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Reward Dependence Moderates Smoking-Cue- and Stress-Induced Cigarette Cravings

Alexandra Michalowski¹ and Joel Erblich^{1,2}

¹Mount Sinai School of Medicine, New York, NY

²City University of New York, Hunter College, New York, NY

Abstract

Cigarette cravings following exposure to smoking cues in a smoker's environment are thought to play an important role in cessation failure. The possibility that dispositional factors may impact cue-induced cravings, though intriguing, has received little attention. According to Cloninger's tridimensional personality theory, factors such as reward dependence (RD), harm avoidance (HA), and novelty seeking (NS) may figure prominently in risk for addiction, as well as relapse, in individuals attempting to abstain from drug and alcohol use. Particularly interesting in this regard is the possibility that smokers with higher levels of RD, who are especially sensitive to reward signals, will have heightened craving reactions to smoking cues. To that end, non-treatment-seeking nicotine dependent smokers ($n=96$, Mean age=41.1, 47% African American, 17% Caucasian, 22% Hispanic, 19.3 cigs/day, FTND=7.5) underwent a classic experimental cue-induction, during which they were exposed to imagery of: (1) smoking, (2) neutral, and (3) stress cues, and reported their cigarette cravings (0-100) before and after each exposure. Participants also completed the Tridimensional Personality Questionnaire. Not surprisingly, smoking and stress cues (but not neutral cues) elicited significant elevations in craving ($p's < 0.0001$). Consistent with study hypothesis, smokers who scored higher on RD had stronger craving reactions to both smoking cues ($p < .02$) and stress cues ($p < .03$). Findings raise the possibility that dispositional characteristics, in particular, reward dependence, influence smoking by potentiating reactions to environmental smoking cues. Furthermore, the similar effects of RD on stress-induced craving suggest that both cue- and stress-induced cravings may be influenced by a common underlying disposition.

Keywords

smoking; cues; craving; reward dependence

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Correspondence can be sent to: Joel Erblich, PhD, MPH Department of Psychology Hunter College 695 Park Avenue, HN628 New York, NY 10065 Telephone: 212-396-6766 jerblich@hunter.cuny.edu.

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1. Introduction

Cigarette smoking is a major public health concern. The Centers for Disease Control and Prevention recently reported that although a majority of smokers aged 18 or older expressed a desire to quit and 52% had attempted to do so, only 6% of them had successfully quit at 12 months (CDC, 2011). Cigarette cravings figure prominently in smoking cessation failure. Prospective research has demonstrated that smokers with high levels of cigarette craving during a quit attempt are more than twice as likely to experience a relapse as smokers with low levels of craving (Killen & Fortmann, 1997). In addition to the cravings that accompany withdrawal, research over the past several decades has highlighted the importance of environmental triggers, or cues, which can elicit cravings to smoke, even after acute symptoms of withdrawal subside during the early trajectory of a quit attempt (Ferguson and Shiffman, 2009). These “cue-elicited” cravings have been reliably modeled under laboratory conditions (e.g., Carter and Tiffany, 1999) and have been shown in some (e.g., Erblich & Bovbjerg, 2004; Waters et al., 2004), but not all (see Perkins, 2012) studies, to be related to increased likelihood of relapse. Similar studies (e.g., Erblich, et al., 2003; Sinha, et al., 1999) have shown that stress can trigger strong cravings as well, and that craving responses to laboratory stressors are predictive of increased smoking behavior (McKee et al., 2011).

A separate line of research has demonstrated that personality factors may play an important role in the onset and maintenance of addiction (e.g., Munafo, et al., 2007). In particular, Cloninger's (1986) Tridimensional Personality Theory has been postulated to be a potentially useful framework to understand addiction (Pomerleau, et al., 1992). Based on this theory, Cloninger (1987) developed the Tridimensional Personality Questionnaire [TPQ], which assesses three traits thought to be important in addiction: novelty seeking (NS), reward dependence (RD), and harm avoidance (HA). According to Cloninger (1987), novelty seeking is a tendency toward intense excitement in response to novel stimuli, which can lead high levels of boredom susceptibility, and the avoidance of monotony. Harm avoidance is a tendency to avoid aversive stimuli. Finally, reward dependence is a tendency toward excessive focus on behavioral reinforcement and external triggers of reward. Cloninger (1986, 1987) posited that these „temperaments' are critical in the genesis and maintenance of addiction. Consistent with this possibility, Pomerleau et al. (1992) reported that Cloninger's TPQ scales were related to a number of smoking-related outcomes including smoking status and self-reported level of nicotine dependence.

Recent research has begun to investigate the potential interplay between personality factors and cue- and stress-induced cravings. For example, in a series of studies, Doran and colleagues (2007, 2008) found that impulsivity predicted heightened cue-induced craving and affective responses. To date, however, research has not addressed the possibility that RD, NS, and HA might predict cue-induced cravings. Particularly intriguing is the possibility that cue-induced craving is moderated by smokers' levels of RD; smokers' reward dependence may significantly impact the degree to which they respond to reward cues. Indeed, consistent with previous research by our group and others (e.g., Styn, et al. 2013; Erblich & Bovbjerg, 2004; Carter & Tiffany, 1999), exposure to rewarding stimuli triggers strong craving reactions. Not yet explored is the possibility that smokers' background levels of reward dependence impact the intensity of cue-induced craving responses. In this study,

we evaluated the role of RD in cue-induced craving. Specifically, we hypothesized that higher levels of RD will predict increased levels of cue-induced craving. In addition, given our previous results demonstrating the reward-seeking properties of exposure to stress (e.g., Erblich et al; 2012), we explored the possibility that RD would predict heightened stress-induced cravings as well. Finally, we explored the possibility that the other TPQ subscales (NS and HA) would also be predictive of changes in craving responses. Understanding the sources of variability in cue- and stress-induced craving responses continues to be important in the development of novel approaches to manage craving.

2. Materials and Methods

2.1 Participants

Adult smokers (n=96) were recruited to an ongoing study of smoking behavior by advertisements placed in and around an urban medical center in New York City. Participants were a subset of those from an earlier report (Erblich & Bovbjerg, 2004) for whom data on Cloninger's Tridimensional Personality Questionnaire were available. Participants qualified for a current DSM-IV diagnosis of nicotine dependence (American Psychiatric Association, 1994) ascertained during initial telephone contact and re-ascertained in-person upon arrival using a structured clinical interview. As in the parent study, to qualify as a smoker, only participants who reported smoking at least 10 cigarettes per day for at least 5 years were included in the study. Participants were excluded if they reported: 1) current treatment for smoking cessation, 2) a history of other substance abuse, or 3) a history of hospitalization for mental illness.

2.2 Measures

Background Questionnaire—Participants completed demographic (e.g., age, gender, education, income, ethnicity, marital status) and personal smoking history (e.g., age at initiation, cigarettes per day, years smoked) questionnaires.

Fagerstrom Test of Nicotine Dependence (FTND)—The 6-item FTND was used as a measure of the strength of participants' dependence. The instrument has documented reliability and validity (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991) and has been used extensively in the literature.

Vividness of Imagery—After each of the three imaginal exposures (neutral, stress and smoking), participants completed a four-item, face-valid (e.g., “How vivid did your images seem?”, “How real did your images seem to you?”) 0–25 scale of imagery strength. This instrument has been used in our previous work (Erblich & Bovbjerg, 2004; Erblich, Lerman, Self, Diaz, & Bovbjerg, 2005), and demonstrated strong internal consistency (Cronbach's alpha ranging from 0.85–0.92 for the three administrations) in the current sample.

Tridimensional Personality Questionnaire [TPQ]—The TPQ is a 100-item true-false self-report instrument designed by Cloninger to identify the degree of each of three personality traits [reward dependence (RD), harm avoidance (HA), and novelty seeking (NS)] in accordance with Cloninger's unified biosocial theory of personality (Cloninger,

1987). The instrument evidenced good internal consistency (Cronbach's $\alpha = 0.72$), and was consistent with normative data for non-clinical samples (Cloninger et al., 1991).

Cigarette Craving Questionnaire—Improving on the use of single-item craving assessments, and following the recommendations of Kozlowski and colleagues (Kozlowski & Wilkinson, 1987; Kozlowski, Mann, Wilkinson, & Poulos, 1989) that craving be assessed using multiple descriptors (e.g., crave, urge, desire), this brief, 5-item (“I have a desire for a cigarette right now,” “If it were possible I would smoke now,” “All I want is a cigarette right now,” “I have an urge for a cigarette right now,” “I crave a cigarette right now”) 0-100 instrument is designed specifically to make rapid assessments of craving during experimental manipulations. The instrument has been used as an outcome measure in previous reports by us (Erblich, Boyarsky, Spring, Niaura, & Bovbjerg, 2003) and others (Hutchison, LaChance, Niaura, Bryan, & Smolen, 2002). The instrument evidenced high levels of internal consistency (Cronbach's $\alpha = 0.96\text{--}0.97$) at all administrations.

2.3 Procedures

Potential participants who responded to advertisements were screened via telephone to determine eligibility. The study was described over the phone, and if eligible, participants were scheduled for the study. Ninety percent of eligible respondents were enrolled in the study, and were scheduled for an in-person visit to the lab. To avoid ceiling effects in cigarette craving associated with cigarette deprivation, participants smoked one cigarette immediately before beginning the study procedures. Briefly, participants completed the questionnaires and were then exposed to a set of three imaginal cues (neutral, stress, smoking) in counterbalanced order. Participants listened to a 60-second script and were instructed to imagine the scene as vividly as possible, followed by a 30-second silent period, during which they were to continue imagining the scene. Before beginning the exposures, participants were read a practice script (a trip to the grocery store) to familiarize them with the task. The imaginal cues employed have been described elsewhere (Maude-Griffin & Tiffany, 1996); the neutral imagery involved changing a light bulb, the stress imagery involved a trip to the dentist, and the smoking imagery involved thinking about lighting up a cigarette after a meal. Participants viewed a nature video for 3 minutes between each presentation to provide a rest and facilitate a return to baseline (Piferi et al., 2000). The craving questionnaire was administered immediately before and immediately after each of the three exposures. Upon completion of the study, participants were thanked for their participation, offered referrals for smoking cessation interventions, and paid an honorarium (\$35) for their time.

2.4 Data Analysis

In a first step, we conducted analyses of background variables to identify potential covariates that may have had an impact on craving outcomes. Next, we performed an omnibus repeated measures ANOVA to confirm that smoking cues and stressors elicited significant craving responses. To that end, we tested a Cue (neutral, stress, smoking) by Time (pre-exposure, post-exposure) interaction term to identify craving responses to the smoking and stress imagery, compared to the neutral imagery. Finally, to address the primary hypothesis, we added RD as a factor¹ to test for the possibility that RD moderated

the observed craving effects. We also explored the possible interactions between the other two TPQ subscales (HA, NS) and craving responses.

3. Results

3.1 Background Variables

Sixty-three percent of participants ($n=61$) were women and 36% ($n=35$) were men. The mean age of the sample was 41.1 years ($SD = 6.8$). Forty-seven percent of participants reported African American ethnicity, 17% reported Caucasian ethnicity, 22% reported Hispanic ethnicity, and 14% reported other ethnic backgrounds. Thirty-three percent of participants had a high school education or lower, and 29% of the sample reported annual incomes of \$20,000 or less. Participants smoked a mean of 19.3 cigarettes ($SD = 11.5$) per day for an average of 21.3 years ($SD = 9.2$). Mean Fagerstrom score of the sample was 7.5 ($SD = 2.5$). Preliminary cue*time analyses for each of the background variables revealed that demographic variables were related to neither cue-induced nor stress-induced craving responses (all p 's $> .15$). Not surprisingly, cigarettes per day were marginally related to both cue- and stress-induced craving responses (p 's $< .09$, and $.07$, respectively). The number of years subjects smoked was related to higher levels of stress-induced ($p < .01$), but not cue-induced ($p > .25$) cravings. Thus, the number of cigarettes smoked per day and the number of years smoked were included as covariates in the analyses. Neither the FTND nor the Vividness of Imagery scales was related to craving responses (p 's $> .15$).

3.2 Cue- and Stress Induced Cigarette Cravings

Confirming the effects observed in the larger sample reported elsewhere (Erblich & Bovbjerg, 2005), we found a significant cue*time interaction, revealing an increase in cigarette craving following exposure to both the stressors and smoking cues (compared to neutral cues) in this subset of smokers: $F(2, 92) = 13.36$, $p < .0001$, $\eta^2 = 0.21$. Participants had mean craving levels of 41.2 (± 3.3) prior to the stress exposure, compared to 50.7 (± 3.6) following the stress exposure. Similarly, participants had mean craving levels of 38.7 (± 3.2) prior to the smoking cue exposure, compared to 57.4 (± 3.3) following the smoking cue exposure. In contrast, cravings before and after the neutral exposure were 44.8 (± 3.5) and 38.1 (± 3.4), respectively (Figure 1). Planned comparisons confirmed that both smoking cue-induced craving responses [$F(1, 93) = 28.7$, $p < .0001$, $\eta^2 = .24$] and stress-induced craving responses [$F(1, 92) = 22.1$, $p < .0001$, $\eta^2 = 0.20$] were greater than neutral cue-induced craving responses. There were no differences between the magnitude of smoking cue- and stress-induced craving reactions [$F(1, 92) = 0.1$, $p > .75$, $\eta^2 = .001$].

¹Although we performed an omnibus ANOVA, including all three types of imagery in a single 3 (neutral, smoking, stress) $\times$ 2 (pre-exposure, post-exposure) analyses, we conducted separate ANOVAs for smoking-cue-induced craving and stress-induced craving when examining the interacting effects of RD for two reasons: First, craving responses to the smoking cue and stress imagery were found to have different covariates (see results), and so we wanted to include only the relevant covariates in each analysis. Second, we felt that separate comparisons of the smoking-cue and stress effects would better highlight the results and increase interpretability. It should be noted that when we conducted a single omnibus ANOVA with RD as a moderator, an identical pattern of significant results were obtained.

3.3 Relationships Between Personality Dimensions and Craving Responses

To test the primary study hypothesis, we included the three TPQ subscales (HA, RD, and NS) as possible moderators of the effects of cues and stressors on craving responses. Consistent with the study hypothesis, we identified a significant cue*time*RD interaction: $F(1, 91) = 6.3, p < .02, \eta^2 = .07$, for craving responses to the smoking cues vs. neutral cues. To further illustrate this interaction, we performed a median split of RD ("High RD" [n=44] vs "Low RD" [n=52]). As depicted in Figures 2a and 2b, smoking-cue-induced craving responses were greater among participants with higher RD than those with lower RD. We also conducted pairwise contrasts of pre-post craving scores in each group. Craving effects were significant in both the Low and High RD groups (p 's $< .01$), suggesting that even though there was a significant interaction effect, the craving response remained robust across groups. Effects of HA and NS on smoking cue-induced craving were not significant (p 's $> .5$).

Interestingly, we found an identical pattern of results for stress-induced craving responses. There was a significant cue*time*RD interaction for craving responses to the stress cues vs. neutral cues: $F(1, 90) = 4.9, p < .03, \eta^2 = .05$. As above, the interaction is illustrated with the dichotomous RD variable. Stress-induced craving responses were greater among participants with higher RD (Figure 3a) than those with lower RD (Figure 3b). Also as above, pairwise contrast revealed significant pre-post craving effects in both Low RD and High RD groups (p 's $< .03$), suggesting the robustness of the stress-induced craving effect across groups. Effects of HA and NS on stress-induced craving were not significant (p 's $> .5$).

To characterize the individual relationships between RD and each of the craving responses, we conducted three separate regression analyses of craving scores pre- post change scores for each of the three stimuli (neutral, smoking, stress) on RD. For each regression, we included the pre-stimulus craving variable as a covariate to adjust for baseline variability. Consistent with the omnibus cue*time*RD ANOVA, reward dependence was significantly predictive of craving reactions to smoking cues ($b = 1.18, p < .05$) and stressors ($b = 1.48, p < .01$), but not to neutral cues ($b = -.51, p > .25$). Finally, we explored the possibility of order effects by including order of stimulus administration as a between subjects factor in the above analyses, and results were unchanged. In addition, order effects were all non-significant (p 's $> .15$).

4. Discussion

The present study aimed to identify the potential moderating role of reward dependence in better understanding reactions to laboratory smoking cues. Consistent with the study hypotheses, smokers who scored higher on the Reward Dependence scale of Cloninger's Tridimensional Personality Questionnaire exhibited significantly higher smoking-cue-induced cigarette craving responses. Interestingly, these smokers also exhibited higher levels of stress-induced craving. Not surprisingly, the other scales (Harm Avoidance, Novelty Seeking) were related to neither smoking cue-induced cravings nor stress-induced cravings.

These findings highlight the importance of dispositional factors in understanding cigarette craving, and raise the possibility that cue- and stress-induced craving responses may be particularly important in smokers with high levels of RD. The literature on relations between cue-induced craving and cessation has been mixed (Perkins, 2009). The present results raise the intriguing possibility that smokers' with high levels of RD, who have particularly high levels cue- and stress-induced cravings, may be at greatest risk for cessation failure. If this is the case, then intervention efforts aimed at managing these cravings might be most efficiently focused on smokers with high RD. These findings might also help explain why classic interventions (e.g., cue- exposure) in the general population of smokers without consideration of personality factors (such as RD) have met with modest clinical success to date (Perkins, 2009). Nevertheless, the effects of cue and stress exposures remained significant in smokers with lower RD, as well, suggesting that cue- and stress-induced cravings are robust and may need to be addressed globally.

Another interesting result of this study is the similarity between cue- and stress-induced cravings. Findings indicated that higher levels of RD predicted elevations in both cue- and stress-induced cravings. These results suggest that cravings elicited by environmental cues and stressors may share a similar underlying process. Previous research has typically focused either on environmental cues (e.g., Carter and Tiffany, 1999), or stress (Sinha et al., 1999), but not both. The possibility that a unifying, underlying propensity for exaggerated craving responses to environmental stimuli, has the potential to improve our understanding of craving responses to daily triggers. From a clinical standpoint, this may become highly relevant. For example, interventions for smokers with high levels of RD may need to take into account the possibility that multiple sources of craving are highly relevant. Furthermore, interventions helping smokers manage their RD may simultaneously, and thus, more efficiently, help reduce both cue- and stress-induced cravings.

Limitations of the present study include the reliance on self-reported craving, the focus on one model of personality, and the lack of a prospective design that would permit the direct study of RD and craving as it relates to cessation failure. Future research continues to explore other dispositional factors [e.g., impulsivity (Doran et al., 2007, 2008)] as potentially important moderators of craving and cessation. Already, multidimensional assessments are being developed to understand effects of smoker disposition on smoking outcomes using various personality tests such as the TPQ (Batra et al., 2008). Studies such as the present augment those broad classification attempts by focusing on a specific set of dispositional factors. In addition, the role of dispositional factors on craving responses to positive cues should be explored in light of recent findings that such cues can enhance cravings (Munoz et al., 2010, Robinson et al, 2011; Veilleux et al., 2013). Finally, prospective research in the future should aim to test the possibility that RD predicts craving, which in turn, affects cessation success. Data in support of this prospective relationship may set the stage for clinical research leading to innovations in managing cravings and enhancing smoking cessation success among smokers with high levels of reward dependence.

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HIGHLIGHTS

- Reward Dependence predicted higher levels of smoking cue-induced craving
- Reward Dependence also predicted higher level of stress-induced craving
- We suggest that dispositional traits are important in addressing triggered cravings

Figure 1. Cue*Time interaction is significant, with responses to smoking cues and stress significantly greater than responses to neutral cues ($p < 0.0001$).

Figures 2a and 2b.

Smoking Cue*Time interaction for low and high levels of reward dependence, respectively. Smoking-cue-Induced craving effects are stronger among participants with higher reward dependence ($p < 0.02$).

Figures 3a and 3b.

Stress Cue*Time interaction for low and high levels of reward dependence, respectively.

Stress-Induced craving effects are stronger among participants with higher reward dependence ($p < 0.02$).