80	1.82_a (5.32)	3.28_b (6.82)	4.16_c (7.37)
Frequency of subjective intoxication	0–81	1.49_a (4.46)	2.81_b (5.67)	3.49_c (6.61)
Social group drinking norms	0–162	5.71_a (8.73)	8.68_b (10.56)	10.13_c (9.89)

Note. Means within rows that do not share subscripts significantly differ, $p < .05$.

Table 3

Fit Indices for Measurement Invariance (MI) Models

Model	χ^2 (df)	$\Delta\chi^2$	CFI	ΔCFI[a]	NCI	ΔNCI	ΔNCI Criteria[a]
Heavy drinking							.0072
Unconstrained	255.20 (24)	-	.982	-	1.0840	-	
Weak MI	**278.95 (28)**	**23.75***	**.980**	**.002**	**1.0912**	**.0072**	
Strong MI	459.19 (33)	180.24*	.966	.014	1.1603	.0688	
Strict MI	546.71 (39)	87.52*	.959	.007	1.1938	.0334	
Sensation Seeking							.0062
Unconstrained	175.33 (8)	-	.943	-	1.0601	-	
Weak MI	176.30 (10)	0.97	.943	.000	1.0597	.0004	
Strong MI	183.43 (12)	7.13*	.941	.002	1.0616	.0019	
Strict MI	**188.20 (15)**	**4.77**	**.941**	**.000**	**1.0622**	**.0006**	
Impulsivity							.0062
Unconstrained	74.23 (8)	-	.973	-	1.0233	-	
Weak MI	74.71 (10)	0.48	.974	.001	1.0228	.0005	
Strong MI	**75.95 (12)**	**1.24**	**.974**	**.000**	**1.0225**	**.0002**	
Strict MI	85.25 (15)	9.30*	.971	.003	1.0248	.002	
Autonomy							.0062
Unconstrained	200.93 (8)	-	.955	-	1.0696	-	
Weak MI	203.64 (10)	2.71	.955	.000	1.0698	.0002	
Strong MI	206.84 (12)	3.20	.955	.000	1.0703	.0005	
Strict MI	**219.00 (15)**	**12.16***	**.953**	**.002**	**1.0737**	**.0034**	

Note. Rows in bold indicate the selected measurement invariance models for each construct. CFI = Comparative fit index; NCI = McDonald's noncentrality index.

[a] The minimum criteria for change in model fit indicated by the CFI (.002) and NCI were taken from Meade and colleagues (2008).

*
$p < .05$.

Table 4

Individual Differences in Change in Personality, Alcohol Use, and Social Norms

Latent Difference Score	Variance	
	Estimate	95% C.I.
Sensation seeking		
High school to senior	0.04	[0.03, 0.04]
Impulsivity		
High school to senior	0.04	[0.03, 0.04]
Autonomy		
High school to senior	0.18	[0.16, 0.20]
Heavy drinking[a]		
High school to sophomore	2.05	[1.88, 2.23]
Sophomore to senior	1.47	[1.34, 1.61]
Social group norms[a]		
High school to sophomore	3.43	[3.18, 3.68]
Sophomore to senior	2.48	[2.30, 2.67]

Note. All variances were significant, $p < .05$.

[a]Variances for heavy drinking and social group norms are from sensation seeking models. Variance estimates from impulsivity models were virtually identical and were also significant.