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Positive smoking outcome expectancies mediate the relation between alcohol consumption and smoking urge among women during a quit attempt

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Abstract

Social learning models of addiction hypothesize that situational factors interact with cognitive determinants to influence a person's motivation to use substances. Ecological momentary assessment was used to examine the association between alcohol consumption, smoking outcome expectancies, and smoking urge during the first 7 days of a smoking quit attempt. Participants were 113 female smokers who enrolled in a study that tested an individually tailored smoking cessation treatment. Participants carried a palm-top personal computer for 7 days and were instructed to complete 4 random assessments each day and to initiate an assessment when they were tempted to smoke. Multilevel mediational analyses were used to examine: 1) the effects of alcohol consumption before time j and positive smoking outcome expectancies at time j on smoking urge at time $j + 1$ (Model 1); and, 2) the effects of alcohol consumption and smoking urge at time j on positive smoking outcome expectancies at time $j + 1$ (Model 2). Model 1 found a significant effect of alcohol consumption before time j on smoking urge at time $j + 1$ ($p = .04$), and this effect was significantly mediated by positive smoking outcome expectancies at time j ($p < .0001$). Model 2 failed to find a significant effect of alcohol consumption before time j on positive smoking outcome expectancies at time $j + 1$. The findings suggest that alcohol consumption is

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significantly associated with increased positive smoking outcome expectancies that in turn, are associated with increased smoking urge in women seeking to quit smoking.

Keywords

Smoking urge; positive smoking outcome expectancies; alcohol; ecological momentary assessment; multilevel mediational analysis

Introduction

According to social learning models of addiction (Cox & Klinger, 1988; Maisto, Karey, & Bradizza, 1999; Marlatt, 1985; Niaura, 2000), environmental and situational factors interact with cognitive determinants (e.g., beliefs and expectations) to influence a person's motivation to use substances. Although the bulk of this research has focused on the individual effects of these constructs on drug use, very few studies have examined the relationships among these factors (Maisto et al., 1999). Furthermore, although many substance use behaviors co-occur, relatively little is known about how cognitive factors may mediate the relationship between use of one substance and motivation to use the other. The current study addressed this issue by examining the relationships among alcohol consumption, smoking outcome expectancies, and urge to smoke.

Alcohol consumption is one of the most frequently studied correlates of smoking. In controlled laboratory studies, smokers smoked more (Griffiths, Bigelow, & Liebson, 1976; McKee, Krishnan-Sarin, Shi, Mase, & O'Malley, 2006; Mitchell, de Wit, & Zacny, 1995) and smoked sooner (McKee et al., 2006) after drinking alcohol than after consuming placebo. In clinical trials and field studies, smokers were more likely to smoke when they had consumed alcohol than when they had not (Delfino, Jamner, & Whalen, 2001; Shapiro, Jamner, Davydov, & James, 2002; Shiffman et al., 2002; Shiffman & Paty, 2006).

Moreover, alcohol consumption augments the intensity of smoking urges, a construct that is often considered to be an index of smoking motivation (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004), and in the case of postcessation smoking urge, a predictor of smoking cessation outcome (Wray, Gass, & Tiffany, 2013). Laboratory studies have found that, relative to placebo, alcohol consumption significantly increased the intensity of smoking urges in moderate to heavy drinkers (Burton & Tiffany, 1997; King, McNamara, Conrad, & Cao, 2009) as well as in chippers (Epstein, Sher, Young, & King, 2007; Sayette, Martin, Wertz, Perrott, & Peters, 2005), light smokers (King & Epstein, 2005), heavy smokers (Sayette et al., 2005), and abstaining smokers (Kirchner & Sayette, 2007). Furthermore, a positive dose-response relationship was found between alcohol consumption and urge to smoke (King & Epstein, 2005). Outside of the laboratory, alcohol use is associated with more frequent and greater self-reported urges to smoke (Delfino et al., 2001; Piasecki, McCarthy, Fiore, & Baker, 2008; Piasecki et al., 2011). This effect of alcohol on smoking urge is independent of smoking status and applies to both abstaining smokers (Epstein, Sher, Young, & King, 2007; King & Epstein, 2005; Kirchner & Sayette, 2007; Sayette et al., 2005) and nonabstaining smokers (Burton & Tiffany, 1997; Delfino et al., 2001; Piasecki et al., 2008). In short, alcohol consumption is a robust situational factor that influences smokers' self-reported smoking urge and cigarette intake. However, there are few studies that have examined the mechanisms that may mediate these relations.

Outcome expectancies refer to a person's beliefs about the probabilities that a behavior will result in specific outcomes or consequences (Maisto et al., 1999). In tobacco research, positive smoking outcome expectancies (e.g., beliefs that smoking will alleviate negative affect or enhance enjoyment of a meal) are associated with tobacco dependence (Copeland, Brandon, & Quinn, 1995; Wetter et al., 1994). In addition, several studies have found that positive smoking outcome expectancies predict nicotine withdrawal severity, negative affect and perceived stress during a quit attempt, smoking lapse, and relapse (Copeland et al., 1995; Gwaltney, Shiffman, Balabanis, & Paty, 2005; Wetter et al., 1994). Using ecological momentary assessment (EMA), Gwaltney and colleagues (2005) found that positive smoking outcome expectancies recorded the day prior to smoking lapse were significantly higher than those recorded on all other preceding days. Among ex-smokers, stronger positive smoking outcome expectancies also predict a higher likelihood of smoking relapse (Dijkstra & Borland, 2003).

Alcohol consumption has been found to enhance smokers' subjective evaluation of the reinforcing properties of cigarettes and to increase smokers' positive expectancies of smoking. Using EMA, Piasecki and colleagues (2008; 2011) found that smokers rated cigarettes as better tasting and as producing a larger rush when they had consumed alcohol than when they had not. In a laboratory experiment, Kirchner and Sayette (2007) found that among nicotine-deprived smokers, those who drank alcohol were significantly more likely to report positive outcome expectancies of smoking than were those who received placebo. The effect of alcohol consumption on positive smoking outcome expectancies has been observed for both abstaining (Piasecki et al., 2008) and nonabstaining smokers (Kirchner & Sayette, 2007).

Previous studies have indicated that women may have greater difficulty quitting smoking than men (e.g., Scharf & Shiffman, 2004; Wetter et al., 1999), and therefore, may benefit from different interventions than men. Data for the current study were collected as part of a clinical trial designed to examine the effectiveness of an individually tailored palm-top computer-based relapse prevention program for female smokers (Wetter et al., 2011). EMA data from this trial examined the associations among alcohol consumption, positive smoking outcome expectancies, and smoking urge among women during a smoking cessation attempt. EMA enhances a study's ecological validity by measuring behaviors and other experiences as they happen in the real world. Furthermore, EMA reduces recall error and bias compared with retrospective measures (Shiffman et al., 1997; Stone et al., 1998; Stone & Shiffman, 1994), improves compliance, and has the ability to rule out faked compliance (e.g., "back-filling" several assessments at the same time) (Stone & Shiffman, 2002).

Although there is evidence that smoking outcome expectancies are correlated with smoking urge (Zinser, Baker, Sherman, & Cannon, 1992), few studies have examined the role that outcome expectancies play in influencing the relation between situational factors and indices of drug motivation such as urge (Brandon, Juliano, & Copeland, 1999). The current study addressed these issues by testing two models that explored the relations among alcohol consumption, smoking outcome expectancies, and smoking urge. In line with Marlatt's theory of relapse (Marlatt, 1985; Witkiewitz & Marlatt, 2004), stronger positive smoking outcome expectancies were hypothesized to increase smoking urges and to mediate the association between alcohol consumption and smoking urge. Therefore, the first model examined hypotheses that 1) moment-to-moment alcohol consumption would be associated with moment-to-moment increases in positive smoking outcomes expectancies and smoking urge, and the moment-to-moment effect of alcohol consumption on moment-to-moment urge to smoke would be mediated by moment-to-moment positive smoking outcome expectancies; and, 2) overall number of alcohol consumption episodes would be associated with overall increase in positive smoking outcomes expectancies and smoking urge, and the effect of overall number of alcohol consumption episodes on overall urge to smoke would be mediated by overall positive smoking outcomes expectancies.

Other researchers have proposed a different direction of effect to describe the relationship between positive smoking outcome expectancies and smoking urge. For instance, Kirchner and Sayette (2007) found evidence that smoking urge mediated the relationship between alcohol consumption and one aspect of positive smoking outcome expectancies (i.e., smokers' response on the positive reinforcement, but not negative reinforcement, subscale of the Smoking Consequences Questionnaire). Therefore, to better understand the manner in which positive smoking outcome expectancies are associated with alcohol consumption and smoking urge, a second set of hypotheses was tested. Specifically, the second model examined hypotheses that 1) moment-to-moment alcohol consumption would be associated with moment-to-moment increases in smoking urge and positive smoking outcomes expectancies, and the moment-to-moment effect of alcohol consumption on moment-to-moment positive smoking outcome expectancies would be mediated by moment-to-moment urge to smoke; and, 2) overall number of alcohol consumption episodes would be associated with overall increase in smoking urge and positive smoking outcomes expectancies, and the effect of overall number of alcohol consumption episodes on overall positive smoking outcome expectancies would be mediated by overall urge to smoke.

As discussed by Chandra and colleagues (2011), the examination of variables collected simultaneously may confound cause and effect, making it difficult to discern the direction of an association. To better examine the temporal relationship among the three factors, alcohol consumption and positive smoking outcome expectancies recorded at one assessment were used to predict smoking urge reported at the immediate subsequent assessment in the first model. In the second model, alcohol consumption and smoking urge recorded at one assessment were used to predict smoking outcome expectancies recorded at the immediate subsequent assessment.

Method

Participants

Between 1999 and 2002, potential participants in the Seattle metropolitan area responded to print, radio, and television advertisements soliciting female smokers interested in quitting smoking. A total of 302 participants enrolled in the parent study, which tested a novel, individually tailored smoking cessation treatment. Further details of the design, participant flow, and treatment results are available in Wetter et al. (2011). Of the 302 participants, only those who reported consuming alcohol in the week following their quit date ($n = 133$) were included in the current study. Eligibility criteria for the study included being female between 18 and 70 years of age, smoking at least 10 cigarettes per day, and the ability to read, speak, and write in English. Women were excluded if they reported pregnancy or lactation, use of bupropion, nicotine patch contraindications, use of tobacco products other than cigarettes, or current psychiatric disorders (i.e., substance use disorder, anxiety disorder, major depression, and eating disorder) assessed using a brief version of the Primary Care Evaluation of Mental Disorders (PRIME-MD, Spitzer, Kroenke, & Williams, 1999).

Procedure

Women responding to the advertisements were screened over the phone, and those eligible to participate were scheduled for an in-person orientation. During the orientation, study procedures were described, informed consent was obtained, baseline questionnaires were administered, and participants set a quit date. Participants returned to the clinic the day before their scheduled quit date (generally within 7 days of their orientation visit) to receive a palm-top personal computer (PPC; Casio model E-10). They were given instructions on how to complete EMAs using the PPC, practiced EMA assessments, and were asked to carry the device with them at all times for 7 consecutive days starting on the participant's quit day. The PPC automatically and randomly cued four assessments each day. Random assessments were prompted via an alarm-style beeping tone delivered three times for 30 seconds with 30-second intervals of silence following each alarm. The prompts were delivered for 2.5 minutes or until the participant responded. If participants could not immediately complete an assessment, they could delay assessments for 5 minutes up to 4 times. Assessments with no response were recorded as missing. Participants also self-initiated assessments when they were tempted to smoke or had just smoked. Each EMA took 2–4 minutes to complete, and participants were compensated based on the percentage of PPC-cued random assessments that they completed during the 7-day assessment period. Specifically, those who completed 50%–69%, 70%–89%, or ≥90% of the random assessments received a gift certificate for $10, $25, or $50, respectively. Additional information on the EMA procedures is described in Cofta-Woerpel et al (2011).

All participants received standard smoking cessation treatment that was consistent with the recommendations set forth in the *Smoking Cessation Clinical Practice Guideline* (Fiore, Bailey, & Cohen, 1996). Treatment included 5 group counseling sessions and 6 weeks of the 21-mg nicotine patch (Nicoderm CQ; GlaxoSmithKline). The first group therapy session was conducted 3 days before the participant's scheduled quit date and the final group session was held 1 week after the quit date. Thus, group therapy and EMA procedures overlapped. Following completion of the group counseling and EMA procedures on Day 7, participants were randomized to either computer-delivered treatment (n=151) or standard treatment (n=151). Participants assigned to the computer-delivered treatment group then utilized the PPC to receive an individualized relapse prevention intervention for one additional month (from Day 7 until Day 35 postcessation).

The following information was collected during the phone screen, orientation sessions, and post-cessation clinic visits.

Sociodemographic information—Participants self-reported their age, ethnicity/race, education, and marital status prior to quitting. History of psychiatric disorders was assessed using a brief version of the PRIME-MD.

Smoking characteristics—Prior to quitting, participants reported their current smoking rate, years smoking, previous quit attempts, and completed the Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerström, 1991).

Smoking abstinence—Smoking abstinence was assessed at each post-cessation clinic visit (i.e., days 3, 5, and 7) via self-report and biochemical confirmation (i.e., carbon monoxide levels < 10 ppm were considered consistent with abstinence). In addition, the first PPC-cued assessment of each day included a question about any smoking during the previous day. On the post-cessation clinic visit at Day 7, participants were considered to have lapsed if they reported smoking in the last 7 days or if their carbon monoxide level was ≥10 ppm at any of these visits.

Ecological momentary assessments—The following items were included in each PPC-based assessment (random and temptation). All EMAs were date and time stamped.

Alcohol consumption: Participants responded "yes" or "no" to the item, "I am currently or have recently been drinking alcohol."

Positive smoking outcome expectancies: Participants responded to the question, "Would smoking right now improve your mood, be pleasurable, or help you cope with this situation?" Possible responses were 1 (definitely NO), 2 (mostly no), 3 (mostly yes), 4 (definitely YES).

Urge to smoke: Participants responded to the question, "How strong is your urge to smoke?" on a five-point scale that ranged from 1 (no urge) to 5 (severe urge).

Although both smoking urge and smoking lapse were assessed using EMA, lapses were reported so infrequently (recorded in <5% of all EMAs) that smoking urge, not smoking lapse, was used as the lagged outcome in this paper.

Statistical Analysis

The longitudinal EMA data were nested within a complex structure (i.e., assessment ratings nested within participants). Taking into account the dependent nature of nested EMA data (Raudenbush & Bryk, 2002), the PROC MIXED procedure in SAS (Littell, Milliken, Stroup, Wolfinger, & Schabenberfer, 2006) was used to conduct linear multilevel modeling (LMM) mediational analyses. There are generally two types of multilevel mediational models–those that involve upper level mediators and/or predictors (e.g., race, treatment group) and those that do not (Kenny, Korchmaros, & Bolger, 2003; Krull & MacKinnon, 2001). In the current study all constructs of interest were level-one variables (i.e., they varied from one participant observation to the next). Thus, two lower-level mediation analyses (Kenny et al., 2003) were conducted.

Procedures outlined by Krull and MacKinnon (1999; 2001) were used to examine the relationships among the predictor (X) measured at time j, mediator (M) at time j, and outcome (Y) at time $j + 1$. This approach allows estimation of the total effect of X on Y (designated by the parameter coefficient c), the effect of X on M (coefficient a), the effect of M on Y (coefficient b), and the direct effect of X on Y (coefficient c') after M is added to the model. Because participants were not required to initiate an assessment in response to drinking, drinking assessments involve alcohol consumption that occurred before the assessment, that is, before time j. Thus, this model has several lagged predictions: the effect of drinking before time j on the mediator at time j, and the effect of drinking before time j and the mediator at time j on the outcome at time $j + 1$. Predictors were group-mean centered to disentangle the within-person effects (i.e., moment-to-moment variation within individuals over time) and the between-person effects (i.e., average differences between individuals)(See Raudenbush & Bryk, 2002 for discussion). The Sobel test (Sobel, 1982; Sobel, 1986) and the confidence interval calculated using the distribution of the product confidence limits for the indirect effect (PRODCLIN) method (MacKinnon, Fritz, Williams, & Lockwood, 2007) were used to test for significance of the mediation effect.

Results

Participant Characteristics

Of the 133 smokers who reported consuming alcohol in the week following their quit date, 20 did not complete any EMAs that followed self-reported alcohol consumption (i.e., these participants had no lagged outcome) and were excluded from the analyses. The average age of the remaining 113 participants was 40.99 years (SD = 10.38), most were Caucasian (82%), had at least some college education (86%), and were married or living with a partner (39%). About a fourth of the participants reported a history of depression. The typical smoking rate, reported at the orientation visit, was 20.50 cigarettes a day on average (SD = 7.60), and the mean Fagerström Test for Nicotine Dependence score was 5.01 (SD = 1.95). A total of 31 participants (27%) reported that they had lapsed during the 7-day assessment period.

Assessment Completion

Participants completed 4,743 random and temptation assessments during the 7-day EMA monitoring period. The vast majority of participants (91%) completed assessments on each day of the 7 day EMA monitoring period, 8% of participants completed assessments on 6 out of 7 days, and 1 participant completed assessments on 5 out of 7 days. More completed assessments were initiated by participants (n = 2,499; 53%) in response to smoking urges (i.e., temptation assessments) than were randomly initiated by the computer (n = 2,244; 47%). An average of 19.85 (SD = 4.53) random assessments and 22.12 (SD = 11.58) temptation assessments per person were completed during the 7-day assessment period (2.88 [SD = 1.11] and 3.20 [SD = 2.48] per day, respectively). The mean time between any two consecutive assessments was 141.65 minutes (SD = 111.73). The overall compliance rate for random assessments was 79.7%, which is comparable to the 80% or higher compliance rates reported in a review of EMA studies (Hufford & Shields, 2002). About 32% of the participants completed <75% of their scheduled random assessments (range: 27% 100%). No significant association was found between the number of completed random assessments and the number of completed temptation assessments, suggesting that participants who were less compliant with respect to the random assessments did not differ from more compliant smokers in initiating and completing temptation assessments.

Participants indicated that they consumed alcohol on 243 (31%) of the 780 days of monitoring. Participants completed more assessments on days when alcohol was consumed than on days when alcohol was not consumed (mean = 6.93 versus 5.70; $t = 5.85$, $p < .0001$). More specifically, participants initiated significantly more temptation assessments on drinking days than on non-drinking days (mean = 3.86 versus 2.91; $t = 5.04$, $p < .0001$) and completed significantly more random assessments on drinking days than on non-drinking days (mean = 3.07 versus 2.80; $t = 3.27$, $p < .001$). Assessments in which participants reported recent alcohol use (drinking assessments) were generally completed later in the day than assessments in which alcohol was not recently consumed (non-drinking assessments) ($t = 11.62$, $p < .0001$). The overall mean of smoking urge was 1.57 (SD = 1.27, median = 2, range: 0–4), and the distribution was positively skewed (skewness = 0.29).

Out of the 4,743 completed assessments, 789 were the last assessment of the day with no lagged outcome. Variables measured at these assessments (e.g., smoking urge, positive smoking outcome expectancies) were not included as time j predictors in the analyses, but could be included as time $j + 1$ outcomes in the analyses. Since the current paper is interested in assessing the effect of alcohol consumption on outcomes measured at both time j and time j +1, we felt that including non-drinking assessments at time j followed by drinking assessments at time $j + 1$ confounds those analyses. Thus, variables measured at 232 non-drinking assessments that were followed by a drinking assessment were also excluded from serving as time j predictors in the analyses. Of the 3722 assessments in which variables were included as time j predictors in the analyses, 3452 (92.75%) were non-drinking assessments that were followed by a non-drinking assessment, 126 (3.39%) were drinking assessments that were followed by a non-drinking assessment, and 144 (3.86%) were drinking assessments that were followed by a drinking assessment.

LMM Mediational Analyses Results

Model 1—LMM mediational analysis was used to examine the moment-to-moment relation between alcohol consumption and smoking urge (i.e., within-person effect), and whether this relation was mediated by moment-to-moment changes in positive smoking outcome expectancies. We also examined the relation between the 7-day overall number of alcohol consumption episodes and smoking urge (i.e., between-person effect), and whether this relation was mediated by a 7-day overall mean of positive smoking outcome expectancies. We first estimated the total effect of alcohol consumption on smoking urge. The moment-to-moment effect of alcohol consumption before time j on smoking urge at time $j + 1$was statistically significant ($t = 2.03$, $p = .04$)(Figure 1), whereas the effect of 7-day overall number of alcohol consumption episodes on smoking urge was not ($t = -1.09$, $p = .28$). We then estimated the effect of alcohol consumption on positive smoking outcome expectancies. Again, the moment-to-moment effect of alcohol consumption before time *j* on positive outcome expectancies at time *j* was significant ($t = 6.71$, $p < .0001$) but the effect of 7-day overall number of alcohol consumption episodes on positive outcome expectancies was not ($t = -0.87$, $p = .39$). Next, we estimated the effect of positive smoking outcome expectancies on smoking urge. Both the moment-to-moment effect of positive outcome expectances at time *j* on smoking urge at time $j + 1$ ($t = 7.46$, $p < .0001$) and the 7-day overall effect ($t = 14.85$, $p < .0001$) of positive outcome expectancies on smoking urge were significant. Finally, we estimated the direct effect of alcohol consumption on smoking urge after positive smoking outcome expectancies was added to the model. The moment-to-moment ($t = 1.35$, $p = .18$) and 7-day overall ($t = -.59$, $p = .55$) direct effects were both nonsignificant. Table 1 showed both moment-to-moment and 7-day overall effects.

To examine the significance of the moment-to-moment mediational relationship, the product of the *a* and *b* coefficients (.341*.162 = .055) and the standard error of the mediated effect ($SE = .011$) were used to estimate the mediated effect of alcohol consumption on smoking urge. The PRODCLIN method (MacKinnon et al., 2007), which uses the distribution of the product coefficient $a*b$ to compute product-specific critical values, was used to construct the confidence interval for the mediated effect, *95% CI*: .035 – .078. The mediated effect was significant by both the Sobel test ($z = 4.99$, $p < .0001$) and the PRODCLIN method, which showed that 0 was not included in the confidence interval. When we compared the indirect and the total effects (MacKinnon, 2008), the proportion mediated effect was .055/.134 = 0.41. That is, 41% of the total effect was explained by the indirect effects.

The significant moment-to-moment mediation effect was unchanged when separate follow-up analyses were conducted that included 1) only temptation assessments ($a*b = .034$, $z = 2.65$, $p < .001$), 2) only random assessments ($a*b = .12$, $z = 5.19$, $p < .0001$), 3) only the 31 participants who lapsed ($a*b = .040$, $z = 3.05$, $p < .01$), and 4) only the 82 participants who did not lapse during the 7-day EMA assessment period ($a*b = .043$, $z = 3.69$, $p < .001$).

In order to better discern the moment-to-moment relations among alcohol consumption before time *j* , positive smoking outcome expectancies at time *j*, and smoking urge at time $j + 1$, we repeated all the analyses with smoking urge at time *j* added as a covariate. Table 1 shows that, with smoking urge at time *j* added to the model, we did not find a significant moment-to-moment total effect of alcohol consumption before time *j* on smoking urge at time $j + 1$ ($t = 0.97$, $p = .33$). Although no significant association between the predictor and outcome was found, Hayes (2009) and others have argued that the predictor can still exert indirect effects on outcome through the mediator (See Hayes, 2009; MacKinnon, 2008; Mathieu & Taylor, 2006 for discussion). After controlling for smoking urge at time *j*, we found a significant moment-to-moment effect of alcohol consumption before time *j* on positive outcome expectancies at time *j* ($t = 2.52$, $p = .01$), a significant moment-to-moment effect of positive smoking outcome expectancies at time *j* on smoking urge at time $j + 1$ ($t = 2.85$, $p < .01$), and a nonsignificant moment-to-moment direct effect of alcohol consumption before time *j* on smoking urge at time $j + 1$ ($t = 0.86$, $p = .39$). The indirect effect, calculated using the product of the *a* and *b* coefficients (.508*.083 = .042), approached significance after controlling for smoking urge at time *j* ($z = 1.89$, $p = .059$).

Model 2—In the second model, the within-person effect examined the moment-to-moment relation between alcohol consumption and positive smoking outcome expectancies, and whether the relation was mediated by smoking urge. The between-person effect examined the relation between the 7-day overall number of alcohol consumption episodes and positive smoking outcome expectancies, and whether or not the relation was mediated by a 7-day overall mean of smoking urge. When positive smoking outcome expectancies was regressed on alcohol consumption, both the moment-to-moment effect of alcohol consumption before time j on positive smoking outcome expectancies at time $j + 1$ ($t = 1.29$, $p = .20$) and the effect of 7-day overall number of alcohol consumption episodes on positive smoking outcome expectancies ($t = -.64$, $p = .52$) were not significant. To examine the indirect effects, we estimated the effects of alcohol consumption on smoking urge as well as the effects of smoking urge on positive smoking outcome expectancies. A significant moment-to-moment effect of alcohol consumption before time j on smoking urge at time j ($t = 7.73$, $p < .0001$) and a nonsignificant 7-day overall number of alcohol consumption episodes effect on smoking urge ($t = -1.41$, $p = .16$) were found. Regressing positive smoking outcome expectancies on smoking urge, a significant moment-to-moment effect of smoking urge at time j on positive smoking outcome expectancies at time $j + 1$ ($t = 6.53$, $p < .0001$) and a significant 7-day overall effect smoking urge on positive smoking outcome expectancies ($t = 14.68$, $p < .0001$) were found. The indirect moment-to-moment effect, calculated using the product of the a and b coefficients (.508*.083 = .042) and the standard error of the indirect effect (SE = .008), was significant by the Sobel test ($z = 4.98$, $p < .0001$). The PRODCLIN method (MacKinnon et al., 2007) was used to estimate the confidence interval for the indirect effect, *95% CI*: .027 – .060, and found that the indirect effect to be significantly different from 0. Limiting the analyses to temptation assessments only ($a*b = .035$, $z = 3.13$, $p < .0001$), random assessments only ($a*b = .094$, $z = 5.32$, $p < .0001$), the 31 participants who lapsed ($a*b = .041$, $z = 2.54$, $p = .01$), or the 82 non-lapsers ($a*b = .043$, $z = 4.32$, $p < .0001$) did not affect the results.

We repeated all moment-to-moment analyses with positive smoking outcome expectancies at time j added as a covariate. After controlling for positive outcome expectancies at time j, we found a nonsignificant moment-to-moment effect of alcohol consumption before time j on positive outcome expectancies at time $j + 1$ ($t = 0.38$, $p = .70$), a significant moment-to-moment effect of alcohol consumption before time j on smoking urge at time j ($t = 4.63$, $p < .0001$), and a nonsignificant moment-to-moment effect smoking urge of at time j on positive smoking outcome expectancies at time $j + 1$ ($t = 2.60$, $p = .11$). The indirect effect was not significant after controlling for smoking urge at time j ($z = 1.52$, $p = .13$).

Discussion

During the first 7 days of a smoking quit attempt, female smokers, regardless of their abstinence status, reported significantly higher smoking urges after they had ingested alcohol than when they had not. A substantial proportion of the association between alcohol use and urge was explained by a mediational path through positive smoking outcome expectancies. That is, alcohol consumption was significantly associated with increased positive smoking outcome expectancies that in turn, were associated with increased smoking urge. The results did not support a significant overall number of alcohol consumption episodes effect on either positive smoking outcome expectancies or smoking urge. In other words, comparing across smokers and aggregating over all assessments within each individual, there was no evidence that smokers who reported more drinking incidents during the 7-day post-cessation period reported higher overall positive smoking outcome expectancies or stronger overall smoking urges than those who reported fewer drinking incidents. However, the results did show a significant overall effect of positive smoking outcome expectancies on smoking urges. Smokers with higher overall positive smoking outcome expectancies reported stronger overall smoking urges.

The results from Model 1 provide support for theoretically derived predictions from social learning models of addiction (e.g., Maisto et al., 1999; Marlatt, 1985). For instance, consistent with Model 1 results, Marlatt's model of relapse (1985) hypothesized that confronting a high-risk situation (e.g., alcohol consumption) could provoke increased positive smoking outcome expectancies, that in turn, would increase urge to smoke and the likelihood of a lapse.

To the best of our knowledge, the current study is one of the first attempts to disentangle the state (i.e., within-person) and trait (i.e., between-person) effects of alcohol consumption on smoking expectancies and urges. The moment-to-moment results in Model 1 are in line with previous findings demonstrating that smokers reported higher positive smoking outcome expectancies (2007; Piasecki et al., 2008; Piasecki et al., 2011) and stronger smoking urges (Burton & Tiffany, 1997; Delfino et al., 2001; Epstein, Sher, Young, & King, 2007; King & Epstein, 2005; King et al., 2009; Kirchner & Sayette, 2007; Piasecki et al., 2008; Sayette et al., 2005) when they had consumed alcohol than when they had not. No significant "trait" results were found, suggesting that smokers who reported drinking on a higher proportion of assessments were no more likely to report higher overall positive smoking outcome expectancies or stronger overall smoking urges than those who reported drinking on a lower proportion of assessments.

The current study is also among the first to report both state and trait effects of positive smoking outcome expectancies on smoking urges. Based on existing social learning theories of addiction, Brandon and colleagues (1999) proposed a conceptual model that makes a distinction between generalized (i.e., trait) and situational (i.e., state) smoking outcome expectancies with respect to their influence on smoking motivation. While generalized smoking outcome expectancies are thought to be stable and are developed through vicarious learning and personal experience with smoking, situational smoking outcome expectancies are assumed to be dynamic and are modified by smoking-related situations. Although previous studies have found evidence that generalized smoking outcome expectancies change gradually over time (Chassin, Presson, Sherman, & Edwards, 1991; Copeland et al., 1995), few studies have been conducted to study active changes in situational smoking outcome expectancies.

The findings from Model 1 provide support for Brandon and colleagues' distinction between generalized and situational positive outcome expectancies (Brandon et al., 1999). Comparing across smokers, the current study found that those with higher generalized expectations about the positive effects of smoking had stronger overall smoking urges. Results are in line with previous findings that reported an association between generalized positive outcome expectances and smoking urge among smokers trying to quit smoking (Wetter et al., 1994). Furthermore, comparing across assessments within smokers, the current study found that alcohol consumption led to stronger smoking urges and that a large proportion of this effect of alcohol use on urge was mediated by positive smoking outcome expectancies. These latter findings support Brandon and colleagues' contention that situational factors (e.g., alcohol consumption) have short-term effects on smokers' situational smoking outcome expectancies, and that these situational smoking outcome expectances mediate the association between situational factors and smoking motivation.

A strength underlying these findings was the use of a lagged analysis, where the effects of alcohol consumption before time j and smoking outcome expectancies at time j were used to predict smoking urge at time $j + 1$. However, conclusions are also tempered by the fact that the moment-to-moment effect of alcohol consumption before time j on smoking urge at time $j + 1$ was rendered nonsignificant after smoking urge at time j was added as a covariate to the model. That is, alcohol consumption before time j did not have a significant effect on smoking urge at time $j + 1$ above and beyond the effect of smoking urge at time j, possibly because alcohol consumption is likely to have a larger influence on smoking urge measured closer in time (i.e., time j) than one measured farther away in time (i.e., time $j + 1$) and a high autocorrelation was likely to exist between urges measured at time j and at time $j + 1$. However, even after smoking urge at time j was included in the model, the indirect effect between among alcohol consumption and smoking urge via positive outcome expectancies approached significance.

Kirchner and Sayette (2007) proposed a different direction of association in which the effect of alcohol consumption on smoking outcome expectancies is mediated by smoking urge. However, the current study failed to find a significant effect of alcohol consumption before time j and positive outcome expectancies at time j +1. Although there was a significant indirect effect between alcohol consumption before time j and positive outcome expectancies at time j +1 through smoking urge at time j., the indirect effect became nonsigificant once positive outcome expectancies at time j was added to the model. As such, there appeared to be less support for Model 2 than Model 1.

The average time interval between any two consecutive assessments was 141.65 minutes (SD = 111.73). Taking the findings from Models 1 and 2 together, the current study found that alcohol consumption (before time j) increased smoking urge both at time j (on average within 2.5 hours of alcohol consumption) and at time $j + 1$. Whereas findings from Model 1 showed that alcohol consumption had a short temporal effect on positive smoking outcome expectances, findings from Model 2 failed to support that alcohol consumption influenced positive smoking outcome expectances measured at a later time. The findings suggest that the direct effect of alcohol consumption on urge may be more durable than is the direct effect of alcohol consumption on smoking outcome expectancies.

Model 1 also showed significant moment-to-moment associations between positive smoking outcome expectancies measured at one time and smoking urge measured at another time, as well as a significant association between generalized positive smoking outcome expectancies and overall smoking urge. These findings are important because they support a major component of Witkiewitz and Marlatt's (2004) new dynamic model of relapse, which hypothesized a reciprocal causation among cognitive processes that included outcome expectancies and urge. Previous studies have shown that positive expectancies and urge are positively correlated (Palfai, Davidson, & Swift, 1999; Zinser et al., 1992). The current findings suggest that once activated by a situational factor, positive smoking outcome expectancies and smoking urge could influence one another in a feedback loop.

These findings have implications for understanding how alcohol use increases the risk for relapse. Specifically, alcohol use may contribute to a brief increase in positive smoking outcome expectancies and a more sustained increase in urge to smoke, both of which have been shown to predict relapse.

The current study has several limitations. First, smoking lapse was reported infrequently such that smoking urge, not smoking lapse, was used as the lagged outcome. Participants in the current study received frequent smoking cessation counseling (3 sessions) during the first postcessation week, which might contribute to the low rate of lapse reported during that week. Although smoking urge is correlated with smoking (Killen & Fortmann, 1997), the relationship may be stronger in situations where smokers are not trying to quit (abstinence-avoidance) than when smokers are trying to quit (abstinence-promotion) (Tiffany, 1990). Therefore, while smoking urge is an important construct, it may not be the ideal proxy for the examination of smoking lapse and relapse. Future studies should extend the current findings by investigating the relationships among alcohol consumption, positive smoking outcome expectancies, and smoking lapse in larger samples. The second limitation is that since only female smokers seeking cessation treatment were enrolled in this study, our findings may not generalize to men or individuals not trying to quit smoking. Third, although participants received training on using the PPC to complete EMAs, they were no given an extended period (e.g., 24 hours) beyond the initial training to practice EMA use. Nevertheless, participants achieved a compliance rate that is comparable to compliance rates reported in a review of EMA studies (Hufford & Shields, 2002). Fourth, participants completed more random and temptation assessments on drinking days than on nondrinking days. This discrepancy might be partly explained by the presence of a situational precipitant of smoking (i.e., alcohol consumption) triggering more temptations, prompting participants to initiate more temptation assessments and to be more vigilant in completing random assessments. Finally, the current study did not examine whether the relationship between alcohol consumption and smoking variables was due to the alcohol's pharmacological effect or to the social setting in which the alcohol is consumed. The distinction between pharmacological and social effects of alcohol on smoking should be addressed in future research using appropriate methodology (e.g., balanced placebo design).

Using EMA, the current study found that among female smokers trying to quit, alcohol consumption increased the intensity of smoking urges reported at a subsequent assessment. Positive expectations of smoking reported near the time of drinking mediated this relationship. Smokers who were heavier drinkers did not differ from those who were lighter drinkers in overall smoking outcome expectancies and smoking urges. Few studies have examined both the state and trait effects of alcohol consumption on smoking urges.

Furthermore, the current study is among the first to consider the effects of generalized and situational positive smoking outcome expectancies on smoking urge, and is among the first to report a positive feedback relation between positive smoking outcome expectancies and smoking urge. The findings of the current study add to our understanding of social learning theories of addiction. To better understand the phenomena reported here, future research should extend the current examination to include men and use smoking lapse and relapse as outcomes, in addition to smoking urge.

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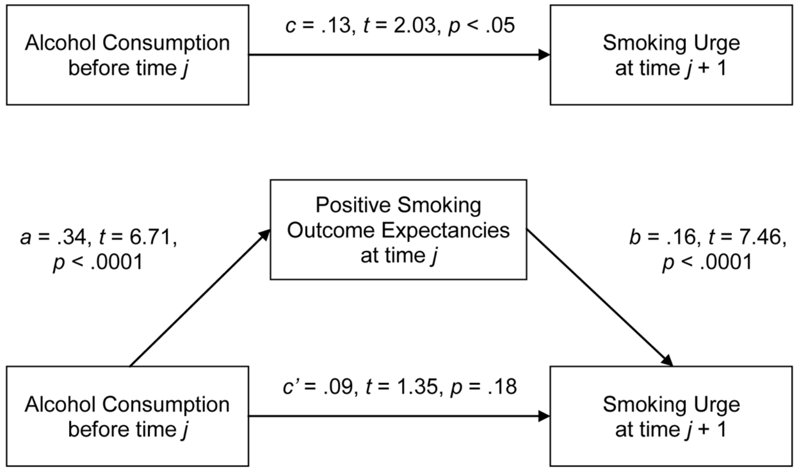

Figure 1.

Moment-to-moment total effect of alcohol consumption on smoking urge (*c*), moment-to-moment effects alcohol consumption and positive smoking outcome expectancies (*a*), moment-to-moment effect of positive smoking outcome expectancies on smoking urge (*b*), and moment-to-moment direct effect of alcohol consumption on smoking urge (*c*´).

Table 1

Linear multilevel mediational model regressing smoking urge at time $j + 1$ (Y) on alcohol consumption before time j (X) and positive smoking outcome expectancies at time j (M)

				Added smoking urge at time *j* as covariate		
Effect	**Estimate (*SE*)**	***df***	***t*-value**	**Estimate (*SE*)**	***df***	***t*-value**
Regressing Y on X (c)						
Intercept	1.59 (0.12)	111	13.72**	1.32 (.10)	111	13.28**
Smoking urge @ time *j*	-	-	-	0.18 (.02)	3607	10.95**
Alcohol consumption (Moment-to-moment)	0.13 (0.07)	3608	2.03*	0.06 (.007)	3607	0.97
Alcohol consumption (Overall)	−1.33 (1.22)	111	−1.09	−1.04 (1.01)	111	−1.03
Regressing M on X (a)						
Intercept	1.12 (0.10)	111	10.99**	0.38 (0.07)	111	5.68**
Smoking urge @ time *j*	-	-	-	0.47 (0.01)	3606	46.97**
Alcohol consumption (Moment-to-moment)	0.34 (0.05)	3607	6.71**	0.10 (0.04)	3606	2.52*
Alcohol consumption (Overall)	−0.93 (1.07)	111	−0.87	−0.14 (0.68)	111	−0.20
Regressing Y on M (b) and X (c')						
Intercept	0.54 (0.10)	110	5.52**	0.47 (0.09)	110	5.48**
Smoking urge @ time *j*	-	-	-	0.14 (0.02)	3604	6.99**
Alcohol consumption (Moment-to-moment)	0.09 (0.07)	3605	1.35	0.06 (0.07)	3604	0.86
Alcohol consumption (Overall)	−0.42 (0.72)	110	−0.59	−0.32 (0.63)	110	−0.51
Positive smoking outcome expectancies (Moment-to-moment)	0.16 (0.02)	3605	7.46**	0.08 (0.03)	3604	2.85*
Positive smoking outcome expectancies (Overall)	0.92 (0.06)	110	14.85**	0.79 (0.06)	110	13.83**

* $p < .01$

** $p < .0001$