ORIGINAL INVESTIGATION

Individual and Combined Effects of Multiple High-Risk Triggers on Postcessation Smoking Urge and Lapse

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ABSTRACT

Introduction: Negative affect, alcohol consumption, and presence of others smoking have consistently been implicated as risk factors for smoking lapse and relapse. What is not known, however, is how these factors work together to affect smoking outcomes. This paper uses ecological momentary assessment (EMA) collected during the first 7 days of a smoking cessation attempt to test the individual and combined effects of high-risk triggers on smoking urge and lapse.

Methods: Participants were 300 female smokers who enrolled in a study that tested an individually tailored smoking cessation treatment. Participants completed EMA, which recorded negative affect, alcohol consumption, presence of others smoking, smoking urge, and smoking lapse for 7 days starting on their quit date.

Results: Alcohol consumption, presence of others smoking, and negative affect were, independently and in combination, associated with increase in smoking urge and lapse. The results also found that the relationship between presence of others smoking and lapse and the relationship between negative affect and lapse were moderated by smoking urge.

Conclusions: The current study found significant individual effects of alcohol consumption, presence of other smoking, and negative affect on smoking urge and lapse. Combining the triggers increased smoking urge and the risk for lapse to varying degrees, and the presence of all 3 triggers resulted in the highest urge and lapse risk.

INTRODUCTION

Smoking is a chronic relapsing disorder. One in five adults living in the United States is a current smoker (CDC, 2005), and every year millions of them try to quit. Unfortunately, almost all unaided quitters (95%) resume regular smoking (Hughes, Keely, & Naud, 2006), and relapse is frequently preceded by isolated incidents of cigarette smoking known as lapses (Kenford et al., 1994). Three specific high-risk triggers—alcohol consumption (Brandon, Tiffany, Obremski, & Baker, 1990; Kahler, Spillane, & Metrik, 2010; Leeman et al., 2008; Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996b; van Zundert, Kuntsche, & Engels, 2012), presence of others smoking (Shiffman, 1982; Shiffman et al., 1996b; Solomon et al., 2007), and negative affect (Kenford et al., 2002; Niaura et al., 2001; Shiffman et al., 1996b)—have consistently been identified as critical postcessation precipitants of lapse/relapse. However, exceedingly few data have addressed how these triggers combine to impact cessation outcomes. For instance, exposure to a single high-risk trigger may be enough to increase lapse/relapse risk above some

“threshold” such that additional triggers do little to further escalate smokers’ odds of lapse/relapse. Or the effects of multiple high-risk triggers may combine to increase risk for lapse/relapse either additively (e.g., the effect of each trigger is added on top of the effects of the other triggers to increase risk) or synergistically (e.g., the effects of multiple triggers act upon each other to increase risk exponentially). For instance, it has been hypothesized that smokers are more reactive to smoking cues like alcohol consumption and presence of others smoking when they are affectively distressed (i.e., experiencing negative affect) than when they are not (see Shiffman & Gwaltney, 2008). That is, negative affect interacts with smoking cues to increase odds of lapse/relapse synergistically. In addition, the effects of these triggers might differ across time and across different combinations. For example, alcohol consumption might cause a greater increase in relapse risk in the presence of others smoking compared to when it is coupled with negative affect. Conversely the presence of others smoking might be so potent that alcohol consumption has only a small effect on boosting relapse risk when others are smoking. Therefore,

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the current study examined the individual and combined effects of alcohol consumption, presence of others smoking, and negative affect on urge and lapse during a smoking cessation attempt.

The association between alcohol consumption and smoking is well documented. Smokers attempting to quit report higher craving for cigarettes (Delfino, Jamner, & Whalen, 2001; Piasecki, McCarthy, Fiore, & Baker, 2008; Piasecki et al., 2011) and are significantly more likely to lapse after they consume alcohol (Brandon et al., 1990; Kahler et al., 2010; Leeman et al., 2008; Shiffman et al., 1996b; van Zundert et al., 2012). Furthermore, smokers who drink more after they quit smoking are significantly less likely than those who drink less to maintain long-term smoking abstinence (Hyland et al., 2004; McClure, Wetter, deMoor, Cinciripini, & Gritz, 2002).

The presence of others smoking exposes smokers to smoking-related cues, which has been shown to increase craving (Carter & Tiffany, 1999) and may signal the availability of cigarettes and/or acceptability of smoking. Previous studies that used retrospective reports to identify predictors of smoking lapse revealed that half or more of all lapses occur when smokers are exposed to other people smoking (Shiffman, 1982; Solomon et al., 2007). Similarly, using ecological momentary assessment (EMA), Shiffman et al. (1996b) found that smokers are significantly more likely to lapse in the presence of others smoking as compared to when they are alone.

Researchers have hypothesized that relief of negative affect is a key motive for smoking (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004) and negative affect has been found to significantly predict cessation failure (Cohen, McCarthy, Brown, & Myers, 2002; Kenford et al., 2002; Niaura et al., 2001). In clinical studies among smokers attempting to quit, real-time assessments of postcessation negative affect have been associated with urge to smoke and lapse (Shiffman et al., 1996b), and negative affect has repeatedly been cited by smokers as a key reason for lapses (Brandon et al., 1990; Shiffman, 1982; Shiffman et al., 1996b). Using EMA, Shiffman and Waters (2004) demonstrated that negative affect increased significantly in the hours before smokers' first lapse. Postcessation negative affect also influenced the progression from lapse to relapse. Smokers whose lapse was set off by negative affect were more likely to progress to a relapse than were those whose lapse was triggered by nonaffective factors (Borland, 1990; Shiffman et al., 1996a).

This current study used EMAs collected during the first 7 days of a smoking cessation attempt to test the individual and combined effects of high-risk triggers on smoking urge and lapse. Once a novel assessment approach, EMA has now become an indispensable tool in health research (Stone & Shiffman, 2002). EMA reduces recall error and bias compared with retrospective measures (Shiffman et al., 1997; Stone & Shiffman, 1994; Stone et al., 1998). Electronically administered EMAs, like those used in the current study, improve compliance and reduce faked compliance (e.g., "back-filling" several assessments at the same time) compared to EMA administered using paper and pencil (Stone & Shiffman, 2002). In addition, because EMA assesses context and behavior in real time and in the natural environment, it is well suited to studying transient phenomena such as high-risk triggers for smoking.

METHODS

Participants

Data for the current study were collected as part of a randomized 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). We recruited 300 female participants who were interested in quitting smoking from the Seattle metropolitan area. 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 assessed using a brief version of the Primary Care Evaluation of Mental Disorders (PRIME-MD, Spitzer, Kroenke, & Williams, 1999). Additional details of the study design, recruitment procedures, participant flow, and treatment results are available in Wetter et al. (2011).

Procedure

Female smokers were screened over the phone, and those who met eligibility criteria were invited to attend 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. In addition to the orientation visit, participants attended two precessation and three postcessation (i.e., 3, 5, and 7 days after quit date) study visits, during which they received smoking cessation treatment that included five group counseling sessions (one per study visit) and 6 weeks of the 21-mg nicotine patch (Nicoderm CQ; GlaxoSmithKline).

Participants received a palm-top personal computer (PPC; Casio model E-10) on their second precessation study visit (1 day before their scheduled quit date). Participants were trained on completing EMAs using the PPC and were asked to carry the device with them at all times for 7 consecutive days starting on their quit date. The PPC automatically and randomly cued four assessments each day. If participants could not immediately complete an assessment, they could delay assessments for 5 min up to 4 times (total of 20 min). Assessments eliciting no response were recorded as missing. Participants were also instructed to self-initiate assessments when they experience an urge, desire, temptation or craving to smoke, or just felt like smoking (i.e., temptation assessments) or had just smoked (i.e., lapse assessments). Each EMA took 2–4 min 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 $\geq 90\%$ 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, McClure, Urbauer, Cinciripini, & Wetter (2011).

Following completion of the group counseling and EMA monitoring on Day 7, participants were randomized to either computer-delivered treatment ($n = 151$) or standard treatment ($n = 149$). Participants assigned to the computer-delivered treatment then utilized the PPC to receive an individualized relapse prevention intervention for four additional weeks (from Day 7

until Day 35 postcessation). Participants returned for follow-up visits at 35 days, 6 months, and 12 months after the quit date.

Sociodemographic and Smoking Characteristics

Participants self-reported their age, race/ethnicity, education, and marital status at the orientation. They also 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 Lapse

Smoking lapse is defined as any incidence of smoking reported by participants using EMA during the first 7 days of quit.

Ecological Momentary Assessments

The following items were included in all EMAs (random, temptation, lapse). All assessments were date and time stamped.

Alcohol Consumption (AC)

Participants responded “yes” or “no” to the item, “I am currently or have recently been drinking alcohol.”

Negative Affect (NA)

Participants responded to the statement, “My mood is negative (e.g., irritable, sad, anxious, tense, stressed, angry, frustrated, etc.)” on a 4-point scale (0—Definitely NO, 1—Mostly no, 2—Mostly yes, 3—Definitely YES).

Presence of Others Smoking (OS)

Participants responded to the statement, “Other people are smoking.” on a 4-point scale (0—Definitely NO, 1—Mostly no, 2—Mostly yes, 3—Definitely YES).

Urge to Smoke

Participants responded to the question, “How strong is your urge to smoke?” on a 5-point scale (0—No Urge, 1—Weak, 2—Moderate, 3—Strong, 4—Severe).

Statistical Analysis

Taking into account the dependent nature of nested EMA data (i.e., assessment ratings nested within participants; [Raudenbush & Bryk, 2002](#)), the PROC MIXED procedures in SAS ([Littell, Milliken, Stroup, Wolfinger, & Schabenberfer, 2006](#)) were used to conduct linear multilevel modeling (LMM) analyses to examine the effects of high-risk triggers on urge to smoke. In addition, we used the PROC GLIMMIX procedures in SAS ([Littell et al., 2006](#)) to conduct generalized linear multilevel modeling (GLMM) analyses to examine the effects of high-risk triggers on smoking lapse. First, to examine the main and interactive effects of AC, NA, and OS, we used a model that regressed smoking lapse on AC, NA, and OS as well as their two-way (AC×OS, AC×NA, OS×NA) and three-way (AC×NA×OS) interaction terms. Because of the relation between smoking urge and smoking ([Killen & Fortmann, 1997](#)), we added smoking urge in the model to examine whether smoking urge moderated the relationship between high-risk triggers and lapse. To examine the specific effect of either an individual trigger or a combination of triggers on EMA outcomes, we used a model that regressed smoking lapse on a single high-risk trigger predictor with eight dummy-coded conditions (i.e., AC alone, NA

alone, OS alone, AC+NA, AC+OS, NA+OS, AC+NA+OS, and no AC+no NA+no OS).

RESULTS

Participant Characteristics

The average age of the participants was 42.78 years ($SD = 10.78$), most were Caucasian (81.67%) with some college education (83.67%). Over one third of the participants were married or living with a partner (39.33%). The average smoking rate was 20.52 cigarettes per day ($SD = 7.75$), and the mean Fagerström Test for Nicotine Dependence score was 5.16 ($SD = 1.94$).

Assessment Completion

Participants completed 12,485 random, temptation, and lapse assessments during the 7-day EMA monitoring period. The vast majority of participants (88%) completed assessments on each day of the 7 day EMA monitoring period, 9% of participants completed assessments on 6 out of 7 days, 8 participants completed assessments on 5 or fewer days. More completed assessments were initiated by participants ($n = 6,754$; 54.10%) than were randomly initiated by the PPC ($n = 5,731$; 45.90%). An average of 22.51 ($SD = 11.78$) self-initiated assessments and 19.10 ($SD = 5.06$) random assessments per person were completed during the 7-day assessment period. Most self-initiated assessments (98%) were temptation assessments. Only 138 of the self-initiated assessments were lapse assessments. The overall compliance rate for random assessments was 78% (range: 12%–100%).

Urge to Smoke

A previous EMA study found that smoking significantly reduced craving for cigarettes ([Carter et al., 2008](#)). Thus, smoking urge recorded at lapse assessments were likely to be influenced by smoking. As such, only temptation and random assessments were included in the urge analyses. LMM analysis was used to estimate the main and interactive effects of AC, NA, and OS on smoking urge. The analysis found that all three main effects on smoking urge were significant (AC: $t = 10.11$, $p < .0001$; NA: $t = 43.74$, $p < .0001$; OS: $t = 12.88$, $p < .0001$). None of the two-way interaction effects were significant, nor was the three-way interaction. Participants reported significantly higher smoking urge during assessments when they encountered high-risk triggers, either alone or in combination, than during assessments when they did not encounter any triggers (see [Figure 1](#) for specific effects). The significant findings remained significant after (a) controlling for nicotine dependence, age, race, and assessment type and (b) excluding 19 participants who reported less than 50% compliance on the random assessments. We repeated all analyses, separating temptation and random assessments, to examine if the significant results were limited to only one type of assessments. The effect sizes obtained from the analysis that was based on all assessments, analysis that was based on temptation assessments only, and analysis that was based on random assessments varied only slightly, and the results remained significant regardless of the type of assessment analyzed.

Smoking Lapse

During the 7-day postcessation EMA monitoring period, 238 participants reported that they had not smoked any cigarettes and 62 participants indicated that they had lapsed in 139 separate occasions. Of the 238 participants who did not report any smoking lapse on EMA, 13 reported, at a study visit, that they had indeed lapsed. Since the lapse incidents for these 13 lapsers were not recorded on EMA, a decision was made to exclude all EMA data of these participants from analysis. Of the 62 participants who lapsed, 43 smoked on 1 day only, 11 smoked on two days, and 10 smoked on 3 or more days. GLMM analysis was used to estimate the main and interactive effects of AC, NA, and OS on smoking lapse. The analysis found significant main effects for AC ($OR = 1.98$, 95% $CI = 1.01$ – 3.89), OS ($OR = 6.79$, 95% $CI = 3.50$ – 13.17), and NA ($OR = 3.28$, 95% $CI = 1.69$ – 6.35) in increasing the risk of lapse (see Figure 2). None of the two-way interaction effects were significant, nor was the three-way interaction. Smoking lapse was also regressed on a single high-risk trigger predictor with eight dummy-coded conditions in a second GLMM analysis, which found an overall significant effect for high-risk trigger on smoking lapse, $F(7, 10101) = 19.09$, $p < .0001$. In general, participants were significantly more likely to lapse during assessments when they encountered high-risk triggers, alone or in combination, than during assessments when they did not encounter any trigger (see Figure 3 for specific effects). For instance, compared to assessments during which

no triggers were present, participants were 47 times (95% $CI = 17.83$ – 127.73) more likely to lapse during assessments when they were exposed to all three triggers. One exception is that no difference in lapse was found between assessments in which participants were exposed to AC alone and those in which participants encountered no trigger at all.

Smoking urge was also positively associated with smoking lapse, $F(1, 10107) = 6.55$, $p = .01$. To examine the relation among smoking urge, high-risk triggers, and smoking lapse, smoking urge, dichotomized into a categorical variable (low vs. high) at its median (median = 2.0), was added to the analysis model with the three high-risk triggers. Significant interaction effects were found between NA and smoking urge, $F(1, 10098) = 6.93$, $p < .01$, and between OS and smoking urge, $F(1, 10098) = 9.69$, $p < .01$. Specifically, the effect of OS on lapse was stronger when participants reported experiencing low urge ($OR = 17.82$, 95% $CI = 16.67$ – 19.04) than when participants reported experiencing high urge ($OR = 4.65$, 95% $CI = 4.22$ – 5.13 ; Figure 4, top panel). Similarly, the effect of NA on lapse was stronger when participants reported experiencing low urge ($OR = 8.95$, 95% $CI = 8.15$ – 9.85) than when participants reported experiencing high urge ($OR = 2.96$, 95% $CI = 2.75$ – 2.96 ; Figure 4, bottom panel). No other interactions were significant. Results from all analyses remained significant after (a) controlling for age, race, and nicotine dependence, and (b) excluded 19 participants who reported less than 50% compliance with random assessments.

Figure 1. Effects of alcohol consumption, presence of others smoking, and negative affect on smoking urge. AC = Alcohol consumption, OS = presence of others smoking, NA = negative affect.

Figure 2. Main effects of alcohol consumption, presence of others smoking, and negative affect on smoking lapse. AC = Alcohol consumption, OS = presence of others smoking, NA = negative affect.

DISCUSSION

The current study used EMAs collected during the first seven days of a smoking quit attempt to examine the individual and combined effects of three empirically-based high-risk triggers on smoking urge and lapse. The results demonstrated that: (a) the alcohol consumption, negative affect, and others smoking exert individual and combined effects on smoking urge and lapse; and (b) smoking urge moderates the relationship between negative affect and lapse and the relationship between others smoking and lapse.

The current findings are in line with results reported by Shiffman and Gwaltney (2008) in a study that used EMAs to examine whether affective distress interacts with smoking cues (e.g., alcohol consumption, coffee consumption, others

Figure 3. Individual and combined effects of alcohol consumption, presence of others smoking, and negative affect on smoking lapse. AC = Alcohol consumption, OS = presence of others smoking, NA = negative affect.

Figure 4. Interaction effects between presence of others smoking and smoking urge (top panel) and between negative affect and smoking urge (bottom panel) on smoking lapse. OS = presence of others smoking, NA = negative affect.

smoking) in promoting smoking lapse. Neither we nor Shiffman et al. found that negative affect enhances the effect of smoking cues (e.g., alcohol consumption, others smoking) on smoking lapse. As such, findings from both ours and Shiffman's studies fail to support the hypothesis that negative affect promotes smoking lapse indirectly by increasing the incentive salience of smoking cues.

The current findings may be relevant to Piasecki, Fiore, McCarthy, & Baker, (2002) organizational framework for relapse, which posits that the likelihood of lapse/relapse is influenced by multiple forces (i.e., withdrawal, stressors/temptation, and cessation fatigue). More specifically, alcohol consumption, negative affect, and the presence of others smoking may be related to these forces in several ways. For example, smoking withdrawal may be exacerbated by, individually or in combination, presence of others smoking via cue-induced craving/urge (Carter & Tiffany, 1999), alcohol consumption via a cross-drug priming effect (Rohsenow et al., 1997), or internal cues of negative affect (Baker et al., 2004). In addition, because multiple high-risk triggers tend to induce higher level of craving, they may increase the likelihood of crossing the lapse/relapse "threshold." Finally, as the cessation process progresses, multiple high-risk triggers may deplete smokers' self-control strength (Muraven & Baumeister, 2000; Muraven, Collins, & Nienhaus, 2002), adding to smokers' cessation fatigue and causing lapse/relapse.

The current study found that all three triggers, either individually or in combination with other triggers, increased smoking urge. It also found that alcohol consumption, negative affect, others smoking, and smoking urge were positively associated with lapse. Combining the triggers increased the risk of lapse to varying degrees and the presence of all three triggers resulted

in the highest lapse risk. Although the study found significant interactions between negative affect and urge and between others smoking and urge on lapse, it failed to demonstrate any synergetic effects between exposure to negative affect and high smoking urge or between exposure to others smoking and high smoking urge in increasing the risk of lapse. Instead, the current study found an unexpected buffering interaction between two lapse-promoting factors (Shiffman, 1989). That is, when smoking urge was high, the effects of NA and OS were less than when smoking urge was low. These observed effects were unexpected and counterintuitive. One possible interpretation is that when smokers are experiencing a high urge to smoke, they are more aware of an increased lapse risk and consequently, more vigilant about maintaining abstinence. More research is needed to explore and characterize these complex relationships among high-risk triggers, smoking urge, and lapse.

All high-risk triggers were assessed concomitantly in this study. Given the dynamic nature of the lapse/relapse processes, it may be especially important to investigate the temporal relation among high-risk triggers (e.g., does feeling sad at time j influence smoker's alcohol consumption at time $j+1$?). These temporal relations among high-risk triggers may be interactive in nature and their effects on smoking outcomes may be different than those reported in this study.

Findings of the current study could have implications for smoking cessation treatments. For instance, participants in the current study received frequent smoking cessation counseling (three sessions) during the first postcessation week, which might contribute to the low rate of lapse reported during that week. Among other smoking cessation skills, the treatment protocol taught participants to identify and limit their exposure to high-risk triggers. Future treatment programs could potentially mitigate smokers' exposure to multiple high-risk triggers by expanding upon current skills training strategies to include a specific focus on the importance of avoiding situations that include multiple triggers to smoke. For instance, abstaining smokers could be advised that if they do plan to drink alcohol, consider consuming alcohol only in environments that prohibit smoking.

A strength of the current study is its use of EMA, a method that is well suited to identifying transient high-risk triggers of smoking urge and lapse (e.g., Shiffman et al., 1996b). With the ubiquity of smart phones and personal computing, today's momentary technologies are beginning to incorporate global positioning system (GPS) and accelerometry capabilities into EMA. For instance, future studies could use GPS to monitor smokers' travel patterns to examine if they enter establishments where alcohol is served. Studies may also use carbon monoxide sensors to monitor ambient air quality to determine if smokers are exposed to others smoking. The addition of these new sensing capabilities will likely lead to better design and delivery of momentary interventions that will minimize smokers' exposure to multiple high-risk triggers. For instance, a smoker who reports high negative affect may be guided in coping strategies by his/her smart phone and to avoid bars and other places where a smoker may be exposed to alcohol and/or others smoking.

The current study has several limitations. First, because 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. Second, only three high-risk triggers were investigated in the current study. We included these three high-risk triggers because they are

consistent, potent predictors of smoking urge and lapse. Nevertheless, future studies should expand upon the current findings to include other high-risk triggers such as low abstinence self-efficacy. In addition, the current study examined high-risk triggers during the first 7 days of a quit attempt, a time period during which most smoking lapses would occur. The short assessment period may preclude the urge and lapse findings from generalizing to time periods beyond the first postcessation week. Furthermore, the current study did not explore the additive, cumulative, or interactive relationships between high risk triggers and enduring personal characteristics (e.g., education) and background variables (e.g., stress), and how these relationships may influence smoking lapse (Shiffman, 1989). When completing a lapse assessment, participants were instructed to report how they felt prior to smoking. Nonetheless, it is possible that in some instances, smokers might report how they felt during or after they have smoked. As such, some of the high-risk triggers reported in the current study might be the results, rather than the potential causes, of smoking. Finally, since we did not measure exposure after the first 7 days of a smoking cessation attempt, it is unclear if and how exposure to high-risk triggers beyond the first 7 days of cessation contributes to risk for lapse later in the quitting process.

In summary, the current study found significant individual and combined effects of alcohol consumption, negative affect, and others smoking on smoking urge and lapse. It also found that smoking urge moderated the relations between negative affect and lapse and between others smoking and lapse. The current study is among the first to examine the individual and combined effect of high-risk triggers and the findings add to our understanding of the processes involved in smoking cessation. To better understand the phenomena reported here, future research should extend the current examination to include male smokers and other high-risk triggers.

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DECLARATION OF INTERESTS

None declared.

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