HHS Public Access

Author manuscript

Psychol Addict Behav. Author manuscript; available in PMC 2017 December 01.

Published in final edited form as:

Psychol Addict Behav. 2016 December ; 30(8): 827–837. doi:10.1037/adb0000214.

Latent Growth Classes of Alcohol-Related Blackouts over the First Two Years of College

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Abstract

Alcohol-related blackouts are common among college student drinkers. The present study extends prior work by examining latent growth classes of blackouts and several predictors of class membership. Participants (N=709 college drinkers) completed a baseline survey at college entry and biweekly online assessments throughout freshman and sophomore years. Results revealed five latent growth class trajectories, reflecting varying experiences of blackouts at the beginning of college and differential change in blackouts over time. The largest class represented a relatively low risk group (LOW DECR; 47.3%) characterized by endorsement of no or very low likelihood of blackouts, and decreasing likelihood of blackouts over time. Another decreasing risk group (HIGH DECR; 11.1%) initially reported a high proportion of blackouts and had the steepest decrease in blackout risk over time. A small percentage showed consistently high likelihood of blackouts over time (HIGH STABLE; 4.1%). The remaining two groups were distinguished by relatively moderate (MOD STABLE; 14.9%) and lower (LOW STABLE; 22.6%) likelihood of blackouts, which remained stable over time. Comparisons between classes revealed that students with greater perceived peer drinking, perceived peer approval of drinking, and enhancement motives upon entry to college tended to be in higher-risk groups with consistent experiences of blackouts over time, whereas blackout likelihood decreased over time for students with greater conformity motives. Findings suggest that pre-college preventive interventions may be strengthened by considering not only factors related to current risk for blackouts and other alcohol-related consequences, but also those factors related to persistence of these behaviors over time.

Keywords

latent growth class; college students; alcohol use; blackout

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These findings were presented at the 2016 annual meeting of the American Psychological Association in Denver, CO.

Introduction

Hazardous drinking practices escalate during the early college years. Over one third of college students report engaging in heavy episodic drinking (5+ drinks in a single sitting for females/males) at least once in the past 2 weeks (Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2016). This type of risky drinking is associated with increases in disordered alcohol use (Chassin, Pitts, & Prost, 2002; Dawson, 2011; Dawson, Smith, Pickering, & Grant, 2012), leading to myriad consequences for drinkers and non-drinking students alike (Hingson, Zha, & Weitzman, 2009). One consequence of risky drinking is alcohol-related blackout, sometimes classified as en bloc (i.e., total absence of memory for a circumscribed period of time) or fragmentary (i.e., ability to retrieve partial memory with appropriate cues) types (Goodwin, Crane, & Guze, 1969). This study sought to identify distinct growth trajectories of alcohol-related blackouts during the first two years of college, a critical developmental period for heavy drinking and related problems, and to examine pre-college predictors of these trajectories.

Alcohol-induced blackouts are a relatively common experience among drinkers, particularly among college students and young adults (Jennison & Johnson, 1994), and are associated with other acute negative outcomes, above and beyond the risks associated with heavy drinking. While there is variability across studies, estimates indicate that at least half of students experience blackouts before or during college (Marino & Fromme, 2015; Perkins, 2002; White, Jamieson-Drake, & Swartzwelder, 2002). Moreover, up to one-third report experiencing a blackout in the past year (White et al., 2002). Blackouts mediate the relationship between alcohol use and behavioral risk, such that experiencing blackouts is associated with an increased likelihood of engaging in risky behavior while drinking (Wray, Simons, Dvorak, & Gaher, 2012). Indeed, approximately half of college students with a history of blackouts report engaging in risky behaviors during a blackout, such as insulting someone (33%) or spending money unintentionally (27%) (White et al., 2002). Other research shows that frequency of blackouts is linked to a higher likelihood of injury and emergency department care (Mundt & Zakletskaia, 2012; Mundt, Zakletskaia, Brown, & Fleming, 2012), and that blackout drinking is prospectively associated with sexual revictimization in college women who had been victimized as adolescents, after controlling for alcohol quantity (Valenstein-Mah, Larimer, Zoellner, & Kaysen, 2015). Clearly, blackouts can lead to negative social and emotional consequences, above the effect of alcohol use per se (Wilhite & Fromme, 2015), making them an important area of study.

Trajectories of Blackouts

Whether and how the occurrence of blackouts may change over time among college students is not well-studied. It is likely that there are individual differences in trajectories of blackouts over time, with some students decreasing, some remaining steady, and others possibly increasing in the likelihood of experiencing blackouts. Generally speaking, some individuals reduce their drinking behavior naturalistically, without formal treatment (Baer, Kivlahan, & Marlatt, 1995; Sobell, Sobell, Toneatto, & Leo, 1993; Watson & Sher, 1998). Behavioral learning theories and research (Barnett, Merrill, Kahler, & Colby, 2015; Merrill, Read, & Barnett, 2013) suggest that negative drinking consequences such as alcohol-related

blackouts may serve as important catalysts of change. Consequently, some individuals may experience fewer and fewer blackouts over time because they find the experience punishing. On the other hand, other individuals who experience greater levels of problems may be at increased risk for continued drinking and/or alcohol-related problems (Read, Wardell, & Bachrach, 2012). As such, it is possible that another subset of individuals continues to experience blackouts consistently, or at increasing levels, if they become more alcohol-involved over time. Developmental theories of psychopathology suggest that subsets of youth may start with similar characteristics but end up with very different endpoints (multifinality) while others may start with very different characteristics and end up with similar endpoints (equifinality) (Cicchetti & Rogosch, 1996). In sum, several different trajectories of blackouts may be expected to emerge across individuals, and assuming a single pattern of change over time would ignore such nuances.

One study among college students examined change over time in blackouts, with a single predictor of interest – early onset of drinking (Marino & Fromme, 2016). The frequency of blackouts was higher among those with earlier onset drinking, though the rate of change in blackouts was not dependent on this predictor. This study represented an important contribution to the literature but did not take into account potential variability in trajectories of blackouts over time or a range of possible predictor variables. Examining latent trajectory classes of alcohol-related blackouts and their predictors may help to distinguish college students who are likely to show naturalistic reductions in this high-risk behavior from those who might require further intervention.

In a recent study that did examine different change patterns, Schuckit and colleagues (2015) investigated latent class trajectories of blackouts and predictors of those classes in a longitudinal study of 1,402 adolescent drinkers (ages 15–19). Latent growth modeling identified four classes of trajectories of blackout occurrence over the 4-year study period. The four classes were characterized by no blackouts, gradually increasing blackouts, rapidly increasing blackouts, or consistent blackouts at each time point (Schuckit et al., 2015). The class reporting consistent blackouts was significantly higher in proportion of females, alcohol use quantity and frequency, externalizing traits, cannabis use, tobacco use, and peer substance use (Schuckit et al., 2015). Further, rapid increasers were differentiated from gradual increasers by higher extraversion and peer substance use. This study offered evidence that distinct patterns of blackout occurrence over time can be either fluid or static. Similar investigations in other populations (e.g., college students) that identify characteristics associated with risk for consistently high or increasing rates of blackout, as well as protective factors for decreasing or maintaining low rates, can inform interventions targeting at-risk individuals. In determining which characteristics to examine as predictors of latent growth classes of blackouts among college students, we turn briefly to theory and prior research on correlates of static levels of blackouts.

Social and Cognitive Predictors of Risk for Blackouts

Students who appear similar at the start of college in terms of blackouts and other alcohol-related risky behaviors may appear very different after the first years of college experiences. Thus, although we may not be able to differentiate some groups on the basis of blackouts at

the beginning of college, we may be able to use pre-existing differences in other individual-level characteristics to predict who will persist at high risk of blackouts over the early college years from those who will improve (i.e., decrease in blackout likelihood) over time. While neurobiological and/or genetic influences play an important role in predicting blackouts (Marino & Fromme, 2015; Nelson et al., 2004; Wetherill, Castro, Squeglia, & Tapert, 2013), they do not explain all of the variance in blackout risk and may be less amenable to direct intervention, making examination of psychosocial influences fruitful. According to social cognitive theory (Bandura, 1986), two categories of influence that may be particularly relevant are (1) social influences and (2) cognitions.

Social Influences—Social cognitive theory posits a role for learning from one's social environment. In line with this, studies report that blackout risk is higher among those with heavier drinking peers (Schuckit et al., 2015) and among those whose peers also experience blackouts (White et al., 2002). Students with perceptions of higher peer drinking prior to college were more likely to report multiple alcohol-related consequences (including blackouts) during college (Varvil-Weld, Mallett, Turrisi, Cleveland, & Abar, 2013; Wood, Read, Mitchell, & Brand, 2004). In the present study we examine the unique influence of perceptions of peer approval of drinking (injunctive norms) and perceptions of actual peer drinking (descriptive norms), measured prior to college, on trajectories of blackouts over the course of college. It is plausible that youth with beliefs that drinking behavior is more acceptable or common among their peers also believe that it is common and/or acceptable to experience alcohol consequences such as blackouts. As such, they may increase or remain at stable, higher levels of blackout likelihood over time, above and beyond any changes in drinking.

Cognitive Influences—Social cognitive theory explicitly highlights the importance of alcohol expectancies, i.e., beliefs about the likelihood of positive and negative outcomes of drinking, in the prediction of drinking behavior. Stronger negative and positive alcohol expectancies have been demonstrated as potentially important individual-level correlates of blackouts (Buelow & Harbin, 1996; Hartzler & Fromme, 2003). However, this prior work has been cross-sectional, and no study has examined whether expectancies predict changes over time in blackouts. Beliefs that drinking is likely to result in more positive and/or fewer negative outcomes may be associated with increasing or maintaining higher levels of blackouts over time.

Another cognitive predictor of drinking behavior is drinking motives, i.e., reasons for consuming alcohol. In motivational models of drinking, the regulation of affect is highlighted (Cooper, 1994; Cooper, Russell, Skinner, & Windle, 1992; Cox & Klinger, 1988; Grant, Stewart, O'Connor, Blackwell, & Conrod, 2007), with two motive types consistently emerging: coping motives (i.e., drinking to alleviate negative mood states) and enhancement motives (i.e., drinking to enhance positive mood states). Enhancement motives are positively related to a number of consequences, including alcohol-induced memory loss, in both cross-sectional (Merrill & Read, 2010) and longitudinal (Merrill, Wardell, & Read, 2014) studies. It is possible that those drinkers seeking to "get high" and enhance positive mood drink in a way (e.g., quickly or in larger sips) that may be associated with subsequent blackouts

(Goodwin, 1995; Goodwin, Crane, & Guze, 1969; Perry et al., 2006), resulting in an impact of enhancement motives on blackout trajectories above and beyond volume of alcohol use per se.

As suggested by Schuckit et al (2015), coping motives may also be relevant. Indeed, this motive domain also has been linked to a range of alcohol-related consequences above and beyond level of drinking (Merrill & Read, 2010; Merrill et al., 2014). In an attempt to forget their worries, coping-motivated drinkers may be at greater risk for drinking to blackout levels, or may be among a subset of students who intentionally seek to black out. However, no study to date has examined drinking motives as unique predictors of a measure of alcohol-induced blackouts. Thus, whether individuals with stronger affect-regulatory motives display riskier trajectories in blackouts than those with weaker motives remains poorly understood.

The Present Study

In sum, blackouts can increase proximal risks to health, safety, and psychosocial functioning above and beyond the direct risks of heavy drinking. The goals of the present study were to (1) examine latent patterns of growth in blackouts (accounting for heavy drinking) over the course of the first two years of college, thereby extending the findings of Schuckit et al. (2015) to a U.S. college student sample, and (2) test a set of theoretically important social and cognitive predictors of class membership. We address several important gaps in the literature. First, many studies have relied on cross-sectional methods, and even longitudinal studies have had relatively few time points, precluding the ability to examine fine-grained patterns of blackouts. In the present study, we utilize 36 repeated measures over a two-year period to characterize classes of trajectories of alcohol-induced blackouts among college students with high temporal precision. Second, we describe latent growth classes as a function of pre-college individual difference variables, with a particular focus on social and cognitive factors such as drinking motives, which have yet to be examined as predictors of alcohol-related blackouts (either cross-sectionally or longitudinally), and expectancies, which have not been examined as predictors of longitudinal change over time in blackouts. We hypothesized that our data would be characterized by multiple latent class trajectories of blackouts, with at least one class characterized by no/low-risk for blackouts and one exhibiting consistent/high-risk for blackouts. Though we could not make specific *a priori* hypotheses without first estimating growth classes, we generally expected that riskier patterns of blackouts over time would be linked to pre-college perceptions that peers drink more and approve of drinking more, and to higher positive and lower negative expectancies and stronger coping and enhancement motives.

Method

Participants

In the larger study from which these data were drawn, 1,053 participants (57.5% female) from three universities were enrolled in three cohorts. Participants were dropped from the present study if they did not complete any biweekly surveys following the baseline survey (n = 49, 4.7%), or if they did not report lifetime consumption of at least one full drink at

baseline (n = 295; 28%). The final sample for the present study was N = 709. As might be expected in a sample selected for alcohol use, participants included in our analyses were significantly more likely to be White than Asian or other race (χ^2=25.43, p<.01) and reported a greater number of blackouts over the course of the study (t=-6.289, p<.01). However, those included and not included did not differ by gender (χ^2=1.42, p=.13) or age (t=-1.347, p=.18).

Procedures

A random sample of students from three college/university sites was invited to enroll prior to their first year of school. Following the baseline assessment, participants were randomly assigned to one of two biweekly assessment groups. Each week, starting with the first week of the freshman year, one of the two alternating groups received an email containing a link to a brief web-based survey. These assessments were conducted during the freshman and sophomore academic years, including winter but not summer breaks. For each participant, there were a total of 36 possible biweekly assessments over the first two years of college (18 per year). Participants were compensated $20 for the baseline survey and $2 for every completed biweekly survey; additional raffles and bonuses were used to enhance response rates. All procedures were approved by the Institutional Review Boards at the three sites. See Barnett et al. (2014) for additional detail about study procedures.

Measures

Demographics—Gender, race/ethnicity, and age were assessed at baseline.

Blackouts—On each biweekly survey, if a participant endorsed alcohol use, he/she was asked about past week experience of blackouts with the item “I can’t remember some part of the day or night (I said or did things that I did not remember afterwards).” Response options included 0 (no), 1 (yes, lasting less than one hour) and 2 (yes, lasting more than one hour).

Heavy episodic drinking—On each biweekly survey, participants entered drinks consumed on each of the past seven days using an automatically produced past-week diary grid based on the day the survey was completed. These data were used to calculate the number of days on which participants engaged in heavy episodic drinking, defined here as 4+ drinks for women and 5+ drinks for men.

Past-year (high school) alcohol use—At baseline, using the Graduated Frequency for Alcohol Measure (Hilton, 1989), participants reported frequency of consuming their self-reported maximum number of drinks and frequency of drinking at each lower level (12 or more, 8–11, 5–7, 3–4, and 1–2 drinks) during senior year of high school. This measure utilized a Likert-type scale with response options ranging from 1 (“never”) to 9 (“every day or nearly every day”). This measure was used to calculate number of heavy drinking days per month, to be used as a baseline covariate in models estimating latent growth class membership.

Peer variables—Peer items were drawn from Wood et al. (2004). At baseline, perceived peer drinking was assessed with the mean of four items. The first three assessed how many

of the participant's close friends (1) drink alcohol, (2) get drunk on a regular basis (at least once/month), and (3) drink primarily to get drunk (0 = none to 5 = nearly all). The fourth item assessed friends' average quantity (0 = they don't drink to 4 = more than 6 drinks). Alpha was .90. Perceived peer approval of drinking was assessed with the mean of two items (r=.78) asking how most of the participant's friends feel about (1) drinking, and (2) getting drunk (0 = strongly disapprove to 4 = strongly approve).

Expectancies—At baseline, positive and negative expectancies were assessed with the Brief-Comprehensive Effects of Alcohol Scale (B-CEOA; (Ham, Stewart, Norton, & Hope, 2005), a validated shortened version of the CEOA (Fromme, Stroot, & Kaplan, 1993). Individuals rated the extent to which they agreed with each item (1 = disagree, 4 = agree). Eight items assessed positive (α = .81; e.g., I would feel calm, I would act sociable) and seven items assessed negative expectancies (α = .72; e.g., I would feel dizzy, I would act aggressively).

Drinking motives—Using the Drinking Motives Questionnaire Revised (DMQ-R, Cooper, 1994), respondents who reported past-year drinking (n=675) rated their frequency of drinking for each of 20 reasons on a scale from 1 (almost never/never) to 5 (almost always/always). Subscale scores were created by summing the five subscale items. In the present sample, internal reliabilities were α = .81 (Coping), α = .89 (Enhancement), α = .87 (Social), and α = .84 (Conformity).

Analytic Plan

Latent class growth analysis (LCGA) was implemented with Mplus software version 7.0 (Muthen & Muthen, 1998–2012) to describe the longitudinal patterns of blackouts over the first two years of college in this sample. LCGA is a model-based approach to cluster individuals into groups (i.e., classes) based on their responses to a set of observed variables measured repeatedly over time (Nagin, 2005). To better delineate trajectories of blackouts, per se, above and beyond what may be explained by heavy drinking, a dual trajectory model was implemented whereby two growth processes were modeled: one accounting for change in blackouts over the two-year period, and one accounting for change in heavy drinking over the same period. Thus, the latent class groups were defined by both blackout and heavy drinking growth factors. Our approach was to first specify an unconditional LCGA dual-trajectory model without additional covariates to determine class membership, and then conduct a subsequent covariate analysis.

Blackouts were assessed as a categorical variable with three response categories (i.e., 0 = no blackout, 1 = blackout < 1 hour, 2 = blackout > 1 hour). Blackouts were reported at 36 time points over first two years of college, exclusive of summer weeks. Thus, time in the LCGA was coded 0 through 17, then 26 through 42, to correspond to assessment number. First, an unconditional (single class) latent growth model evaluated general trends in blackouts and heavy drinking reported over assessment weeks to identify a functional form. Next, a series of LCGA models with 2 to 6 classes were compared to determine the optimal number of groups (classes) of students with distinct growth trajectories. Each model accounted for pre-college number of heavy drinking days per month. Selection of the most representative

model for our data was based on a combination of quantitative criteria (i.e., entropy, the Akaike Information Criterion [AIC], Bayesian Information Criterion [BIC], Sample-size adjusted BIC, posterior probabilities, likelihood ratio tests [LRTs]) and consideration of qualitative aspects (i.e., interpretability, discriminant ability) for each model.

After the LCGA model with the most informative number of groups (classes) was selected, students were assigned to their most likely class based on model probabilities. First, class membership was explored with descriptive statistics (i.e., means and frequencies) and univariate tests. Next, multinomial logistic regression analysis implemented with SAS 9.3 software PROC LOGISTIC (SAS Institute Inc., 2001–2010) examined the influence of pre-college characteristics on class membership. In addition to our primary focus on peer influences, alcohol expectancies, and drinking motives, we modeled demographic covariates shown to relate to blackouts in prior work. These included gender (Marino & Fromme, 2015; Schuckit et al., 2015; White et al., 2002), age (Jennison & Johnson, 1994; Mundt et al., 2012; Perry et al., 2006), and race/ethnicity (Hingson, Zha, Simons-Morton, & White, 2016; LaBrie, Hummer, Kenney, Lac, & Pedersen, 2011; Marino & Fromme, 2015). Of note, this analysis was conducted on the subset of participants who provided drinking motives data (n=675).

Specific post-hoc group comparisons were informed by developmental theory, with the goal of providing comparisons of substantive interest and potential for meaningful clinical contribution. We systematically shifted the reference group in order to conduct comparisons that would be of theoretical interest (e.g., a contrast that differentiated among two trajectories that began at the same place and ended at different places, multifinality, or between two trajectories that began at different places and ended at the same place, equifinality). Pre-college predictors were entered simultaneously to evaluate the unique significance of each predictor over and above other characteristics. Continuous predictors were standardized and multiple category predictors were effect-coded to facilitate interpretation of odds ratios (ORs) across predictors.

Results

Sample Description

Participants were 709 students (59% female, $n = 417$), with an average age of 18.36 years at their first assessment ($SD = 0.46$, range 15.51–20.22). The sample was 12% ($n = 83$) Latino/Hispanic. Participants were 70% ($n = 498$) White, 9% ($n = 67$) Asian-American, 6% ($n = 42$) Black, and 6% ($n = 45$) Multiracial; 8% ($n = 57$) indicated “other” or did not indicate a race (most of these participants reported Latino/Hispanic ethnicity). For analyses, to capture potential differences between the largest racial/ethnic groups in our sample, race/ethnicity was collapsed into White (70.2%) vs Asian (9.4%) vs other (20.3%). First semester GPA in this sample averaged 3.26 (SD=0.61), and 99% and 88% of participants lived on campus in their first and second year, respectively.

Response rates for each of the 36 study weeks, as well as rates of blackouts and mean levels of heavy drinking days are included in Supplementary Table 1. Briefly, response rates on biweekly surveys ranged from 77–91%. The number of surveys completed over the course

of the 2 years was not correlated with either past year or lifetime blackouts as reported at baseline, gender, race, or baseline age (ps>.05). Across the two years of the study, 36% of participants (n = 255) did not report any blackouts. Among the remaining students who reported one or more blackouts, it was more common to report blackouts lasting less than 1 hour (57.8% of the sample reported at least one) than longer blackouts lasting more than 1 hour (36.8% of the sample reported at least one). There were no differences in the total number of blackouts experienced or average number of heavy episodic drinking episodes across the 36 assessments by either study site or cohort (ps>.05), so remaining analyses collapsed across both.

Latent Class Growth Analysis

As an initial step, an unconditional (single-class) latent growth model (LGM) was conducted to describe general trends in blackouts over time. A linear model fit the data well, χ^2 (661) = 757.38, p = .005, RMSEA = .014, CFI = .97, TLI = .97, WRMR = 1.07. Convergence issues were indicative of poor fit for a quadratic model. A significant negative slope for the linear model suggested that, on average, blackouts decreased as students progressed through their first two years of college, b = −0.02, SE = .004, p < .001. An unconditional LGM for heavy drinking also provided adequate fit for these data, χ^2 (661) = 2420.75, p < .001, RMSEA = .061, CFI = .83, TLI = .84, SRMR = 0.07. In contrast to blackouts, heavy drinking did not significantly decrease over time, b = − 0.001, SE = .001, p = .464. Finally, a combined parallel process LGM indicated a positive association of growth in heavy drinking with growth in blackouts over time, r = .45, SE = .001, p < .001.[1]

Next, we used LCGA to characterize patterns in the occurrence of blackouts over time using the parallel process model (hence accounting for heavy drinking in our model). Table 1 shows fit parameters and class proportions for successive LCGAs comparing k and k – 1 classes. Of the likelihood-based tests and the traditionally used Information Criterion (ICs) reported, the BLRT is shown to perform the best for growth mixture modeling in general, followed by BIC and ABIC (Nylund, Asparouhov, & Muthén, 2007). In the present case, the BLRT did not become nonsignificant, and the BIC or ABIC did not reach a minimum. Turning to qualitative considerations, class solutions for 2 to 6 classes are shown in Supplemental Figure 1. With respect to our goal to explain patterns in blackout during a high-risk period, the 5-class model was the first to offer considerably more meaningful and interesting group comparisons, and the 6-class model did not add beyond that. We thus selected the more parsimonious model.

Entropy for the 5-class model was relatively high (i.e., .90), with posterior probabilities for most likely class membership ranging from .87 to .97, and low off-diagonal probabilities ≤ .07. These statistics suggested good class identification and separation in the 5-class model. Two groups showed decreasing slopes over time, which was consistent with the unconditional growth and overall trend, and three groups showed relatively stable slopes over time. The majority of the sample represented a relatively low risk group (LOW DECR; Class 3; 48.0%) characterized by endorsement of no or very low endorsement of blackouts,

[1]Because convergence problems were encountered when intercept variances were freely estimated in this parallel process LGM, these variances were set to zero.

and decreasing blackouts over time, $b = -0.04$, $SE = .01$, $p = .001$. Another decreasing risk group (HIGH DECR; Class 1; 10.9%) initially reported high blackouts and decreasing blackouts over time, $b = -.04$, $SE = .01$, $p < .001$. A much smaller percentage (HIGH STABLE; Class 5; 4.1%) showed high endorsement of blackouts, with a non-significant decrease over time, $b = -0.01$, $SE = .01$, $p = .126$. The remaining two groups reported fairly consistent blackouts over the first two years of college and were distinguished by relatively moderate (MOD STABLE; Class 4; 14.8%) and lower (LOW STABLE; Class 2; 22.3%) blackouts, in general. Slopes for Classes 4 and 2 were not significant, $b = -0.01$, $SE = .006$, $p = .140$, and $b = .00$, $SE = .01$, $p = .947$, respectively. Table 2 displays results of models relating pre-college characteristics to class membership, and descriptives on model variables for the full sample and within each class.

Multinomial Logistic Models Relating Pre-College Characteristics to Class Membership

Prior to running multivariate models, we determined that the lowest tolerance of all predictors was .42, indicating that collinearity among additional predictors was not an issue (Tabachnick & Fidell, 2007). Table 3 displays results of multinomial logistic regression models (conducted with SAS software) relating pre-college predictors to patterns of change in blackouts over the first two years of college. Tabled odds ratios reflect the log likelihood of being in a particular group (class), relative to a given reference group. Generally, consistent with hypotheses, students' normative beliefs about peer drinking levels and acceptance of drinking, as well as enhancement drinking motives, emerged as significant predictors of increased likelihood of membership in classes with greater endorsement of blackouts. Further, there was some evidence that pre-college conformity motives were a protective factor.

The comparisons of HIGH STABLE v. HIGH DECR and LOW STABLE v. LOW DECR reflect examples of multifinality, in that initial proportions of blackouts were similar, but change over time led to varying proportions of blackouts by the end of the second college year. Although these groups would not be differentiated at the start of college based on their experience of blackouts or heavy drinking alone, students with greater enhancement motives were more likely to be in groups characterized by consistent endorsement of blackouts over time, rather than groups characterized by decreasing endorsement of blackouts over the first two years of college. Enhancement motives were associated with 49% greater log odds of remaining in the LOW STABLE group, rather than the LOW DECR group (OR = 1.49, 95%CI [1.13, 1.96]) and associated with 88% greater log odds of remaining in the HIGH STABLE group, rather than the HIGH DECR group (OR = 1.88, 95%CI [1.02, 3.45]). Perceived peer drinking similarly differentiated the LOW STABLE and LOW DECR groups, whereas perceived peer approval of drinking differentiated between the HIGH STABLE and HIGH DECR group. Indeed, the log odds of remaining in the LOW STABLE group increased by 72% for youth with greater perceived peer drinking (OR = 1.72, 95%CI [1.26, 2.34]), and log odds of remaining in the HIGH STABLE group increased by 195% for youth with greater perceived peer approval (OR = 2.95, 95%CI [1.20, 7.26]). Figure 2 illustrates average pre-college levels of each of these four characteristics (i.e., peer drinking, peer approval, enhancement motives, conformity motives) plotted separately for each class.

As shown in Table 3, we chose a third comparison based on a pattern of equifinality, whereby the HIGH DECR and LOW STABLE groups began at very different levels but ended at similar levels of blackouts. However, we did not observe any significant pre-college predictors of this comparison. The remaining three comparisons focused on more general "level differences." Students with greater conformity motives were less likely to be in the HIGH STABLE and MOD STABLE groups, relative to the LOW DECR and HIGH DECR groups (ORs = .24 and .57, respectively, *p*s < .05). Finally, those students with higher perceived peer drinking and enhancement motives were more likely to be in the most problematic group (HIGH STABLE), rather than the least problematic group (LOW DECR) (ORs = 4.41 and 3.41, respectively, *p*s < .001).

Discussion

This study was the first to identify patterns of change in alcohol-related blackouts and predictors of those patterns in a large sample of college students followed for a two-year period. Findings extended prior work by examining blackout trajectories in a sample of college students in the U.S. during an important developmental period (i.e., the transition into and across the first two years of college). Other strengths include frequent blackout assessments over time and tests of theoretically important psychosocial variables in both social and cognitive domains. Results revealed five latent growth trajectories and unique predictors of change in blackouts over time, with converging evidence for higher enhancement motives and perceived peer drinking as correlates for riskier blackout groups.

Latent Growth Class Trajectories of Blackouts

We identified five classes of blackouts over time: low decreasing, high decreasing, high stable, moderate stable, and low stable. In their younger sample from the U.K., Schuckit et al. (2015) also observed consistently low-risk and high-risk classes. However, they observed two increasing risk groups (slowly vs rapidly), in contrast to our observation of two decreasing, and no increasing risk groups. This is likely a function of the differences in the developmental period of interest. In adolescence, youth are just beginning to have experiences with drinking and its consequences, with room for upward growth. On the other hand, many emerging adults in college already have considerable experience with drinking, with more time to learn from negative experiences, and more potential for blackouts to decline. Our more frequent assessment and controls for trends in heavy drinking when estimating latent growth classes of blackouts are important methodological differences that may further explain divergent findings.

Our findings were in line with behavioral learning theories, which would suggest that negative consequences should be punishing and result in lower likelihood of such behavior over time. The only group with clearly similar proportions of blackouts from the beginning of their first college year to the end of their second year was already relatively low risk (LOW STABLE). As noted, significant decreases in blackouts were observed in two groups (HIGH DECR, LOW DECR), and though non-significant, even those in the HIGH STABLE and MOD STABLE groups also had lower proportions of blackouts by the end of the study. These observations suggest that students may modify their drinking behavior over time to

avoid negative consequences such as blackouts (i.e., by using protective behavioral strategies; Pearson, 2013), or perhaps have developed a tolerance to alcohol that reduces experiences of alcohol-related memory loss.

Although no class of students *increased* in the probability of reporting blackouts in this U.S. college student sample, close to 20% (i.e, HIGH STABLE and MID STABLE groups combined) remained at concerning levels of risk. Blackouts may not be universally punishing, given that some college students do not perceive blackouts to be bothersome (Barnett et al., 2015; Mallett, Bachrach, & Turrisi, 2008; Merrill et al., 2013), or because blackouts may protect individuals from encoding negative memories (Knowles & Duka, 2004). Alternatively, some students may persist in blacking out because they overestimate the number of drinks it would take them to black out (Mallett, Lee, Neighbors, Larimer, & Turrisi, 2006). Again, understanding the mechanisms of repeated experience of blackouts represents an exciting and important future research direction.

Pre-College Correlates of Latent Class Membership

In examining pre-college characteristics that explained blackout patterns, we chose a series of pairwise class comparisons that were theoretically and practically interesting. The pre-college characteristics measured were not helpful to explain equifinality, whereby individuals started in different places but ended up looking more similar over time. In contrast, peer influences and enhancement motives emerged as important for comparisons that evidenced multifinality, where individuals started at similar points but ended at different points. Those who started and remained low risk had higher perceived peer drinking than those who started low and decreased their blackouts. Similarly, those who started and remained high risk had higher perceived *approval* of drinking than those who started high and decreased their blackouts over time. That is, students who perceive that their peers drink more and more often, and those who perceive their peers to be more accepting of drinking behavior, are likely to remain consistent in their levels of blackouts (low and high, respectively). These findings are consistent with prior research showing increased risk for blackouts among those with heavier drinking peers (Schuckit et al., 2015) and those with peers who also experience blackouts (White et al., 2002).Holding such perceptions prior to entering college may result in choosing social networks supportive of drinking at levels that result in blackouts, or may be associated with less desire to change such behavior.

In both of these multifinality comparisons, as hypothesized, higher enhancement motives also were associated with a maintenance of levels of blackouts, suggesting that those who more often drink to enhance positive mood states may be less likely to find alcohol-related memory loss punishing or to attempt to avoid such experiences. It is possible that enhancement motivated drinkers are so eager to “get high” that they drink larger quantities (which was controlled in the present study) and/or do so faster or in larger sips, both of which have been shown to relate to alcohol-induced memory loss (Goodwin, 1995; Goodwin et al., 1969; Perry et al., 2006). In the remaining three comparisons, in which we focused on more general “level differences,” evidence converged to suggest that enhancement motives and perceived peer drinking measured prior to college entry confer risk for continued experience of blackouts during the early college years. This prospective finding extends

prior research demonstrating a positive association both cross-sectionally (Merrill & Read, 2010) and longitudinally (Merrill et al., 2014) between enhancement motives and the blackouts subscale of a consequence measure.

Interestingly, conformity motives also distinguished some of the classes. In particular, relative to those who started high but decreased over time, those in the two stable high-risk groups had lower pre-college conformity motives. Perhaps those who drink to conform in high school find other ways to "fit in" upon starting college, and subsequently learn to avoid alcohol-related blackouts. Alternatively, those high on conformity motives prior to college may also conform to general downward trends in alcohol use behavior that occur as students age. However, as these effects were not hypothesized, we interpret them tentatively.

In contrast to prior cross-sectional research, expectancies prior to college entry were not a correlate of trajectories of blackouts over a two-year period, after accounting for other psychosocial variables (Buelow & Harbin, 1996; Hartzler & Fromme, 2003). However, it is possible that expectancies change over time and may represent a more proximal cause or consequence of blackouts during the college year, leaving baseline measures of expectancies only less than ideal. The potentially dynamic interplay between expecting and experiencing negative effects of drinking warrants additional exploration.

Finally, the demographic variables hypothesized to be important covariates in this study did not relate to class membership in the multivariate context. Whereas some studies show higher risk for blackouts for women as compared to men (Marino & Fromme, 2015; Schuckit et al., 2015; White et al., 2002), our findings are more consistent with other studies that do not (Barnett et al., 2014; Mundt, Zakletskaia, Brown, & Fleming, 2012). The lack of age or race effects in the present study also contrast with prior work showing blackouts to be more common among younger as compared to older students and young adults (Jennison & Johnson, 1994; Mundt et al., 2012; Perry et al., 2006), and among White college students compared to those of other ethnicities (Hingson et al., 2016; LaBrie et al., 2011; Marino & Fromme, 2015). While a range of variables may be important cross-sectional correlates of blackouts, the current study suggests that demographic variables may not be important correlates of change *over time* in blackouts.

Clinical Implications

The majority of participants (64%) reported at least one blackout, and among many of these, blackouts were not a one-time experience. Students should be made aware early on of the potential concurrent and long-term risks associated with blackouts. The finding that higher perceptions of drinking among one's peers and higher enhancement motives were robustly associated with greater endorsement of blackouts during college is noteworthy in regard to research demonstrating the efficacy of brief interventions for college drinkers that target perceptions of peer drinking (Carey, 2012). Such interventions prior to college entry may encourage students to select into less risky drinking networks or may lower misperceptions about how common and acceptable drinking or heavy drinking is, potentially leading to reduction in blackouts specifically. As others have noted, prevention efforts for college drinking may best be implemented long before high school students graduate to help prevent alcohol-related problems once students matriculate (White et al., 2002). Screening for

blackouts in incoming freshmen or at student health services also may be a useful tool to identify and better inform students at greatest risk for negative outcomes that occur concurrently or as a function of blackouts. Intervention for those reporting repeated experiences of blackouts specifically may help deter maintenance of or transition to chronic problem drinking patterns. Research has indicated the potential to save close to half a million dollars in emergency department utilization costs on a large university campus if interventions targeting blackouts were successful (Mundt & Zakletskaia, 2012).

Strengths, Limitations and Future Directions

Strengths of the present study include data collected from participants followed for two academic years from several campuses and cohorts and use of an approach with the flexibility to account for group differences in change trajectories over time. This is a distinct advantage over other approaches, providing that average blackout trajectories are, in truth, a mixture of different patterns of growth. Importantly, we controlled for change over time in heavy drinking, allowing us to demonstrate theoretically important pre-college predictors of blackout patterns above and beyond their influence on heavy drinking alone. The fine-grained assessment procedure utilizing 36 repeated measures likely improved recall accuracy and allowed us to characterize classes of trajectories of alcohol-induced blackouts among college students with high temporal precision.

Additional work on factors predicting risk for continued blackouts even upon the transition out of college and into more adult roles is needed. Further, given problems inherent in the LCGA approach (e.g., the “cat’s cradle” pattern, whereby low, increasing, decreasing, and high classes tend to emerge across samples and research questions) (Sher, Jackson, & Steinley, 2011), we encourage restraint from making strong conclusions about specific ‘classes’ of individuals. Rather, we suggest that our LCGA serves as a useful data reduction technique to aid in identification of risk factors for problematic drinking trajectories.

Results should also be viewed in light of the limitations of our measures. All variables were measured with self-report and therefore our measures of blackouts and their correlates could be subject to bias and demand characteristics. Yet, weekly assessments of past-week behavior likely facilitated accurate recall. Our trichotomous measure of blackouts (none, <1 hour, > 1 hour) does not fully map on to definitions of en bloc vs fragmentary blackouts. Also, the extent to which participants can accurately distinguish the length of their memory loss is unclear. Future work that distinguishes trajectories between these more and less severe types of memory loss would be of interest. We did not have measures of genetic or neurobiological risks, which are known to explain variability in blackouts (Marino & Fromme, 2015; Nelson et al., 2004; Wetherill et al., 2013), and should be examined alongside psychosocial risk factors in future work. Finally, baseline measures were collected prior to college entry so they represent pre-existing individual differences; we cannot draw conclusions about how variables such as peer approval *during* college impact change over time in blackout risk.

Conclusions

Results of this study highlight variability in patterns of blackouts over the course of the first two years of college. There was robust evidence that individuals at highest risk for repeated blackouts during this developmental period reported higher perceptions of drinking among peers and stronger enhancement motives. Problematic drinkers should be prioritized even before college matriculation for interventions focused on blackouts and/or alcohol misuse more generally, and perceptions of peer drinking and enhancement motives may be useful targets. Examining time-varying correlates of blackouts is an exciting and essential future direction.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding: This study was supported by grants from the National Institute on Alcohol Abuse and Alcoholism (R01AA013970 [Barnett], T32AA007459 [training support for Treloar, Fernandez, and Monnig], K02 AA13938 [Jackson] and K01AA022938 [Merrill]).

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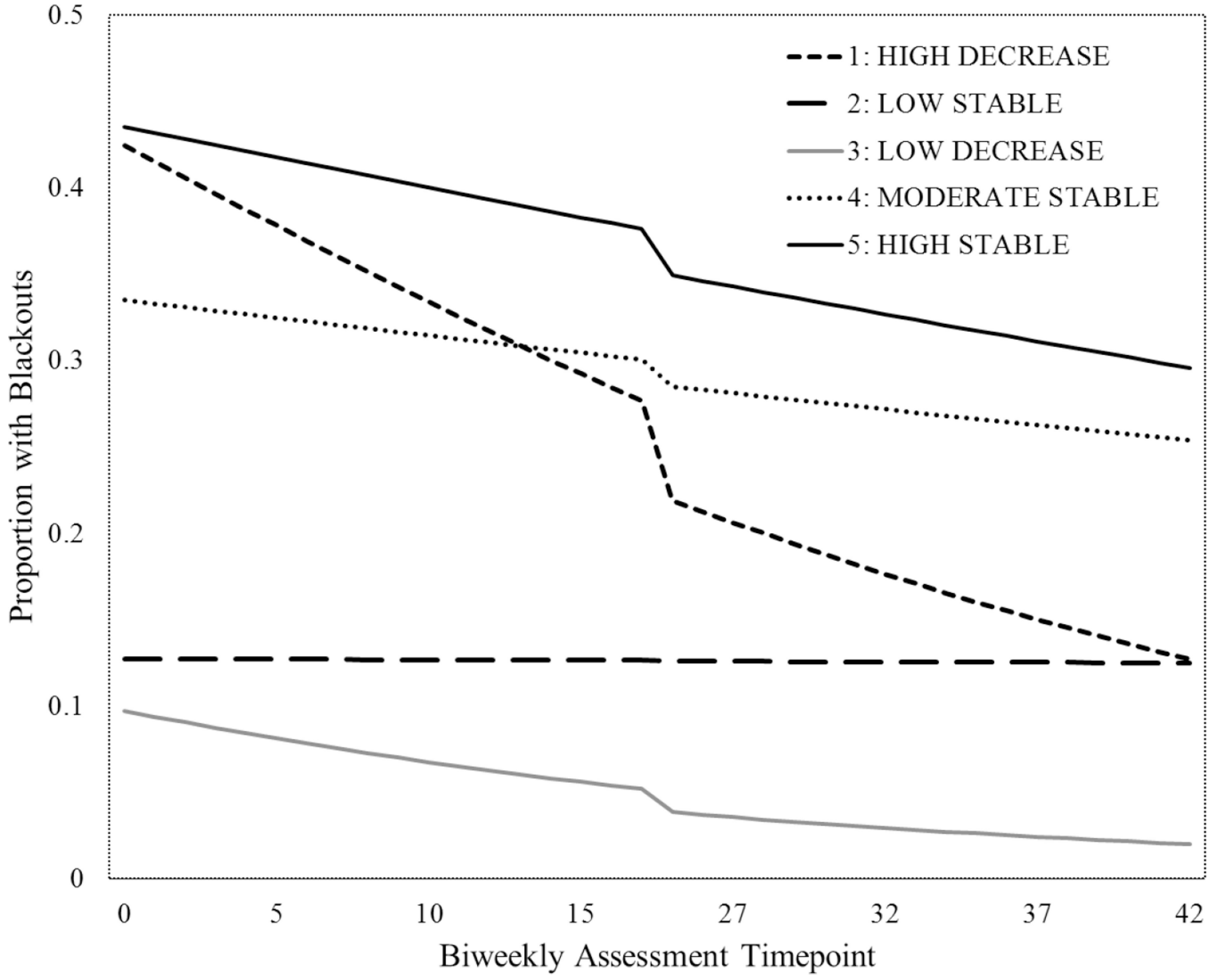

Figure 1.

Results from latent class growth analysis (LCGA) with 5 patterns (classes) of change in proportion of students reporting blackouts over the first two years of college. Class 1, "HIGH DECR," *n* = 77, 10.9%; Class 2, "LOW STABLE," *n* = 158, 22.3%; Class 3 "LOW DECR," *n* = 340, 48.0%; Class 4, "MOD STABLE," *n* = 105, 14.8%; Class 5, "HIGH STABLE," *n* = 29, 4.1%.

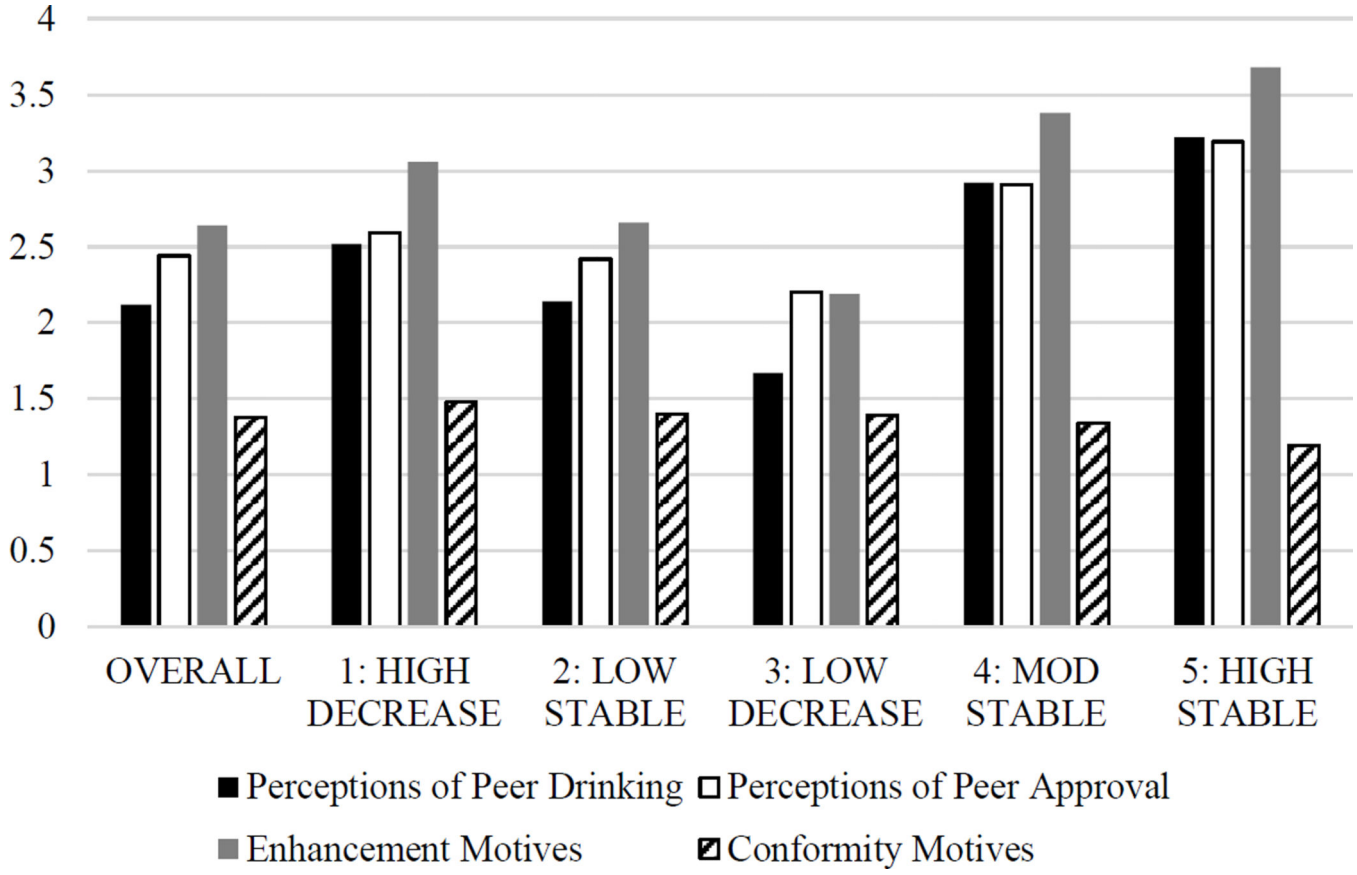

Figure 2.
Levels of pre-college predictors that significantly distinguished blackout risk groups (classes).

Table 1

Parameters of Fit for Latent Class Growth Analyses

Number of Classes	Optimal LL	Entropy	AIC	BIC	ABIC	Likelihood Ratio Tests *P*-values			Class proportions					
						VLMR	ALMR	BLRT	1	2	3	4	5	6
2	−37219.43	.96	74538.86	74767.05	74608.29	< .001	< .001	< .001	.75	.25	—	—	—	—
3	−36404.73	.93	72921.45	73177.03	72999.22	.104	.109	<.001	.34	.12	.54	—	—	—
4	−35972.90	.92	72069.80	72352.76	72155.90	.121	.126	< .001	.18	.04	.32	.47	—	—
5	−35787.09	.90	71710.18	72020.53	71804.61	.740	.744	.020	.11	.23	.47	.15	.04	—
6	−35610.67	.90	71369.33	71707.06	71472.09	.561	.563	<.001	.45	.23	.06	.11	.12	.03

Note. LL = loglikelihood; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; ABIC = Sample-size Adjusted Bayesian Information Criterion; VLMR= Vuong-Lo-Mendell-Rubin; ALMR= Adjusted Lo-Mendell-Rubin; BLRT = Bootstrap Likelihood Ratio Test.

Table 2

Descriptives and Univariate Prediction of Latent Trajectory Classes from Pre-College Characteristics

Variable	**Full sample *N* = 709 % or *M* (*SD*)**	**Class 1 HIGH DECR (n=77) % or *M* (*SD*)**	**Class 2 LOW STABLE (n=158) % or *M* (*SD*)**	**Class 3 LOW DECR (n=340) % or *M* (*SD*)**	**Class 4 MOD STABLE (n=105) % or *M* (*SD*)**	**Class 5 HIGH STABLE (n=29) % or *M* (*SD*)**	**F or χ^2 test**	***p***
Number of Blackouts over study	3.06 (4.25)	5.56 (4.21)	2.99 (2.45)	0.66 (1.09)	7.71 (5.56)	8.00 (7.26)	------	------
Sex (Female)	59%	53 %	59 %	63 %	52%	48%	6.50	.165
Age	18.36 (.46)	18.36 (.40)	18.38 (.43)	18.33 (.50)	18.41 (.39)	18.51 (.53)	1.67	.155
Race							23.87	**.002**
White	70%	77%	73%	62%	84%	83%		
Asian	9%	6%	8%	12%	5%	7%		
Other	20%	17%	19%	25%	11%	10%		
Perceived Peer Variables								
Peer Drinking	2.12 (1.04)	2.52 (0.89)	2.14 (0.99)	1.67 (0.93)	2.92 (0.78)	3.22 (0.52)	55.57	**<.001**
Peer Approval	2.44 (0.81)	2.59 (0.74)	2.42 (0.82)	2.20 (0.79)	2.91 (0.61)	3.19 (0.49)	26.18	**<.001**
Expectancies								
Positive Expectancies	2.57 (0.57)	2.70 (0.55)	2.66 (0.56)	2.47 (0.59)	2.76 (0.49)	2.88 (0.44)	8.88	**< .001**
Negative Expectancies	2.55 (0.53)	2.55 (0.53)	2.52 (0.54)	2.53 (0.55)	2.61 (0.49)	2.59 (0.42)	0.50	.736
Drinking Motives								
Coping Motives	1.58 (0.69)	1.72 (0.68)	1.57 (0.69)	1.47 (0.66)	1.78 (0.63)	1.90 (0.83)	17.01	**< .001**
Social Motives	2.85 (1.06)	3.17 (0.95)	2.84 (1.02)	2.54 (1.04)	3.43 (0.87)	3.37 (0.98)	20.39	**< .001**
Enhance Motives	2.64 (1.12)	3.06(1.07)	2.66 (1.03)	2.19 (1.03)	3.38 (0.89)	3.68 (0.89)	40.46	**< .001**
Conformity Motives	1.38 (0.61)	1.48 (0.73)	1.40 (0.65)	1.39 (0.60)	1.34 (0.51)	1.19 (0.43)	1.32	.263

Note. MOD = Moderate; DECR = Decrease. Bolded text indicates $p \leq .002$.

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Table 3

Odds Ratios (and 95% Confidence Intervals) from Multinomial Regression Models Relating Class Membership to Baseline Characteristics

Variable	HIGH DECR v. LOW STABLE (equifinality)	LOW STABLE v. LOW DECR (multifinality)	HIGH STABLE v. HIGH DECR (mutlifinality)	MOD STABLE v. HIGH DECR	MOD STABLE v. LOW STABLE	HIGH STABLE v. LOW DECR
Sex	0.85 (0.47, 1.51)	0.80 (0.52, 1.21)	0.89 (0.34, 2.30)	0.97 (0.52, 1.81)	0.82 (0.30, 1.86)	0.60 (0.24, 1.48)
Age	0.84 (0.45, 1.55)	1.08 (0.69, 1.68)	1.47 (0.53, 4.03)	1.06 (0.54, 2.08)	0.88 (0.49, 1.61)	1.32 (0.51, 3.44)
Race						
Asian	0.79 (0.26, 2.40)	0.79 (0.39, 1.59)	1.91 (0.30, 12.33)	0.91 (0.24, 3.42)	0.72 (0.23, 2.24)	1.19 (0.21, 6.65)
Other	1.05 (0.50, 2.22)	0.78 (0.47, 1.31)	0.47 (0.11, 1.59)	0.66 (0.27, 2.45)	0.69 (0.32, 1.51)	0.39 (0.09, 1.62)
White						
Perceived Peer Variables						
Peer Drinking	1.52 (0.98, 2.34)	**1.72 (1.26, 2.34)** ***	1.69 (0.76, 3.79)	1.26 (0.77, 2.05)	**1.91 (1.24, 2.94)** **	**4.41 (2.03, 9.55)** ***
Peer Approval	0.80 (0.47, 1.36)	0.78 (0.54, 1.12)	**2.95 (1.20, 7.26)** *	1.70 (0.94, 3.10)	1.37 (0.81, 2.32)	1.85 (0.79, 4.35)
Alcohol Expectancies						
Positive	1.36 (0.72, 2.56)	0.90 (0.58, 1.40)	1.29 (0.47, 4.70)	0.77 (0.38, 1.55)	1.04 (0.56, 1.92)	1.81 (0.60, 5.42)
Negative	0.88 (0.47, 1.62)	1.03 (0.68, 1.58)	1.34 (0.46, 3.88)	1.55 (0.78, 3.10)	1.36 (0.75, 2.49)	1.21 (0.44, 3.32)
Motives						
Coping	1.07 (0.68, 1.71)	1.03 (0.72, 1.47)	1.42 (0.71, 2.85)	1.00 (0.62, 1.63)	1.07 (0.69, 1.67)	1.57 (0.81, 3.04)
Social	1.00 (0.66, 1.53)	0.90 (0.67, 1.22)	0.60 (0.29, 1.23)	1.18 (0.74, 1.88)	1.18 (0.79, 1.76)	0.54 (0.28, 1.07)
Enhancement	1.22 (0.84, 1.76)	**1.49 (1.13, 1.96)** **	**1.88 (1.02, 3.45)** *	1.15 (0.77, 1.72)	1.40 (0.99, 1.99) †	**3.41 (1.91, 6.08)** ***
Conformity	1.06 (0.65, 1.70)	0.89 (0.62, 1.28)	**0.25 (0.07, 0.88)** *	**0.57 (0.33, 0.99)** *	0.60 (0.36, 1.01) †	**0.24 (0.07, 0.80)** *

Note. MOD = Moderate; DECR = Decrease. Odds ratios reflect the log likelihood of being in a particular group (class), relative to a given reference group. The reference category changes for each model and appears after the "v." in each column title. Bold effects are significant at p<.05

† $p < .10$,

* $p < .05$,

** $p < .01$,

*** $p < .001$.