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Longitudinal Conjoint Patterns of Alcohol and Tobacco Use throughout Emerging Adulthood

Jessica Duncan Cance, Ph.D.[1], **Anna E. Talley, M.A.**[1], **Antonio Morgan-Lopez, Ph.D.**[2], and **Kim Fromme, Ph.D.**[3]

[1]Department of Kinesiology and Health Education, the University of Texas at Austin

[2]RTI International, Research Triangle Park, North Carolina

[3]Department of Psychology, the University of Texas at Austin

Abstract

Background—The concurrent use of alcohol and tobacco has a multiplicative effect on both social and physical consequences. While it is known that alcohol and tobacco use are strongly correlated in emerging adulthood, there is significant individual variability in use. However, little research has examined how patterns of concurrent use are related over time.

Objectives—The current study explores these longitudinal conjoint trajectories, as well as the associated sociodemographic factors.

Methods—We used sequential latent class growth analysis to explore the co-occurring longitudinal patterns of recent alcohol and tobacco use across emerging adulthood (10 data collection periods, 2004–2009) with a diverse sample of 2,244 college students (60% female; 54% White).

Results—Twenty distinct patterns of conjoint alcohol and tobacco use were found. There was more variation in tobacco use trajectories among alcohol users than variation in alcohol trajectories among tobacco users. Using multinomial logistic regression models we determined the impact of sociodemographic characteristics on classification into each conjoint pattern versus the normative trajectory (Abstaining tobacco/Low alcohol). Male gender, White race, fraternity/sorority affiliation, and higher family income were significantly associated with riskier conjoint trajectory patterns.

Conclusions/Importance—Findings highlight the diversity of alcohol and tobacco use behaviors across emerging adulthood. The low variation in alcohol use among tobacco users indicates that tobacco use is a significant risk factor for heavier drinking. A better understanding

Correspondence concerning this article should be addressed to Dr. Jessica Duncan Cance, Department of Kinesiology and Health Education, The University of Texas at Austin, 2109 San Jacinto Blvd, D3700, Bellmont Hall 718, Austin, Texas, 78712. Jessica.cance@gmail.com.

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of the covarying use of these two ubiquitous substances may provide new avenues for preventing and reducing the use of both.

Keywords

alcohol; tobacco; longitudinal studies; emerging adulthood; college

Substance use and abuse peaks during emerging adulthood (ages 18 to 26) (Arnett, 2000, 2005, 2007; Brook et al., 2008; Chassin, Flora, & King, 2004; H. White, Bray, Fleming, & Catalano, 2009). Among full-time college students, 60% identify as current drinkers, 40% as binge drinkers, 21% report past month smoking, and over 25% have used other tobacco products within the past year; rates which have remained consistent in the college population since the 1990s (Johnston, O'Malley, Bachman, Schulenberg, & Miech, 2015; SAMHSA, 2014). Compared to peers not enrolled in college, students are more likely to increase binge drinking behavior post high school (Bingham, Shope, & Tang, 2005; Johnston et al., 2015; Schulenberg & Maggs, 2008; Slutske, 2005). And while tobacco use is less common among college students than their non-student peers (Green et al., 2007), it remains an important health issue because the majority of daily smokers and almost 50% of occasional smokers continue smoking throughout college (Kenford et al., 2004). The social and physical consequences of substance use are significant (CDC, 2014; Goudriaan, Grekin, & Sher, 2007; Hingson, Heeren, Winter, & Wechsler, 2005; Perkins, 2002; WHO, 2011) and impact not only the user but the entire campus (Wechsler, Moeykens, Davenport, Castillo, & Hansen, 1995; Wolfson, McCoy, & Sutfin, 2009).

While there is a great deal of overlap, or co-occurrence, in the use of alcohol and tobacco throughout emerging adulthood (Halperin, Smith, Heiligenstein, Brown, & Fleming, 2010; Jackson, Sher, & Schulenberg, 2008; Weitzman & Chen, 2005), there is also substantial individual heterogeneity. Research has consistently identified four distinct patterns of alcohol use: nonuser/stable low-user, chronic high-use, decreasing use, and escalating use (Jackson, Sher, & Schulenberg, 2009; Schuckit et al., 2014; Sher, Jackson, & Steinley, 2011). Tobacco research (primarily focused on cigarette smoking) has shown three to seven discrete longitudinal patterns, with three typical classes: nonuser, light-use, and chronic high-use (Chassin, Curran, Presson, Wirth, & Sherman, 2009). In cross-sectional research, predominately with adolescent and/or non-US samples, trends of cooccurring tobacco and alcohol use have emerged: while an alcohol-only subgroup is typical, tobacco use is almost always accompanied by alcohol use (Cleveland, Collins, Lanza, Greenberg, & Feinberg, 2010; Connell, Gilreath, Aklin, & Brex, 2010; Gilreath et al., 2014; Hedden, Whitaker, von Thomsen, Severtson, & Latimer, 2011; Kelly et al., 2014; A. White et al., 2013). This is supported by research using latent transition analysis which demonstrates adolescents typically initiate alcohol use prior to tobacco use (L. M. Collins, Hyatt, & Graham, 2000).

Little is known about how the prospective patterns of alcohol and tobacco use are related. However, a series of studies with a sample of 18 to 26 year olds found, using mixture modeling procedures, that patterns of heavy alcohol use and cigarette smoking were similar (Jackson et al., 2008) and drinking without smoking was more common than smoking without drinking (Jackson et al., 2009). Another study of 13 to 23 year olds found the

majority of participants were in a conjoint trajectory class consisting of experimental cigarette smoking and moderate drinking (Orlando, Tucker, Ellickson, & Klein, 2005).

There have been limitations, however, in the past research. These past studies have been with predominately White samples and a relatively limited number of assessments with at least one year between each assessment. The number of assessments can impact the classification of individuals into different trajectories (Tan, Dierker, Rose, & Li, 2011) so it is critical to replicate these studies with a sample including more frequent assessments in order to ensure an accurate understanding of the interplay of alcohol and tobacco use, particularly during this developmental period of rapidly changing substance use. Furthermore, emerging adulthood is known to be a heterogeneous experience and cooccurring use among college students is likely different from their peers not enrolled in school. For example, daily tobacco use is often stigmatized among college students but smoking in social situations while consuming alcohol is socially acceptable (Nichter, Nichter, Carkoglu, & Lloyd-Richardson, 2010).

Alcohol and tobacco use among college students are associated with several sociodemographic factors. Higher rates of alcohol consumption have been linked to male gender, White ethnicity, fraternity/sorority affiliation, and higher family income; student smokers are also more likely to be White, better educated, and wealthier than their peers (Capone, Wood, Borsari, & Laird, 2007; Kenford et al., 2004; Schane, Glantz, & Ling, 2009; Sutfin, Reboussin, McCoy, & Wolfson, 2009; H. White & Jackson, 2004). Yet little is known about how these characteristics may be associated with longitudinal patterns of use. Two longitudinal studies linked males and White race to a higher likelihood of classification into increasing and consistently high smoking and drinking trajectories (Orlando et al., 2005; Schuckit et al., 2014).

The purpose of this study is to identify the co-occurring longitudinal patterns in alcohol and tobacco use across a six-year period of emerging adulthood. We also examine how sociodemographic characteristics are associated with the specific conjoint patterns of use. Understanding the individual developmental patterns will make it possible to target interventions to those individuals at highest risk for persistent and problematic co-occurring substance use.

Methods

Participants and Procedures

Data are from a six-year study (10 data waves; N=2,244; 60% female) that began the summer before enrollment (2004) at a large public university in the Southwestern United States (Table 1). Participants were incoming freshmen between the ages of 17 and 19 who had not previously attended college. Of the 6,390 invited to participate (94% of the incoming class), 4,832 expressed interest in the study and met the additional eligibility criteria of being unmarried. These students were randomly assigned to one of three study samples, including 3,046 who were asked to complete semiannual web-based surveys (Corbin, Vaughan, & Fromme, 2008). Participants who completed the first survey (N=2,244) are included in the current analyses; 55% identified as White, 18% Asian-American, 16%

Hispanic/Latino, 4% African-American, and 7% belonging to other racial/ethnic groups (Table 1). The racial/ethnic and gender distribution was comparable to the university's enrollment demographics. Internet-based surveys were administered twice annually at the end of fall and spring semesters during years 1–3 (Waves 1–7) and once a year at the end of fall semester during years 4–6 (Waves 8–10). Attrition from wave-to-wave ranged from 2–7%; approximately 40% of the sample completed all 10 waves of data, 17% completed 9 waves of data, 13% completed 8 waves of data, and 30% of the sample completed 7 or fewer waves of data. Attrition analyses suggest that males were more likely to drop out of the study than females. No other variables included in the present study (covariates or substance use outcomes) were associated with attrition. Participants received $30 for the baseline survey, $20 for the Years 1–3 fall surveys, $25 for the Years 1–3 spring surveys, and $40 for the Years 4–6 surveys.

Measures

Alcohol use—Two items from the Daily Drinking Questionnaire (DDQ) assessed number of drinking days and number of drinks per drinking day during a typical week (R. Collins, Parks, & Marlatt, 1985). The frequencies of intoxication and binge drinking (four/five or more drinks at a sitting for women/men) were each assessed with single items (Wechsler & Isaac, 1992).

We created a latent alcohol use factor with the four items. Confirmatory factor analysis demonstrated an excellent fit at each data collection wave (e.g., CFI values all above .98; SRMR all below .05; 95% confidence intervals for RMSEA all include .05). Longitudinal measurement invariance was assessed following procedures outlined in (Vandenberg & Lance, 2000), confirming partial metric invariance (i.e., equivalence of factor loadings across time). Analyses were conducted using the continuous individual alcohol factor scores (wave mean scores ranged from 1.14 – 2.13; total range .29–10.41) computed at each wave.

Tobacco use—Participants indicated how often they used tobacco in the past three months (range 0="never" to 3="daily"). "Never" users were further asked if they never used in the past three months, only rarely used, or typically used tobacco but not in the past three months. A new five-level variable was constructed indicating frequency of tobacco use in the past three months (0="never" and "typically use but not in past three months", 1="rarely use tobacco", 2="occasionally", 3="weekly, but not daily", and 4="daily").

Sociodemographic characteristics—Participants reported gender, race/ethnicity (White/non-White), place of residence (on- vs. off-campus), fraternity/sorority (Greek) membership, estimated family income, and highest parent education.

Statistical Analyses

Sequential Latent Class Growth Analysis—LCGA is a person-centered approach to longitudinal data analysis that aims to determine unobserved subgroups or classes of growth patterns that exist within the data (Jung & Wickrama, 2008; B. O. Muthén & Muthén, 2000; Nagin & Tremblay, 2001). The result is a set of latent trajectory classes whereby individuals within a class are more alike than individuals in other classes. Membership in a specific

class is stated in terms of a probability estimate. LCGA is a special case of growth mixture modeling where the assumption is made that the heterogeneity among individuals within each latent class is explained by the latent class membership; the within-class variances are fixed to zero. In this way LCGA models are more parsimonious than growth mixture models.

A series of latent class growth analysis (LCGA) models first estimated the number of underlying latent trajectory classes for alcohol use and tobacco frequency separately. To lessen bias in the selection of the number of latent trajectory classes, several criteria were considered: the Bayesian information criterion (BIC; lower values preferred); entropy (ranging from 0 to 1; preferred values closer to 1); the Lo-Mendell-Rubin likelihood ratio test (LMR-LRT p-values; $p<.05$ supports a model of K+1 versus K classes); the bootstrap likelihood ratio test (BLRT; $p<.05$ supports a model of K+1 versus K classes); posterior class probabilities and proportions; and theoretical considerations regarding the interpretation of the unique latent classes (Bauer & Curran, 2003; Jung & Wickrama, 2008).

After determining the number of latent trajectory classes for each substance a sequential process LCGA was implemented. This model provided conjoint trajectory probabilities, as well as probabilities for membership in one substance use trajectory class conditional upon classification in the other substance. The probabilities for tobacco frequency class membership conditional upon alcohol classification and the probabilities for alcohol class membership conditional upon tobacco classification were calculated. All LCGA models were implemented with Mplus 7.11 using the maximum likelihood estimator with robust standard errors (MLR) to account for the non-normal distribution of the substance use variables and allow for all participants who contributed at least one wave of data to be retained in the sample through the MLR missing data estimation (B. O. Muthén & Muthén, 2012).

Multinomial Logistic Regression—Multinomial logistic regression with SPSS 21 determined how sociodemographics were associated with conjoint trajectory class membership, with the most commonly occurring conjoint class serving as the reference category. To reduce the likelihood of Type I error omnibus tests were conducted. If the omnibus test was significant the relationship was further probed to determine the specific ability to differentiate class membership.

Results

Alcohol and tobacco use latent trajectory classes

For both substances, the underlying functional form was determined to be quadratic in shape. On average, alcohol and tobacco use increased after college entry and then began to desist towards the end of the study. Fit criteria confirmed that a four-class model provided the best fit for alcohol (Table 2; Figure 1), including (1) a low use class exhibiting moderate increase across the duration of the study (Low, 47%); (2) a class with medium use at baseline that also gradually increased use (Low Increase, 30%); (3) a steadily increasing medium use class that showed slight desistance over the final two waves (Medium High, 17%); and (4) a high use class that dramatically increased use and then desisted during the

final two waves (Steady High, 6%). This model correctly classified 97–99% of individuals into one of the four classes. The five-class solution emerged as the best fitting model for tobacco use (Table 2; Figure 1), including: (1) a steady low or abstaining class (Abstaining; 68%); (2) a class exhibiting low use at Wave 1 that increased throughout college, followed by a decline in Waves 8 – 10 (Low Increasing; 11%); (3) a class exhibiting moderate use at Wave 1 than increased throughout college, followed by a decline in Waves 8–10 (Moderate Increasing; 6%); (4) a steadily decreasing use class with a slight increase in use at Wave 9 (Decreasing; 11%); and (5) a consistently heavy use class (Steady High; 4%). This solution correctly classified 88–99% of individuals into one of the five classes.

Concerns have emerged about the potential risk of overestimating the number of classes when LCGA is conducted with non-normally distributed data (B. Muthén & Asparouhov, 2015). We explored the sensitivity of our tobacco trajectory results by re-testing the LCGA models after removing participants who indicated never using tobacco. The best fitting model confirmed the remaining four non-abstaining tobacco use classes.

Conjoint alcohol and tobacco use latent trajectory classes

The sequential process LCGA was implemented to determine the percentage of participants in each of the twenty conjoint patterns (i.e., all combinations of the four alcohol and five tobacco trajectories). Two models were run to be able to determine the probability of being in a certain tobacco class given a specific alcohol classification (e.g., what proportion of Low alcohol users were classified as being Steady High tobacco users) and the probability of being in a certain alcohol class given a specific tobacco classification (e.g., what proportion of Steady High tobacco users were classified as Low alcohol users).

The largest percentage of participants was classified into the Low alcohol/Abstaining tobacco conjoint trajectory (41%). Less than 1% of participants were predicted to belong to the Low alcohol/Steady High tobacco use conjoint trajectory. There was a clear pattern in how members within each alcohol use class were distributed across the different tobacco use classes (Table 3; Figure 2a). The alcohol class with the largest proportion of members classified in the Abstaining tobacco class was the Low class (88%), and the Steady High alcohol class had the smallest proportion of members classified in the Abstaining tobacco class (18%). The Steady High alcohol class had the highest proportion of members classified in the Steady High tobacco class (25%), over six times higher than the proportion in the overall sample (4%).

There was a less distinct pattern for how members within each tobacco class were distributed across the different alcohol classes (Table 3; Figure 2b). The Abstaining tobacco class had the highest proportion of members classified in the Low alcohol class (61%) and the Steady High tobacco class had the smallest proportion in the Low alcohol class (7%). The Low Increasing tobacco use class had the highest proportion of members in the Low Increase alcohol class (45%). Membership in the Medium High alcohol class was relatively similar for the Decreasing (33%), Moderate Increasing (40%), and the Steady High (35%) tobacco use classes. The Steady High tobacco class had the highest proportion of members classified in the Steady High alcohol class (34%), almost six times higher than the proportion of members in the Steady High alcohol class in the overall sample (6%).

Sociodemographic differences in conjoint trajectory class membership

We first tested the relationship between the sociodemographic characteristics and patterns of each substance (data not shown). The overall likelihood ratio tests indicated that all sociodemographic characteristics except parent education were significantly associated with alcohol use latent trajectory class membership. Contrary to alcohol use, only White race and gender emerged as significant predictors of tobacco use latent trajectory class membership.

Parent education and place of residence were not significantly associated with conjoint latent trajectory class membership (Table 4). Male gender (OR=2.744), White race (OR=9.263), fraternity/sorority (Greek) affiliation (OR=4.831), and higher family income (OR=1.300) increased the odds of belonging to the highest risk conjoint trajectory class (Steady High alcohol/Steady High tobacco) compared with the Low alcohol/Abstaining tobacco conjoint trajectory class. Family income was most strongly associated with the conjoint trajectory classes involving decreasing tobacco use, such that individuals with higher family income were more likely to be classified in the decreasing tobacco conjoint classes compared with the Low alcohol/Abstaining tobacco conjoint trajectory class. Overall, male gender, White race, and Greek affiliation were predictive of a higher likelihood of belonging to the conjoint classes involving the Steady High and Low Increase alcohol classes compared with the lowest risk conjoint class.

Discussion

While emerging adulthood is known as a risk period for substance use, this study provides further support for significant individual differences in the longitudinal patterns of alcohol and tobacco use. Important conjoint relationships emerged, such that there was more variability in the tobacco use patterns among drinkers than variability in the alcohol patterns among tobacco users. The results have implications both for the understanding of substance use in emerging adulthood as well as programming to prevent problematic use.

The results both support and extend previous research on the individual trajectories of alcohol and smoking. The four-class model was the best fit for alcohol use but the shape of these classes differed from past research (Jackson et al., 2009; Schuckit et al., 2014; Sher et al., 2011). The most common class in this study was not stable in alcohol use but rather had a slow increase. The two typical classes of decreasing use and escalating use were also not confirmed in this study. Differences in the pattern of classes are likely due to the use of a latent factor for alcohol based on four measures of use, rather than focusing on one item of risky alcohol use (e.g., heavy drinking). Whereas our results supported a five class model of tobacco use, the findings were similar to previous cigarette smoking research, in that by the end of data collection it appears that the patterns were merging into three main classes: low or abstaining, light use, and high use (Chassin et al., 2009).

The largest percentage of participants was classified into the Abstaining tobacco, Low alcohol conjoint trajectory class (41%). This was counter to a previous study where the majority was engaging in experimental smoking and moderate drinking, likely due to the differences between the two samples (i.e., college students vs. a general emerging adult sample) (Orlando et al., 2005). Similar to other research, users in the Low alcohol class were

the least likely to be in any of the tobacco classes and participants in the Steady High alcohol class had the highest likelihood of being in the Steady High, or chronic, tobacco use class (Jackson et al., 2009). Also, we confirmed that moderate alcohol use without tobacco use is more common in emerging adulthood than tobacco use without alcohol use. A lower proportion of the Steady High tobacco users were classified as Steady High alcohol users compared with previous research (approximately 34% vs. 40%), but this could be due to the use of the latent alcohol factor rather than a single item assessing heavy drinking (Jackson et al., 2009). Results from this study support that emerging adulthood is an individually variable developmental period and results from one study sample may not be representative of other emerging adults (Arnett, 2000).

Another unique contribution of this study is the understanding of how sociodemographic characteristics are associated with the conjoint trajectory patterns. Students who were male, White, affiliated with Greek organizations, and reported higher family income were significantly more likely to belong to the highest risk conjoint class (Steady High alcohol/ Steady High tobacco) compared with the lowest risk conjoint class. This finding is supported by previous research into the sociodemographic correlates of individual alcohol and tobacco use trajectories (Capone et al., 2007; Kenford et al., 2004; Orlando et al., 2005; Schane et al., 2009; Schuckit et al., 2014; Sutfin et al., 2009; H. White & Jackson, 2004).

There are limitations to the current research. While this study benefits from a large number of measurement occasions, it was not possible to determine simultaneous alcohol and tobacco use, but rather use of both substances within the same three months. Moreover, due to model complexity and limited measures, marijuana and other illicit drug use were not included in this study, all of which are known to vary conjointly with alcohol and alcohol use trajectories in emerging adulthood. Further, the design of the questionnaire necessitated examining overall tobacco use frequency rather than specific tobacco products. This prevents a direct comparison of our study findings to previous research that examined the co-occurrence of cigarette smoking, for example, and alcohol use. While the sample attrition was not related to the variables of interest and the modeling technique allowed for all participants to be maintained in the analyses, it is possible that attrition impacted the observed patterns of use, particularly at the later waves. Due to the complexity of the analytic models it was not possible to include the covariates in the LCGA models. The multinomial logistic regressions treated the latent classes as observed variables with zero variance, which could have influenced the relationships between the covariates and the conjoint latent classes. However, given the high classification probabilities (88–99% depending on the class of interest) this is of relatively low concern. Furthermore, given that some conjoint classes had low overall membership (e.g., the low alcohol/medium increase tobacco and the low alcohol/steady high tobacco classes), the results of the multinomial logistic regression were likely impacted towards non-significance due to large confidence intervals. Finally, identification of covariates was limited to sociodemographics factors and did not include important contextual variables such as family history of substance use that could further explain membership in the different latent conjoint trajectory classes.

Despite these limitations, the current study adds important information about the co-occurrence of alcohol and tobacco use in emerging adulthood. The use of person-centered

methods in a large, diverse longitudinal sample assessed on a regular basis during this heightened risk period, and the use of a broader measure of alcohol consumption than in previous studies, further elucidated the cooccurring patterns of alcohol and tobacco use. Findings indicate that tobacco use is prospectively associated with heavier drinking in emerging adulthood. Efforts to reduce co-occurrence should focus on the drinking behaviors of tobacco users.

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References

Arnett J. Emerging adulthood: A theory of development from the late teens through the twenties. American Psychologist. 2000; 55(5):469–480. DOI: 10.1037//0003-066X.55.5.469 [PubMed: 10842426]

Arnett J. The developmental context of substance use in emerging adulthood. Journal of Drug Issues. 2005; 35(2):235–254. DOI: 10.1177/002204260503500202

Arnett J. Emerging adulthood: What is it, and what is it good for? Child Development. 2007; 1(2):68–73. DOI: 10.1111/j.1750-8606.2007.00016.x

Bauer DJ, Curran PJ. Distributional assumptions of growth mixture models: Implications for overextraction of latent trajectory classes. Psychological Methods. 2003; 8:338–363. DOI: 10.1037/1082989X.8.3.338 [PubMed: 14596495]

Bingham C, Shope J, Tang X. Drinking behavior from high school to young adulthood: Differences by college education. Alcohol Clin Exp Research. 2005; 29(12):2170–2180. DOI: 10.1097/01.alc.0000191763.56873.c4

Brook D, Brook J, Zhang C, Whiteman M, Cohen P, Finch S. Developmental trajectories of cigarette smoking from adolescence to the early thirties: Personality and behavioral risk factors. Nicotine and Tobacco Research. 2008; 10(8):1283–1291. DOI: 10.1080/14622200802238993 [PubMed: 18686175]

Capone C, Wood M, Borsari B, Laird R. Fraternity and sorority involvement, social influences, and alcohol use among college students: A prospective examination. Psychology of Addictive Behaviors. 2007; 21(3):316–327. DOI: 10.1037/0893-164X.21.3.316 [PubMed: 17874882]

CDC. The health consequences of smoking -- 50 years of progress: A report of the Surgeon General. 2014. Retrieved from Atlanta

Chassin, L., Curran, PJ., Presson, C., Wirth, R., Sherman, S. Trajectories of adolescent smoking: Conceptual issues and an empirical example. Bethesda, MD: National Cancer Institute, NIH; 2009.

Chassin L, Flora D, King K. Trajectories of alcohol and drug use and dependence from adolescence to adulthood: The effects of familial alcoholism and personality. Journal of Abnormal Psychology. 2004; 113(4):483–498. DOI: 10.1037/0021-843X.113.4.483 [PubMed: 15535782]

Cleveland M, Collins LM, Lanza ST, Greenberg M, Feinberg M. Does individual risk moderate the effect of contextual-level protective factors? A latent class analysis of substance use. Journal of Prevention and Intervention in the Community. 2010; 38(3):213–228. DOI: 10.1080/10852352.2010.486299 [PubMed: 20603758]

Collins, LM., Hyatt, SL., Graham, JW. Latent transition analysis as a way of testing models of stage-sequential change in longitudinal data. In: Little, TD.Schnabel, KU., Baumert, J., editors. Modeling longitudinal and multilevel data: Practical issues, applied approaches, and specific examples. Mahwah, NJ: Lawrence Erlbaum Associates Publishers; 2000. p. 147-161.

Collins R, Parks G, Marlatt G. Social determinants of alcohol consumption: The effects of social interaction and model status on the self-administration of alcohol. Journal of Consulting and Clinical Psychology. 1985; 53:189–200. DOI: 10.1037/0022-006X.53.2.189 [PubMed: 3998247]

Connell C, Gilreath T, Aklin W, Brex R. Social-ecological influences on patterns of substance use among non-metropolitan high school students. American Journal of Community Psychology. 2010; 45:36–48. DOI: 10.1007/s10464-009-9289-x [PubMed: 20077132]

Corbin W, Vaughan E, Fromme K. Ethnic differences and the closing of the sex gap in alcohol use among college-bound students. Psychology of Addictive Behaviors. 2008; 22(2):240–248. DOI: 10.1037/0893164X.22.2.240 [PubMed: 18540721]

Gilreath T, Astor R, Estrada J, Johnson R, Benbenishty R, Unger J. Substance use among adolescents in California: A latent class analysis. Substance Use and Misuse. 2014; 49:116–123. DOI: 10.3109/10826084.2013.824468

Goudriaan A, Grekin E, Sher K. Decision making and binge drinking: A longitudinal study. Alcoholism, Clinical and Experimental Research. 2007; 31(6):928–938. DOI: 10.1111/j.15300277.2007.00378.x

Green M, McCausland K, Xiao H, Duke J, Vallone D, Healton C. A closer look at smoking among young adults: Where tobacco control should focus its attention. American Journal of Public Health. 2007; 97(8):1427–1433. DOI: 10.2105/AJPH.2006.103945 [PubMed: 17600242]

Halperin A, Smith S, Heiligenstein E, Brown D, Fleming M. Cigarette smoking and associated health risks among students at five universities. Nicotine and Tobacco Research. 2010; 12(2):96–104. DOI: 10.1093/ntr/ntp182 [PubMed: 20018947]

Hedden S, Whitaker D, von Thomsen S, Severtson S, Latimer W. Latent patterns of risk behavior in urban African-American middle school students in Baltimore City. Journal of Child and Adolescent Substance Abuse. 2011; 20:34–47. DOI: 10.1080/1067828X.2011.534358

Hingson R, Heeren T, Winter M, Wechsler H. Magnitude of alcohol-related mortality and morbidity among college students ages 18–24: Changes from 1998 to 2001. Annu Rev Publ Health. 2005; 26:259–279. DOI: 10.1146/annurev.publhealth.26.021304.144652

Jackson K, Sher K, Schulenberg JE. Conjoint developmental trajectories of young adult substance use. Alcohol Clin Exp Research. 2008; 32(5):723–737. DOI: 10.1111/j.1530-0277.2008.00643.x

Jackson, K., Sher, K., Schulenberg, JE. Conjoint developmental trajectories of young adult alcohol and tobacco use. Washington, DC, US: American Psychological Association; 2009.

Johnston, LD., O'Malley, PM., Bachman, JG., Schulenberg, JE., Miech, RA. Monitoring the Future national survey results on drug use, 1975–2014: Volume II, college students and adults ages 19–55. 2015. Retrieved from Ann Arbor: Institute for Social Research, The University of Michigan

Jung T, Wickrama KAS. An introduction to latent class growth analysis and growth mixture modeling. Social and Personality Psychology Compass. 2008; 2(1):302–317. DOI: 10.1111/j.17519004.2007.00054.x

Kelly A, Chan G, White A, Saunders J, Baker P, Connor J. Is there any evidence of changes in patterns of concurrent drug use among young Australians 18–29 years between 2007 and 2010? Addictive Behaviors. 2014; 39(8):1249–1252. DOI: 10.1016/j.addbeh.2014.04.009 [PubMed: 24813551]

Kenford S, Wetter D, Welsch S, Smith S, Fouladi R, Fiore M, Baker T. Prevalence and predictors of transitions in smoking behavior among college students. Health Psychology. 2004; 23(2):168–177. DOI: 10.1037/0278-6133.23.2.168 [PubMed: 15008662]

Muthén B, Asparouhov T. Growth mixture modeling with non-normal distributions. Statistics in Medicine. 2015; 34(6):1041–1058. DOI: 10.1002/sim6388 [PubMed: 25504555]

Muthén BO, Muthén LK. Integrating person-centered and variable-centered analyses: Growth mixture modeling with latent trajectory classes. Alcohol Clin Exp Research. 2000; 24:882–891. DOI: 10.1111/j.1530-0277.2000.tb02070.x

Muthén, BO., Muthén, LK. MPlus User's Guide. Los Angeles, CA: Authors; 2012.

Nagin D, Tremblay RE. Analyzing developmental trajectories of distinct but related behaviors: A group-based method. Psychological Methods. 2001; 6(1):18–34. DOI: 10.1037/1082-989X.6.1.18 [PubMed: 11285809]

Nichter M, Nichter M, Carkoglu A, Lloyd-Richardson E. Smoking and drinking among college students: “it’s a package deal”. Drug and Alcohol Dependence. 2010; 106(1):16–20. DOI: 10.1016/j.drugalcdep.2009.07.025 [PubMed: 19758771]

Orlando M, Tucker J, Ellickson P, Klein D. Concurrent use of alcohol and cigarettes from adolescence to young adulthood: An examination of developmental trajectories and outcomes. Substance Use and Misuse. 2005; 40:1051–1069. DOI: 10.1081/JA-200030789 [PubMed: 16040368]

Perkins H. Surveying the damage: A review of research on consequences of alcohol misuse in college populations. Journal of Studies on Alcohol. 2002; 14:91–100. DOI: 10.15288/jsas.2002.s14.91

SAMHSA. Results from the 2013 National Survey on Drug Use and Health: Summary of national findings. 2014. Retrieved from Rockville, MD: http://www.samhsa.gov/data/NSDUH/2012SummNatFindDetTables/NationalFindings/NSDUHresults2012.htm

Schane R, Glantz S, Ling P. Social smoking: Implications for public health, clinical practice, and intervention research. American Journal of Preventive Medicine. 2009; 37(2):124–131. DOI: 10.1016/j.amepre.2009.03.020 [PubMed: 19589449]

Schuckit M, Smith T, Danko G, Bucholz K, Agrawal A, Dick DM, … Hesselbrock V. Predictors of subgroups based on maximum drinks per occasion over six years for 833 adolescents and young adults in COGA. Journal of Studies on Alcohol and Drugs. 2014; 75(1):24–34. DOI: 10.15288/jsad.2014.75.24 [PubMed: 24411794]

Schulenberg JE, Maggs JL. Destiny matters: Distal developmental influences on adult alcohol use and abuse. Addiction. 2008; 103(Suppl1):1–6. DOI: 10.1111/j.1360-0443.2008.02172.x

Sher K, Jackson K, Steinley D. Alcohol use trajectories and the ubiquitous cat’s cradle: Cause for concern? Journal of Abnormal Psychology. 2011; 120(2):322–335. DOI: 10.1037/a0021813 [PubMed: 21319874]

Slutske W. Alcohol use disorders among US college students and their non-college-attending peers. Archives of General Psychiatry. 2005; 62:321–327. DOI: 10.1001/archpsyc.62.3.321 [PubMed: 15753245]

Sutfin E, Reboussin B, McCoy T, Wolfson M. Are college student smokers really a homogeneous group? A latent class analysis of college student smokers. Nicotine and Tobacco Research. 2009; 11(4):444–454. DOI: 10.1093/ntr/ntp006 [PubMed: 19264866]

Tan X, Dierker L, Rose J, Li R. How spacing of data collection may impact estimates of substance use trajectories. Substance Use and Misuse. 2011; 46(6):758–768. DOI: 10.3109/10826084.2010.537731 [PubMed: 21174495]

Vandenberg R, Lance C. A review and synthesis of the measurement invariance literature: Suggestions, practices, and recommendations for organizational research. Organizational Research Methods. 2000; 3(1):4–70. DOI: 10.1177/109442810031002

Wechsler H, Isaac N. ‘Binge’ drinkers at Massachusetts colleges. Prevalence, drinking style, time trends, and associated problems. JAMA. 1992; 267(21):2929–2931. DOI: 10.1001/jama.267.21.2929 [PubMed: 1583763]

Wechsler H, Moeykens B, Davenport A, Castillo S, Hansen JD. The adverse impact of heavy episodic drinkers on other college students. Journal of Studies on Alcohol. 1995; 56(6):628–634. DOI: 10.15288/jsa.1995.56.628 [PubMed: 8558894]

Weitzman E, Chen Y. The co-occurrence of smoking and drinking among young adults in college: National survey results from the United States. Drug and Alcohol Dependence. 2005; 80:377–386. DOI: 10.1016/j.drugalcdep.2005.05.008 [PubMed: 16009507]

White A, Chan G, Quek L, Connor J, Saunders J, Baker P, … Kelly A. The topography of multiple drug use among adolescent Australians: Findings from the National Drug Strategy Household Survey. Addictive Behaviors. 2013; 38:2068–2073. DOI: 10.1016/j.addbeh.2013.01.001 [PubMed: 23403274]

White H, Bray B, Fleming C, Catalano RF. Transitions into and out of light and intermittent smoking during emerging adulthood. Nicotine and Tobacco Research. 2009; 11(2):211–219. DOI: 10.1093/ntr/ntn017 [PubMed: 19246434]

White H, Jackson K. Social and psychological influences on emerging adult drinking behavior. Alcohol Res Health. 2004; 28(4):182–190. DOI: 10.1037/a0013855

WHO. WHO report on the global tobacco epidemic, 2011. 2011. Retrieved from Geneva

Wolfson M, McCoy T, Sutfin E. College students' exposure to secondhand smoke. Nicotine and Tobacco Research. 2009; 11(8):977–984. DOI: 10.1093/ntr/ntp100 [PubMed: 19516049]

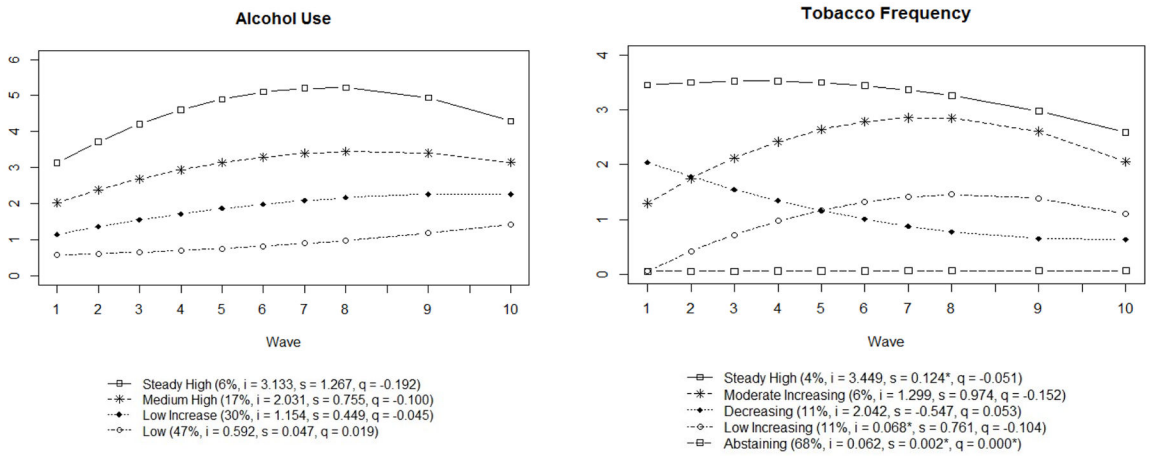
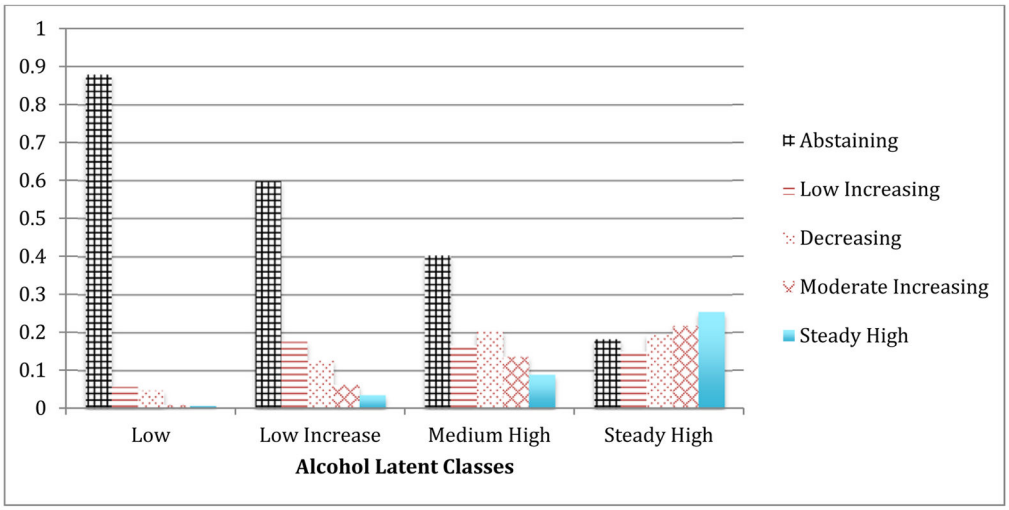


Figure 1.

Alcohol and tobacco latent trajectory classes as estimated by the latent class growth analyses (LCGA) (N=2,244)

Note. i: intercept; s: linear slope; q: quadratic slope; * indicates non-significant growth parameter

a)



b)

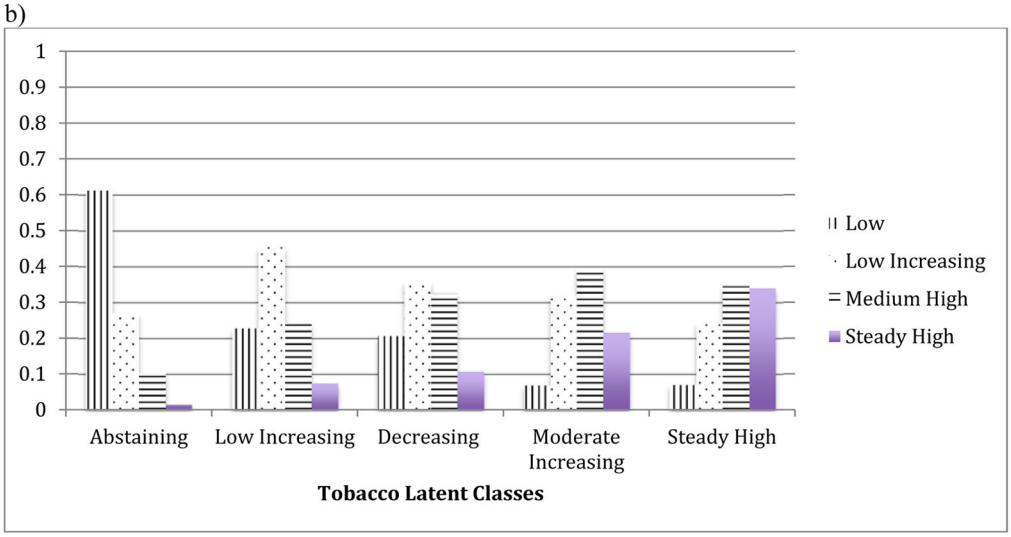


Figure 2.

Conditional probabilities of substance use trajectory class membership: a) Tobacco class membership conditional on alcohol class membership and b) Alcohol class membership conditional on tobacco class membership (N = 2,244)

Note: a) Conditional probabilities sum to 1.0 within each alcohol class; b) Conditional probabilities sum to 1.0 within each tobacco class.

Table 1

Characteristics of the study population at baseline (N = 2,244)

Variable	
Age (years±SD)	18.41±0.35
Male, n (%)	900 (40.1)
White, n (%)	1210 (53.9)
Family income, n (%)	
< $40,000	463 (22.4)
$40,000 – $69,999	471 (22.8)
≥ $70,000	1135 (54.8)
Parent education	
High school or less	244 (10.9)
Some college – college degree	1203 (54.1)
Post-graduate degree	778 (35.0)
Live on campus, n (%) [a]	1785 (86.0)
Greek membership, n (%) [a]	242 (11.7)
Alcohol use in past 3 months	
Frequency (drinking days/week)	0.82±1.24
Quantity (drinks/drinking day)	1.34±2.21
Binge frequency (past 3 mos)	2.16±5.41
Drunk frequency (past 3 mos)	1.71±4.45
Tobacco use frequency in past 3 months, n (%)	
Never use	1726 (77.3)
Rarely use	111 (5.0)
Occasionally	266 (11.9)
Weekly, but not daily	72 (3.2)
Daily	59 (2.6)

[a] measured at Wave 2 (first semester of college)

Table 2

Comparison of fit indices for alcohol use and tobacco use latent class growth analysis (LCGA) model series (N = 2,244)

No. of classes	Log Likelihood	No. of parameters	BIC	LMR-LRT (*p* value)	BLRT (*p* value)	Entropy
Alcohol LCGA						
2	−26516.344	17	53163.861	<.001	<.001*	.969
3	−22170.676	21	44503.387	.264	<.001*	.969
4	**−19592.146**	**25**	**39377.192**	**.062**	**<.001**	**.970**
5	−18033.489	29	36290.742	.237	<.001	.967
6	−16767.286	33	33789.201	.173	<.001	.968
Tobacco LCGA						
2	−20204.623	17	40540.410	<.001	<.001	.966
3	−18523.752	21	37209.530	<.001	<.001*	.943
4	−17814.229	25	35821.348	.020	<.001*	.942
5	**−17211.667**	**29**	**34647.086**	**.059**	**<.001**	**.955**
6	−16790.502	33	33835.618	.202	<.001*	.956

Note.

* BLRT non-convergence; bolded line indicates the best fitting model

Table 3

Conditional probabilities of substance use trajectory class membership: Results from sequential process latent class growth analysis (N = 2,244)

Tobacco Class	Alcohol Class			
	1. Low (47%)	**2. Low Increase (30%)**	**3. Medium High (17%)**	**4. Steady High (6%)**
1. Abstaining (68%)	0.880	0.599	0.404	0.183
	0.612	*0.269*	*0.103*	*0.016*
2. Low Increasing (11%)	0.057	0.176	0.166	0.150
	0.228	*0.455*	*0.242*	*0.075*
3. Decreasing (11%)	0.047	0.127	0.205	0.196
	0.207	*0.359*	*0.326*	*0.107*
4. Moderate Increasing (6%)	0.009	0.062	0.136	0.218
	0.068	*0.320*	*0.395*	*0.217*
5. Steady High (4%)	0.007	0.035	0.089	.254
	0.070	*0.244*	*0.346*	*0.340*

Note. Non-italicized probabilities represent tobacco class membership conditional on alcohol class membership and sum to 1.0 within each alcohol class.

Italicized probabilities represent alcohol class membership conditional on tobacco class membership and sum to 1.0 within each tobacco class.

Table 4

Impact of sociodemographic characteristics on conjoint substance use latent trajectory class membership: Results from multivariate multinomial logistic regression models (N = 2,244)

Conjoint latent trajectory class[b] (Alcohol/Tobacco)	OR (95% CI)[a]					
	Male[c]	White[c]	Greek[c]	Live on campus	Family income[c]	Parent Education
Steady High/Steady High	2.744 (1.348, 5.588)	9.263 (3.230, 26.560)	4.831 (2.057, 11.346)	2.836 (0.667, 12.055)	1.300 (1.077, 1.569)	1.145 (0.868, 1.509)
Steady High/Decreasing	3.369 (1.485, 7.643)	9.795 (2.921, 32.851)	5.919 (2.328, 15.047)	2.101 (0.486, 9.084)	1.550 (1.173, 2.047)	1.429 (0.981, 2.082)
Steady High/Med Increase	3.389 (1.558, 7.374)	4.015 (1.699, 9.493)	3.624 (1.411, 9.303)	1.208 (0.412, 3.544)	1.124 (0.952, 1.329)	1.017 (0.782, 1.321)
Steady High/Low Increase	4.638 (1.639, 13.123)	2.008 (0.771, 5.225)	3.624 (1.158, 11.335)	0.735 (0.239, 2.265)	1.006 (0.834, 1.214)	0.988 (0.715, 1.366)
Steady High/Abstaining	2.081 (0.951, 4.552)	3.468 (1.444, 8.329)	7.610 (3.203, 18.078)	0.798 (0.293, 2.172)	1.154 (0.963, 1.384)	1.192 (0.868, 1.636)
Medium High/Steady High	1.070 (0.463, 2.472)	0.767 (0.332, 1.770)	***	1.786 (0.408, 7.811)	1.029 (0.872, 1.215)	1.048 (0.776, 1.415)
Medium High/Decreasing	1.166 (0.742, 1.834)	2.156 (1.366, 3.402)	1.679 (0.800, 3.522)	1.034 (0.555, 1.926)	1.202 (1.076, 1.343)	1.132 (0.954, 1.342)
Medium High/Med Increase	1.098 (0.581, 2.076)	1.405 (0.757, 2.611)	0.668 (0.157, 2.831)	1.471 (0.567, 3.816)	1.044 (0.914, 1.192)	1.063 (0.847, 1.334)
Medium High/Low Increase	1.278 (0.862, 1.895)	1.443 (0.979, 2.128)	1.119 (0.540, 2.318)	1.733 (0.928, 3.236)	1.068 (0.983, 1.162)	0.931 (0.817, 1.060)
Medium High/Abstaining	0.938 (0.735, 1.197)	1.552 (1.229, 1.961)	1.758 (1.180, 2.619)	2.042 (1.389, 3.003)	1.102 (1.046, 1.160)	0.981 (0.905, 1.064)
Low Increase/Steady High	1.502 (0.762, 2.960)	2.788 (1.350, 5.758)	0.453 (0.061, 3.384)	0.660 (0.277, 1.574)	1.097 (0.946, 1.272)	0.922 (0.738, 1.152)
Low Increase/Decreasing	2.112 (1.344, 3.320)	2.510 (1.564, 4.028)	3.053 (1.582, 5.893)	1.549 (0.725, 3.310)	1.218 (1.088, 1.364)	1.138 (0.956, 1.355)
Low Increase/Med Increase	2.016 (1.133, 3.590)	2.896 (1.556, 5.390)	2.336 (1.003, 5.444)	1.366 (0.568, 3.283)	1.211 (1.053, 1.394)	1.176 (0.934, 1.480)
Low Increase/Low Increase	1.843 (1.096, 3.099)	2.434 (1.413, 4.192)	2.206 (0.998, 4.876)	2.626 (0.934, 7.382)	1.085 (0.969, 1.214)	1.109 (0.911, 1.351)
Low Increase/Abstaining	0.918 (0.642, 1.312)	2.790 (1.942, 4.007)	4.345 (2.762, 6.834)	1.835 (1.045, 3.220)	1.159 (1.069, 1.257)	1.076 (0.949, 1.221)
Low/Steady High	0.714 (0.138, 3.698)	7.666 (0.919, 63.927)	6.341 (1.139, 35.294)	0.420 (0.076, 2.315)	1.004 (0.744, 1.353)	0.946 (0.574, 1.557)
Low/Decreasing	2.189 (1.227, 3.905)	1.444 (0.812, 2.569)	1.856 (0.759, 4.539)	1.436 (0.599, 3.442)	1.051 (0.930, 1.187)	1.041 (0.844, 1.284)
Low/Med Increase	2.230 (0.595, 8.360)	1.597 (0.426, 5.895)	***	0.735 (0.151, 3.574)	1.086 (0.820, 1.439)	1.045 (0.649, 1.683)
Low/Low Increase	1.982 (1.159, 3.391)	1.420 (0.831, 2.426)	1.015 (0.355, 2.900)	2.101 (0.824, 5.357)	1.113 (0.985, 1.258)	1.268 (1.008, 1.594)

[a] OR, odds ratio; CI, confidence interval;

[b] Normative conjoint latent trajectory class (Low alcohol/Abstaining tobacco) serves as reference group (41% of participants);

[c] significant predictor of conjoint class membership in omnibus chi-square test, $p<.05$;

*** Comparison could not be conducted because there were zero individuals of Greek status in this class.

Note. Shaded cells indicate significance in both omnibus test and multivariate multinomial test