



Impulsivity moderates the relationship between previous quit failure and cue-induced craving



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HIGHLIGHTS

- The effects of trait impulsivity on past quit failures and cue-induced cigarette craving responses were examined.
- Exposure to smoking cues elicited significant craving reactions.
- Smokers who reported shorter past quit attempts exhibited significantly higher levels of cue-induced craving.
- This effect was particularly pronounced among smokers who reported high levels of trait impulsivity.

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ABSTRACT

Introduction: Poor inhibitory control has been shown to be an important predictor of relapse to a number of drugs, including nicotine. Indeed, smokers who exhibit higher levels of impulsivity are thought to have impaired regulation of urges to smoke, and previous research has suggested that impulsivity may moderate cue-induced cigarette cravings. To that end, we conducted a study to evaluate the interplay between failed smoking cessation, cue-induced craving, and impulsivity.

Methods: Current smokers ($n = 151$) rated their cigarette cravings before and after laboratory to exposure to smoking cues, and completed questionnaires assessing impulsivity and previous failed quit attempts.

Results: Findings indicated that shorter duration of previous failed quit attempts was related to higher cue-induced cigarette craving, especially among smokers with higher levels of impulsivity.

Conclusions: Results underscore the importance of considering trait impulsivity as a factor in better understanding the management of cue-induced cravings.

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Cigarette smoking is the number one preventable cause of death in the U.S. and abroad (U.S. Department of Health & Human Services, Public Health Service, & Office of the Surgeon General, 2014; World Health Organization, 2015). One prominent explanation for difficulty in quitting smoking is the ubiquitous presence of smoking-related cues in the environment that trigger strong, difficult-to-resist, cravings to smoke (Tiffany, 1990). Considerable evidence has shown that cue-induced cravings can be reliably modeled under laboratory conditions (Carter & Tiffany, 1999). As just one example, Erbllich and Bovbjerg (2004) found that exposure to both imaginal and in vivo smoking cues delivered to smokers under laboratory conditions elicited robust self-reported cravings to smoke.

Less well established, however, is the relationship between smoking cessation failure and these cue-induced cravings. Few studies actually examine relations between laboratory cue-induced craving and

cessation outcomes, and those that do have yielded mixed results. For example, Waters and colleagues (Waters et al., 2004) found that cue-induced craving was predictive of poorer smoking cessation in a prospective study, but only among smokers randomized to receive nicotine patch treatment. Our group (Erbllich & Bovbjerg, 2004) found in a retrospective study that shorter durations of previous failed quit attempts were related to elevated cravings in response to in vivo, but not imaginal, smoking cues in a sample of current smokers. Another study (Shadel et al., 1998) found no association between cue-induced cravings and cessation in a group of self-quitters. A recent study (Conklin et al., 2015) found that cue-induced cravings were related to decrease latency to smoke and increased smoking topography measures during an ad lib smoking opportunity immediately following a cue exposure. These seemingly disparate results raise the possibility that additional factors need to be considered when evaluating the relationship between cessation failure and cue-induced cravings.

Accumulating evidence has pointed to the importance of trait impulsivity in the genesis and maintenance of addictive behaviors. Impulsivity is a multifaceted phenomenon characterized by the overvaluation of

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immediate gratification, poor behavioral inhibition, and sensation-seeking (de Wit, 2008). The possibility that impulsivity is related to cue-induced craving has been investigated in a series of studies by Doran and colleagues, with mixed results (Doran, Spring, & McChargue, 2007, 2009; Doran, Cook, McChargue, & Spring, 2009; Doran, Cook, McChargue, Myers, & Spring, 2008). In addition, recent behavioral and neurobiological studies suggest that trait impulsivity may potentiate craving reactions to smoking cues (Bourque, Mendrek, Dinh-Williams, & Potvin, 2013; Papachristou, Nederkoorn, Corstjens, & Jansen, 2012). The possibility that impulsivity moderates the relationship between craving and cessation, however, has yet to be investigated. Indeed, it is tempting to speculate that the lack of inhibitory control characteristic of impulsive individuals would make environmental smoking cues and their attendant cravings particularly difficult to resist, resulting in increased risk of relapse. Recent theoretical conceptualizations of the impact of impulsivity on smoking and other drug use are consistent with this possibility. According to Mitchell (2004), trait impulsivity may operate at multiple levels, including potentiating sensitivity to rewarding stimuli, as well as creating difficulty resisting smoking and drug use behavior in the face of motivationally salient emotions, such as cravings. Similarly, Belin, Belin-Rauscent, Murray, and Everitt (2013) have recently argued, based on neurobiological evidence, that trait impulsivity is characterized by impaired executive control over maladaptive habits during motivational states, resulting in a maladaptive stimulus–response pattern.

Based on these theoretical and empirical considerations, we aimed to evaluate the role of impulsivity on failed cessation attempts and cue-induced craving in a cross-sectional study. Specifically, we hypothesized that 1) higher levels of trait impulsivity will be related to elevated cue-induced cravings, 2) shorter durations of previous failed quit attempts will be related to higher cue-induced cravings, and, 3) relations between previous unsuccessful quit attempts and cue induced craving would be particularly strong among smokers with higher levels of trait impulsivity. Given recent findings linking impulsivity to tonic levels of cigarette craving (Mathew, Burris, Froeliger, Saladin, & Carpenter, 2015), as well as conceptualizations of the role of impulsivity in addiction (Mitchell, 2004), we also explored the possibility that impulsivity would predict increased baseline levels of craving in our sample.

1. Method

1.1. Participants

Adult smokers ($n = 151$) were recruited to a study of smoking behavior by advertisements (for a smoking study) placed in and around an urban medical center in New York City. All participants qualified for a current DSM-IV (American Psychiatric Association, 1994) diagnosis of nicotine dependence by endorsing a minimum of 3 of 7 criteria during a structured interview at screening. Qualifying smokers for this study were required to smoke at least 10 cigarettes per day for at least 5 years. To reduce sources of heterogeneity in smoking behavior associated with sample characteristics, 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.

1.2. Measures

1.2.1. Demographic and smoking questionnaire

Participants completed questionnaires assessing basic demographic information (e.g., age, gender, education, income, race/ethnicity [freeform self-report], marital status) and personal smoking history (e.g., age at initiation, cigarettes per day, years smoked). In addition, participants completed a face-valid item assessing the duration of their most recent quit attempt (# of days remained abstinent).

1.2.2. Fagerstrom test of nicotine dependence (FTND)

The FTND is a six-item instrument that measures 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. Cronbach's alpha in the current sample was 0.48, somewhat lower than the alpha of 0.64 reported in an initial psychometric investigation (Pomerleau, Carton, Lutzke, Flessland, & Pomerleau, 1994).

1.2.3. Impulsivity

The Impulsive Sensation Seeking Scale (ISS) of the Zuckerman–Kuhlman Personality Questionnaire is a validated, frequently used self-report measure of impulsivity. The scale has 19 items and evidences excellent psychometric properties (Zuckerman, Kuhlman, Joireman, Teta, & Kraft, 1993). Cronbach's alpha in the current sample was 0.80, indicating good internal consistency.

1.2.4. Cigarette craving questionnaire

Improving on the use of single-item craving assessments, and following the recommendations of Kozlowski and colleagues (Kozlowski, Mann, Wilkinson, & Poulos, 1989; Kozlowski & Wilkinson, 1987) that craving be assessed using multiple descriptors (e.g., crave, urge, desire), this brief, 5-item, 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 was administered immediately prior to and following each stimulus, so that a change score could be calculated as a measure of cue-induced craving. The instrument evidenced high levels of internal consistency (Cronbach's alpha = 0.96–0.97) at all administrations.

1.3. 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 a study session. Ninety percent of eligible respondents were enrolled in the study.

During the study session, participants completed questionnaires and were exposed to neutral and smoking cues. Consistent with methods in previous studies (e.g., Doran et al., 2007; Erblich & Bovbjerg, 2004; Erblich et al., 2003), participants smoked one cigarette immediately before beginning the study procedures. This method was employed because pilot studies in our lab had revealed that deprived smokers consistently reported very high levels of prestimulus craving, effectively preventing the detection of cue-induced craving effects (unpublished data). For the smoking cue, participants were presented with their cigarette box, asked to remove one cigarette, and hold it for 90 s. For the neutral cue, they were presented with a stapler and asked to hold it for the same amount of time. Cigarette cravings were measured immediately before and after each cue exposure. To avoid possible carryover effects (Heishman, Lee, Taylor, & Singleton, 2010; Sayette, Griffin, & Sayers, 2010), participants were exposed to the neutral cue first, followed by the smoking cue. In addition, participants viewed a nature video for 3 min between the two presentations. This nature video (Coral Sea Dreaming, DVD International) has been shown to help return participants undergoing experimental laboratory challenges to a resting state (Piferi, Kline, Younger, & Lawler, 2000). Upon completion of the study, participants were thanked for their participation, offered referrals for smoking cessation interventions, and paid an honorarium of \$50 for their time.

1.4. Data analyses

To address the study hypotheses, we employed hierarchical linear regression models (HLM) with random effects, calculating growth curves for craving responses to neutral and smoking cues. Because each of these outcomes have two levels (pre-stimulus, post-stimulus), we employed split-scale methodology to fit the growth curves (Lyons, Zarit, Sayer, & Whitlatch, 2002). We modeled smoking cue-induced cigarette craving as a function of time, including responses to the neutral cues as a time-varying covariate. We then included impulsivity, the duration of the most recent failed quit attempt, as well as their interaction, as predictors of craving effects. All predictors were mean-centered, as recommended by Aiken and West (1991) as well as others (e.g., Hayes, 2013), and were fit as predictors of both the slope (cue-induced craving effects) and intercept (baseline craving effects).

2. Results

2.1. Background variables

Fifty-two percent of participants ($n = 78$) were men and 48% ($n = 73$) were women. The mean age of the sample was 37.5 years ($SD = 10.9$). Thirty-six percent of participants reported African American ethnicity, 28% reported Caucasian ethnicity, 26% reported Hispanic ethnicity, and 10% reported other ethnic backgrounds. Twenty-eight percent of participants had a high school education or lower, and 36% of the sample reported annual incomes of \$20,000 or less. Participants smoked a mean of 17.2 cigarettes ($SD = 8.8$) per day for an average of 17.8 years ($SD = 10.2$). Mean Fagerstrom score of the sample was 5.4 ($SD = 2.2$).

2.2. Predictors of baseline cigarette craving

Not surprisingly, analysis of predictors of the growth curve intercept revealed that FTND scores were significantly positively related to baseline cigarette craving levels: $b = 2.68$ ($SE = 0.96$); $t(150) = 2.79$; $p < 0.006$. In addition, the duration of participants' most recent failed quit attempt was inversely related to baseline cigarette craving; participants who relapsed to smoking more quickly in the past exhibited higher current basal cigarette craving levels; $b = -0.017$ ($SE = 0.007$); $t(150) = -2.39$, $p < 0.018$. Neither impulsivity, nor its interaction with past quit durations, however, was related to baseline craving levels (p 's > 0.10).

2.3. Predictors of cue-induced craving

Consistent with the larger literature (Carter & Tiffany, 1999), a significant effect of time was observed, confirming that smoking cues elicited strong craving reactions; $t(150) = 11.7$, $p < 0.0001$. Exposure to smoking cues resulted in a mean increase in craving of 26.0 (± 2.2) units on the 0–100 craving scale. Interestingly, FTND scores were not related to cue-induced craving ($p > 0.1$). Similarly, we did not find a significant relationship between impulsivity and cue-induced craving ($p > 0.1$). We did, however, observe a significant inverse relationship between the duration of the most recent failed quit attempt and cue-induced craving; participants who reported shorter failed quit attempts exhibited significantly higher cue-induced cravings; $b = -0.0035$ ($SE = 0.0017$); $t(150) = -2.04$, $p < 0.05$. Perhaps most interestingly, however, was a significant interaction between impulsivity and quit duration; $b = -0.0015$ ($SE = 0.001$); $t(150) = -2.22$, $p < 0.05$. To better characterize this interaction, we performed a simple slopes analysis following the recommendation of Aiken and West (1991) for examining interactions between continuous variables. We computed slopes for the relationship between past failed quit duration and cue-induced craving for two subgroups: 1) those scoring 1 SD below the mean on the ISS, and 2) those scoring 1 SD above the mean on the ISS. These

analyses revealed that the relationship between past failed quit duration and cue-induced craving was not significant among participants who scored lower on the ISS; $b = 0.001$ ($SE = 0.002$), $t(150) = 0.64$, $p > 0.05$, but was significant for participants who scored more highly on the ISS; $b = 0.008$ ($SE = 0.003$), $t(150) = -2.56$, $p < 0.01$. See Fig. 1 for a graphical depiction of these effects.

3. Discussion

The current study aimed to examine the interplay between impulsivity, previous failed quit attempts, and cue-induced craving. Not surprisingly, findings indicated that shorter failed quit attempts in the past were related to higher cue-induced cigarette craving among current smokers. Interestingly, trait impulsivity was found to predict neither general craving levels nor cue-induced craving as main effects, but it did moderate the relationship between previous failed quit duration and cue-induced craving. In particular, the relationship between quit failure and cue-induced craving was stronger in smokers with higher levels of trait impulsivity. Findings suggest that trait impulsivity might be an important factor linking cravings and quit failure. Results are partially consistent with the theoretical considerations of Mitchell (2004) and Belin et al. (2013), who suggest that impulsivity and poor executive control of behavior may be related to both the magnitude of motivational responses per se (e.g., craving), as well as their attendant behavioral correlates (e.g., abstinence).

In contrast with the present results, Doran et al. (2007, 2009) found that impulsivity was related to elevated cue-induced craving in an ethnically diverse sample similar to ours. The effects were observed for only one subtype of impulsivity (i.e., sensation seeking), and were not observed in a different study (Doran et al., 2008) when using a different measure of impulsivity (i.e., the Barratt Impulsiveness scale). Interestingly, the measure we used in the present study from the ZKPKQ is quite similar to the sensation seeking component of the UPPS scale employed by Doran et al. (2009). It is possible that main effects in our study were masked by the significant interaction effect, or that other methodological and/or measurement variations contributed to disparate findings. As one example, the cue-exposures in Doran et al.'s (2007, 2009) work lasted for 5 min, compared to 90 s in the present study. It is possible that with longer, more protracted exposures, impulsive smokers begin to become more dysregulated, leading to higher levels of cravings. Both of these laboratory models (brief exposure, more protracted exposure) have real-world validity; smokers can encounter cues for brief intervals, but may also find themselves exposed for longer intervals, possibly requiring more intense craving management, which may be particularly difficult for impulsive smokers. Either way, however, the present results are consistent with the possibility

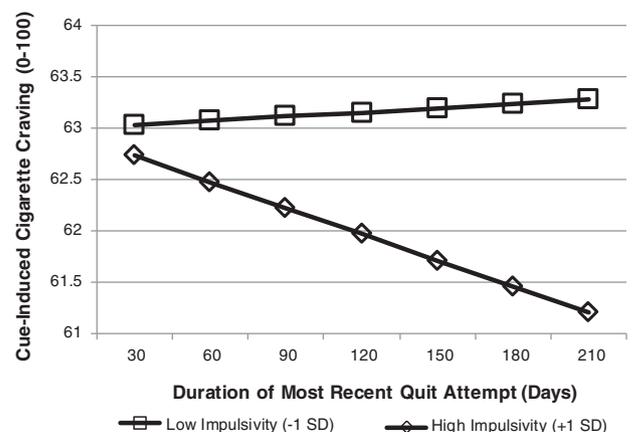


Fig. 1. Relationship between duration of previous failed quit attempts and cue-induced craving among smokers high and low in trait impulsivity.

that cravings following cue-exposures are related to unsuccessful cessation in impulsive smokers.

These findings highlight the important relationship between previous quit failure and cue-induced cigarette craving, and demonstrate that trait impulsivity contributes to this relationship. Indeed, previous research has yielded mixed results when examining relations between smoking behaviors and cue-induced craving (see Ferguson & Shiffman, 2009; Perkins, 2009). The current study suggests that stable traits such as impulsivity may need to be taken into account when trying to understand the relationship between craving and smoking behavior. Indeed, the present results raise the possibility that impulsive smokers are especially challenged to resist triggered cravings, potentially leading to failed quit attempts. Although the study employed a cross-sectional approach, the current data are supportive of such a pathway. Conversely, the observation that cue-induced cravings were not related to shorter failed quits among smokers with lower levels of impulsivity may explain why studies searching for overall relationships have yielded mixed results. These results support a more complex, moderated relationship between smoking behavior and cue-induced craving.

The current study is consistent with a growing literature emphasizing the interplay between constitutional factors (e.g., personality traits) and risk for drug use and/or relapse (Ameringer & Leventhal, 2010; de Wit, 2008). Based on the current findings, it is tempting to speculate that a propensity for dysregulated behavior (e.g., impulsivity) may give rise to increased difficulties managing and resisting urges to smoke that may be triggered by environmental cues, and provides further support for previously elucidated models of impulsive drug use (Papachristou et al., 2012; Belin et al., 2013; Mitchell, 2004). Clinically, identification of impulsive traits in smokers may be particularly useful, so that more intense efforts could be developed to help this subset of smokers manage the ubiquitous cue-induced cravings that they likely encounter during a quit attempt. Conversely, cue-induced cravings appear to be less important for smokers with lower levels of impulsivity, and it is possible that other clinical foci would be relevant to explore (e.g., negative affect, stress management).

Limitations of the current study include its cross-sectional design, as well as a limited assessment of trait impulsivity. Although in this study we identified relationships between shorter previous quit attempts and elevated cue-induced cravings, a more definitive longitudinal approach testing effects of cue-induced craving on cessation failure, especially in impulsive smokers, would be a logical next step. Numerous studies (e.g., de Wit, 2008) have pointed to the possibility that impulsivity, or behavioral dysregulation, is a diverse, multifaceted, and complex construct, and self-report measures likely only capture a small part of what is thought to be a complex character trait with many dimensions. Future prospective research identifying relations between cue-induced craving and cessation success among smokers with different subtypes and facets of impulsivity would provide further support for the importance of dysregulation of inhibitory control as a key factor in understanding the management of urges and risk of relapse. In addition, the systematic use of multiple cue exposure modalities (e.g., imaginal, in-vivo; brief cue exposure, longer exposure) may yield novel findings that would help elucidate some of the potentially subtle effects of methodology that might contribute to the understanding of cigarette cravings in the highly varied day-to-environments of smokers.

Author disclosures

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Authors Erbllich and Michalowski both contributed to conceptualization of the research. Both authors contributed to the writing of the manuscript and have approved the final version.

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