Psychology of Addictive Behaviors

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Trajectories of Binge Drinking and Personality Change Across Emerging Adulthood

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College students binge drink more frequently than the broader population, yet most individuals "mature out" of binge drinking. Impulsivity and sensation seeking traits are important for understanding who is at risk for maintaining binge drinking across college and the transition to adult roles. We use latent class growth analysis (LCGA) to examine longitudinal binge-drinking trajectories spanning from the end of high school through 2 years after college (M ages = 18.4 to 23.8). Data were gathered over 10 waves from students at a large Southwestern university (N = 2,245). We use latent factor models to estimate changes in self-reported impulsive (IMP) and sensation-seeking (SS) personality traits across 2 time periods—(a) the end of high school to the end of college and (b) the 2-year transition out of college. LCGA suggested 7 binge-drinking trajectories: frequent, moderate, increasing, occasional, low increasing, decreasing, and rare. Models of personality showed that from high school through college, change in SS and IMP generally paralleled drinking trajectories, with increasing and decreasing individuals showing corresponding changes in SS. Across the transition out of college, only the increasing group demonstrated a developmentally deviant *increase* in IMP, whereas all other groups showed normative stability or decreases in both IMP and SS. These data indicate that "late bloomers," who begin binge drinking only in the later years of college, are a unique at-risk group for drinking associated with abnormal patterns of personality maturation during emerging adulthood. Our results indicate that personality targeted interventions may benefit college students.

Keywords: impulsivity, sensation seeking, binge drinking, college drinking, personality maturation

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Across the transition from high school through the duration of college, many young people increase their alcohol consumption to hazardous levels (Bachman, Wadsworth, O'Malley, Johnston, & Schulenberg, 1997), which is typically followed by a decrease with increasing age (Dawson, Grant, Stinson, & Chou, 2004; Fillmore, 1988; Littlefield, Sher, & Wood, 2009). Binge drinking, a hazardous pattern of use often defined as five or more drinks in a row, is reported by 35% of U.S. college students (Johnston, O'Malley, Bachman, Schulenberg, & Miech, 2014). Consequences of binge drinking among college populations include injury, unplanned or unsafe sex, drunk driving, memory loss, property damage, and assault (Wechsler, Davenport, Dowdall, Moeykens, & Castillo, 1994; White & Hingson, 2013). This cohort is also at elevated risk for alcohol use disorders (AUDs); 12-month prevalence of meeting *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; American Psychiatric Association, 1994) diagnostic criteria for alcohol abuse and dependence in U.S. college samples are around 31% and 6%, respectively (Knight et al., 2002), compared with 4.7% for abuse (Hasin, Stinson, Ogburn, & Grant, 2007) and 3.5% for dependence (Esser et al., 2014) in the U.S. population as a whole. As such, understanding the causes and correlates of binge drinking in college students is a significant public health goal.

Many students reduce binge drinking across the transition out of college without need for clinical interventions (Jochman & Fromme, 2010). This process has been termed "maturing out" of heavy substance use (Donovan, Jessor, & Jessor, 1983; Littlefield et al., 2009; Winick, 1962). Some individuals, however, persist in hazardous alcohol involvement (Jackson, Sher, Gotham, & Wood, 2001), potentially resulting in lifelong struggles with AUDs. Determining which factors predict who will and who will not mature out of hazardous drinking across college is therefore important for understanding the etiology of AUDs.

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Modeling Trajectories of Binge Drinking

Several studies have examined distinct trajectories of binge or heavy drinking across adolescence and emerging adulthood in order to identify clinically meaningful groups at risk for AUDs (Muthén & Muthén, 2000; Schulenberg, O'Malley, Bachman, Wadsworth, & Johnston, 1996; Sher, Jackson, & Steinley, 2011). Trajectory analyses accomplish this goal by identifying qualitatively distinct groups within a heterogeneous sample that differ in terms of level of use at the initiation of the time-window under examination (intercept) and the rate and shape of change over time (slope). Such modeling approaches commonly find between three and nine kinds of trajectories, with most showing a "cat's cradle" pattern including persistently high or low groups, and groups that increase or decrease over time (Sher et al., 2011).

Whether LCGA models, which are ultimately categorization schemes, represent "true" distinct groups independent of context, these methods are nonetheless useful for relating patterns of change over time. Turkheimer, Ford, and Oltmanns (2008) provided a useful metaphor for understanding the utility of meaningful but arbitrary categorization schemes in a discussion on personality disorder criteria: although landforms are obviously continuous masses, we commonly place regional boundaries on maps related to topography (mountainous areas, coastal areas). Although there is no "real" singular discrete line indicating where the coastal areas end and the mountains begin, such distinctions are still useful (Turkheimer et al., 2008). Similarly, although the quantity and "boundaries" between binge-drinking groups are somewhat arbitrary, they still convey meaningful information. In particular, we believe that examining trajectory group differences in traits related to drinking, like personality, provides evidence for mechanisms that may explain those who do and those who do not "mature out" of binge drinking. Thus, we sought to use these advanced LCGA modeling methods to examine if groups exhibiting distinct patterns of binge-drinking "topography" over time also show differences in terms of personality change.

Personality and Alcohol Use

Researchers have proposed several mechanisms that may explain the normative maturing out process and may differentiate those who decrease their consumption from those who do not. Some have attributed the decrease in heavy drinking to life-role changes and to new adult responsibilities, including having children, marriage, and peer selection (Bachman et al., 2002; Boyd, Corbin, & Fromme, 2014). Others have demonstrated that maturation of personality may influence the trajectory of drinking across emerging adulthood, as change in personality is correlated with change in drinking behavior even when controlling for life role changes (Littlefield, Sher, & Wood, 2009). These data suggest that, although adoption of new adult roles are important mechanisms for maturing out, personality maturation per se is also critical for understanding individual differences in drinking during and after college.

Impulsivity and Sensation Seeking

Two personality domains that are frequently associated with binge drinking are impulsivity and sensation seeking. Impulsivity is broadly defined as possessing the trait-like propensity to engage in maladaptive behavior due to difficulty with decision-making or self-control (Dick et al., 2010; Jentsch et al., 2014). Sensation seeking, on the other hand, is commonly defined as a preference for exciting, novel, and varied experiences (Duckworth & Kern, 2011; Hittner & Swickert, 2006; Zuckerman, Kuhlman, Joireman, Teta, & Kraft, 1993).

Over the past several decades, researchers have developed a diverse set of self-report inventories containing items that assess impulsivity and sensation seeking as defined in various ways. Factor analyses of a number of commonly used questionnaires identified four distinct factors described as urgency, (lack of) premeditation, (lack of) perseverance, and sensation seeking (UPSS; Whiteside & Lynam, 2001). In this UPPS framework, urgency is the tendency to commit rash actions in response to negative affect, whereas lack of premeditation reflects a tendency to act without forethought. Lack of perseverance is akin to a lack of patience or the ability to persist in a tiresome task. Sensation seeking continues to be defined as the preference for exciting or novel stimuli. Thus, current evidence is consistent with conceptualizing domains of impulsivity and sensation seeking as distinct constructs.

Convergent evidence across humans and model animals has demonstrated transactional relationships among dimensions of impulsivity, sensation seeking, and problematic drug and alcohol use across development (Dick et al., 2010; Jentsch et al., 2014; Jentsch & Taylor, 1999; Quinn, Stappenbeck, & Fromme, 2011; Weafer, Mitchell, & de Wit, 2014). First, initially high levels of impulsivity prospectively predict future alcohol problems (Sher, Bartholow, & Wood, 2000), and several studies have found that greater levels of impulsivity are more prevalent among those who meet AUD criteria (Bennett, McCrady, Johnson, & Pandina, 1999; Kollins, 2003; Trull, Waudby, & Sher, 2004). On the other hand, human and animal work has shown that alcohol use itself deleteriously impacts dimensions of impulsivity, particularly lack of perseverance (Dick et al., 2010; Irimia et al., 2013).

Similarly, greater sensation seeking correlates with greater quantity and frequency of alcohol use (Zuckerman, 1994), and dozens of studies have found positive relations between sensation seeking and alcohol use both cross-sectionally and prospectively (Alterman et al., 1990; Cherpitel, 1993; Donohew et al., 1999; Hittner & Swickert, 2006). A recent large meta-analysis using the UPPS framework found that sensation seeking and positive urgency had the largest association with alcohol consumption (Stautz & Cooper, 2013). In terms of longitudinal associations, analyses of data across ages 15 to 26 shows that those with slower rates of decline in impulsivity and sensation seeking are more likely to rapidly increase alcohol use (Quinn & Harden, 2013). Overall, there is a clear relation between these traits and alcohol consumption, and further research will refine our understanding of the links between personality traits and behavior.

Personality and Principles of Change

Facets of personality adapt and change across development, particularly during emerging adulthood including the typical college years (McCrae & Costa, 1994; McCrae et al., 1999). During late adolescence and emerging adulthood, the normative, mean-level declines in impulsivity and sensation seeking are consistent

with a more general trend toward greater self-control and emotional stability as people age (Roberts, Walton, & Viechtbauer, 2006). This developmental pattern, perhaps an adaptive response to new adult roles and responsibilities in addition to biological processes underlying brain maturation, has been termed the "maturity principle" (Caspi, Roberts, & Shiner, 2005). In this framework, Caspi and colleagues (2005) define maturity as "the capacity to become a productive and involved contributor to society, with the process of becoming more planful, deliberate, and decisive" (p. 469).

Among emerging adults, therefore, there is a normative maturational pattern characterized by less problematic drinking and less impulsive-sensation seeking with age. Previous research has shown that a minority of individuals fail to mature out of heavy/problematic alcohol use, but whether these same individuals show aberrant patterns of personality change is not yet clear. Our hypothesis is that individuals who do not "mature out" of heavy alcohol use may also buck the trends of normative personality maturation. According to the "corresponsive principle" (Caspi et al., 2005), the effects of life experiences on personality are likely to reinforce the specific personality facets that lead people toward those very same experiences. Thus, consistent with the transactional nature of the relation between heavy alcohol use and personality (Quinn et al., 2011), changes in alcohol use are likely associated with changes in impulsivity and sensation seeking over time. Determining *who* is most likely to change in troublesome directions (i.e., become more impulsive) or buck normative trends (i.e., fail to mature out of binge drinking) and *when* these processes are most pronounced may inform efforts to prevent current and future AUDs among college students.

The Present Study

We examined longitudinal data from a college sample spanning the end of high school through 2 years after the transition out of college. The goals of the analyses were to (a) determine and describe trajectories of binge drinking, (b) model change in impulsive and sensation seeking personality traits across college and across the transition out of college, and (c) determine if unique patterns of personality change are associated with specific trajectories of binge drinking. We hypothesized that we would find between three and nine trajectories of binge drinking, consistent with previous trajectory analyses of binge drinking (Muthén & Muthén, 2000; Schulenberg et al., 1996; Sher et al., 2011). Furthermore, we expected that patterns of personality change would differ by binge-drinking trajectory such that those who increased versus decreased in frequency of binge drinking would show corresponding increases or decreases in impulsivity/sensation seeking. These analyses advance the literature by determining which kind(s) of binge drinker(s) might be most at risk for current and future heavy alcohol use, potentially as a function of nonnormative personality maturation.

Method

Participants

Study participants were recruited from an entering freshman class at a large Southwestern university beginning in 2004. Of those invited (N = 6,391), 76% agreed to complete survey data (N = 4,832). Of those who also met the inclusion criterion of being unmarried, a subset were randomized to complete a series of surveys beginning at the end of high school and continuing over the following 6 years (N = 3,046). The sample included in the present analysis comprises those who provided informed consent and completed the high school survey (N = 2,245), the majority of whom were female (N = 1,345, 59.9%). Demographic composition of the sample is presented in Table 1. The local institutional review board approved all study surveys and procedures.

Longitudinal Design

The longitudinal data used for the present analysis are from assessments across 10 waves of data collection, which are presented in Table 1. Waves 1 through 8 were assessed biannually, whereas Waves 9 and 10 occurred 1 year after the previous assessment. Respondents were compensated $30 for completion of the Wave 1 survey, $20 for the Fall college surveys (Waves 2, 4, 6), $25 for the Spring college surveys (Waves 3, 5, 7), and $40 for the remaining surveys (Waves 8–10).

Table 1
Descriptive Statistics of Drinking and Personality Traits at Each Wave

				Age	No. binge-drinking episodes	ZK Impulsivity	Sensation seeking
Wave	Time point	N	% total N	M (SD)	M (SD)	M (SD)	M (SD)
1	Summer 2004	2,245	100	18.4 (0.35)	2.16 (5.41)	2.07 (2.01)	5.58 (2.69)
2	Fall 2004	2,077	92.5	18.8 (0.35)	2.92 (6.22)		
3	Spring 2005	2,026	90.2	19.2 (0.35)	3.51 (7.19)		
4	Fall 2005	1,896	88.5	19.8 (0.35)	3.75 (6.96)		
5	Spring 2006	1,790	79.7	20.2 (0.35)	3.50 (6.99)		
6	Fall 2006	1,675	74.6	20.8 (0.36)	3.82 (7.29)		
7	Spring 2007	1,639	73.0	21.2 (0.35)	4.24 (7.50)		
8	Fall 2007	1,539	68.6	21.8 (0.35)	4.13 (7.26)	1.82 (1.99)	5.29 (3.05)
9	Fall 2008	1,429	63.7	22.8 (0.35)	3.51 (6.42)		
10	Fall 2009	1,407	62.7	23.8 (0.35)	3.31 (6.55)	1.79 (2.03)	5.31 (3.13)

Note. ZK = Zuckerman–Kuhlman.

Measures

Demographics. Basic demographic measures ascertained at Wave 1 included in the analysis were: gender (coded 0 = female [59.9%], 1 = male), ethnicity (dummy coded as three variables: Asian = 1 [18%], Latino = 1 [15.2%], Black/other/multiethnic = 1 [12.8%], with White as the reference group [53.9%]), family income (coded 0 = under $20k, 1 = $20k–$30k, 2 = $30k–$40k, 3 = $40k–$50k, 4 = $50k–$60k, 5 = $60k–$70k, 6 = $70k–$90k, and 7 = over $100k; $M = 5.8$, $SD = 2.4$), and mothers and father's highest level of education (coded separately for mother/father as 0 = did not complete high school, 1 = High school diploma, 2 = Some college, 3 = Junior college degree, 4 = College degree, 5 = Postgraduate degree; Father $M = 3.4$, $SD = 1.5$, Mother $M = 3.1$, $SD = 1.6$). Family income and parental education measures included the option, "I choose not to answer," which was scored as missing data.

Binge drinking. Respondents were asked, "*During the past 3 months, how many times did you have* [*five* (men) / *four* (women)] *drinks at a sitting?*" These values were chosen as consistent with National Institute for Alcohol Abuse and Alcoholism (NIAAA) guidelines on the definition of a binge episode (NIAAA, 2004). Sample statistics at each wave are presented in Table 1.

Personality scales. Impulsivity and sensation seeking were assessed at Waves 1, 8 and 10 to capture two periods: the duration of college (W1 to W8) and the transition out of college (W8 to W10). Data at intervening waves was not available. These domains of personality were taken from the Impulsivity (8 item) and Sensation Seeking (11 item) subscales of the Zuckerman–Kuhlman Personality Questionnaire (Zuckerman et al., 1993). Examples of items for each scale include: Impulsivity, "*I very seldom spend much time on the details of planning ahead,*" and Sensation Seeking, "*I'll try anything once."* Descriptively, these impulsivity items are most related to the "lack of premeditation" facet of personality described in factor analytic and meta-analytic work on impulsivity (Stautz & Cooper, 2013). In the current article, data from this scale is referred to as "Zuckerman–Kuhlman Impulsivity" (ZK Impulsivity). Each item was scored dichotomously (reversed scored where appropriate), with respondents endorsing either 0 = *false* or 1 = *true*. Internal reliability was good at all three waves for ZK Impulsivity (α range = 0.73 to 0.76) and Sensation Seeking (α range = 0.73 to 0.81). Sample statistics at Waves 1, 8, and 10 are presented in Table 1.

Analyses

Latent class growth analyses (LCGA) of binge drinking. Growth analyses of binge drinking over assessment Waves 1–10 were conducted in Mplus, Version 7.2 (Muthén & Muthén, Los Angeles, CA). In a structural equation modeling framework, repeated measures data on binge drinking was modeled as a function of three latent factors: intercept (*I*), linear slope (*S*), and quadratic slope (*Q*; McArdle & Nesselroade, 2003). The latent *I* factor represents individual differences in the level of binge drinking at the beginning of the time window examined; the latent *S* factor represents individual differences in linear growth across all assessment waves; and the *Q* factor represents individual differences in nonlinear acceleration or deceleration in binge drinking. Constraining the paths between these latent factors and the observed binge-drinking accounts for the effect of time on the repeated measure.

Specifically, all paths between *I* and the repeated measure are set to be equal to 1; As the last two assessment waves were collected after a year instead of six months paths between *S* and the first eight waves increased by one unit ($t = 0$ to 7), but then by two units for Waves 9 and 10 ($t = 9, 11$). Similarly, the paths between *Q* and the first eight waves also increased by one unit squared ($t^2 = 0$ to 49), followed by two units squared for Waves 9 and 10 ($t^2 = 81, 121$). Finally, to estimate distinct patterns of growth within the sample, a categorical latent factor (*C*) with a given number of levels can be added that allows *I*, *S*, and *Q* to be freely estimated for each latent category of *C* (see Figure 1). Variances of *I*, *S*, and *Q* within each category of *C* were constrained to be zero, because allowing variation within a given latent class was com-

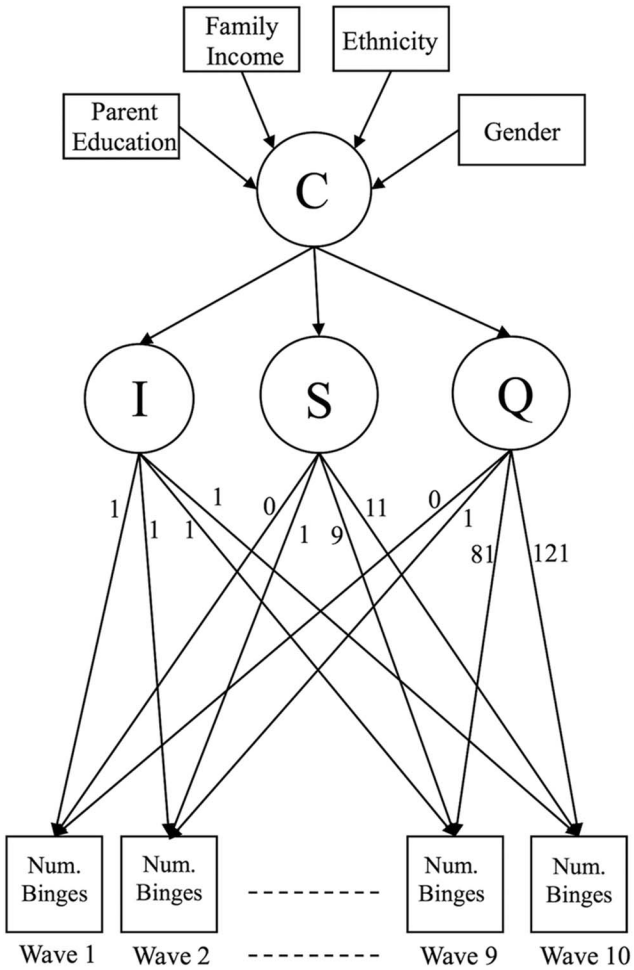

Figure 1. Latent class growth analysis model: Structural equation modeling on the longitudinal data from Waves 1 through 10 (W1–W10) was conducted such that a latent class category (C) predicted intercept (I) linear slope (S) and quadratic slope (Q) of growth over time. Paths between I and each wave are constant at 1, and those between S and each wave increase linearly (e.g., 0, 1, 2, 3). Paths between Q and each wave increase quadratically (e.g., 0, 1, 4, 9). Variances of I, S, and Q fixed to zero within each class. Demographic variables were entered as additional predictors of class membership.

putationally intractable. To determine if demographic variables (gender, ethnicity, family income, mother's and father's highest education) were significant predictors of latent class *C* membership, these variables were entered into the model as auxiliary (Type R) variables. By using the auxiliary variables option in Mplus, all individuals were included in the LCGA analysis even if data were missing on demographic variables (Asparouhov & Muthén, 2013). The model design is presented in Figure 1.

LCGA models with two to eight latent classes were sequentially tested under assumptions of a Poisson, negative binomial, or zero-inflated Poisson distribution, to determine the best fitting and most parsimonious model. Whereas previous studies have mostly used dichotomous or censored categorical schemes to represent drinking count data (Sher et al., 2011), we sought to include as much information as possible by allowing the full range of binge-drinking frequencies. The best fitting model was selected based on the following: Akaike information criterion (AIC; Akaike, 1987) and Bayesian information criterion (BIC; Schwarz, 1978; Sclove, 1987). Lower values of both of these criteria are indicators of improved relative model selection. Additionally, we examined entropy, or the certainty of categorizing individuals between one class and another. Entropy values range between 0–1, with values approaching 1 indicating a high degree of certainty in classification of individuals as belonging to a given latent category of *C* (Celeux & Soromenho, 1996). To ensure that latent classes capture a meaningful portion of the sample, models that produced latent classes with fewer than 5% (based on posterior probabilities) of the sample were discarded (Nagin, 2005). Last, we conducted Vuong–Lo–Mendell–Rubin likelihood ratio tests (Lo, Mendell, & Rubin, 2001; Vuong, 1989) to assess the likelihood ratio of the k to $k - 1$ class models. This test provides additional evidence for the superiority of one model over another.

Latent factor models of personality. As observed difference scores are often unreliable metrics (Cronbach & Furby, 1970), we used latent measurement models to account for change in personality over time. To estimate latent factor scores for personality at each wave, we followed the parceling procedures suggested by Little and colleagues (Little, Cunningham, Shahar, & Widaman, 2002). First, as a preliminary step, a confirmatory factor analysis was conducted with a single-factor for each personality construct, with all of the individual personality items as categorical indicators. Items were ranked by loadings, and then distributed among three item parcels, such that each parcel had approximately equal average loadings (Hagtvet & Nasser, 2004; Little et al., 2002).

We then used the item parcels as continuous indicators of latent factors representing ZK Impulsivity and Sensation Seeking at senior year of high school (Wave 1), senior year of college (Wave 8) and 2 years out of college (Wave 10; Figure 3). Goodness-of-fit for the latent factor model was evaluated using root mean square error of approximation (RMSEA), with values less than 0.05 indicating good fit (Steiger, 1990). We also used the Bentler comparative fit index (CFI) and Tucker–Lewis Index (TLI), which are sensitive to model fit and as well as parsimony, with penalization for more complex models. Values of CFI and TLI vary between 0 and 1 with acceptable values being greater than 0.95 (Hu & Bentler, 1999).

Combined models of binge-drinking trajectories and personality. Our final analysis combined this factor model of personality with the LCGA trajectory analyses, so that personality difference scores could be estimated for each latent class. Specifically, we used MODEL CONSTRAINT functions of Mplus to create a set of new variables, defined as the difference between the Wave 1 latent factor and the Wave 8 latent factor and the difference between the Wave 8 latent factor and the Wave 10 latent factor. The means of the latent factors for ZK Impulsivity and Sensation Seeking, as well as these difference scores, were allowed to vary between classes. The means of the factor representing Wave 1 in the lowest-drinking class was constrained to be zero for model identification.

The resulting three dependent variables were: mean at Wave 1 (an estimate of high school personality), the difference between Wave 8 and Wave 1 (capturing change from senior year of high school to senior year of college), and the difference between Wave 10 and Wave 8 (capturing change in late emerging adulthood). Subsequently, to determine if there was a significant main effect of latent class on these three dependent variables, estimates were constrained to be equal across all classes using MODEL TEST functions of Mplus. Finally, for measures showing a significant main effect of trajectory class, pairwise comparisons were made by constraining individual pairs of classes to be equal. These analyses were used to determine if there were significant differences between latent classes in terms of personality at the end of high school, and in terms of changes across emerging adulthood across two developmental periods.

Results

Respondent Demographics and Attrition

By Wave 10, 63.8% of the original sample was retained (N = 1,401), with partial data present in intervening waves. Full information maximum likelihood was used to account for missing data (Schafer & Graham, 2002). Those lost to attrition by Wave 10 were no more likely to be at any level of family income, $\chi^2(7) = 4.25$, $p > .05$, but were more likely to be male, $\chi^2(1) = 19.25$, $p < .001$. Attrition differed by binge trajectory class, $\chi^2(6) = 42.71$, $p < .05$, with the least retention in the rare group (55.6%) followed by moderate (58.7%), frequent (61.3%), increasing (61.7%), occasional (63.8%), decreasing (72.8%), and low increasing (74.7%). Additionally, differential attrition by ethnic category was significant, $\chi^2(3) = 8.82$, $p < .05$, with the greatest proportional loss among Latinos (41.2%) versus Black/Other (38.9%), Whites (38.4%), and Asians (31.5%). Mean ages, percent of the sample lost to attrition, and descriptive statistics for drinking and personality measures are provided in Table 1. Full sample demographics are presented in Table 3.

A Seven-Class Model of Binge-Drinking Trajectories

As a first step in model selection, latent class growth models were fit assuming two to eight latent classes and under assumptions of negative binomial, Poisson, or zero-inflated Poisson distributions. Model selection indices are shown in Table 2. Consistent with the distributions commonly observed with substance use data (Atkins, Baldwin, Zheng, Gallop, & Neighbors, 2013), models that assumed a negative binomial distribution showed the lowest values, and all subsequent model testing was done under this distributional assumption. The latent class structure best meet-

Table 2
Fit Indices for Two to Eight Class Latent Class Growth Analysis Models

	AIC			BIC		
Classes	NB	Poisson	ZIP	NB	Poisson	ZIP
2	66,399.016	104,653.161	88,635.459	66,496.196	104,693.176	88,732.639
3	64,161.085	89,788.948	80,680.620	64,281.130	89,851.829	80,800.666
4	63,472.377	84,579.598	76,539.981	63,615.289	84,665.345	76,682.893
5	63,047.507	82,057.271	75,023.237	63,213.285	82,165.884	75,189.014
6	62,707.199	79,917.933	73,859.504	62,892.842	80,049.412	74,048.147
7	62,523.859	79,097.607	72,910.230	62,735.368	79,251.952	73,121.739
8	62,493.391	77,716.149	71,955.760	62,727.766	77,893.359	72,190.134

Note. Akaike information criterion (AIC) and Bayesian information criterion (BIC) model selection indices under distribution assumptions of negative binomial (NB), Poisson, and zero-inflated Poisson (ZIP). Models with the NB distribution assumption consistently showed the lowest values. Consequently, all subsequent modeling was done using an NB distribution of the main dependent variable: binge-drinking frequency.

ing criteria for model selection was one with seven latent classes of binge-drinking trajectories (see Table 2). A model with eight classes yielded a group with only 18 individuals (0.8% of the sample). A seven-class solution had acceptable levels of entropy (0.767), which was not considerably worse than models with six (0.774) and five (0.785) classes. As a final test of model selection, *k* versus *k*-1 class models were compared using a Vuong–Lo–Mendell–Rubin likelihood ratio test (Lo et al., 2001; Vuong, 1989). The seven versus six comparison was significant ($p = .0013$), whereas the eight versus seven class comparison was not ($p = .322$). As such, a model with seven latent classes best represented the data, and was selected as the final growth model.

The distinct patterns of drinking over time can be described as those whose binge-drinking profile is described as (a) frequent, (b) moderate, (c) increasing, (d) occasional, (e) low increasing, (f) decreasing, and (g) rare (Figure 2A). Among these groups, four differed in absolute levels but were characterized by limited change over time (rare, occasional, moderate, and frequent), versus three that showed more considerable change (low increasing, increasing, and decreasing). Intercepts, linear and quadratic slopes for each class are presented in the online supplemental material for Table S1.

Demographic Predictors of Class Membership

Demographic composition of each latent trajectory class is presented in Table 3, and odds ratios of class membership by demographic variables are in Table 4. Although gender was not equally distributed by trajectory class, $\chi^2(6) = 21.15$, $p < .01$, being male did not significantly predict class membership relative to the rare drinking class (see Table 4). Ethnic groups were also not evenly distributed across trajectory classes, $\chi^2(18) = 166.79$, $p < .001$. In general, Asian, Black, or multiethnic individuals were more likely than Whites to be in the rare class versus any other class except the decreasing class. Increases in family income increased the odds of being in any other binge-drinking class relative to the rare class except the low increasing class.

Latent Factor Models Capturing Change in Personality

First, we assessed the fit of personality measurement models for ZK Impulsivity and Sensation Seeking separately (see Figure 3). A strict measurement invariance model was imposed by constraining factor loadings and intercepts for each parcel to be equal across all waves. Models that did not allow for correlated residuals for each parcel showed some misfit: Sensation Seeking, RMSEA = 0.077, CFI = 0.926, TLI = 0.917, $\chi^2(32) = 456494$, $p < .001$; ZK Impulsivity, RMSEA = 0.070, CFI = 0.921, TLI = 0.911, $\chi^2(32) = 378.999$, $p < .001$. To improve the model, parcel residuals were allowed to correlate (shown in Figure 3), resulting in excellent model fit: Sensation Seeking, RMSEA = 0.020, CFI = 0.997, TLI = 0.995, $\chi^2(23) = 42.563$, $p = .008$; ZK

Table 3
Demographic Composition of Trajectory Groups Based on Most Likely Class

Binge class	Frequent	Moderate	Increasing	Occasional	Low increasing	Decreasing	Rare	Total	Overall
Female	51.1%	57.0%	67.7%	66.1%	61.1%	65.0%	57.8%	**1,344**	59.9%
Male	48.9%	43.0%	32.3%	33.9%	38.9%	35.0%	42.2%	**901**	40.1%
White	77.3%	63.9%	56.9%	54.8%	53.3%	49.5%	42.7%	**1246**	55.5%
Asian	5.3%	10.4%	15.0%	17.5%	20.6%	12.6%	29.5%	**404**	18.0%
Latino	8.9%	17.6%	18.6%	17.8%	14.2%	25.2%	12.2%	**342**	15.2%
Black/other	8.4%	8.0%	9.6%	9.9%	11.9%	12.6%	15.6%	**253**	11.3%
Total	**225**	**460**	**167**	**354**	**360**	**103**	**576**	**2,245**	
% by most likely class	10.0%	20.5%	7.4%	15.8%	16.0%	4.6%	25.7%		
% by posterior probabilities	10.7%	19.5%	8.2%	16.2%	17.2%	5.9%	22.3%		

Note. Demographic category percentages are within-column (e.g., 51.1% of those in the frequent binge group were female and 77.3% were White). Percent of the sample captured by each class are provided two ways on the basis of (a) most likely class membership and (b) proportional class membership calculated from posterior probabilities.

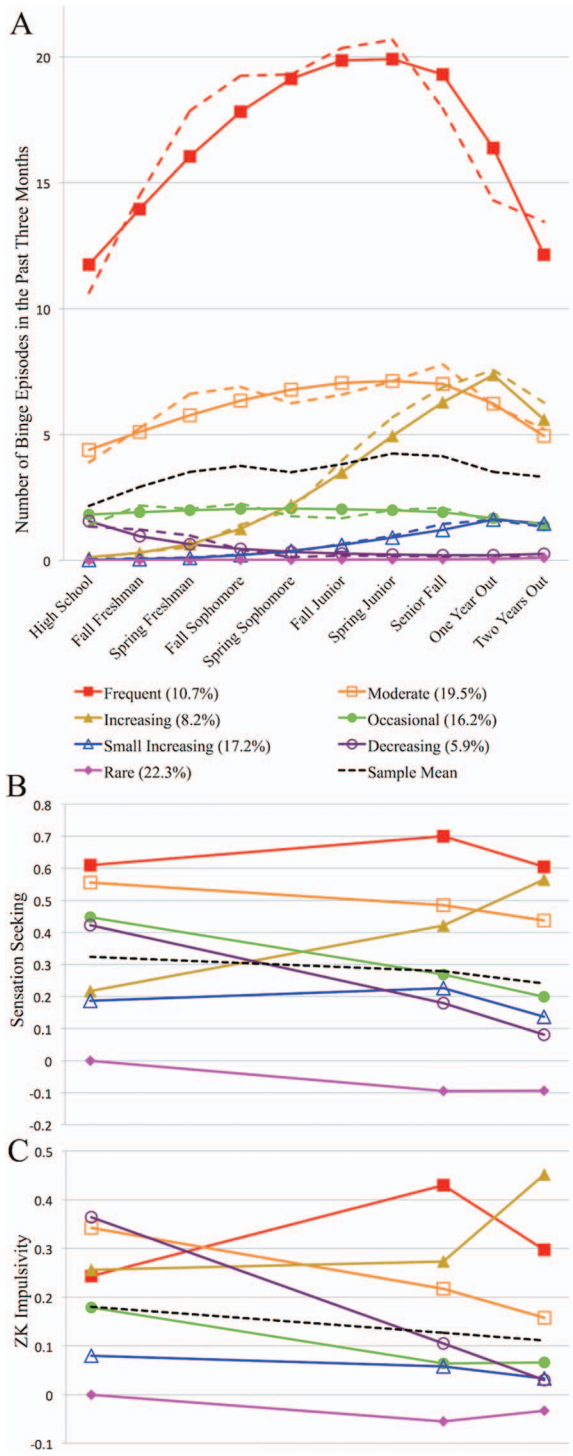

Figure 2. Binge-drinking trajectories and personality change. Panel A: Solid lines are model-implied values, and the dotted lines trace observed values for the seven binge-drinking classes. The fine-dotted black line shows whole sample means across time. Personality trait measures (represented as latent class factor means, shown in Figure 3) had different maturation patterns by class for Sensation Seeking (Panel B) and Zuckerman–Kuhlman (ZK) Impulsivity (Panel C). The mean of the rare class at Wave 1 (High School) was constrained to be zero to identify the model. See the online article for the color version of this figure.

Impulsivity, RMSEA = 0.024, CFI = 0.993, TLI = 0.989, $\chi^2(23) = 53.378$, $p = .0003$.

Next, MODEL CONSTRAINT functions of Mplus were used to create new variables based on linear combinations of other variables. The latent difference scores between Waves 8 and 1 and between Waves 10 and 8 can be directly estimated as the difference between latent factors. Overall, Sensation Seeking significantly decreased across college ($M = -0.079$, $p < .001$, 95% confidence interval [CI] [−0.139, −0.019]) and across the 2 years after ($M = -0.060$, $p < .05$, 95% CI [−0.120, −0.001]). Similarly, ZK Impulsivity decreased across college ($M = -0.060$, $p < .001$, 95% CI [−0.095, −0.024]), but did not significantly decrease across the 2 years after ($M = -0.012$, $p = .488$, 95% CI [−0.047, 0.023]).

Change in Personality Within Latent Classes

Once we confirmed that latent factor models of personality fit the data well, we combined the personality model with the LCGA model to examine class differences in high school personality (W1), change across college (Δ1) and change across the transition out of college (Δ2). Models for Sensation Seeking and ZK Impulsivity were tested separately. Full models combining latent drinking classes and latent factors of personality had the following fit indices: Sensation Seeking (AIC: 102,897.40, BIC: 103,389.016) and Impulsivity (AIC: 95,556.545, BIC: 96,048.160). Within-class difference scores are shown in Figure 4.

To determine if there was a main effect of latent class across these three dependent variables, values across all of the latent classes were constrained to be equal using MODEL TEST functions. For Sensation Seeking, there was a main effect of class on W1 means, Wald(6) = 177.833, $p < .0001$, and on Δ1, Wald(6) = 27.663, $p < .001$, but not on Δ2, Wald(6) = 7.728, $p = .26$. Similarly, for ZK Impulsivity there was a main effect of class on W1 means, Wald(6) = 58.328, $p < .0001$, and on Δ1 Wald(6) = 17.825, $p < .01$, but not on Δ2, Wald(6) = 10.359, $p = .11$.

Next, we tested for significant differences using pairwise comparisons between individual classes for each of these three dependent variables for the two personality traits. This was achieved by using MODEL TEST functions to constrain the dependent variables between two given classes to be equal resulting in a Wald statistic with one degree of freedom. As there was no main effect of trajectory class across the transition out of college (Δ2), pairwise tests were conducted for W1 and Δ1 periods only. To adjust for multiple testing, all p values from these pairwise tests (84 pairwise comparisons) were subject to a false discovery rate p value correction (Benjamini & Hochberg, 1995). The adjustment reduced the number of significant pairwise differences from 36 to 27. Pairwise Wald statistics and adjusted significance are presented in Tables 5 and 6, with Sensation Seeking above the diagonal and ZK Impulsivity below the diagonal.

In terms of Sensation Seeking, most groups showed decreases across college, with significant declines in the occasional, decreasing, and rare groups (Figure 4A). There were no significant changes in the period after college. The increasing group, on the other hand, was the sole group showing a corresponding increase in Sensation Seeking across college, but not significantly so across the transition out of college. The pattern for ZK Impulsivity was a bit different. Whereas the sample-level change was a decrease across college (Figure 4B),

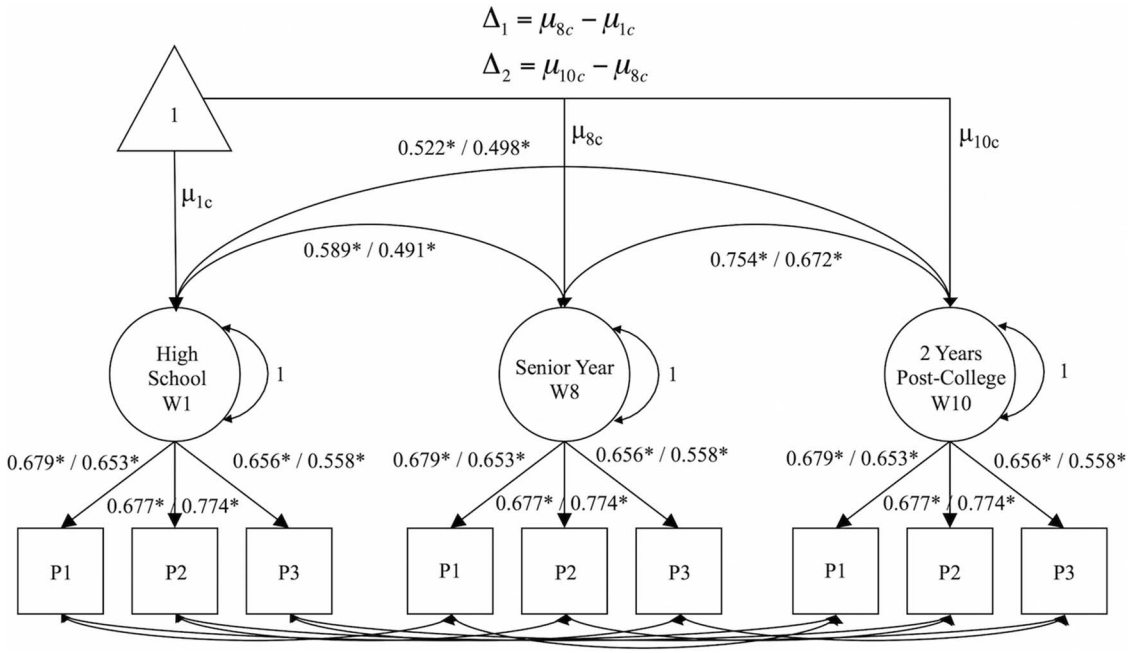

Figure 3. Personality measurement factor model. Factor model of Sensation Seeking (left values) and Zuckerman–Kuhlman Impulsivity (right values) across the college years (Δ_1), and across the transition out of college (Δ_2). Factor scores were estimated at each of three waves within each of seven latent classes. Standardized parameters are provided. Squares represent observed variables, circles represent latent factors, and the triangle represents a constant to indicate latent factor means (μ_1, μ_8, μ_{10}) within each latent class *c*. W = Wave; P = Parcel. * $p < .05$.

only the moderate group showed a significant decline. Although the increasing group did not show a change in ZK Impulsivity across college, the frequent group did show a significant increase. Across the transition out of college, the frequent group reported a significant decrease in ZK Impulsivity, whereas the increasing group reported a significant increase.

Discussion

The primary aims of this study were to describe longitudinal trajectories of binge drinking over the college years and beyond into emerging adulthood as well as to determine if these latent class trajectories correlate with unique patterns of personality maturation over the same time span. Results of LCGA modeling demonstrated that seven latent classes capture longitudinal patterns of binge drinking with unique developmental patterns for each group. Two notably deviant patterns of personality maturation are evident for the increasing and frequent groups: these "late-blooming" and behaviorally extreme individuals violate the "maturity principle" (Caspi et al., 2005) of normative declines in impulsivity and sensation seeking with increasing age. Additionally, despite showing initial personality risks that were comparable to those in classes who persisted in binge drinking, the decreasing group binge drank less with time and showed a corresponding decrease in sensation seeking, The fact that all three of these latent classes created on the basis of binge-drinking data also show differences in personality maturation provides additional evidence

Table 4
Odds Ratios of Latent Class Membership by Demographic Variables

Binge class	Frequent	Moderate	Increasing	Occasional	Low increasing	Decreasing
Male	1.27	1.02	0.8	0.78	0.92	0.91
Family income	1.17**	1.18***	1.15*	1.16**	1.05	1.15*
Asian	0.12***	0.32***	0.46*	0.41***	0.53**	0.62
Latino	0.51*	1.03	1.26	1.22	0.84	1.68
Black/other	0.38**	0.40**	0.44*	0.49*	0.59*	0.86
Mother's education	0.99	0.97	0.96	1.01	0.96	0.93
Father's education	0.90	0.90	0.90	0.84*	0.96	0.91

Note. Reference categories are Female sex, White ethnicity, and the Rare Binge class. Family income and education variables were quasicontinuous with 8 and 6 levels, respectively.
* $p < .05$. ** $p < .01$. *** $p < .001$.

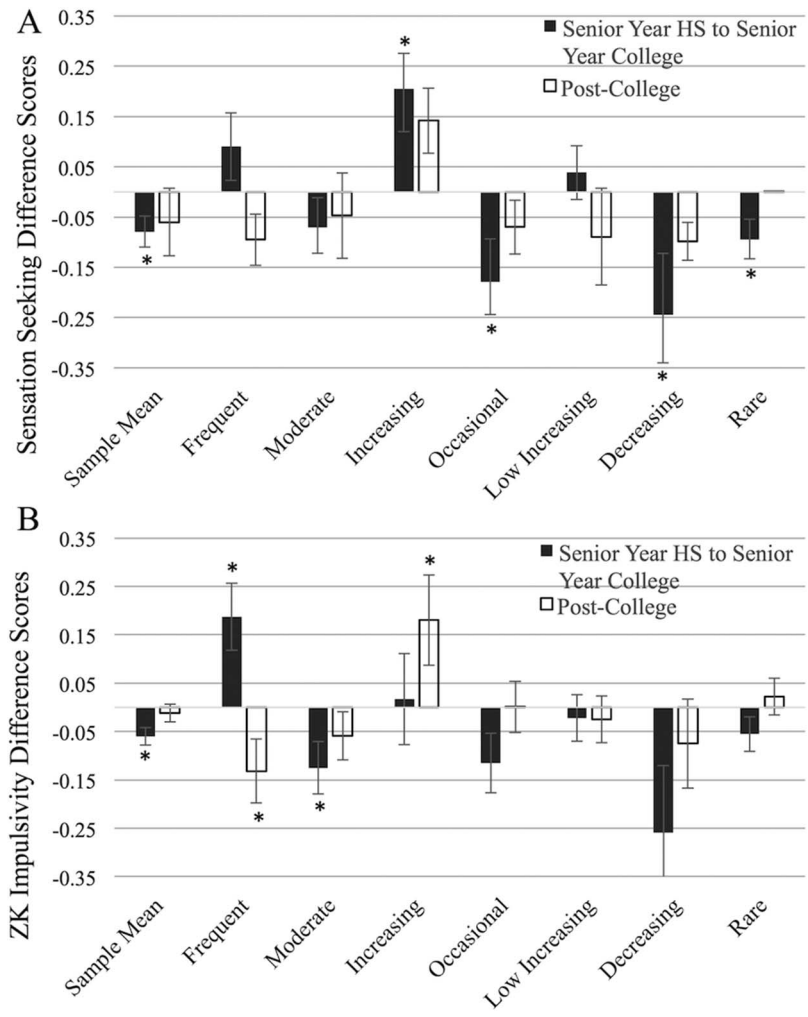

Figure 4. Latent difference scores by latent trajectory class. Estimated differences scores capturing change from senior year of high school (HS; Wave 1) to senior year of college (Wave 8) and change across the 2 years after (Wave 10) in terms of Sensation Seeking (Panel A) and Zuckerman–Kuhlman (ZK) Impulsivity (Panel B). Some but not all latent classes had difference score estimates that were significantly different from zero, primarily during the first period under examination. * $p < .05$.

that personality-related mechanisms may determine who does and does not "mature out" of binge drinking across college.

Patterns of Binge-Drinking Trajectories

The analyses presented here, using robust and advanced modeling techniques, produced results mostly consistent with previous research on classes of binge drinkers across college or this age group, and highlighted groups of individuals who do not fully "mature out" of binge drinking. All groups—except the decreasing and rare binge groups—increased binge drinking to some degree during the course of college (Figure 2A). The peak of drinking for the frequent and moderate binge groups, both of which ended up binge drinking postcollege at a nearly identical rate as seen earlier in high school, occurred during junior year, corresponding to when most of the cohort reached age 21. Thereafter, and across the transition out of college, binge drinking decreased except in the increasing group, which showed a peak 1 year out of college. Although the frequent and moderate groups persisted in potentially hazardous rates of binge drinking, the steep decline across the transition out of college is consistent with the idea of "maturing out" of elevated binge drinking.

A cluster analysis in the Monitoring the Future project described six classes of binge drinkers that closely resemble those described here (Schulenberg et al., 1996). These six classes, formed on a priori hypotheses and confirmed with cluster analysis were characterized as never (35.8%), rare (16.7%), fling (9.9%), increased (9.5%), decreased (11.7%), and chronic (6.7%). This previous analysis did not use growth modeling as implemented in the present study. Nevertheless, our results are consistent with this previous model in terms of the common patterns of drinking over time.

Modeling of data on heavy drinking from the National Longitudinal Survey of Youth (NLSY) identified nine groups (Muthén

Table 5
Pairwise Comparisons of Wave 1 (W1) Estimated Latent Means

Trajectory class	1	2	3	4	5	6	7
1. Frequent	—	0.49	23.28***	3.33	32.39***	2.43	90.89***
2. Moderate	1.5	—	19.03***	1.07	27.56***	1.44	91.22***
3. Increasing	0.02	0.81	—	4.93	0.13	2.83	9.80**
4. Occasional	0.77	4.33	0.53	—	8.16*	0.03	28.34***
5. Low increasing	5.40	16.79***	3.37	2.15	—	4.10	8.90*
6. Decreasing	0.90	0.04	0.64	1.76	5.25	—	14.43***
7. Rare	14.51***	36.44***	8.73*	8.14*	2.10	9.74**	—

Note. Pairwise Wald statistics ($df = 1$) from model tests constraining W1 (high school) latent means of personality factors to be equal. Sensation Seeking is above the diagonal and Zuckerman–Kuhlman Impulsivity is below the diagonal. Significance threshold was adjusted using a study-wise false discovery rate correction. W1 means are presented visually in Figure 2BC.
* $p < .05$. ** $p < .01$. *** $p < .001$.

& Muthén, 2000), although the authors collapsed several small groups to achieve a more parsimonious model. The final four groups consisted of one that was low and relatively stable (73%), two groups with different levels of early heavy drinking that decreased with time (14%, 5%), and one group that increased with time (7%). These analyses included alcohol dependence diagnoses at age 30, whereby the increasing group was the most likely to meet diagnostic criteria (odds ratio = 30 relative to the low drinking class). This was remarkably greater than the initially heavy drinking classes (odds ratios = 3.92, 7.06). Whereas our data did not include assessments of AUDs, the increasing group from our sample is likely similar to this previously reported increasing group, and therefore may also be at high risk for development or persistence of AUDs into the 30s. Importantly, however, NLSY is not a college-only sample. Thus, comparisons between our results and those of Muthén and Muthén (2000) must be done with caution.

Last, our results relating personality traits to binge-drinking trajectories are partially consistent with those of a study that examined the determinants of binge drinking in a large longitudinal Canadian cohort spanning from 12 to 24 years old (Wellman, Contreras, Dugas, O'Loughlin, & O'Loughlin, 2014). Wellman and colleagues (2014) categorized individuals who persisted in binge drinking from an assessment wave at mean age 20 to a wave at mean age 24 as "sustainers," whereas those who indicated previous binge drinking but none at age 24 were characterized as "stoppers." Traits that predicted sustained binge drinking included high levels of impulsivity and novelty seeking in adolescence, being male, and initiating drinking earlier. Among sustainers, those who binge drank more frequently at age 24 scored significantly higher on a novelty seeking scale, but not on an impulsivity scale.

LCGA attempts to represent the vast diversity of people's drinking experiences over time with a finite and parsimonious set of homogenous groups. Like any categorization scheme, however, determining the "best" number of classes in a LCGA is ultimately arbitrary, and must be informed by theory and previous research. Notably, our seven-class solution is consistent with previous results using different methods in independent samples, and exhibited patterns of change consistently found across analyses of this kind (Sher et al., 2011). The number of classes previously identified ranges from three to nine (Muthén & Muthén, 2000; Schulenberg et al., 1996; Sher et al., 2011), and our models indicated a number on the higher end of this spectrum. This is likely due to the fact that we used the full available range of frequency of binge drinking rather than collapsing data into smaller categorical bins or treating it as a dichotomous variable.

Table 6
Pairwise Comparisons of Latent Difference Scores From High School to Senior Year of College (Delta 1)

Trajectory class	1	2	3	4	5	6	7
1. Frequent	—	2.76	1.43	6.47*	0.36	5.70	5.64
2. Moderate	11.43*	—	8.08*	0.79	1.89	1.71	0.11
3. Increasing	2.07	1.62	—	12.84**	3.37	9.85**	13.62**
4. Occasional	10.69**	0.01	1.21	—	4.67	0.16	0.78
5. Low increasing	6.15*	2.09	0.12	1.42	—	4.23	3.75
6. Decreasing	8.16*	0.84	2.74	0.76	2.36	—	1.29
7. Rare	9.57**	1.18	0.51	0.69	0.30	2.00	—

Note. Pairwise Wald statistics ($df = 1$) from model tests constraining the differences between Wave 8 (senior year of college) and Wave 1 (high school) latent means of personality factors to be equal across latent classes. Sensation Seeking is above the diagonal and Zuckerman–Kuhlman Impulsivity is below the diagonal. Significance threshold was adjusted using a study-wise false discovery rate correction. Estimated difference scores are presented visually in Figure 4.
* $p < .05$. ** $p < .01$.

Predictors of Class Membership

Although gender was not equally distributed across latent classes and the general pattern was that men were more likely to be in higher drinking classes (see Table 4), these odds ratios were not significant with reference to the rare class. Consistent with prior research indicating that greater family financial resources are a risk factor for substance use including alcohol (Hanson & Chen, 2007), being from a family with greater income increased the risk of being in heavier drinking classes compared with the rare class. Also notable, being White versus Asian or Black/multiethnic increased the odds of being in a heavier drinking class relative to the rare class. This result is consistent with models of NLSY data (Muthén & Muthén, 2000), Monitoring the Future data (Schulenberg et al., 1996), and other independent college samples examining alcohol consumption and ethnicity (Cacciola & Nevid, 2014; O'Malley & Johnston, 2002).

Patterns of Personality Change and Unique At-Risk Groups

Our results are generally consistent with both the corresponsive and maturity principles of personality development (Caspi et al., 2005). The corresponsive principle holds that personality characteristics most related to experiencing an outcome are also the most likely to change as a consequence of the experience (Caspi et al., 2005). Here, we see that change in impulsivity (most closely resembling lack of premeditation) and sensation seeking corresponds with frequency of binge drinking in distinct groups of binge drinkers. Across college, the frequent binge group accelerates in binge drinking through the spring of junior year followed by a decrease across the transition out of college, and ZK Impulsivity increases but then decreases over these same time periods. Similarly, the decreasing and increasing groups show corresponding decreases and increases, respectively, in sensation seeking over college. Nevertheless, mean-level estimates across the sample of both personality constructs decrease over college, consistent with the "maturity principle" (Caspi et al., 2005), but there was no overall significant change across the transition out of college (Figure 2BC, Figure 4). It is important to note that the first period of change was examined across 4 years versus only 2 years for the latter, presenting a more limited window for change to occur.

Our analyses indicate that the increasing and frequent classes are unique risk groups for heavy drinking in relation to personality development, although we are unable to determine the cause of these changes. Of the several significant pairwise comparisons in regard to changes in Sensation Seeking over college (see Table 6) all involved comparisons with the increasing class, identifying these individuals as a unique at-risk group. The pattern was quite different for the frequent group, who exhibited the heaviest levels of binge drinking overall. Across college, the frequent class increased in terms of impulsivity, whereas they showed a significant decrease in the period after college (Figure 4B). Sensation Seeking, on the other hand, did not significantly change for this group. Thus, these personality traits exhibited different patterns of change between these two groups, potentially indicating specific mechanisms contributing to the different patterns of binge drinking over time.

Implications for Modifying Intervention Approaches

Most college prevention/intervention programs are delivered in the first year of college, and the majority emphasize alcohol risk-reduction or protective behavioral strategies (Mun et al., 2015). Our results, however, suggest that different risk factors, and therefore different prevention approaches, may be warranted for those entering college and for those leaving college. Whereas change in sensation seeking across college was statistically equivalent between all other classes, the increasing class stood out as changing the most. After college, this group showed an increase in impulsivity that was significantly greater than zero (Figure 4B). Thus, overall, it appears that sensation seeking is most related to binge drinking during college, but the transition out is more associated with impulsivity (most closely resembling lack of premeditation).

Recently developed prevention programs have begun to focus on specific risk factors, including personality (Conrod, Castellanos, & Mackie, 2008; Conrod, Stewart, Comeau, & Maclean, 2006; Lammers et al., 2015) and low level of response to alcohol (Schuckit et al., 2015). Our results indicate that college students may benefit from personality trait-related programs originally developed for adolescents (e.g., PreVenture; Conrod et al., 2008) as an adjunct to existing programs. Furthermore, the timing of personality change within our results (see Figure 4) indicates that incoming students would benefit from programs with an emphasis on sensation seeking and impulsivity, whereas a "booster" program delivered later in college could focus specifically on impulsivity. The trait-based PreVenture program has shown promising results in terms of slowing the growth of binge drinking among adolescents (Conrod et al., 2006, 2008), and similarly focused interventions may also be effective for slowing the growth of binge drinking in college, particularly among individuals who show a pattern of use like the increasing class.

Limitations

Our results must be interpreted with respect to the relative strengths and weaknesses of our data and analyses. First, our large college sample yielded data with relatively fine resolution in terms of drinking data (three month windows up to twice yearly). Personality measures, on the other hand, were given less frequently, which limits our ability to model co-occurring change. Next, although about 37% of the sample was lost to attrition by the final assessment wave, our models used robust methods for missing data. Additionally, we used negative binomial distributions with continuous count data to maximize available information. Last, latent factor models were used to increase the reliability of estimates of change in personality, compared with using observed difference scores.

There remain several notable limitations of the current analysis. First, we cannot determine causal relations between alcohol use and personality development due to the survey methodology. Next, with respect to the sample under examination, a sizable majority was white and it was comprised entirely of college students, which limits generalization to the population as a whole. Furthermore, our analyses did not include genetic risk for AUDs, or additional facets of personality that likely relate to binge drinking including negative emotionality, and we could not account for additional contextual information, such as changes in responsibilities that

might prompt adjustments in drinking behaviors or personality maturation. Whereas the primary focus of this analysis was on binge drinking, there are other drinking metrics one could potentially examine such as drinking quantity (weekly sum, drinks per drinking day) and frequency (drinking days per week). Bivariate within-wave correlations between these measures and binge drinking were high (Pearson's r range = 0.52–0.82), indicating that results using these metrics as dependent variables would likely be similar. Last, because of computational burden, we were unable to explore growth mixture models where variation of intercepts and slopes within latent classes are freely estimated instead of being constrained to zero.

Conclusions

Our analyses demonstrate that distinct trajectories of binge drinking correlate with distinct patterns of personality maturation across college and the transition out into adulthood. Our results support the idea that facets of personality most closely associated with problematic alcohol use, namely impulsivity and sensation seeking, change in correspondence with binge drinking over time. Furthermore, our results identify a group of individuals, an increasing group, who deviate from normative patterns of personality maturation, putting them at risk for continued hazardous use of alcohol. Investigation into the causes of this persistent increase in sensation seeking beyond the college years may yield development of fruitful interventions for the prevention of adult alcohol use disorders in a group that in high school would otherwise appear to be at low risk. Furthermore, existing personality-based interventions developed for use in adolescence, like PreVenture (Conrod et al., 2008), may also benefit college students.

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