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Authors

Schweizer, CA
Roesch, SC
Khoddam, R
[et al.](#)

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Running head: EXAMINING THE STABILITY OF ALCOHOL TOBACCO CO-USE

Examining the stability of young-adult alcohol and tobacco co-use:

A latent transition analysis

C. Amanda Schweizer^{1,2}, Scott C. Roesch³, Rubin Khoddam⁴, Neal Doran⁵, &

Mark G. Myers^{2,5}

¹Department of Psychology/Psychiatry, SDSU/UCSD Joint Doctoral Program in Clinical Psychology,
San Diego, CA, USA,

²Veterans Affairs San Diego Healthcare System, La Jolla, CA, USA,

³Department of Psychology, San Diego State University, San Diego, CA, USA,

⁴Department of Psychology, University of Southern California, Los Angeles, CA, USA, and

⁵Department of Psychiatry, University of California,

San Diego, CA, USA

ABSTRACT

Although use of both alcohol and tobacco is common among college-attending young adults, little is known about the stability of co-use over time. Difficulties in studying change in these behaviors may reflect inconsistencies in how smoking in particular is categorized. The current study used longitudinal data, gathered at three time points three months apart, to examine cigarette and alcohol use profiles and the stability of profile structure and membership.

Undergraduate student smokers' (N=320) past 30-day alcohol and cigarette use was assessed using the timeline followback procedure. Smoking (number of cigarettes and number of smoking days) and drinking (number of drinks and number of binges) were entered into a latent transition analysis (LTA) to identify the latent taxonomic structure within the sample, and determine the probability of movement between groups over time. A 3-profile solution emerged at each time-point. The LTA probabilities highlighted both progression and reduction in the lower use groups. Overall, findings revealed notable changes in tobacco and alcohol use behaviors over the span of six months, affecting both profile structures and individual membership status. This suggests that among young adults both tobacco and alcohol use are temporally unstable behaviors, particularly among those using at lower levels.

Keywords: college students, young adults, alcohol tobacco co-use, latent transition analysis

Cigarettes and alcohol are the most commonly used psychoactive substances in the United States (Falk, Yi, & Hiller-Sturmhofel, 2006; L.D. Johnston, O'Malley, Bachman, & Schulenberg, 2006). Co-use or conjoint use, defined as use of both substances by the same person in a given time period (Falk et al., 2006), and concurrent use, defined as simultaneous use of both substances, are also common. Used alone each substance poses health risks to the individual. Cigarette use is a persistent behavior and, along with obesity, is the leading cause of preventable death in the United States (CDC, 2008). Heavy alcohol use is also a major public health concern for its role in many chronic diseases and numerous high risk behaviors, including driving while intoxicated, accidents, violence, and unsafe sex practices (Hingson, Heeren, Zakocs, Kopstein, & Wechsler, 2002; Naimi et al., 2003). Research demonstrates chronically using the two substances in conjunction may produce, at minimum, additive risk for various cancers (e.g. throat, mouth, esophageal), cardiovascular disease, and hypertension (Zancy, 1990).

Use of either alcohol or cigarettes may place an individual at increased risk for initiation or progression in use of the other substance (Fleming, Leventhal, Glynn, & Ershler, 1989; Kahler et al., 2008; Reed, McCabe, Lange, Clapp, & Shillington, 2010; Reed, Wang, Shillington, Clapp, & Lange, 2007; Saules et al., 2004; Schorling, Gutgesell, Klas, Smith, & Keller, 1994; Sher, Gotham, Erickson, & Wood, 1996). This may be explained by alcohol and tobacco use sharing common risk factors, such as family history of alcoholism, sex, ethnicity, availability, social cues, expectancies, or stress (Bobo & Husten, 2000; Jackson, Colby, & Sher, 2010; McKee, Harrison, & Shi, 2010; Sher et al., 1996), or alcohol and tobacco directly influencing each other. Cross-sectional experimental studies show a cross-substance craving effect with alcohol or tobacco acting as a conditioned cue for the other substance (Burton & Tiffany, 1997; Piasecki et al., 2011). Smokers report greater subjective rewarding effects from the concurrent use of

alcohol and tobacco (McKee, Hinson, Rounsaville, & Petrelli, 2004; J. E. Rose et al., 2002), are more likely to report positive reinforcement from smoking while under the influence of alcohol (McKee et al., 2004; Piasecki et al., 2011), and smoke more while drinking (Harrison, Hinson, & McKee, 2009; McKee et al., 2010). Nondaily smokers hold similar subjective expectations for the effects of alcohol improving the cigarette smoking experience as do daily smokers (McKee et al., 2010) yet may be at higher risk for problems from drinking. Harrison and colleagues found 63% of daily smokers and 72% of nondaily smokers who participated in the National Epidemiological Survey on Alcohol and Related Conditions (NESARC) reported engaging in hazardous drinking (Harrison, Desai, & McKee, 2008).

Prevalence rates from the NESARC indicate problematic alcohol use, cigarette use, and co-use are highest among young adults aged 18-24 (Falk et al., 2006). Among college students in the United States, approximately twenty percent report cigarette use in the past month and about 40% report drinking 5 or more drinks in a row in the past two weeks (L. D. Johnston, O'Malley, Bachman, & Schulenberg, 2011). Rates of alcohol use among college student smokers are especially high, with 98% of past 30 day cigarette smokers in the Harvard School of Public Health College Alcohol Study reporting they used alcohol in the last year (Weitzman & Chen, 2005). Additionally, young adults frequently use tobacco and alcohol concurrently and report the majority of their smoking occurs on drinking days, smoking increases while drinking, and drinking increases while smoking (Harrison & McKee, 2008; Jackson et al., 2010; Witkiewitz et al., 2011). Jackson and colleagues (2010) found smoking was 2.75 times more likely to occur for college student smokers on a drinking day than a nondrinking day.

While population-based cross-sectional studies show alcohol and tobacco use are prevalent among college students, the instability of these behaviors during the college years is

demonstrated with findings from several prospective studies. High rates of smoking initiation are observed during college (Myers, Doran, Trinidad, Wall, & Klonoff, 2009; Wechsler, Rigotti, Gledhill-Hoyt, & Lee, 1998; Wetter et al., 2004), and are associated with greater alcohol involvement (Reed et al., 2010; Reed et al., 2007; Saules et al., 2004). Additionally, there is evidence students' smoking may generally decrease over the school year (Colder et al., 2006). Variability in alcohol use is also observed. Substance use trajectory studies suggest young adults follow one of several paths of alcohol use, the majority of which indicate changes in use over the college years (Chassin, Fora, & King, 2004; Jackson, Sher, & Schulenberg, 2005; Tucker, Orlando, & Ellickson, 2003), with a notable proportion of students reporting increases in problematic drinking during college (Doran, Myers, Luczak, Carr, & Wall, 2007; Greenbaum, Del Boca, Darkes, Wang, & Goldman, 2005; Schweizer, Doran, Roesch, & Myers, 2011). While longitudinal studies with infrequent assessment provide information about general use patterns over long periods of time, Del Boca and colleagues (2004) highlight the significant temporal variability in alcohol use among first-year college students and emphasize the importance of frequent assessment for observing changes in substance use over time (Del Boca, Darkes, Greenbaum, & Goldman, 2004).

Smoking on an intermittent or occasional basis, i.e., a smoking pattern that is inconsistent over time, is more common than daily smoking among college students (S. Ames et al., 2009; Moran, Wechsler, & Rigotti, 2004; Sutfin, Reboussin, McCoy, & Wolfson, 2009). This pattern of smoking may reflect an early stage of smoking progression, with subsequent transition to heavier daily smoking and nicotine dependence, or a time-limited period of experimentation (Kenford et al., 2005). Alternatively, there is evidence individuals may maintain relatively low levels of smoking for extended periods of time (Hassmiller, Warner, Mendez, Levy, & Romano,

2003; Levy, Biener, & Rigotti, 2009) or may transition back and forth regularly between daily and nondaily smoking (Etter, 2004; Hennrikus, Jeffrey, & Lando, 1996; Nguyen & Zhu, 2009; Zhu, Sun, Hawkins, Pierce, & Cummins, 2003; White, Bray, Fleming, & Catalano, 2009). The tobacco research community has identified the need to focus on light and nondaily smoking (Dierker et al., 2007, Okuyemi & Harris, 2002, Shiffman, 2009) to further understanding of this smoking pattern.

Defining and classifying smoking patterns remains a challenge; researchers have employed diverse indicators to capture tobacco use, which has undoubtedly affected research findings (An et al., 2009; Buolos, Loffredo, Setouhy, Abdel-Aziz, Israel, & Mohamed, 2009; Husten, 2009; Harrison et al., 2008, McKee et al., 2004; Nichter, Nichter, Loyd-Richardson, Flaherty, Carkoglu, & Taylor, 2006). A shift toward using multiple indicators and latent variable modeling techniques may enhance our ability to identify and distinguish between different classes of smokers, particularly those who smoke at lower levels. Additionally, using latent variable modeling techniques with longitudinal smoking and alcohol use data will add to the sparse literature on the temporal patterns of smoking and alcohol use. One such analytic technique, growth mixture modeling, was applied to longitudinal epidemiological data from the Monitoring the Future (MTF) survey to model developmental trajectories of conjoint alcohol and tobacco use over a five-year period by Jackson and colleagues (2005). Participants were young adults (18-26) assessed every one to two years, with up to five data points per person. Results yielded seven trajectories, with the largest groups representing non-users (56%) and heavy drinkers with low rates of smoking (14%), with the remaining five groups each comprising 5-8% of the sample (Jackson et al., 2005). Notably, individuals who did not use tobacco or alcohol were included in the study; including nonusers likely affected the emergent trajectories. While participants who

are similar to each other are grouped together in latent trajectory analysis, there is also the possibility that nonsmokers or nondrinkers could be placed into a conjoint use trajectory and slightly affect the use characteristics of the group. The study by Jackson and colleagues (2005) revealed a general reduction in alcohol use through young adulthood and, for many, what appears to be stable cigarette use, both at high and low or nonsmoking levels. However, meaningful change occurring over briefer time periods may be obscured by this method. For example, An and colleagues found more than half the young adults they surveyed reported smoking different amounts at baseline and seven months later (An et al., 2009). The methodology used by Jackson and colleagues (2005) provides a broad picture of the stability and change in alcohol and tobacco use over young adulthood. An investigation of the change in conjoint alcohol and tobacco use occurring over briefer time periods will allow for a more detailed analysis of the course of use.

Several latent variable techniques have been used by researchers in recognition of the heterogeneity of young adult substance use, such as latent growth curve modeling, growth mixture modeling (Colder et al., 2006; Jackson et al., 2005), latent class analysis (J. S. Rose et al., 2007), and latent transition analysis (Jackson, Sher, Gotham, & Wood, 2001; B.O. Muthen & Muthen, 2000; Velicer, Martin, & Collins, 1996a). Each method has particular strengths for answering questions about changes in substance use over time. For exploring the co-use of alcohol and tobacco over time, an understudied area of research, the use of latent transition analysis in particular permits a detailed examination of temporal variability in use over time, while contributing to understanding of how these two behaviors cluster together. This technique has been identified as particularly useful in the study of substance use (H. Chung, Y. Park, & S. T. Lanza, 2005; Lanza, Patrick, & Maggs, 2010); and has revealed the probability of movement

between classes varies by alcohol consumption (Auerbach & Collins, 2006; Guo, Collins, Hill, & Hawkins, 2000; Jackson et al., 2001) or readiness to quit smoking (Martin, Velicer, & Fava, 1996).

The current study examined temporal patterns of alcohol and tobacco co-use in a sample of cigarette using college students, extending previous work in this area by employing a briefer assessment interval than previous studies and through the novel use of LTA with continuous variables. The goal of the present investigation was to identify subtypes of young adult alcohol and tobacco users and examine the stability of the subtypes and of use over time. The primary hypotheses for the current study are that patterns of alcohol and tobacco co-use among young adults will be relatively stable over this brief assessment period, and that movement between classes representing differing levels of use will be common as participants increase or decrease their use.

METHOD

Participants

Participants (N = 322; 59.3% male) were undergraduates at two public universities in the Southwestern United States who were interviewed in person at three time points, three months apart. Participants had a mean age of 19.87 years (SD = 1.54) and the ethnic composition of the sample was Asian (37.6%), White (35.0%), Mixed (9.1%), Hispanic/Latino (8.4%), Pacific Islander (2.7%), African-American (1.1%), Native American (.4%) and other (5.7%). Data were drawn from two longitudinal studies of smoking self-change in college students (ns = 111 and 211, respectively). Inclusion criteria for the studies were identical: 1) having smoked at least one cigarette in each of the four weeks prior to the baseline interview, 2) aged between 18 and 24 years old, and 3) enrollment as an undergraduate student for the duration of the study (six

months). Participants completed in-person interviews at baseline and again 3- and 6-months post-baseline. Two participants were excluded because they did not complete any portion of the measure used in the current study (but did complete the rest of the interview), yielding a final sample of 320. Seventy-six percent ($n=243$) completed all three interviews, 14% ($n=46$) completed two (baseline and either the three-month or six-month follow-up), and 10% ($n=31$) completed only the baseline interview. Those who completed all three interviews did not differ from those who completed only one or two interviews with regard to gender, age, ethnicity, or baseline alcohol and tobacco use (p 's $> .05$).

Procedure

The universities' Institutional Review Boards approved the studies prior to commencement. After screening for eligibility, a trained research assistant explained study participation and obtained informed written consent. Participants were interviewed individually in person. Each interview occurred approximately three months apart and lasted approximately 90 minutes. Participants were reimbursed \$30-\$40 for their time.

Measures

Alcohol and Cigarette Use. Cigarette and alcohol use over the previous 90 days was assessed at each interview with the Timeline Followback procedure (L. C. Sobell & Sobell, 1992; M. B. Sobell, Sobell, Klajner, Pavan, & Basian, 1986), which has been shown to have good psychometric properties when assessing alcohol and tobacco use, including nondaily tobacco use (Harris et al., 2009), with college students. Past 30-day data from the TLFB were used to compute number of smoking days, number of total cigarettes smoked, number of total drinks consumed, and number of binge drinking episodes. A binge drinking episode was defined as

consuming 4 or more drinks on one occasion for women and 5 or more drinks on one occasion for men (NIAAA, 2005).

Data Analysis

First, latent profile analysis (LPA) models, specifying 2-5 classes, for each time point (T1: baseline, T2: three-month follow-up, and T3: six-month follow-up) were fit using maximum likelihood estimation in MPlus version 5.1 (Muthén & Muthén, 2007). Participants were grouped into a profile with others who have common tobacco and alcohol use patterns, with each profile representing a distinct and unique group. For each profile conditional response means for each observed variable were calculated for interpretation, and a probability of group membership was generated for each individual (i.e. the likelihood of being in each profile group). Fit criteria consulted to determine goodness of fit of the LPA models included the sample size adjusted Bayesian information criterion (sBIC; Schwartz, 1978) and the Aikake information criterion (AIC; Akaike, 1973), and entropy. To compare solutions to each other these three values were utilized (lower AIC and BIC and higher entropy values were considered indicators of better fit) as well as the Lo-Mendell-Rubin adjusted likelihood ratio test (Lo, Mendell, & Rubin, 2001) and the Bootstrapped Parametric Likelihood Ratio Test (BLRT; McLachlan & Peel, 2000), which statistically compared a model with k profiles to one with one with $k-1$ profiles, with a significant test indicating that the model with more profiles was an improvement (Nylund, Asparouhov, & Muthen, 2007). Final model selection was based on these fit indicators as well as substantive coherence.

Latent transition analysis (LTA) was applied to the TLFB data to examine stability and change of profiles of alcohol and cigarette use among young adults. This approach has previously been used for examining substance use stability and progression (e.g. Lanza, Patrick,

and Maggs, 2009). However, previous applications of this technique have been limited to categorical manifest variables and predetermined stages. In addition to contributing to the extant alcohol and tobacco co-use literature, using latent transition analysis with continuous variables and allowing for profile structure to vary between time points is a novel methodological approach.

Once LPA solutions were selected for all three time points, LTA was applied to the data to determine the probability of profile membership at T3, given profile membership at T2 and the probability of profile membership at T2, given profile membership at T1 (H. Chung, Y. Park, & S.T. Lanza, 2005; Collins, 2006; Velicer, Martin, & Collins, 1996b). By determining the LPA models separately, starting values and profile structure could be entered into the LPA analysis, wherein the profile solutions are re-estimated. MPlus assumes missing values are missing at random (B.O. Muthen & Muthen, 2005). In the current study, LTA was used to model the stability of alcohol and tobacco co-use over the course of six months in college, from baseline interview to three-month follow-up to six-month follow-up, taking into account missing data at three and six months.

RESULTS

Cigarette and Alcohol Use Profiles

Using LPA, models with two to five profiles were fit separately for T1, T2, and T3. Manifest variables included in the each of the LPA models represented quantity and frequency of past 30-day cigarette use (smoking days and total cigarettes) and frequency and intensity of past 30-day alcohol use (total drinks and number of binge drinking episodes). Model fit statistics are presented in Table 1. For T1 and T2, model fit criteria supported a three-profile solution, which was corroborated by an examination of the conditional response means. For T3, model fit criteria

supported both a two-profile and a three-profile solution, so both solutions were tested with LTA. An LTA model was then applied to the profile solutions from all three time points simultaneously to model the probability of movement from one class to another using all available data. Two LTA models were tested; the first specified a three-profile structure at each time point (3-3-3) and the second specified a three-profile structure at T1 and T2 and two-profile structure at T3 (3-3-2). Starting values with the conditional response means from the latent profiles structures outlined above were entered into each the model. We allowed the conditional response means to be re-estimated in the LTA for T2 and T3 profiles and fixed the values for T1 profiles. The model fit criteria for the two LTA models were compared and the 3-3-3 model was retained. The entropy value for the 3-3-3 model (.862) was slightly higher than the entropy value for the 3-3-2 model (.861) and so does not distinguish between the two well, however, the 3-3-3 model had a lower AIC value than the 3-3-2 model (28217.975 vs. 28442.489) and a lower sBIC value than the 3-3-2 model (28247.800 vs. 28468.139), taking the three together the 3-3-3 model was preferred. Conditional response means for the profile solutions that emerged from the retained LTA are presented in Table 2. At T1, all three profiles are suggestive of regular, but less than daily smoking that differ on amount smoked per smoking day, and differing levels of alcohol use, including light alcohol use (b), heavy (a), and very heavy alcohol use (c). Profiles at T2 and T3 are similar and are suggestive of a) nondaily but frequent smoking and heavy drinking, b) occasional smoking and light drinking, and c) daily smoking and light alcohol use.

Given the three profiles at each time point, there were 27 (3^3) possible transition patterns, however only 21 patterns were observed. Seventy-nine percent of participants fell into one of five patterns, each containing 5-35% of the sample, with the other sixteen patterns representing the other 21% and including < 4% of the sample each (Figure 1 indicates the most common

transition patterns). Next the transition probabilities, which are presented in Table 3, were examined. These values indicate the probability of being in a given class at time t based on class membership at time $t-1$ (i.e., probability of T2 profile membership given T1 profile membership and probability of T3 profile membership given T2 profile membership). The latent transition probabilities revealed movement between groups, with both reductions and increases in alcohol and tobacco use over six months. The group with the lowest tobacco and alcohol use at T1 was most likely to be in a group at T2 with similar tobacco use and higher alcohol use (probability = .482). The smallest group at T1 with the heaviest mean tobacco and alcohol use, was most likely (probability = .713) to be in the heaviest drinking group at T2. The group at T1 with the lowest mean alcohol use had the highest probability of transitioning to a profile with lower mean tobacco use and similar alcohol use (probability = .509) and also were likely (probability = .440) to be in a group at T2 with much higher mean tobacco use and similar alcohol use. From T2 to T3, participants in the frequent smoking/heavy drinking group were most likely (probability = .457) to transition to the occasional smoking/light drinking group. Participants in the occasional smoking/light drinking group were most likely (probability = .833) to be in the occasional smoking/light drinking group at T3 and participants in the heavy smoking/light drinking group at T2 were most likely (probability = .776) to remain in the heavy smoking/light drinking group at T3.

DISCUSSION

Previous longitudinal studies of the co-use of alcohol and cigarettes have largely utilized epidemiological survey data collected at annual or longer intervals over several years. These methods do not allow for an examination of the changes occurring in alcohol and tobacco use during relatively short time periods during young adulthood. The current study examined

changes in conjoint tobacco and alcohol use among college-attending young adult cigarette users at three time-points over six months. Profiles were determined using latent profile analysis and latent transition analysis was subsequently applied to the profile structures to characterize stability and change in use over the six months. Results supported a three-profile structure at each time point, with each profile solution including groups reflecting heavy drinking with nondaily smoking and nondaily smoking with low drinking. Changes in use over time were revealed in the differing profile structures between baseline and three and six month follow-ups, as characterized by the conditional response means between time points, as well as in the transition probabilities. The latent transition probabilities revealed participants were more likely to move into a group with higher or lower use between baseline to 3-month followup, while less change was observed in the latter three month interval.

At baseline, participants were grouped into one of three profiles. Although the average amount of cigarettes smoked differed between groups, all three reflected tobacco use that was on average frequent (> 15 days during the month) but less than daily, with alcohol use levels varying across profiles. The largest group at baseline (n=226) represented nondaily smoking and relatively light alcohol use, followed by the nondaily smoking/heavy drinking group (n=86), and lastly, a very small group (n=8) with the highest average alcohol and tobacco use. The three-profile structures that emerged from both follow-up interviews were very similar to each other and included groups who could be summarized as nondaily but frequent smokers/heavy drinkers, daily smokers/light drinkers, and occasional smokers/light drinkers. Sample-wide change, (i.e., change on a macro level) is observed in the varying profile structure between time points. While we hypothesized the profile structure would remain relatively stable over time given that individuals' environments and external factors were not likely to change during this period (i.e.

all were enrolled in school for the duration of the study), the characteristics of each group differed between time points. On a macro-level college student use and changes in use would primarily be influenced by external factors, such as education or advertising campaigns, campus use policies, and changes in access to substances (Borders, Xu, Bacchi, Cohen, & SoRelle-Miner, 2005; Clapp, Whitney, & Shillington, 2002; Ling & Glantz, 2002; Nelson & Wechsler, 2003; Wechsler, Seibring, Liu, & Ahl, 2004). As noted previously, another potential source of macro-level change is the seasonal fluctuations in use rates observed in college students (Colder et al., 2006; Del Boca et al., 2004). However, external factors are not likely the primary influence for the observed profile changes. Data for the current study were collected throughout the school year over three calendar years from two very large universities and across classes (i.e. freshman, sophomores, juniors, and seniors). While predictors of macro level changes will differ between universities, the long assessment period and the distribution of participants across campuses makes this an unlikely source for the change observed. Given this, we expected profile structure to be relatively stable over the six-month period. It is likely the changes in profile structure represent group level fluctuations in use that may not be indicative of long-term shifts in use, as may be expected from policy changes or public health campaigns. One potential explanation for the changes in conditional response mean values from three month follow-up to six month follow-up is that while all participants in the current study reported recent smoking, for some smoking had recently been initiated. Greater changes to the profile characteristics were observed in the profiles with lower mean tobacco use. Progression or discontinuation among the recently initiated during the six-month period may influence the mean use of these profiles, as expected with the current methodology (continuous observed variables). Those who recently initiated tobacco use are not likely to have progressed to daily smoking during this period (Wetter et al.,

2004), which is corroborated by the relative stability of the use characteristics of the heaviest smoking groups between three months and six months. Also, while more substantial changes in profile structure were noted from baseline to three months than from three to six months, it may be that the participants in the very small heavy smoking/very heavy drinking group (representing 2.5% of the sample) were interviewed during an irregular very heavy alcohol use period.

While there was some change in profile structure across time, the trajectories presented by Jackson and colleagues (2005) have similarities to the profiles derived in the current study. In both studies the profiles/trajectories represented a range of possible combinations of alcohol and tobacco use, and did not indicate an exclusively linear relationship between alcohol and tobacco use (i.e., heavy drinking did not only occur with heavy smoking). In the current study at both three-month and six-month follow-ups the group with the heaviest smoking, on average, did not have the heaviest average drinking. Consistent with findings from Harrison and colleagues (2008), the group representing regular but less than daily smoking had a higher average number of binge drinking episodes than the group who smoked more frequently. While the profiles are influenced by the current sample, inherent in the methodology, and might not replicate in subsequent studies, a similar profile structure has emerged using cross-sectional latent profile analysis (Schweizer, Roesch, & Myers, 2010). Taken together, these findings lend support to the concern that individuals who smoke on less than daily basis or who smoke primarily in the context of alcohol use may be at higher risk for problems from alcohol use than those who frequently smoke when they are not drinking (Harrison et al., 2008).

The latent transition probabilities revealed changes in use occurring over six months on the individual level (i.e., change on a micro level). Given that profile characteristics changed between baseline and three months, all transition probabilities between baseline and six months

reflected change in use over the three-month period. For example, participants in the two largest groups at baseline were likely to subsequently be placed in groups that had either overall lower or higher mean alcohol and tobacco use. From three-month follow-up to six-month follow-up participants in the heaviest smoking groups and heaviest drinking groups at three months were most likely to be in similar groups at six months. However, while the groups can be similarly characterized, the conditional response means for the groups differed and so the profiles cannot be considered identical. Considering all three timepoints together, the largest proportion of participants transitioned from the frequent smokers/heavy drinkers at baseline (T1b), to the daily smoking group at three months to the daily smoking group at six months. This is not surprising, given that daily smoking is associated with nicotine dependence, which may be contributing to persistent smoking patterns among heavier smokers. Progression of smoking and stability of heavy smoking may also be observed in that the proportion of the sample in the heaviest smoking group increased from three-month follow-up (31.6%, n=101) to six-month follow-up (37.2%, n=119). Reduction in tobacco use may also be occurring among the most common transition patterns, particularly among those who fell into two transition patterns, including those who moved from either T1a or T1b to T2b to T3a. The pattern from T1a to T2a to T3c appears to characterize stable nondaily smoking and high drinking. Among the most common transition patterns (those representing $\geq 5\%$ of the sample each), it is notable that change in use over the six-month period is more common than stability in use, particularly among those who do not smoke daily.

The predictors of stability and change in young adult alcohol and tobacco co-use would likely differ between macro level and micro level. As stated above, macro level change is affected by influences such as campus-wide policy enactment or changes to access. In contrast,

micro level change predictors common to both alcohol and tobacco use are individual level variables including personality and emotional factors (e.g., sensation seeking, negative affectivity, anxiety), family history of alcoholism, demographic variables, expectancies for use, and social factors (Borsari, Murphy, & Barnett, 2007; Emmons, Wechsler, Dowdall, & Abraham, 1998; Wechsler et al., 1998; Wetter et al., 2004). For example, peer use and perceptions of social approval may effect change for both smoking and alcohol use (Andrews, Tildesley, Hops, & Fuzhong, 2002; Moran et al., 2004; Myers & MacPherson, 2008; Yanovitzky, Stewart, & Lederman, 2006). Additionally, individual level variables may differentially predict transitions for those at lower levels of use than those for whom smoking and drinking is more established (Wetter et al., 2004). Social factors and expectancies may more strongly influence those who use at lower levels, while internal cues and physiological dependence may account for continued heavy use.

Previous research has noted the temporal instability of smoking patterns among college students (An et al, 2009) and has prospectively investigated alcohol and tobacco co-use over several years (Jackson et al., 2005). The current study adds to this literature by focusing on change in the co-use of alcohol and tobacco during a brief time period during college. Differences in the methods of the current study and those of Jackson and colleagues (2005) regard the variables used and the cohort examined. Large-scale surveys are limited by the information that can be extracted from the ordinal variables included, whereby individuals indicated the quantity of cigarettes smoked per day in one ordinal-choice question and frequency of heavy alcohol use in another (Jackson et al., 2005). The sample characteristics also differ between studies. Jackson and colleagues included individuals who do not smoke cigarettes, whereas the current student restricted eligibility to current smokers. Additionally, the choices

available in the survey questions create a distribution that may not reflect the current smoking patterns of young adults, such that those who smoke less than one cigarette per day are grouped into one response category, obscuring the wide variability observed among nondaily users.

The analyses employed in the current study have not been previously applied to the present question and type of data (i.e. using latent trajectory analysis with continuous manifest variables and allowing profile structure to differ between times). By identifying the changes in latent taxonomic structure over time, rather than imposing a structure, the drawbacks of creating ordinal categories of use to indicate smoking and drinking became even clearer since the common ordinal categories (e.g. non-smoker, light smoker, heavy smoker) do not reliably emerge. Predetermined categories, as with studies that have used LTA to model transitions in stage of change for smoking cessation (Martin et al., 1996) or progression to alcohol dependence (Guo et al., 2000) are theory-driven predictions of diagnostic categories or readiness for treatment. However, discrete categories of young-adult substance use require further research and replication (Sutfin et al., 2009).

The limitations in the current study include sample size and generalizability as well as other methodological issues. First, the sample size of the current study and large number of transition patterns precluded our ability to examine predictors of group membership or transitions between groups. Second, the data were collected from two large universities in the Southwestern United States and may not generalize to college students in other geographic areas. However, strengths of the study lending to its generalizability are the ethnic diversity present in the sample and that two universities were included reducing the likelihood the findings were site specific. Third, drawing conclusions about progression during college is precluded by the recruitment of the sample across years in college; however, including students distributed across the college years

does demonstrate instability in use occurring throughout college. Fourth, results of latent profile analysis are based on mean responses to manifest variables and individual variability exists within groups, so the use of a small number of individuals in each group will not be well represented by the mean values. Fifth, as previously noted, external factors may affect college student substance use, however, recruiting participants throughout the school year reduces the likelihood that these factors affected the current findings.

The developmental period of young adulthood is characterized by experimentation and the seeking out of new behaviors, particularly health risk behaviors such as alcohol and tobacco use. It has been previously noted that college student smoking is a mutable behavior, however, an effective treatment for smoking cessation has not been well established (Villanti, McKay, Abrams, Holtgrave, & Bowie, 2010) nor for alcohol and tobacco co-use (S. C. Ames et al., 2010). The present findings suggest individuals early in tobacco use or who use at low levels change their behaviors rapidly. These rapid changes highlight that these behaviors are not well established, indicating an opportunity for intervention. However, low rates of use point to the difficulty of engaging those who would benefit from intervention and suggest urgency for intervening before behaviors are entrenched. Intervening with cigarette and alcohol use behaviors, particularly in conjunction given the high rates of co-use, while they are still forming may prevent some of the costs associated with continued use. To inform interventions, future studies may build upon the current research by investigating the influence of alcohol on smoking progression across baseline levels of smoking as well as identifying the predictors of transitions in use.

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Table 1. Fit indices for LPA models with 2-5 profiles at both at all three timepoints. The models selected for the LTA are indicated in bold.

# of Profiles	AIC	Sample-Size Adjusted BIC	Entropy	Lo-Mendell- Rubin Adjusted Likelihood Ratio Test	Parametric Bootstrapped Likelihood Ratio Test
Baseline					
2	10902.906	10910.620	.905	ns	$p < .0001$
3	10648.804	10659.485	.940	$p = .024$	$p < .0001$
4	10515.842	10529.490	.901	ns	$p < .0001$
5	10392.344	10408.959	.914	ns	$p < .0001$
3-mo follow-up					
2	9431.558	9437.385	.959	$p = .0210$	$p < .0001$
3	9259.066	9267.093	.965	$p = .0004$	$p < .0001$
4	9115.200	9125.457	.939	ns	$p < .0001$
5	8966.477	8978.964	.947	ns	ns
6-mo follow-up					
2	8628.220	8623.942	.969	$p = .0120$	$p < .0001$
3	8454.585	8460.758	.950	ns	$p < .0001$
4	8318.767	8327.121	.961	ns	ns
5	8164.204	8174.374	.959	ns	ns

Table 2. Conditional response means of past-30 day alcohol and tobacco use for each emergent latent profile at T1, T2, and T3.

Profile	Cigarettes M (SE)	Smoking Days M (SE)	Drinks M (SE)	Binge Episodes M (SE)
Baseline				
T1a (n=86)	83.46 (9.01)	19.49 (1.10)	64.61 (3.29)	6.89 (0.36)
T1b (n=226)	113.64 (8.76)	20.49 (0.69)	15.68 (1.19)	1.41 (0.13)
T1c (n=8)	201.74 (49.61)	22.63 (2.76)	170.38 (14.01)	15.00 (1.38)
3-mo follow-up				
T2a (n=54)	85.94 (17.03)	16.12 (1.72)	96.83 (5.91)	9.84 (0.67)
T2b (n=165)	16.68 (2.46)	6.46 (0.86)	18.71 (1.77)	1.86 (0.19)
T2c (n=101)	169.45 (16.78)	27.18 (0.57)	17.55 (2.21)	1.66 (0.23)
6-mo follow-up				
T3a (n=166)	9.41 (1.34)	4.08 (0.53)	18.39 (1.92)	1.69 (0.23)
T3b (n=119)	170.38 (13.69)	27.18 (0.44)	22.51 (3.44)	2.20 (0.34)
T3c (n=35)	67.37 (30.05)	11.03 (3.32)	98.03 (12.01)	9.85 (0.99)

Table 3. Conditional latent transition probability estimates representing probability of group membership at time t (columns) given membership at time $t-1$ (rows).

Profile	T2a	T2b	T2c
T1a	0.482	0.355	0.163
T1b	0.051	0.509	0.440
T1c	0.713	0.142	0.145

Profile	T3a	T3b	T3c
T2a	0.161	0.382	0.457
T2b	0.833	0.136	0.031
T2c	0.173	0.776	0.051

Figure 1. The five most common transitional paths, with latent transition probabilities

