Published in final edited form as:
Psychol Addict Behav. 2010 September ; 24(3): 424–435. doi:10.1037/a0019793.

Daily Patterns of Conjoint Smoking and Drinking in College Student Smokers

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Abstract

Epidemiological data indicate a robust association between smoking and alcohol use. However, a critical question that is less resolved is the extent to which the smoking event takes place during the time of alcohol consumption. The present study used data from an eight-week prospective web-based study of college student smokers to examine daily associations between smoking and alcohol use, using measures of both likelihood and level of use. Findings indicated that within a person, consumption of alcohol and smoking covaried on a daily basis. In addition, consistent with the idea of smoking as a social activity for college students, light smokers were more likely than heavier smokers to smoke while drinking and to smoke more cigarettes while drinking. Smoking behavior among light smokers may be influenced by external social contextual cues, in contrast to heavier smokers who may be more affected by internal cues. Implications of findings for prevention work suggest the importance of targeting social situations in which smoking and drinking co-occur.

Keywords

alcohol; cigarettes; drinking; smoking; daily; college

There is a wide body of literature showing a robust association between smoking and alcohol involvement (Anthony & Echeagaray-Wagner, 2000; Bien & Burge, 1990). Smoking is highly associated with alcohol use among adolescents (Everett, Giovino, Warren, Crossett, & Kann, 1998; Ritchey, Reid, & Hasse, 2001; Wetzels, Kremers, & Vitoria, 2003) and young adults (Jackson, Sher, Cooper, & Wood, 2002) including college students (e.g., Jones, Oeltmann, & Wilson, 2001; Reed, Wang, Shillington, Clapp, & Lange, 2007; Weitzman & Chen, 2005).

Several hypotheses have been offered to explain the association between tobacco and alcohol use, generally falling into one of two classes: (1) the association is due to a common risk factor underlying involvement with both alcohol and cigarettes, and (2) the association is attributable

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to directional influences between the two substances. Risk factors such as family and peer influences, stress, outcome expectancies, and substance availability are common to use of both substances (Bobo & Husten, 2000; Jackson, Sher, & Wood, 2000a), and much of the association between smoking and drinking can be explained by individual vulnerability to substance use/problem behavior (Donovan, Jessor, & Costa, 1988; Jackson, Sher, & Wood, 2000b; Jessor & Jessor, 1977; McGue, Iacono, & Krueger, 2006).

Other work supports a directional association between drinking and smoking. In controlled laboratory experiments, alcohol administration results in greater cravings to smoke (Epstein, Sher, Young, & King, 2007; Sayette, Martin, Wertz, Perrott, & Peters, 2005) and increased smoking (Keenan, Hatsukami, Pickens, Gust, & Strelow, 1990; Mitchell, de Wit, & Zacny, 1995). A smaller body of work supports the converse association, with increased drinking following pre-treatment with nicotine (Barrett, Tichauer, Leyton, & Pihl, 2006; Kouri et al., 2004). Animal studies also indicate that nicotine administration increases ethanol consumption, perhaps due to acute cross-tolerance (Collins, Romm, Selvaag, Turner, & Marks, 1993) or enhanced reinforcement (Clark et al., 2001).

Prospective studies show that tobacco use and dependence predict subsequent alcohol use (Chen et al., 2002; Jackson et al., 2002) and alcohol dependence (Brook, Brook, Zhang, Cohen, & Whiteman, 2002; Sher, Gotham, Erickson, & Wood, 1996). Conversely, alcohol involvement predicts subsequent cigarette initiation and use (Jackson et al., 2002; Sher et al., 1996; Simon et al., 1995), although these directional relationships are not evident when the general propensity to experience tobacco dependence and alcohol use disorders is controlled (Jackson et al., 2000b).

Although epidemiological and laboratory studies enhance our understanding of smoking and drinking from a between-subjects perspective, a critical question is whether smoking and alcohol use are linked at the event-level within individuals. Between-subjects associations often reflect within-subjects effects, but this does not hold in all situations; opposite direction effects have been observed in within- versus between-subject analyses of alcohol use and high-risk sexual behavior (Leigh, 1993). The distinction between between-person and within-person associations has important implications for identifying optimal intervention strategies. Interventions that target stable aspects of the individual that underlie both drinking and smoking could reduce smoking among individuals who drink (and vice versa). In contrast, a program that aims to reduce smoking during a drinking event might target environmental factors in settings where drinking and smoking co-occur.

A relatively small literature addresses naturalistic associations between drinking and smoking. Using a daily Interactive Voice Response (IVR) assessment, Searles, Perrine, Mundt, and Helzer (1995) found that adult males smoked more on heavier drinking days. Using retrospective time-line follow-back (TLFB) data, Duhig, Cavallo, McKee, George, and Krishnan-Sarin (2005) showed that the majority of adolescent past-month smokers reported using both alcohol and cigarettes on the same day, and none reported heavy drinking without smoking cigarettes. Using TLFB with college freshmen, Dierker et al. (2006) found high synchronous cross-associations between drinking and smoking. Three studies using more refined analyses of event-level data showed that the likelihood of smoking in adults was greater when alcohol was consumed (Shapiro, Jamner, Davydov, & James, 2002; Shiffman & Paty, 2006; Shiffman et al., 1994c).

Social Smoking and Social Contexts of Smoking

Event-level analyses of smoking and drinking may be particularly relevant when looking at smoking context. Many smokers report that their smoking occurs primarily in a social context. For example, the majority (70%) of adult smokers who regularly attend social venues report

smoking more in social settings than in other settings (Trotter, Wakefield, & Borland, 2002). "Social" smokers have been variously defined to include individuals who self-classify as social smokers (Morley, Hall, Hausdorf, & Owen, 2006) and individuals who smoke only while others are smoking (Gilpin, White, & Pierce, 2005). Social smokers also tend to be lighter smokers, generally smoking on a non-daily basis (Levinson et al., 2007; Moran, Wechsler, & Rigotti, 2004). These light and intermittent tobacco smokers (LITS; National Cancer Institute, 2008; also labeled chippers; Shiffman, 1989) comprise a significant proportion of the smoking population.

College student smokers are particularly likely to be social smokers (Gilpin et al., 2005; Moran et al., 2004; Waters, Harris, Hall, Nazir, & Waigandt, 2006). Their likelihood of smoking and average cigarettes per day are greater on weekends than weekdays, and their smoking is particularly high on "party weekends" (Colder et al., 2006). Smoking in college students is highly variable; a sizeable proportion smoke in low quantities (Rigotti, Lee, & Wechsler, 2000; Waters et al., 2006; Wechsler, Rigotti, Gledhill-Hoyt, & Lee, 1998) and with low frequency (Rigotti et al. 2000; Thompson et al., 2007). In general, much of college student smoking can be characterized as social smoking and/or light and intermittent smoking. Both of these patterns (which are related) seem to be more context-dependent than heavier and more regular smoking patterns. For college students, these social contexts very often involve alcohol consumption.

Understanding the Nature of the Drinking-Smoking Association in College: Distinguishing Social from Nonsocial Smoking

Given the relationship between light and intermittent smoking and social smoking, and accepting that alcohol use in college is predominantly a social phenomenon, we would expect that LITS in college would be more likely to drink while smoking than would regular or heavier smokers, for whom smoking would be distributed across more contexts. In Shiffman et al. (1994b), chippers were more likely than dependent smokers to report that smoking while drinking alcohol would be difficult to give up. In a survey of college student smokers (McKee, Hinson, Rounsaville, & Petrelli, 2004), students in the initial stage of smoking (<100 lifetime cigarettes) estimated a greater likelihood of smoking during a drinking occasion (86% of smoking episodes) than more established smokers (63%), although established smokers were more likely than experimenters to report increasing their smoking rate while drinking.

Naturalistic studies of the event-level link between smoking and drinking have been mixed with regard to evaluating differences by smoker type (e.g., LITS versus heavy smoker). Shiffman et al. (1994c) observed that the association between drinking and smoking did not differ by individual smoking rate, perhaps due to limited variability in their predominantly heavy drinking sample. A review by Shiffman and Balabanis (1995) concluded that alcohol and smoking become more related as drinking and smoking rates increase, i.e., the association may be driven by heavy drinkers and heavy smokers. In college students, Dierker et al. (2006) found support for a dose-dependent association between drinking and smoking; the association was greatest among those averaging 3+ cigarettes daily and the lowest among those averaging less than one cigarette per day. The sample, however, was a light-smoking one (averaging 2.4 cigarettes per day), so they were unable to resolve smoking levels beyond 3+ cigarettes per day.

Other studies have suggested a negative association between heaviness of smoking and concurrent smoking and drinking. Krukowski, Soloman, and Naud (2005) found that lighter smoking college students consumed a greater proportion of cigarettes when drinking alcohol (27%) than heavier smokers (10%). Similarly, Shiffman and Paty (2006) found the odds of smoking (versus non-smoking) while drinking were considerably higher for chippers than heavy smokers. Studies that examine the odds of smoking generally support a stronger

association between smoking and drinking among LITS (McKee et al., 2004; Krukowski et al., 2005; Shiffman & Paty, 2006), whereas studies that examine number of cigarettes (Dierker et al., 2006; Shiffman & Balabanis, 1995) suggest a weaker association. This suggests that *whether* an individual is more likely to smoke while drinking may differ from *how much* one smokes while drinking. The goal of the present study is to clarify the nature of the association between smoking status and concurrent drinking and both likelihood and rate of smoking.

Overview

Using data from an eight-week prospective web-based study, we examine daily associations between smoking and alcohol use. We also explore person-level differences in the within-person alcohol-tobacco association by examining the extent to which the association differs as a function of person-level smoking status. Use of a college student sample presents a valuable opportunity to examine this phenomenon given that many college students smoke intermittently and socially and have variability in smoking pattern. As there may be different associations for any use versus level of use, we examine any smoking and any alcohol use as well as number of cigarettes and number of drinks.

Method

Participants

Study participants consisted of college students at a large Midwestern university enrolled in an introductory psychology course. Eligible participants were smokers who endorsed past-month smoking and having smoked at least 100 cigarettes in their lifetime as assessed via a brief telephone or email survey and were required to have endorsed past-month drinking and lifetime consumption of at least six drinks. These eligibility requirements were intended to ensure sufficient variability in both smoking and drinking. In all, 115 students were recruited (57% female; 96% Caucasian; 90% age 18 or 19 years). Participants were comprised of three cohorts beginning a week apart (Cohort 1 N=18; Cohort 2 N=33; Cohort 3 N=64).

Procedure

Prior to the eight-week web-based survey, participants received a brief training session (including the definition of a standard drink) and were administered a paper-and-pencil baseline survey assessing substance use and other psychosocial constructs. After one week (Cohort 1), two weeks (Cohort 2), or three weeks (Cohort 3), participants received their first of 56 morning email notices prompting them to complete the web-based survey. Assessment occurred via a 26-item survey that assessed prior-day alcohol and tobacco use. Participants received either $10 or 2 course credits for the baseline survey and for each week of complete data, with cash bonuses for on-time survey completion.

Measures

The daily report covered several indices of drinking and smoking, described below. In addition, survey date was coded, from which weekday/weekend status was calculated. Sex was assessed by the baseline survey, as were indicators of smoking status.

Drinking—Respondents indicated the number of standard drinks consumed the prior day, ranging from zero to 25 or more. From this variable, a binary variable reflecting whether or not the respondent drank also was coded.[1]

[1]Analyses were also conducted using a variable corresponding to the extent to which the respondent felt "drunk" (speech slurred, unsteady on feet), assessed using a 7-point scale ranging from (1) *not at all* to (7) *extremely* (*M*=1.80, *SD*=1.64). The results using the drunk variable were largely consistent with those for number of drinks and are not presented here.

Smoking—Respondents reported the number of cigarettes smoked the prior day. Options included none, 1 or 2 puffs of a cigarette (recoded to 0.2 cigarettes), less than 1 cigarette (recoded to 0.5 cigarettes), values ranging from one cigarette to 20 cigarettes (with an interval of 1 cigarette), and half-packs thereafter up to 3 packs (coded as 60 cigarettes). Half-pack intervals were coded using the midpoint of the range; for example, the option '36 to 40 cigarettes (2 packs)' was coded as 38 cigarettes. Note that the values of "1 or 2 puffs" and "less than 1 cigarette" were coded as 1 cigarette for Poisson analyses which call for integer values. A binary variable representing whether or not the respondent smoked on each day also was coded.

Co-occurring drinking and smoking—Three variables were constructed to represent self-report of concurrent use. Each of these was based on a single-item worded as "What percentage of cigarettes smoked yesterday were smoked while drinking alcohol (or later, while under the influence of alcohol)?" First, a binary variable was computed that reflected whether the respondent smoked at all while drinking on a given day. The second variable was the item assessing percentage of cigarettes smoked while drinking, ranging in quartiles from 0 to 100%. Finally, a variable was created to index the number of cigarettes while drinking by computing the product of smoking quantity and the percentage item; this variable ranged from 0 to 28.

Smoking status—To explore between-person differences by smoking status, we created three alternative definitions of light (versus heavy) smoker.[2] The first was a binary *daily smoking* status item from the baseline survey, coded if a respondent endorsed "daily or almost daily (26 to 30 days a month)" to the item "How frequently did you smoke in the past month?" Using data from the daily survey, we also created a continuous *intensity* (quantity) item, which was computed as the mean number of cigarettes per day over the 8-week interval where a high score corresponds to a high-intensity smoker. Finally, we created a continuous *"frequent" smoker* item, which was based on the mean frequency of smoking days over the 8-week interval.

Data Analysis

Because of the structure of the data where days were clustered within person, we used multilevel modeling (MLM; also called hierarchical linear modeling; Raudenbush & Bryk, 2002; Snijders & Bosker, 1999). These models are ideal for event-level data because they allow for varying numbers of observations and missing observations. Within-person (Level 1) associations and fixed between-person (Level 2) variables can be tested along with cross-level interactions. We included the aggregated measure of the Level 1 predictor at Level 2 (i.e., the compositional effect; Raudenbush & Bryk, 2002), which controls for the effect of individual-level smoking (or drinking). This permits us to interpret the effects of the Level 1 predictors on the outcomes as purely within-person associations. We used HLM 6.06 (Raudenbush, Bryk, Cheong, & Congdon, 2004) to conduct the multilevel analyses. For binary variables, we used a Bernoulli (unit-specific) model for binary data, for frequency variables, a Poisson link was used, also with a unit-specific model.

The model that was fit was as follows (using the example of smoking as a predictor): Level-1 model: (Day)

$$\eta_{ij}=\beta_{0j}+\beta_{1j}(\text{smoking})+\beta_{2j}(\text{weekday})+r_{ij}$$

[2]We also computed a binary *dependent smoking* status item (endorsed by 69.9% of the sample), coded positively if a respondent endorsed "yes, but not in the past year," "yes, in the past year, but not in the past month," or "yes, in the past month" to the item "Have you ever felt that you needed tobacco or that you were dependent on it (by tobacco, we mean cigarettes, cigars, pipe tobacco, chewing tobacco, or snuff)?" The findings were very similar to those using the daily smoking status item.

Level 2 model: (Participant)

$$\beta_0=\gamma_{00}+\gamma_{01}(\text{sex})+\gamma_{02}(\text{aggregate smoking})+u_{0j}$$
$$\beta_1=\gamma_{10}+u_{1j}$$
$$\beta_2=\gamma_{20}+u_{2j}$$

For the Bernoulli models (which use a logit link function), $\eta_{ij} = \log[p/(1-p)]$ and $r_{ij}= 1/[p(1-p)]$. For the Poisson models (which use a log link function), $\eta_{ij} = \log(\lambda_{ij})$, and $r_{ij}=1/\lambda_{ij}$.

For all models, Level 1 variables were person-centered and Level 2 variables were grand mean-centered.

Results

Descriptive Information

Across all possible person days (56 days × 115 participants), 92% of daily reports (5,930/6,440) were obtained. Daily participation rates, which declined over the 8-week interval, ranged from 100% to 71% (on the last survey day); the median daily retention rate was 93% (107/115). Over the study interval, individuals reported drinking on 29.4% (1,739/5,910) of the days and smoking on 60.6% (3,588/5,919) of the days. The average number of drinks consumed was 2.55 drinks (*SD*=4.74), and the average number of cigarettes smoked was 5.05 cigarettes (*SD*=6.33). Respondents self-reported that they were drinking on 32% (1,155/3,574) of the smoking days. The average percentage of cigarettes smoked while drinking alcohol was 19.52 cigarettes (*SD*=32.15), and the average number of cigarettes smoked while drinking was 1.78 cigarettes (*SD*= 3.62). On the drinking days, smoking occurred while drinking on 66% (1,153/1,739) of the days. In addition, the odds of smoking on a drinking day were 2.75 (95% CI: 2.42, 3.12) times the odds of smoking on a non-drinking day.

When data were aggregated over occasions (56 days), on average, participants drank on 29.3% of the days; rates across individuals ranged from 0% to 72.1%. On average, participants smoked on 61.5% of the days (rates ranged from 0% to 100%), and participants reported that alcohol was consumed while smoking on 39.4% of these smoking occasions (rates ranged from 0% to 100%).[3]

Figure 1 portrays smoking and drinking behavior over the 56-day interval. A strong seven-day pattern was evident for all indices of smoking and drinking. A series of multilevel models indicated that alcohol use (any drinking; number of drinks) was greatest on the weekend (Friday and Saturday), γ =1.70; $F(1,112)=501.67$, $p < .001$; γ =1.53, $F(1,112)=392.48$, $p < .001$; respectively). To a lesser extent this was true for smoking: for any smoking, γ =0.18; $F(1,112) = 9.65$, $p < .01$; for cigarette quantity γ =0.42; $F(1,112)= 57.94$, $p < .001$. Based on these findings, we created a binary weekend (Friday and Saturday) versus weekday variable which was controlled for in all analyses.[4] The figure also suggests that substance use declined over the course of the semester. A test of the linear trend using multilevel modeling, controlling for weekend, indicated that any alcohol use, $F(1, 111)=13.07$, $p < .01$, and number of drinks, $F(1, 111)=22.27$, $p < .001$, declined over time, as did any smoking and number of cigarettes, $F(1, 111)=56.87$, $p < .001$ and $F(1, 111)=70.11$, $p < .001$, respectively. Quadratic trends were

[3]We considered a variable that coded weekend as Thursday, Friday, and Saturday, but this variable was less predictive of alcohol use than the coding of Friday and Saturday as weekend.

[4]During the 8-week period, two individuals did not drink and two individuals did not smoke. When these four individuals were excluded from analyses, findings were virtually identical.

not significant for either smoking or drinking. Sex did not interact with the linear trend for any drinking, but women showed a greater decline for number of drinks, $F(1, 110)=4.64$, $p < .05$, number of cigarettes, $F(1, 110)=4.93$, $p < .05$, and any smoking, $F(1, 110)=4.52$, $p < .05$.

Finally, controlling for weekend, men reported a greater number of drinks per day than women [$\gamma =0.43$; $F(1, 111)=10.18$, $p < .001$] but did not differ in reporting any drinking, any smoking, or number of cigarettes per day (Fs from 0.01 to 1.46).

Association between Drinking and Smoking

Table 1 shows the bivariate associations between measures of drinking and smoking at the person-level, collapsed over occasion (between-subjects association); Table 2 presents correlations at the within-subjects (daily) level. Drinking and smoking were consistently associated both within-day and across the eight-week study interval. At the person-level, those who consumed any alcohol were more likely to smoke (r=.26) and to smoke a greater number of cigarettes (r=.18). Heavier alcohol drinkers were also more likely to smoke at all and in greater quantities (r=.14 and r=.14, respectively). At the event level, any drinking and heavy drinking on a given day were strongly associated with any smoking on that day (Φ=.21 and r=.17, respectively) and with cigarette quantity on that day (r=.23 and r=.25, respectively).

At the person-level (Table 1), heavier smokers were less likely than lighter smokers to report smoking while consuming alcohol; associations between person-level smoking level and (aggregated) drinking and smoking ranged from $r= -.32$ to $r=-.58$. Heavier drinkers were more likely than light drinkers to report that they smoked while drinking (r's ranged from r=.20 to r=.55). At the event-level (Table 2), on days when more cigarettes were smoked, smoking while drinking was more likely to occur (r=.17); not surprisingly, larger numbers of cigarettes while drinking were consumed on days when more cigarettes were smoked ($r=-.47$). Proportion of cigarettes smoked while drinking was less correlated with number of cigarettes on a given day (r=.07). Finally, at the event-level, smoking while drinking was very likely on drinking days (r's ranged from r=.64 to r=.90). Among those who reported smoking and drinking on the same day, cigarettes were consumed *while* drinking a full 86.8% (1153/1328 days) of the time.

Next, we examined the extent to which smoking and drinking were related within a day using multilevel models. These extend the correlations shown in Table 2 by adjusting for the nested structure of the data as well as controlling for sex and weekend. In order to gauge the extent of nesting in the data, we estimated a series of unconditional models to calculate intraclass correlations (ICC) for drinking and smoking variables. Eleven percent of the variability in any drinking and 12% of the variability in number of drinks was within-person daily variability. A full 71% of the variability in any smoking and 67% of the variability in number of cigarettes was within-person daily variability.

We conducted two sets of analyses: (1) smoking predicting drinking, and (2) drinking predicting smoking. Across all indicators of drinking and smoking, there was a strong association between the two on a given day. In the prediction of drinking from smoking, any smoking ($\gamma =1.92$, $p < .01$) and number of cigarettes ($\gamma =0.36$, $p < .01$) predicted any drinking. Likewise, any smoking ($\gamma =1.65$, $p < .01$) and number of cigarettes ($\gamma =0.21$, $p < .01$) predicted number of drinks. In the prediction of smoking from drinking, any drinking ($\gamma = 1.71$, $p < .01$) and number of drinks ($\gamma =0.24$, $p < .01$) predicted any smoking and any drinking ($\gamma =1.07$, $p < .01$) and number of drinks ($\gamma =0.11$, $p < .01$) predicted number of cigarettes.

The majority of the within-day associations between drinking and smoking did not differ for men and women.[5] However, the extent to which smoking was predictive of whether a respondent drank was stronger for women than for men ($\gamma = -0.68$, $p < .05$ for any smoking;

$\gamma = -0.18$, $p < .01$ for number of cigarettes), as was the prediction of number of drinks from number of cigarettes ($\gamma = -0.08$, $p < .01$). Additionally, number of drinks was more predictive of any smoking for women than men ($\gamma = -0.15$, $p < .01$).

Drinking-Smoking Association by Smoking Status

We conducted multilevel models to examine whether there were differences in self-reported conjoint smoking and drinking between heavier and lighter smokers, using the three operational definitions of smoking status: daily smoker (reported by 51.8% of the sample), high-intensity smoker, and frequent smoker. For these analyses, the between-subject smoking status variable served as the predictor and the outcomes were (1) any alcohol use, number of drinks, (2) any smoking, smoking quantity, and (3) the three variables that were constructed to reflect concurrent use: whether the respondent smoked while drinking, the percentage of time he/she smoked while drinking, and the number of cigarettes smoked while drinking.

As shown in Table 3, not surprisingly, heavy smokers were more likely to smoke and to smoke in greater quantities than light smokers (*p*s < .01). Second, high-intensity and high-frequency (but not daily) smokers were more likely to drink and to drink in high quantities. Third, there were strong effects of smoking status on the three conjoint drinking-smoking variables. Light smokers reported a greater proportion of smoking during a drinking episode than heavy smokers, whether defining smoking status according to daily smoking, level of smoking intensity, and level of smoking frequency ($\gamma = -0.74$, $p < .01$, $\gamma = -0.05$, $p < .05$; $\gamma = -1.26$, $p < .01$, respectively) and reported a larger percentage of cigarettes were smoked while drinking ($\gamma = -0.47$ $p < .01$; $\gamma = -0.05$, $p < .01$; $\gamma = -0.75$ $p < .05$, respectively). Interestingly, smoking status was positively associated with the actual number of cigarettes smoked while drinking ($\gamma = 0.06$, $p < .01$; $\gamma = 0.71$, $p < .01$ for smoking status based on intensity and frequency, respectively). This latter effect may be due to the fact that heavy smokers simply smoke more in general.

Next, we analyzed the association between daily self-reports of drinking and daily self-reports of smoking to evaluate whether the relationship between these reports differed by smoking status (the three constructed measures of concurrent alcohol-tobacco use were not included in this analysis). Specifically, we examined whether light smokers were more or less likely to show a significant association between alcohol and tobacco use by testing the interaction between smoking status and smoking in predicting drinking, and vice versa (see Table 4). As demonstrated in Table 4, person-level smoking status significantly interacted with number of cigarettes smoked on a given day in predicting alcohol use on that day such that lighter smokers showed a stronger association between smoking quantity and any drinking ($\gamma = -0.19$; $\gamma = -0.02$; $\gamma = -0.28$ for daily, high-intensity, and frequent smoking status, respectively) and number of drinks ($\gamma = -0.07$; $\gamma = -0.01$; $\gamma = -0.14$, respectively). The interaction between smoking status and any smoking was non-significant when predicting any drinking, but unexpectedly, more drinks were consumed on smoking days for high-intensity and frequent smokers ($\gamma = 0.22$; $\gamma = 1.37$, respectively). This may be because heavier smokers are heavier drinkers in general, consistent with the positive person-level correlations between smoking and drinking and with the findings in Table 3 that high-intensity and high-frequency smokers were more likely to drink and to drink in high quantities.

Given the convergence of many findings across three alternative definitions of smoking status as well as across measures of cigarette and alcohol use, we present some illustrative figures depicting the nature of the interaction. Figure 2 portrays the prediction of any drinking from

[5]For models that included cross-level interactions with sex (or with smoking status), this was entered in the Level 2 model as $\beta_1 = \gamma_{10} + \gamma_{11}$ (sex) + u_{1j}.

number of cigarettes as a function of daily smoking status (top panel) and high-intensity smoking status (bottom panel). It is evident from these graphs that the association between drinking and smoking was stronger for LITS than heavy smokers. Figure 3 portrays the same association but with number of drinks as the outcome.

We also examined the converse association where we tested the interaction between drinking and person-level smoking status in predicting smoking. Any drinking was a stronger predictor of number of cigarettes for lighter smokers than heavier smokers ($\gamma = -1.22$; $\gamma = -0.12$; $\gamma = -1.93$, respectively). In addition, non-daily and less frequent smokers were more likely to report any smoking when reporting any drinking ($\gamma = -0.60$; $\gamma = -0.88$, respectively). Finally, the interaction between smoking status and number of drinks was not significant when predicting any smoking, but number of cigarettes increased as a function of number of drinks to a greater extent among lighter smokers ($\gamma = -0.10$; $\gamma = -0.01$; $\gamma = -0.16$, respectively); see Figure 4 for an illustration of this association.

Discussion

The present study extends the larger literature on smoking-drinking co-occurrence at the person-level by demonstrating fine-grained within-day associations between smoking and alcohol consumption. Participants reported greater likelihood of drinking and number of drinks on smoking days and greater likelihood of smoking and number of cigarettes on drinking days. In fact, on days when respondents drank, over 85% of the cigarettes smoked that day were smoked while drinking. Moreover, LITS, who frequently are social smokers, showed stronger associations between smoking and drinking than more regular/heavier smokers. Whereas heavier smokers may be more affected by internal physiological and psychological cues (Krukowski et al., 2005), smoking behavior among LITS seems to be influenced by external environmental cues. The social context in which both smoking and drinking tend to occur may be an important factor that accounts for the association between the two. While other theories and models attempt to explain the alcohol-smoking link in general, this research contributes the perspective that smoking-alcohol relationships (some directional, some due to shared underlying factors) can be usefully considered within-person and within the social context specifically, and that this is particularly important for some subgroups of smokers and drinkers.

Socializing is a central part of the college lifestyle, particularly for heavy drinkers (Colby, Colby & Raymond, 2009; Weschler, Dowdall, Davenport, & Castillo, 1995). Several factors may increase smoking in social situations involving alcohol use. Smoking is more likely to be perceived as accepted, even normative, in social settings such as bars, parties, and clubs (McDermott, Dobson, & Owen, 2007), and college student smokers perceive smoking to reduce self-consciousness and facilitate social interaction (Stromberg, Nichter, & Nichter, 2007). Alcohol may weaken self-control efforts to avoid smoking (Shiffman, 1982). Smokers may be directly offered cigarettes, or there may be indirect pressure to smoke through observation of other smokers (Shiffman, 1982). In addition, individuals may smoke in a self-contained group in response to an unfavorable smoking environment (e.g., smoking outside of a drinking establishment where smoking is prohibited; Stromberg et al., 2007).

Other contextual factors that enable or constrain substance use in general may partly explain conjoint use of alcohol and cigarettes. Opportunities to use alcohol and tobacco are rare early in the week but increase as the weekend approaches (Dierker et al., 2006). In this college sample as well as in other studies (Colder et al., 2006; Del Boca, Darkes, Greenbaum, & Goldman, 2004; Mundt, Searles, Perrine, & Helzer, 1995; Tiffany et al., 2007), smoking and drinking rates were elevated on weekends versus weekdays. Having a light course schedule on a given day may increase opportunity or desire to both smoke and drink on that day. Co-occurring smoking and drinking may also occur due to a learned association, given that both behaviors

occur in similar social contexts, although Shiffman et al. (1994c) observed situational associations between smoking and drinking even when contextual variables such as activity, setting, or others' smoking were controlled, suggesting additional causal factors.

Alcohol use may not only influence smoking likelihood and rate, but may also interact with contextual influences. Consistent with the alcohol myopia model (Steele & Josephs, 1990), alcohol use may restrict attentional capacity; as a result, drinkers may attend to salient environmental cues that promote smoking more than cues that discourage smoking (Reed et al., 2007). Consistent with this idea, smokers who consumed alcohol paid greater attention to smoking-related cues (Field, Mogg, & Bradley, 2005) and reported greater smoking urges in response to smoking-related cues (Sayette et al., 2005).

Although the present study supports a social contextual explanation for co-occurring smoking and drinking, alcohol use may influence cigarette smoking in other ways. Alcohol may increase the rewarding effects of nicotine (Rose et al., 2004). According to McKee et al. (2004), smoking during alcohol consumption may potentiate reward for continued drinking, and may counteract the sedating effects of alcohol allowing for continued drinking. Researchers also have posited that alcohol and tobacco evoke reciprocal activation whereby one substance acts as a cue for the second (Gulliver et al., 1995; Shiffman et al., 1994a). These sorts of explanations require confirmation from data that are more fine-grained than the current daily data.

Implications

Because the association between smoking and drinking is particularly strong in college students (many of whom are LITS), the social context should be considered and perhaps even targeted in smoking interventions for college student smokers. College smoking interventions have generally failed to adequately consider the smoking-alcohol link and the potential role of alcohol in smoking relapse (Tevyaw et al., in press). Rigotti et al. (2000) suggested that smoking interventions be incorporated into existing alcohol programs in college.

Both light and intermittent smoking (Evans et al., 1992; Hennrikus, Jeffery & Lando, 1996) and social smoking (Moran et al., 2004) are critical stages in the initiation of regular smoking. Also, the college years are a time of transition during which risky health behaviors are consolidated into lifetime patterns (Schulenberg, Sameroff, & Cicchetti, 2004). In young adulthood, social smoking LITS may be at risk for progression to regular smoking as parental monitoring decreases and inhibitions about risky behaviors are reduced (Chassin, Presson, Pitts, & Sherman, 2000). The tobacco industry's prioritized targeting of young adult smokers likely reflects an understanding of this stage as a critical time in progression to established smoking behavior (Ling & Glantz, 2002; Sepe, Ling, & Glantz, 2002). Aware of the social nature of smoking among young adults, the industry invests heavily in sponsoring events in bars proximal to college campuses (Gilpin, White, & Pierce, 2005; Krukowski et al., 2005; Moran et al., 2004). Our findings underscore the importance of prohibiting smoking in hospitality settings where alcohol is consumed; such bans could reduce smoking and promote cessation, especially among LITS (McDermott et al., 2007; Trotter et al., 2002). These smoking bans, which are designed to delay smoking progression by changing the environment (Forster, Widome, & Bernat, 2007; Siegel, Albers, Cheng, Biener, & Rigotti, 2005), are increasingly common.

Strengths and Limitations

This study used data on likelihood and rate of smoking and drinking across an eight-week period. Our sample, although small, is larger than many samples in EMA studies that examine conjoint use, and there is good variability in person-level smoking status. The college sample permitted examination of the concept of social smoking in the context of alcohol use. The

predominately White sample precludes generalization to minority groups. Although social smoking is more common among White than Black smokers (Moran et al., 2004), LITS are more likely than other groups to be Black or Latino (Centers for Disease Control and Prevention, 1998). Thus, future studies should extend these findings to other ethnic/racial groups. The majority of the sample was 18 or 19 years old, which further limits the generalizability of the findings. Finally, despite the power of the social context in understanding smoking behavior (especially for light smokers), we lack insight into the characteristics of the contexts surrounding the drinking-smoking episode.

Acknowledgments

Preparation of this paper was supported by National Institute on Alcohol Abuse and Alcoholism Grant K01 AA13938.

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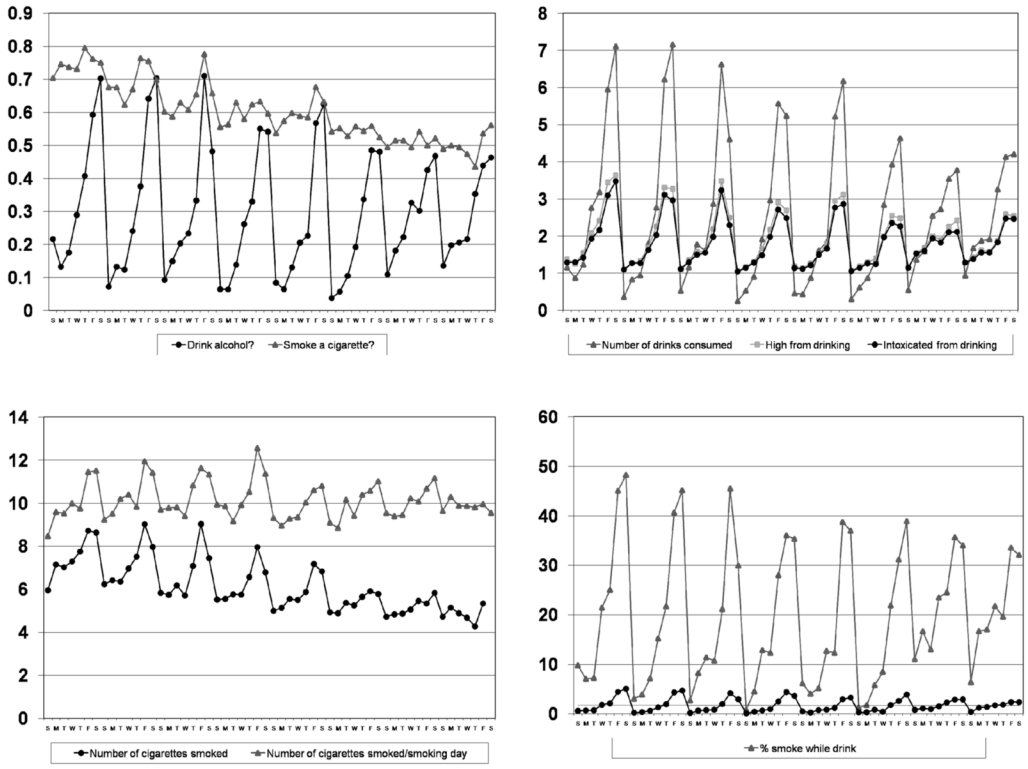

Figure 1.

Prevalence of any drinking and any smoking (top left panel), mean number of drinks consumed, feeling high, and feeling intoxicated (top right panel), mean number of cigarettes smoked and number of cigarettes smoked per smoking day (bottom left panel), and percent time smoke while drink and number of cigarettes while drinking (bottom right panel). N's range from 82 to 115 across days and variables, with the exception of percent smoked while drinking (N's ranged from 37 to 85). Note that due to a one-day delay in survey commencement for Cohort 1, data for Day 1 contain responses for Cohorts 2 and 3 only.

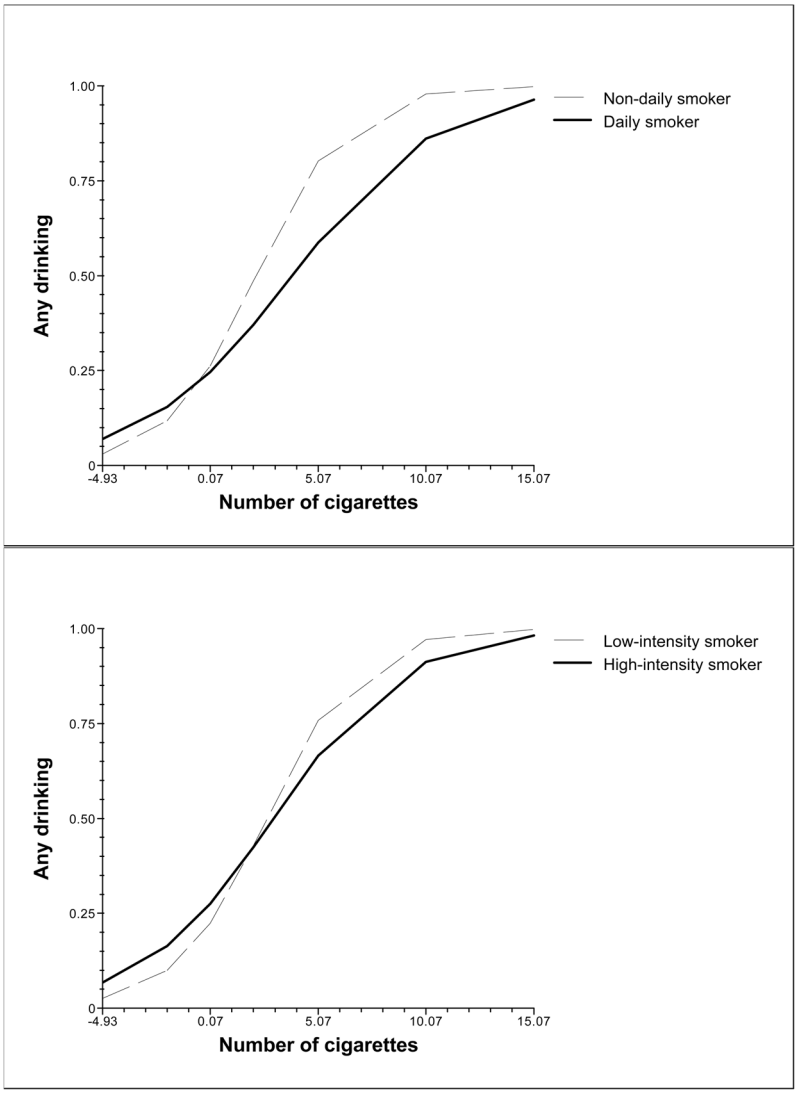

Figure 2.
Predicted values of any drinking as a function of smoking, for non-daily and daily smokers (top panel) and for low- and high-intensity smokers (bottom panel). Models control for sex and weekend. Note that as smoking was "group-centered," the range across the x-axis (values from 5% to 95%) includes both negative and positive values.

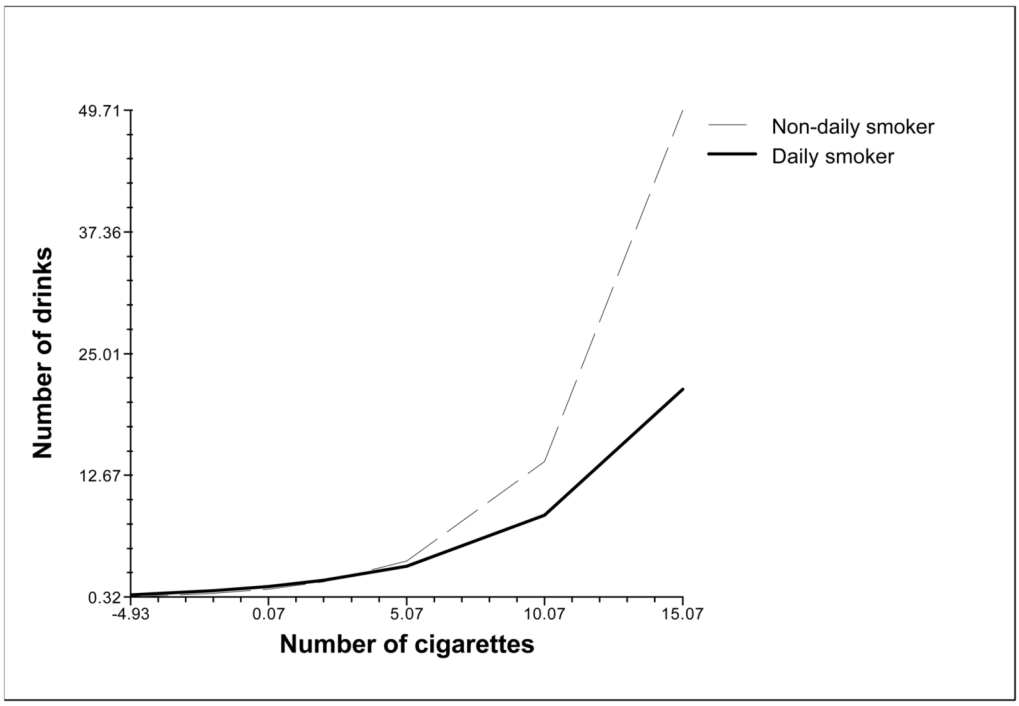

Figure 3.
Predicted values of number of drinks as a function of smoking, for non-daily and daily smokers. Models control for sex and weekend. Note that as smoking was "group-centered," the range across the x-axis (values from 5% to 95%) includes both negative and positive values.

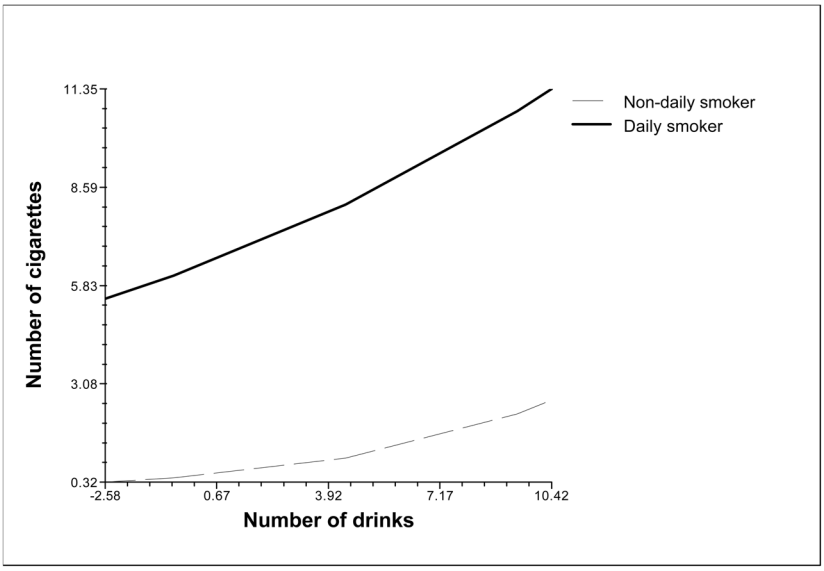

Figure 4.
Predicted values of number of cigarettes as a function of drinking, for non-daily and daily smokers. Models control for sex and weekend. Note that as drinking was "group-centered," the range across the x-axis (values from 5% to 95%) includes both negative and positive values.

Psychol Addict Behav. Author manuscript; available in PMC 2011 September 1.

Table 1

Between-subjects (person-level) correlations among measures of drinking and smoking (associations aggregated across individuals).

	Any drink	Number drinks	Any smoke	Number cigarette	Smoke while drink	% smoke w/drink	# cigs while drinking
Any drinking							
Number drinks	.88**						
Any smoking	.26**	.14					
Number cigarettes	.18	.14	.77**				
Smoke while drinking	.42**	.37**	−.42**	−.31**			
% smoke while drinking	.22*	.21*	−.58**	−.44**	.94**		
Number cigs while drinking	.49**	.54**	.16	.32**	.40**	.26**	

Note. N=113–115. For binary variables (any drink, any smoke), correlations are phi coefficients or point-biserials.

* $p < .05$;

** $p < .01$

Table 2

Within-subjects correlations among measures of drinking and smoking (event-level associations).

	Any drink	Number drinks	Any smoke	Number cigarette	Smoke while drink	% smoke w/drink	# cigs while drinking
Any drinking							
Number drinks	.84						
Any smoking	.21	.17					
Number cigarettes	.23	.25	.64				
Smoke while drinking	.90	.83	--	.17			
% smoke while drinking	.79	.80	--	.07	.88		
Number cigs while drinking	.64	.76	--	.47	.71	.71	

Note. N ranges from 5,887 to 5,919 for drinking and smoking variables and from 3,569 to 3,574 for the three conjoint smoking-drinking variables. For binary variables (any drink, any smoke), correlations are phi coefficients or point-biserials. All correlations are significant at $p < .001$.

Table 3

Mixed model parameter estimates for the prediction of daily measures of smoking, alcohol use, and smoking while drinking from smoking status, controlling for sex and weekday/weekend.

	Cigarette Use		Alcohol Use		Conjoint Use		
Smoking status	**any smoking**	**# cigarettes**	**any drinking**	**# drinks**	**smoked while drinking**	**% time smoked while drinking**	**# cigarettes smoked while drinking**
Daily smoker	4.10**	2.26**	0.25	−0.23	−0.74**	−0.47**	0.26
High-intensity smoker	0.62**	0.25**	0.04*	0.03*	−0.05*	−0.05**	0.06**
Frequent smoker	6.64**	4.08**	0.73**	0.36**	−1.26**	−0.75*	0.71**

Note.

* $p < .05$;

** $p < .01$.

Table 4

Mixed model parameter estimates (γ) for the interaction between person-level smoking status and smoking in the prediction of drinking (top panel) and between person-level smoking status and drinking in the prediction of smoking (bottom panel), controlling for sex and weekday/weekend.

	Operationalization of Smoking Status					
	Daily Smoker		**High-intensity Smoker**		**Frequent Smoker**	
Smoking predictor	Any drinking	Number drinks	Any drinking	Number drinks	Any drinking	Number drinks
Any smoking	−0.54	0.36	0.05	0.22**	−0.34	1.37**
Number cigarettes	−0.19**	−0.07*	−0.02**	−0.01**	−0.28*	−0.14*
Drinking predictor	Any smoking	Number cigarettes	Any smoking	Number cigarettes	Any smoking	Number cigarettes
Any drinking	−0.60*	−1.22**	0.09	−0.12**	−0.88*	−1.93**
Number of drinks	0.01	−0.10**	0.02	−0.01**	−0.04	−0.16**

Note.

* $p < .05$,

** $p < .01$.