The proximal association between smoking and alcohol use among first year college students

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Abstract

Objective: This study was undertaken to evaluate the association between patterns of day-to-day smoking and drinking among first year college students.

Method: Using 210 days of weekly time-line follow-back diary data, the authors examined the within-person relationships between smoking and drinking. Bivariate time series procedures were utilized.

Results: Findings revealed a high degree of significant cross-correlations between smoking and drinking in which the amount of use of one substance could be predicted by current, as well as past and future use of the other. For the majority of participants, smoking and drinking were positively associated with the alternate behavior. The most common pattern of prediction for individuals was within day (i.e. synchronous correlations). When examining rates of individuals showing significant cross-correlations according to their level of either smoking or drinking, those smoking less than one cigarette on average per day were found to be less likely to demonstrate a synchronous cross-correlation between the two behaviors than those smoking at higher rates. No significant association was found between level of drinking and the rate of significant synchronous cross-correlations between smoking and drinking.

Conclusions: Reports of daily behavior over long periods of time have the potential to provide insight into the more proximal influences of smoking and alcohol use on one another. Future research is needed to establish the specific factors (i.e. third variables) and related mechanisms that may drive both behaviors.

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Keywords: Smoking; Drinking; College students

I. Introduction

The positive association between smoking and alcohol use has been consistently demonstrated across age (Koopmans et al., 1997), gender (Flay et al., 1998; Epstein et al., 1999), and ethnicity (Taylor et al., 1997; Epstein et al., 1999; Holowaty et al., 2000; Chen et al., 2002). Further, in their chronic and abusive phases, smoking and drinking have been clearly linked to premature disability and death through increased risk for cancers, hypertension, and stroke (Istvan and Matarazzo, 1984; Bobo, 1992; USDHHS, 1994). Despite the risks, use of both substances remains high with over 23% of adult Americans describing themselves as current smokers (CDC, 2003) and 8.5% meeting standard diagnostic criteria for an alcohol use disorder (Grant et al., 2004).

Research within adolescence and young adulthood has clearly demonstrated the predictive value of both smoking and drinking in mapping the initiation and escalation of the
other (Duncan et al., 1998; Flay et al., 1998; Jensen et al., 2003). Based on data from the 1997 National Household Survey on Drug Abuse, adolescents who reported engaging in binge drinking within the past 30 days were more than five times more likely to smoke than were adolescents who denied participating in binge drinking (76.8% versus 14.1%) (Bobo and Husten, 2000). Adolescents who experimented with smoking in early adolescence have been shown to be two to three times more likely to become heavy drinkers as high school seniors compared with those who had never smoked (Griffin et al., 1999). Even for low levels of use, such as exposure to only a few puffs, the likelihood of becoming a heavy drinker by grade 12 was increased by 2.5 times (Griffin et al., 1999).

The strength of the relationship has been further demonstrated to be dose related with the association becoming stronger in the context of heavier use of either substance (Bien and Burge, 1990; Schorling et al., 1994). Binge drinkers, for example, are more likely to smoke than non-binge drinkers (Sutherland and Willner, 1998; Tucker et al., 2002). Similarly, occasional cigarette users have been shown to report lower rates of heavy alcohol use compared to heavy smokers (Resnicow et al., 1999). Among college students, tobacco use was one of the most important predictors of problem drinking (Werner et al., 1996). Overall, evidence suggests that there is a significant association between smoking and drinking which becomes stronger with the heavier use of either substance (Bien and Burge, 1990).

Aside from these relatively distal associations, smoking and drinking are often engaged in simultaneously suggesting possible causal links through a number of hypothesized mechanisms including affects on similar biological systems, the counteracting of aversive effects of one drug by the other, shared sensitivity to the effects of each drug (Istvan and Matarazzo, 1984; Bien and Burge, 1990; Collins, 1990; Littleton and Little, 2002; Prendergast et al., 2002), and the development of classically conditioned behavioral associations (Burton and Tiffany, 1997; Sayette, 2002). Experimental work focused on the proximal association between the two behaviors has demonstrated that alcohol administration increases the number of cigarettes smoked (Griffiths et al., 1976; Mello et al., 1988; Henningfield et al., 1984), extends the duration of a smoking episode (Glaudier et al., 1996), and increases the amount of smoke inhaled (Nil et al., 1984; Mintz et al., 1985). This proximal association may be further influenced by an individual’s lifetime history of smoking or drinking. Generally, moderate drinkers, for example, smoked more in response to an experimental 1-l alcohol priming dose, while cigarette consumption was not altered in generally lighter drinkers (Henningfield et al., 1984). Moreover, female heavy smokers have been found to consume significantly more cigarettes during an experimental alcohol available phase than a no alcohol phase, an association that was not established among lighter smokers (Mello et al., 1987).

When examined cross-sectionally, the relationship between smoking and drinking has most commonly been demonstrated in terms of associations between relatively recent behaviors defined in diverse ways (e.g. past week, past 30 days, or past year) (Federman et al., 1997; Everett et al., 1998; Grant, 1998; Epstein et al., 1999; Bierent et al., 2000; Flischer et al., 2000; Hoffman et al., 2001). Further, while the prospective examination of the smoking–drinking link has received dramatically increased attention over the past decade, study designs have typically included long periods between assessments (e.g. 1 or more years) (Duncan et al., 1998; Bucholz et al., 2000; Griffin et al., 2000; Jensen et al., 2003). Taken together, cross-sectional and prospective surveys have consistently documented a significant association between drinking and smoking, but have revealed little about the day-to-day influence of these behaviors over time.

Conversely, while experimental studies have examined the more proximal relationships between drinking and smoking, within day associations have been the common focus (Mello et al., 1980; Henningfield et al., 1984; Nil et al., 1984; Mintz et al., 1985; Glaudier et al., 1996), leaving the consideration of day-to-day relationships unexplored. Further, their focus has been on small samples of established users and by their nature, experimentally manipulated substance use events. To date, neither survey research nor laboratory-based studies have provided insight into the smoking–alcohol link (1) across the range of substance use levels, (2) both within and between days, and (3) within naturally occurring substance use episodes.

In 1996, the Robert Wood Johnson Foundation established the Tobacco Etiology Research Network (TERN) in an attempt to develop a transdisciplinary approach to the problem of smoking. A major focus of the Network has been on describing detailed individual variability of substance use and its link to outcomes of dependence. One way to address this question is to examine behavior over time in more fine-grained ways than has been traditionally attempted in survey research. TERN decided to start with students in their first year of college. Although smokers typically initiate smoking in their teenage years, for many, smoking does not emerge at high frequencies until after they have left home. In fact, more than one quarter of college students nationwide have smoked cigarettes during the past 30 days. Increases in alcohol consumption during the college years are also dramatic and have been shown to exceed that of similarly aged non-college samples (Johnson et al., 1996). Finally, the first year at college represents a compressed period of change, not only in terms of substance use opportunity, but also with regard to friendship patterns, finances, stressors, time management, intimate relationships, and personal responsibilities (Read et al., 2002, 2005; Shaver et al., 1985).

In the present study, we examine reports of daily smoking and drinking across the entire first year of college in order to establish the proximal predictive relationship between smoking and drinking. The following questions are addressed: (1) Are increases in alcohol consumption associated with...
increases in smoking? (2) What is the direction of the relationship? (3) Are heavier users more likely to demonstrate a drinking/smoking link than lighter users?

Bivariate time series methods were employed in order to characterize detailed within-person smoking and drinking patterns in hopes of better understanding the natural process that links the two behaviors.

2. Method

2.1. Participants

Details regarding the selection and retention of participants for the present study are available elsewhere (Tiffany et al., unpublished). Briefly, participants were selected from responses to a screener survey (N = 4690) administered to incoming students during the orientation program in the summer of 2002 (response rate 71%). Two thousand and one individuals completing the screener reported at least some experience with smoking (i.e. one or more puffs lifetime) and were invited to participate in the study (43%). Nine hundred and twelve of these individuals completed the baseline survey and took part in weekly web-based surveys throughout their first year (45%). One hundred and fifteen participants were excluded from the present analyses due to missing data on more than 30% of the observations (Rankin and Marsh, 1985; Velicer and Colby, unpublished manuscript). The present analyses focus on 225 participants who reported smoking on 10 or more occasions and drinking on 10 or more occasions during their first year. Since times series analyses were employed to detect predictable patterns of behavior, a minimum of observable behavior is required. A comparison of participants dropped due to missing data and those included in the present analyses showed similar levels of lifetime exposure to cigarettes and alcohol. The sample is 48% female and largely Caucasian.

2.2. Procedure

Each week, participants were asked to provide 7-day time-line follow-back reports on their tobacco smoking and alcohol consumption. Using a web-based survey protocol, participants were asked to enter the “number of cigarettes you smoked” and “the number of drinks you had” on each day of the preceding week. For the present analyses, winter and spring vacation periods were removed so that we could examine the short and long term substance use patterns tied to the academic schedule. Time series analyses uses data with evenly spaced observations to detect behavior patterns that may be present at regular intervals. Because, the vacations are not regularly distributed across the year, this method would not be able to detect the meaningfulness of these events. Additionally, vacations represent the periods with the highest rate of missing data, making their impact on the findings less certain. Thus, 210 reporting days were analyzed (105 from each academic semester) representing 30 full weeks of data with an average response rate for the sample slightly over 90% for each week of the study.

2.3. Data analyses

This study employed bivariate time series analysis as the primary method (Chatfield, 2004). In contrast to the univariate time series analysis that examines the correlations between observations of a single behavior (i.e. autocorrelations), bivariate time series analysis addresses the cross-correlations between smoking and drinking observations. Specifically, individual cross-correlations between smoking and drinking were estimated using the detrended and pre-whitened residuals from univariate alcohol and smoking models (i.e. trends and autocorrelations for each participant and each substance were statistically removed to assure that demonstrated effects are not better accounted for by trends and autocorrelations within alcohol and smoking behavior) (Fuller et al., 2003). Synchronous (within day) and lagged (across day) predictions between smoking and alcohol use were then estimated.

Missing data were handled with maximum likelihood procedures available through PROC ARIMA and PROC AUTOREG (Brocklebank and Dickey, 2003). Due to our expectation that the smoking and drinking relationship may differ based on substance use level, the sample was then divided into three groups for smoking and alcohol use separately based on the average number of tobacco cigarettes and drinks reported per day. For each substance, the first group included individuals who used the substance less than once a day on average (i.e. less than one cigarette per day or less than one drink per day), the second group included those who used on average between once and twice a day), and the third group included those who used three or more times per day on average. Given the small number of heavier smokers and drinkers in this sample, it was not possible to further divide the sample above 3+ cigarettes or drinks per day. Rates and direction of significant cross-correlations were compared across these groups.

3. Results

3.1. Drinking and smoking characteristics

Over the course of the 210 days, the sample reported an average of 2.4 cigarettes (S.D. 3.33) and 1.5 drinks (S.D. 1.01) per day. Smoking was reported on an average of 36.7% of days (S.D. 32.12, range 5.3–100%). Drinking was reported on an average of 21.5% of days (S.D. 30.9, range 5.3–51.3%). Fig. 1 illustrates the average number of cigarettes smoked and alcoholic drinks consumed by day of the week for the sample. Both smoking and drinking patterns were found to differ based on day of the week. For smoking and drinking, there were significantly higher levels of use on weekends (Friday

Fig. 1. Average smoking and drinking by day of the week.

and Saturday) compared to the rest of the week. Additionally, drinking on Thursdays was significantly greater than mean drinking levels seen on Sunday to Wednesday.

3.2. Time series

We used bivariate time series analysis to examine the relationship between smoking and drinking both within day (i.e. synchronous correlation) and between days (i.e. lagged correlations) after factoring out the influences of autocorrelations and trend demonstrated when examining individual substances (Dierker et al., unpublished). SAS ARIMA was used to estimate within-person models including a synchronous lag (Lag 0), testing for the relationship between smoking and drinking within day, 21 days of past lags (Lag-1 to Lag-21) testing for the relationship between smoking and drinking when smoking precedes drinking, and 21 days of future lags (Lag 1 to Lag 21) testing for the relationship between smoking and drinking when smoking follows drinking. We created corresponding indicator variables for each lag to reflect the significance of the cross-correlation as well as its direction: negative and significant (−1), non-significant (0), or positive and significant (1). Previous univariate time series work within the substance use field has largely examined only one previous lag and to our knowledge, no bivariate time series analyses have examined smoking and alcohol use. The 21-lag structure was selected because it was the largest number that could be evaluated with this methodology. Given the exploratory nature of these analyses, the test for significance was set at \( p < .05 \).

Fig. 2 presents the proportion of participants at each of the 43 lags (−21 to +21) showing significant cross-correlations between smoking and alcohol use by direction of the relationship (i.e. positive or negative). Overall, positive cross-correlations were found to be more common than negative cross-correlations. That is, higher levels of smoking or drinking predicted higher levels in the alternate behavior within day and on past and future days, while lower levels of either behavior predicted lower levels in the alternate behavior. This pattern was most common at Lag 0 with 86% of the sample showing significant cross-correlations between smoking and alcohol use within day. Significant cross-correlations at Lag 1 (both past and future) were also notable, representing over 15% of the sample. Further, spikes in the proportion of participants with a significant positive cross-correlation was seen at the 1-, 2-, and 3-week lags both past and future (approximately 10–20% of participants), suggesting the possibility of a regular and bidirectional pattern of prediction between smoking and drinking for the overall sample. These patterns were not found to differ by gender.

A closer look at positive cross-correlations within-person revealed 135 (60%) of the participants showed a significant cross-correlation for one or more past and future lags, suggesting a relationship between smoking and drinking when smoking precedes or follows drinking (i.e. a bidirectional relationship). Thirty-nine participants (17%) showed past, but not future positive cross-correlations, suggesting that smoking predicted drinking across time for these participants. Thirty-six participants (16%) showed future, but not past positive cross-correlations, suggesting that drinking predicted smoking across time. Seven participants (3.1%) showed only a synchronous cross-correlation suggesting a relationship between smoking and drinking only within day. Again, no differences in these patterns were detected when stratified by gender.

3.3. Level of use

Tables 1 and 2 present rates of significant cross-correlations for within day and weekly lags by level of smoking and alcohol use. Those smoking less than one cigarette on average per day were found to be less likely to
Fig. 2. Proportion of subjects by temporal direction and behavioral direction with significant alcohol × smoking cross-lags.

### Table 1
Rate of significant, positive magnitude alcohol–smoking cross-correlations by level of smoking

<table>
<thead>
<tr>
<th></th>
<th>Average less than one cigarette per day (n = 128)</th>
<th>Average one to two cigarettes per day (n = 43)</th>
<th>Average three or more cigarettes per day (n = 55)</th>
<th>p-Value</th>
</tr>
</thead>
</table>
| Total cigarettes smoked: M (S.D.) and range | 77.0 (59.91) / 13–209 | 373.5 (121.61) / 211–597 | 1392.8 (706.44) / 631–3317 | **
| Lag 0 (positive CR) V (%) | 102 (79.7%) a | 40 (90.9%) b | 53 (96.4%) b | **
| Lag 1 (positive CR) V (%) | 20 (15.6%) | 11 (25.6%) | 11 (20.0%) | n.s.
| Lag 7 (positive CR) V (%) | 19 (14.8%) | 5 (11.6%) | 9 (16.4%) | n.s.
| Lag 14 (positive CR) V (%) | 21 (18.0%) | 14 (32.6%) | 11 (20.0%) | n.s.
| Lag 21 (positive CR) V (%) | 18 (14.0%) | 12 (27.9%) | 12 (21.8%) | n.s.
| Lag minus 1 (positive CR) V (%) | 21 (16.4%) | 10 (23.3%) | 10 (18.2%) | n.s.
| Lag minus 7 (positive CR) V (%) | 28 (21.9%) | 6 (14.0%) | 8 (14.6%) | n.s.
| Lag minus 14 (positive CR) V (%) | 19 (14.8%) | 7 (16.3%) | 7 (12.7%) | n.s.
| Lag minus 21 (positive CR) V (%) | 20 (15.6%) | 6 (14.0%) | 6 (10.9%) | n.s.

Note: Means and standard deviations based on ANOVA. N’s and proportions based on Chi-square analyses with 2 d.f. Different superscript letters (a–c) represent means or proportions that significantly differ from one another within row. ** = p < .01.

### Table 2
Rate of significant, positive magnitude alcohol–smoking cross-correlations by level of alcohol use

<table>
<thead>
<tr>
<th></th>
<th>Average less than one drink per day (n = 96)</th>
<th>Average one to two drinks per day (n = 116)</th>
<th>Average three or more drinks per day (n = 14)</th>
<th>p-Value</th>
</tr>
</thead>
</table>
| Total number of drinks: M (S.D.) and range | 122.6 (54.05) / 21–209 | 357.5 (107.92) / 213–618 | 792.1 (123.72) / 634–977 | **
| Lag 0 (positive CR) V (%) | 79 (82.3%) | 104 (89.9%) | 12 (85.7%) | n.s.
| Lag 1 (positive CR) V (%) | 14 (14.6%) | 24 (20.7%) | 12 (85.7%) | n.s.
| Lag 7 (positive CR) V (%) | 14 (14.6%) | 18 (15.5%) | 1 (7.1%) | n.s.
| Lag 14 (positive CR) V (%) | 22 (22.9%) | 24 (20.7%) | 2 (14.3%) | n.s.
| Lag 21 (positive CR) V (%) | 22 (22.9%) | 18 (18.7%) | 2 (14.3%) | n.s.
| Lag minus 1 (positive CR) V (%) | 18 (18.8%) | 21 (18.1%) | 2 (14.3%) | n.s.
| Lag minus 7 (positive CR) V (%) | 16 (16.7%) | 22 (19.0%) | 4 (28.6%) | n.s.
| Lag minus 14 (positive CR) V (%) | 18 (18.8%) | 13 (11.2%) | 2 (14.3%) | n.s.
| Lag minus 21 (positive CR) V (%) | 12 (12.5%) | 17 (14.7%) | 3 (21.4%) | n.s.

Note: Means and standard deviations based on ANOVA. N’s and proportions based on Chi-square analyses with 2 d.f. Different superscript letters (a–c) represent means or proportions that significantly differ from one another within row. ** = p < .01.
demonstrate a significant positive cross-correlation between smoking and drinking at Lag 0 (i.e. within day) than those smoking 1 or more cigarettes on average per day ($\chi^2 = 16.2, 2$ d.f., $p < .0001$). In contrast, individuals in each of the three alcohol use groups showed statistically similar rates of significant positive cross-correlation between smoking and drinking at Lag 0. Rates of significant positive cross-correlations between smoking and drinking at each of the weekly lags did not differ by either smoking or drinking level. These findings held for both males and females.

4. Discussion

Experimental work (Mello et al., 1980, 1987; Henningfield et al., 1984) has converged to establish the effect of alcohol on subsequent smoking. Alcohol use has been tied to the number of cigarettes smoked (Nil et al., 1984; Mintz et al., 1985), the duration of a smoking episode (Glastetter et al., 1996), and increases in the amount of smoke consumed (Nil et al., 1984; Mintz et al., 1985). While fewer studies have experimentally evaluated whether smoking similarly potentiates alcohol use, theories to explain the mechanism of association between the two substances have often alluded to the possibility of a bidirectional relationship. For example, there is evidence to suggest that alcohol and nicotine affect similar systems, that some aversive effects of one drug may be counteracted by the other, that increasing tolerance for one substance may have cross-over effects in terms of tolerance for the other substance, and that levels of sensitivity for one substance which can be selectively bred within mouse lines is related to differential sensitivity to the other substance (Istvan and Matarazzo, 1984; Bien and Burge, 1990; Collins, 1990; Littleron and Little, 2002; Prendergast et al., 2002). Further, beyond an established relationship between nicotine and alcohol at the receptor level, both experimental and survey research has identified mechanisms involving classically conditioned associations between stimuli that link smoking and drinking (Bunton and Tiffany, 1997; Sayette, 2002), as well as the influence of poly substance use among peers or within social contexts in the form of peer pressure, teenage experimentation and role-modeling (Oetting and Donnemeyer, 1998).

Our examination of the cross-correlations between drinking and smoking across time strongly supported the general association between these behaviors within day and preliminarily demonstrated a greater likelihood of a bidirectional relationship between alcohol and smoking rather than a unidirectional relationship among individuals showing significant positive cross-correlations. That is, fully 86% of the sample exhibited a significant association between reports of smoking and drinking within day, the majority of whom also demonstrated a significant relationship where their drinking was related to reports of smoking that either preceded or followed it. In contrast, much smaller groups exhibited associations in only one direction (i.e. drinking associated with prior smoking versus drinking associated with later smoking). While a synchronous, within day correlation was the most common relationship to reach statistical significance, it was rare that the association between smoking and drinking within day fully described the predictive relationship between these behaviors for individual participants. Further, relationships between these behaviors were most often positive. This relationship was not only common among participants with regard to reports of within day substance use, but notably described a subgroup at 1-, 2-, and 3-week intervals both past and future.

In the context of non-experimental research, efforts to evaluate the presence of cause–effect relationships are tied in part to our ability to demonstrate temporal ordering between two behaviors (West and Hepworth, 1991). In that the predominant pattern demonstrated in the present study did not suggest an exclusive temporal ordering for the majority of participants, our findings seem more in line with the presence of a third variable or variables that may be causally related to both behaviors. The weekly patterning of associations between smoking and drinking suggest that for many participants this third variable is likely related to social constraints in which opportunities for substance use increase dramatically at weeks’ end and are rarer earlier in the week (Mundt et al., 1995). This is confirmed by mean substance use rates by day of the week in the present study, a pattern that has been reported in previous work examining smoking and alcohol use (Mundt et al., 1995; Del Boca et al., 2004).

As demonstrated in previous experimental studies, the association between smoking and drinking may be further moderated by general levels of use. For example, in a study by Mello et al. (1987), while all participants were found to smoke more while alcohol was available, the size of the association was related to overall smoking and drinking levels. That is, heavy smoking and both heavy and moderate drinking were associated with larger increases in smoking during drinking than lower levels of smoking and/or alcohol use. Henningfield et al. (1984) demonstrated a significant relationship between smoking and drinking among more moderate drinkers, but failed to establish this relationship among lighter drinkers. Further, in a field study of established adult smokers, the use of Ecological Momentary Assessment (EMA) showed that smoking and drinking were more strongly associated for heavier compared to lighter drinkers (Shiffman et al., 1994).

Our findings support this general pattern for smoking, in that the smoking and drinking association within day was stronger for individuals smoking at higher levels. This finding is particularly notable because the present sample was not selected for chronic substance use patterns as were samples from previous studies focusing on daily behavior. That is, even with our high representation of individuals reporting relatively low level smoking, we demonstrated what has been referred to as a “dose–effect” phenomenon in which the association between smoking and drinking becomes stronger in the context of heavier use (Bien and Burge, 1990). Notably, level of use was not found to be associated with significant
weekly lags for either substance suggesting that social factors likely play a similar role in the association between smoking and alcohol use across the range of substance use levels. Similar to our previous work considering use within substance (Dierker et al., unpublished), again it seems clear that the more accurate prediction of behavior across levels of use will require theory and measurement that accounts for a range of pharmacologic, social and contextual factors (Flay and Clayton, 2003).

While daily measurement of natural episodes of smoking or drinking have been examined in separate studies, to our knowledge, this is the first to examine the cross-association of these behaviors using such fine-grained reports of in vivo use. As this kind of intensive behavioral measurement is particularly challenging in terms of time, retention, and resources, previous studies utilizing time series to characterize longitudinal substance use patterns have typically relied on the description of only a handful of participants. By comparison, the present sample provides greater generalizability for the individual patterns identified. Finally, the narrow age range, homogenous context, and selection of a transition point in adolescent development permitted for a relatively straightforward examination of time effects without confounding of multiple ages, stages, and contexts. Because the examination of previous and future lags was exploratory and significance was set at the $p < .05$ level, these results should be considered in the context of an elevated Type I error rate. Thus, the weekly patterning of significant cross-lags, which remains even when more conservative $p$-values are set, may be somewhat more important than the specific rates of individual cross-lags.

It should be noted that while assessment was frequent, it was based exclusively on self-reports of retrospectively recalled behavior during the previous week. While the advantages of using self-monitoring techniques are commonly believed to outweigh the disadvantages (e.g. reports of number of cigarettes smoked per day have been shown to be a valuable index of smoking heaviness, being positively correlated with level of CO, cotinine, and nicotine (Heatherton et al., 1989)), our requirement of reporting on daily behavior over the preceding week, leaves open the possibility of recall bias. Further, given that timing of smoking and drinking was not assessed within day, a causal mechanism that might be suggested by a unidirectional temporal ordering could not be evaluated.

Future research is certainly needed to establish the wider generalizability of substance use patterns described in the present study. For example, although college students are relatively similar to their non-college peers in terms of alcohol consumption, they have been found to exhibit less tobacco use (Johnson et al., 1996) the reasons for which may influence emerging patterns of co-use. Further, the racial homogeneity of the present sample limits our ability to generalize to more diverse populations. Notably, however, our high rates of adherence may have been linked to the college environment where computers are readily available, communication through electronic mail is the norm, and a sense of community involvement in the project could be more readily established. It will be important to evaluate the feasibility of this sort of frequent monitoring of behavior in both more diverse samples and under less ideal conditions.

The most important implication of these findings is the need for intervention strategies that target contextual aspects of substance use including increased opportunities for use on the weekends. On a college campus, many opportunities exist for extended party weekends, with "weekends" often encompassing Thursday to Saturday. Intervention must further target co-use rather than focusing initiatives on individual substances. Even when individual types of substance use are merely correlated and not causally associated, their co-occurrence may significantly impact upon program effectiveness. As the present study has demonstrated that smoking and drinking are predictive of within day levels of the alternate behavior for the vast majority of participants, reductions in use will be well served by carefully articulating and targeting the third variables that drive these behaviors.

While a highly replicable phenomenon both in terms of survey and experimental research, the association between smoking and drinking has most often been demonstrated through assessment intervals that are too coarse to permit an evaluation of the more proximal and ongoing relationships between these behaviors. Through weekly follow-back evaluation of natural day-to-day episodes of substance use, the present study provides unique insights into the co-occurrence and predictive relationships between smoking and drinking during the critical transition to college and across the first academic year. Future research is needed to establish the specific factors (i.e. third variables) and related mechanisms that may drive both behaviors.

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