HHS Public Access

Author manuscript

Nicotine Tob Res. Author manuscript; available in PMC 2015 March 02.

Published in final edited form as:

Nicotine Tob Res. 2008 July ; 10(7): 1165–1169. doi:10.1080/14622200802163084.

Real-time craving and mood assessments before and after smoking

Brian L. Carter, Ph.D., **Cho Y. Lam, Ph.D.**, **Jason D. Robinson, Ph.D.**, **Megan M. Paris, B.A.**, **Andrew J. Waters, Ph.D.**, **David W. Wetter, Ph.D.**, and **Paul M. Cinciripini, Ph.D.**

University of Texas M.D. Anderson Cancer Center

Abstract

This study explored some quandaries concerning craving and mood as motivators to smoke. Craving and negative mood have long been associated with day-to-day smoking as two of the primary motivational forces behind the maintenance of the behavior, as well as significant barriers in smokers' attempts to quit. Craving remains a clinically relevant phenomenon, with most smokers describing craving as a troublesome problem when quitting. Smokers' self-reports of negative mood, as an antecedent for smoking, are so robustly reported that many models of nicotine dependence have incorporated a critical role for negative mood in maintaining smoking behavior. However, several naturalistic studies that collected mood ratings with hand held computers from smokers in real time, just before smoking a cigarette, have provided scant evidence that negative mood plays a major role in motivation to smoke. No study to date has examined craving and mood data as a consequence of smoking, that is, collecting the same data immediately after smoking. This study used personal digital assistants (PDAs) to collect craving and mood data immediately before smoking, immediately after smoking, and at random times of day. Nontreatment seeking smokers (N=72) carried a PDA for an average of 10 days while they recorded their smoking behavior. Results showed that craving and negative mood ratings were lowest immediately after smoking compared with immediately before smoking and at random times of day. These findings suggest that smokers may be at least partially motivated to smoke to lower their craving and improve their mood states.

Introduction

Craving and negative mood have long been associated with day-to-day smoking as two of the primary motivational forces behind the maintenance of the behavior, as well as significant barriers to smokers' attempts to quit (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Hughes, Higgins, & Hatsukami, 1990; Shiffman et al., 1997; Tiffany, 1990). Smokers making quit attempts readily describe their craving as the most frequent and salient symptom of abstinence (Center for Disease Control, 1994; Gritz, Carr, & Marcus, 1991), and craving remains a clinically relevant phenomenon, with treated and nontreated smokers

Correspondence: Brian L. Carter, Ph.D., Assistant Professor, Department of Behavioral Science—Unit 1330, University of Texas M. D. Anderson Cancer Center, PO Box 301439, Houston, TX 77230-1439, USA. Tel: +1 (713) 745-4294; Fax: +1 (713) 745-4286; bcarter@mdanderson.org.

alike readily able to report and describe the experience of craving (Shadel, Niaura, Brown, Hutchison, & Abrams, 2001).

Another important factor presumed to influence motivation to smoke is negative mood. Smokers' self-reports of negative mood, as an antecedent for smoking, are so robustly reported that many models of nicotine dependence have incorporated a critical role for negative mood in maintaining smoking behavior (e.g., Baker et al., 2004). For example, the negative experience of nicotine withdrawal symptoms is posited as a strong motivator to smoke. This proposition is supported by studies that show withdrawal symptoms are readily reduced by smoking (Parrott & Garnham, 1998). However, the research on the relationship between negative mood unrelated to withdrawal (e.g., stress) and smoking is ambiguous at best. Laboratory studies have frequently failed to find a strong effect of negative mood on smoking behavior. For example, a recent study by Conklin and Perkins (2005) sought to shed more light on the potential reinforcing effects of smoking while in a negative mood. They induced negative mood in smokers, expecting an increase in craving and smoking behavior. Although their results showed that smoking did not reduce negative mood, greater levels of negative mood shortened latency to smoke and increased smoking behavior.

Recently, researchers have turned to craving and mood assessments taken at the moment they happen in the smoker's natural environment. Several naturalistic studies have used Ecological Momentary Assessment (EMA; Schwarz, 2007; see Stone, Shiffman, Atienza, & Nebeling, 2007, for review), collecting mood and craving ratings with hand held computers from smokers in their day-to-day lives, in real time. These studies have investigated the temporal relationship between craving, negative mood, and smoking. For example, Shiffman and colleagues (2002) used EMA to study the antecedents of cigarette smoking and found that smoking increased with higher craving, but level of negative mood was unrelated to the initiation of smoking. That is, negative mood was no higher just before smoking than it was at random times of day. More recent EMA studies by Shiffman and colleagues have shown similar results. In a study of nontreatment seeking smokers, craving to smoke was the strongest predictor of subsequent smoking, while little relationship was found between mood and smoking (Shiffman, Paty, Gwaltney, & Dang, 2004). In another study comparing chippers (light, nonaddicted smokers) to heavy smokers, only chippers' smoking was predicted by negative affect (Shiffman & Paty, 2006). Given the prominence of negative affect in theoretical models of nicotine dependence, these results from real-time assessments are perplexing. In the case of the EMA studies previously cited, perhaps the right questions were asked, but were not asked at a critical time.

In determining factors that contribute to motivation to smoke, a logical approach is trying to determine what contingencies operate before a smoker lights up, but it also seems logical that smokers may be motivated to smoke because they desire a certain effect after smoking, even if the effect is brief (or in terms of the power of intermittent reinforcement, nonexistent) most of the time. In fact, Kassel, Stroud, and Paronis (2003) make a conceptual distinction between negative mood serving as an antecedent versus a consequence of smoking. In a study using electronic diaries, Beckham and colleagues (2007) found smokers reported a significant reduction in craving after smoking, and smokers with posttraumatic stress disorder also reported decreased negative mood. Therefore, an important piece of the

negative affect puzzle may lie in negative mood and craving ratings taken immediately after smoking. Given reports by Kassel et al. (2003) and Beckham et al. (2007) we predict that smokers will report decreases in negative mood and craving immediately after smoking compared with immediately before smoking and at random times of day.

Methods

Participants

Non-treatment-seeking smokers (*N*=72) were recruited from the Houston metropolitan area through newspaper advertisements. Participants were an average age of 43.2 years (*SD*=10.0), were 53% female, smoked 21.8 cigarettes per day (*SD*=9.7), had Fagerström Nicotine Tolerance scores of 5.5 (*SD*=1.8), had a baseline expired carbon monoxide level of 23.7 (*SD*=9.5), were 54% Black, 38% White, and 8% Asian, Hispanic, or other. Participants were originally enrolled in a larger study, which included four laboratory sessions scheduled approximately 3 days apart. Participants carried personal digital assistants (PDAs) an average of 12.5 days (*SD*=4.3) on the days between laboratory sessions. Because of the demands of the main study, the number of days each participant carried the PDA varied because of rescheduling, missed laboratory sessions, or study dropouts.

Apparatus

Participants carried a Cassiopeia Pocket PC PDA (Casio Model E-125, Casio Computer Co., Japan). The Cassiopeia Pocket PC has a touch-sensitive color screen and a silo for a stylus. Native pocket PC programming (calendar, date book, address book, etc.) was blocked, and a specialized EMA program was put in its place. Participants were instructed to access the PDA before smoking each cigarette throughout the day and night, and to answer questions if they appeared on the screen. They were also instructed to respond to PDA alarms that would occur periodically throughout the day and to answer any questions that appeared on the PDA screen. Each day was tailored to the participant (based on their typical wake-up and bed time) by dividing the day into three epochs roughly corresponding to morning, afternoon, and evening. The program was designed to randomly obtain one of each type of assessment (before, after, random) once during each epoch to gain a representative sample of smoking throughout the day.

EMA Questionnaires

Craving self-report was derived as a composite score from three questions, “I have a craving for a cigarette,” “I really need a cigarette,” and “I want a cigarette.” *Negative mood* was assessed as a composite score from four questions, “I feel bored,” “I feel sad,” “I feel anxious,” and “I feel angry.” *Positive mood* was assessed as a composite score from three questions, “I feel happy,” “I feel relaxed,” and “I feel enthusiastic.” A single *expectancy* item, “Smoking will improve my mood or make me feel better,” was included, as well as a *smoking enjoyment* assessment made of two questions, “I enjoyed my last cigarette,” and “My last cigarette was pleasurable.” All assessments used a 5-point scale with anchor points of “Strongly Disagree” (1), to “Strongly Agree” (5).

PDA programming was designed to obtain craving and mood assessments at least nine times per day, three immediately before smoking, three at 20 min after a smoked cigarette, and three not associated with smoking and randomly placed 20 min or more from any previous reported smoking. The participants were not informed of the study's specific goal to examine craving and mood ratings before and after smoking. Very few participants' individual cigarette recordings were assessed both before and after smoking (n~1, per day). That is, practically all assessments associated with a single smoking occurrence were requested either before smoking or after, but not both. Moreover, to decrease participant burden, the majority of recorded cigarettes required no further assessment at all.

Statistical approach

The primary analytic strategy involved a mixed model approach to examine the effects of the dependent variables (e.g., craving, mood) across assessment types. The mixed model approach is ideally suited for analysis of repeated-measures data because it allows for more specific estimation of the correlation structure of the residuals, and more efficiently handles unbalanced designs and missing data, without excluding participants or imputing values (Gibbons, Hedeker, & Waternaux 1988; Gibbons et al., 1993). Because of the the repeated nature of EMA data, the residuals may be both homoscedastic and autocorrelated (Schwartz & Stone 1998). Thus, to allow for heteroscedastic variance over time, a first-order autoregressive error structure was added to the model. Changes in model deviance were compared with a chi-square distribution, between the model with and without an autoregressive error structure, to examine whether adding an autoregressive error structure yielded significant improvement in model fit. An initial analysis was conducted without covariates in the model. Baseline levels of cotinine, FTND, age, cigarettes per day, and sex were then entered into the model for a second analysis. Because there was no change in results related to the covariates, the results of the initial analysis are reported here. We used a computer program, PROC MIXED (SAS Institute Inc., Cary, NC) to estimate and test the models.

Results

Participants recorded an average of 16.5 (SD=7) cigarettes per day and provided a daily average of 2.75 before smoking assessments, 2.26 after smoking assessments, and 2.46 random assessments. Participants were 81% compliant on after assessment prompts and 76% on random prompts, based on the percentage of time they responded to a PDA initiated prompt and completed all questionnaire items.

When the craving, positive, and negative mood scales were evaluated for reliability using Cronbach's alpha, for each assessment time, the alphas ranged from .77 to .95 for craving, . 86 to .88 for positive mood, and .86 to .91 for negative mood. A correlational analysis was conducted with positive and negative mood scores. Mean positive mood scores for each participant (N=72), taken at each assessment point (before, after, and random), were highly correlated with each other (range .94 to .89). Likewise, negative mood scores were also highly correlated with each other (.94 to .91). However, positive and negative mood scores were only modestly negatively correlated (range −.44 to −.55). This indicates that positive

and negative self report are not simply mirror images of each other and should be treated as separate scales (Watson, Clark, & Tellegen, 1988).

There was a main effect for assessment type (before, after, and random) on craving self-report $F(2,119)=955.9$, $p<.0001$. Post hoc analyses, with Bonferroni adjustment, indicated that craving level was significantly different at each time point (Figure 1). Smokers reported significantly higher craving just before smoking, lowest craving immediately after smoking, and an intermediate level of craving at random assessments.

There was a main effect for assessment type on negative mood $F(2,119)=7.06$, $p<.001$. Post hoc analyses, with Bonferroni adjustment, indicated that negative mood was significantly lower immediately after smoking compared with ratings taken immediately before smoking and ratings taken at random (Figure 2). There was no significant difference between before and random negative mood ratings.

There was a main effect for assessment time on expectancy $F(2,119)=134.7$, $p<.0001$. Post hoc analyses, with Bonferroni adjustment, indicated that expectancy was significantly higher immediately before smoking compared with ratings taken immediately after smoking and ratings taken at random. There was no significant difference between after and random expectancy ratings. There were no main effects or interactions on positive mood ratings or smoking enjoyment ratings.

Discussion

The results found here support the conventional wisdom that smokers are motivated to smoke in order to lower craving and negative mood and that smoking generally accomplishes this goal. These findings replicate Shiffman and colleagues' (2002) finding that there were no differences in level of negative mood immediately before smoking compared with mood ratings taken at random. However, in the present study participants reported a significant drop in negative mood immediately after smoking, suggesting that smokers may not smoke in response to increased levels of negative mood, but may be motivated to smoke in order to occasionally reduce baseline levels of negative mood. This result is consistent with the work of Beckham and colleagues (2007) who found smokers with posttraumatic stress disorder, a population with higher baseline levels of stress and anxiety, experienced a reduction in negative mood as a consequence of smoking. These findings stand in contrast to Conklin and Perkins' (2005) laboratory study, which did not find a reduction in negative mood after smoking. However, their study induced high levels of negative mood, which one would not expect to be sustained in our smokers' multiple assessments over multiple days. It should be noted, in the present study, the effects found were statistically significant, yet a very small effect. This brings into question whether the negative mood effect found here is clinically or theoretically relevant. This finding bears replication with closer scrutiny, using other negative mood assessments that might be more sensitive to changes in mood. Given these results, and their need for further study, it is too early to posit broad theoretical implications from this data.

The results of this study also support the role of craving as a motivating factor in smoking. As found in numerous studies (e.g., Carter & Tiffany, 2001; Shiffman et al., 2002) there is a positive relationship between high levels of craving and smoking behavior. However, the present study is among the first naturalistic studies to demonstrate reduced craving immediately after smoking (Beckham et al., 1996), offering empirical support to the common-sense belief that smoking is at least partly motivated by the desire to reduce craving, a psychological and physiological state that most smokers report as generally unpleasant.

Smokers' expectation that smoking will help improve mood or help them feel better is well established (e.g., Gilbert, Sharpe, Ramanaiah, Detwiler, & Anderson, 2000). At issue is whether these beliefs are justified by empirical evidence. Although the craving and negative mood reductions found here offer support for these beliefs, a number of other studies call these beliefs into question (see Kassel et al., 2003, for review). In the present study, smokers confirmed their belief in the ability of smoking to help regulate mood by having significantly higher expectations immediately before smoking and at random assessments. Somewhat telling are the significantly lower expectations immediately after smoking. On one hand, had smoking done its mood improvement job, one would expect smokers to confirm it with the highest expectancy ratings immediately after smoking. On the other hand, this may be related to the nature of the question: "Smoking *will* improve my mood or make me feel better" (italics added). At this point, having just smoked a cigarette, the smokers may express the belief that further smoking at that time would not help.

No effects of smoking on positive mood self-report were found in the present study. This is not surprising given positive mood's somewhat secondary role as an antecedent for smoking in many models of nicotine dependence. Moreover, as Watson et al. (1988) and others have proposed, negative and positive moods are more accurately assessed with independent scales, as they were in the current study. If one views negative mood scales and positive mood scales as capturing separate, but only modestly correlated, mood states, then positive mood findings can easily fail to track negative mood effects.

It seems clear that, in the real world, psychological, physical, emotional, and cognitive factors are related to smoking in a more complex manner than previous experimentation in laboratories has revealed. EMA methodology helps capture this complexity because multiple measurements can be taken in the moment, without the confound of time passing between behavior and conventional self-reports. As EMA technology becomes more sophisticated, further EMA studies could fruitfully investigate more complex questions and test the common assumptions regarding smoking and the factors that maintain it.

Acknowledgments

This research was funded by a National Cancer Institute grant to Brian Carter (CA92209), and National Cancer Institute grants (R21CA81649) and (P50CA70907) to Paul Cinciripini. The authors thank research assistant Meredith Carson for her valuable work on this project, and thank Susan X Day for her helpful comments on this manuscript. There were no actual or potential conflicts of interests among the authors, consultants, or funding agencies in the completion of this study.

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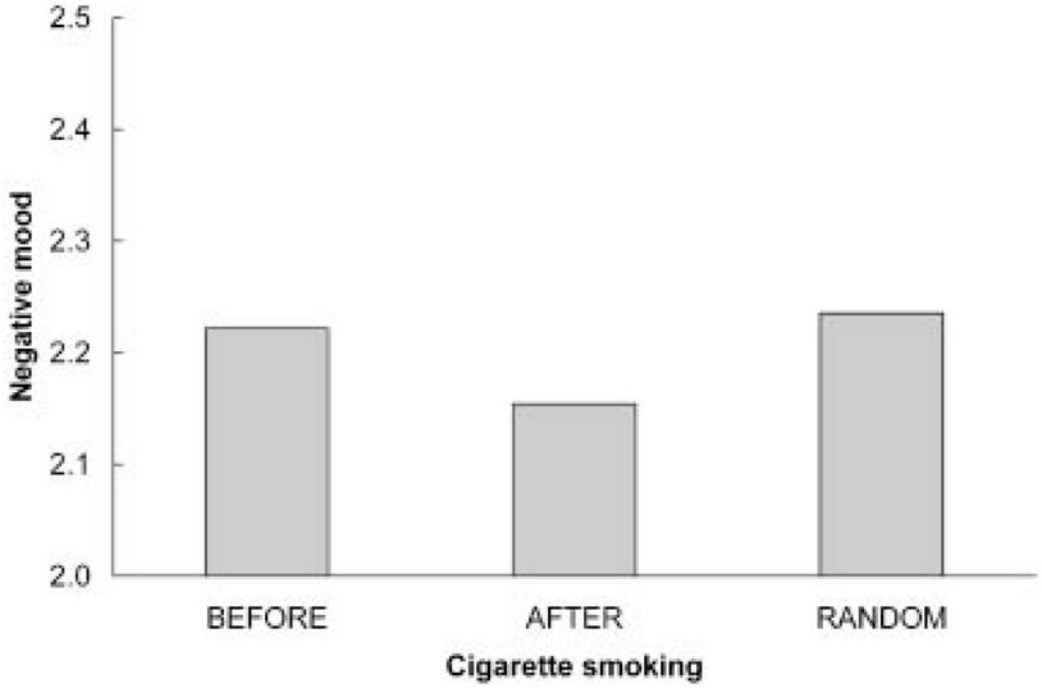

Figure 1.

Mean craving scores by assessment type. Note: Standard error bars were omitted because the size of the standard errors (~.021) lacks visual utility. Means and standard deviations were Before=3.89 (*SD*=.44), After 2.97, (*SD*=.67), and Random 3.21 (*SD*=.78). All means were significantly different from each other at the $p<.0001$ level using Bonferroni adjustment.

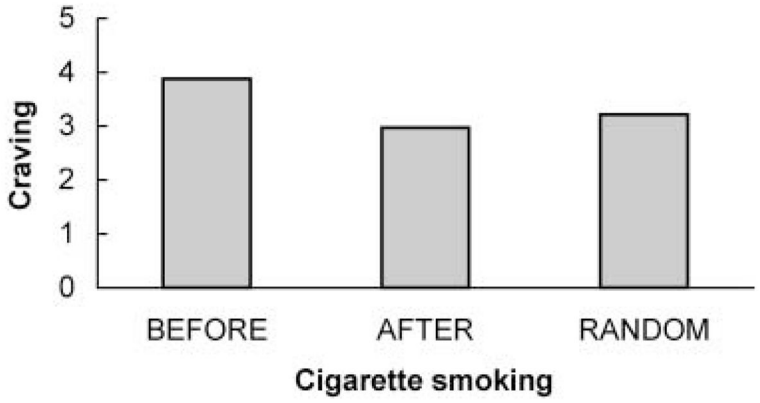

Figure 2.

Mean negative mood scores by assessment type. Note: Standard error bars were omitted because the size of the standard errors (~.015) lacks visual utility. Also note that the *y*-axis has been truncated to illustrate the effect. Means and standard deviations were Before=2.22 (*SD*=.54), After 2.15, (*SD*=.*54*), and Random 2.23, (*SD*=.55). Before and Random means were not significantly different, but both were significant from After at the $p<.05$ level using Bonferroni adjustment.