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The role of impulsivity on smoking maintenance

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In order to better understand why those higher in impulsivity experience more difficulties during smoking abstinence, the current study examined the possible mechanisms contributing to cigarette smoking relapse. Fifty dependent cigarette smokers completed measures designed to assess craving, tobacco withdrawal severity, and negative affect during 48 hours of nicotine abstinence. Using a series of multilevel models (SAS Proc Mixed Procedure), significant impulsivity × time analyses revealed differences in craving, $F(2, 96)=3.74$, $p<.05$, and anxiety, $F(2, 96)=3.23$, $p<.05$. Simple slopes analyses indicated that heightened trait-impulsivity predicted greater increases in craving and anxiety during a 48-hour abstinence period. These findings suggest that smokers with higher levels of impulsivity may lack the ability to find an accessible and comparable substitute for cigarette smoking during a cessation attempt. This study also highlights the importance of considering individual differences when treating those who wish to quit smoking.

Introduction

Despite the well-known health risks associated with cigarette smoking, this behavior remains one of the leading causes of preventable death in the United States (Centers for Disease Control and Prevention [CDC], 2005). It is estimated that approximately 20.9% (45.1 million) of U.S. adults are current cigarette smokers, with 80.8% (36.5 million) of this group smoking daily (CDC, 2006). Although effective interventions have been developed (U.S. Department of Health and Human Sciences, 1990) and smoking rates have been on the decline during the last 10 years, a close examination of the percentages of those who report current smoking behavior during the last 2 years suggests that this decline has stagnated (CDC, 2006).

The consensus among researchers is that one of the primary obstacles to successful smoking cessation is nicotine withdrawal (Kassel, Stroud, & Paronis, 2003; Niaura et al., 1999; Robinson et al., 1995; West, 1984). In particular, research has shown that during cessation, smokers will experience heightened levels of negative affect (Kassel et al., 2003; Tiffany & Drobes, 1990) in addition to other physical symptoms such as restlessness and decreased heart rate (Hughes & Hatsukami, 1986). Thus, smoking behavior becomes negatively reinforced via attempts to alleviate these symptoms. In fact, previous research has reliably shown that smokers report using cigarettes as a means of relieving negative affect (Gilbert, Sharpe, Ramanaiah, Detwiler, & Anderson, 2000; Wetter et al., 1994). Craving is another important construct that appears to contribute to the maintenance of smoking behavior (Shapiro, Jamner, Davydov, & Porsha, 2002; Shiffman, Paty, Gwalney, & Dang, 2004). Craving, which is currently not considered a symptom of nicotine withdrawal, tends to develop gradually during an abstinence period, rather than increasing sharply post-quit like other withdrawal symptoms (Hughes & Hatsukami, 1986; Shiffman et al., 1997). Thus preparing individuals to cope effectively with craving is difficult given its unpredictable nature.

Other important factors that appear to be related to smoking relapse are personality traits (Gilbert, Crauthers, Mooney, McClernon, & Jensen, 1999; Spielberger & Jacobs, 1982). Impulsivity is one such trait that has been linked to a higher probability of the initiation as well as the continued use of a variety

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of substances including alcohol (Allen, Moeller, Rhoades, & Cherek, 1998), cocaine (Cascella, Nagoshi, Muntaner, & Walter, 1994), heroin (Kirby, Petry, & Bickel, 1999), and cigarette smoking (Bickel, Odum, & Madden, 1999; Mitchell, 1999). Consistent with the existing substance abuse literature, trait-impulsivity is defined as a pattern of behaviors predicting a tendency to respond to a given stimulus or to readily available rewards, without forethought of possible negative consequences (Bickel et al., 1999; Mitchell, 1999; Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001; Monterosso & Ainslie, 1999).

Impulsive behaviors, unlike poor decision making, involve a predisposition towards an action that may be ill-advised (Moeller & Dougherty, 2002). Working within a cognitive-motivational framework, impulsivity is regarded as a personality trait that reflects an increased awareness to reward cues as well as heightened emotional reactivity to that reward (Finn, 2002). In other words, when an individual with a high level of impulsivity is confronted with a potentially rewarding stimulus, that person will have a greater difficulty inhibiting their behavior compared to an individual with lower levels of impulsivity (Finn, Mazas, Justus, & Steinmetz, 2002; Newman, 1987). This difference may explain why previous literature in the field has consistently linked higher levels of impulsivity to those who have used (Allen et al., 1998; Fishbein, Lozovsky, & Jaffe, 1989) or currently use substances (Beckwith, 1986; Patton, Stanford, & Barratt, 1995; Sher, Trull, Bartholow, & Vieth, 1999). Cigarette smokers have also been found to have higher rates of impulsivity compared to their nonsmoking peers (Bickel et al., 1999; Kassel, Shiffman, Gnys, Paty, & Zettler-Segal, 1994; Mitchell, 1999; Zuckerman & Kuhlman, 2000). Despite this clear relationship, few studies have examined the relationship between impulsivity and successful abstinence.

With regard to the relationship of smoking relapse and impulsivity, Doran, Spring, McChargue, Pergadia and Richmond (2004) found that smokers with higher levels of trait-impulsivity experienced greater difficulty in maintaining smoking abstinence. Specifically, those participants with higher levels of trait-impulsivity were significantly more likely to relapse within 48 hours of completing a 1-day smoking cessation workshop compared to their peers with lower levels of this trait. These results map onto previous findings in the cocaine literature, indicating that highly impulsive, cocaine-dependent individuals showed greater treatment dropout rates compared to their counterparts with lower levels of impulsivity (Moeller et al., 2001). However, both of these studies involved treatment components, which may put inherent limitations on answering the question of why these individuals are more likely to relapse. Specifically, Doran and colleagues (2004) failed to find significant relationships between trait-impulsivity and post-quit changes in affect and cigarette craving.

Several additional explanations have been postulated in an attempt to explain why those higher in trait-impulsivity may be more prone to relapse. Specifically, substances like nicotine that have been shown to enhance dopaminergic neurotransmission have been linked to greater increases of craving among those higher in impulsivity (Reuter & Netter, 2001). More recently, this finding was confirmed using a smoking cue reactivity paradigm where disproportionate levels of craving were observed among smokers with higher levels of trait-impulsivity (Spring et al., 2008). Finally, other studies have shown that impulsive individuals may experience heightened levels of reward (or heightened expectations of reward) from substances of abuse compared to non-impulsive individuals, which may reinforce their continued smoking behavior (Doran, McChargue, & Cohen, 2007; Doran et al., 2006; Martin & Potts, 2004; Cascella et al., 1994).

The primary aim of the present study was to examine mechanisms whereby individuals higher in trait-impulsivity relapse more quickly compared to individuals lower in trait-impulsivity during a 48-hour period of smoking abstinence. Therefore, we investigated the moderating effects of craving, tobacco withdrawal, and negative affect (e.g. anxiety and depression) on the relationship between increased trait-impulsivity and 48-hour smoking abstinence. It was hypothesized that the decreased reward consumption from not smoking experienced by those high in impulsivity would be directly related to increases in the above-mentioned mechanisms of relapse. Despite the fact that withdrawal symptoms have been shown to occur within hours of abstinence (McCarthy, Piasecki, Fiore, & Baker, 2006), the present study utilized a 48-hour period of abstinence in order to build upon previous research assessing impulsivity and relapse (Doran et al., 2004) and because tobacco withdrawal symptoms have been shown to peak during the first 48 hours after abstinence (Hughes, 2007; Hughes & Hatsukami, 1986).

Method

Participants

Participants were undergraduate smokers recruited via flyers and e-mail list announcements seeking individuals who smoked at least 16 cigarettes per day for the past 6 months. Eligible smokers ($N=50$, 32% female) had to score a 5 or greater on the Fagerström

Table 1. Sample characteristics (N=50).

Variable	*Mean (SD)*
Age	22.72 (4.7)
Gender (% female)	32.0
Nicotine dependence*	6.2 (1.2)
Cigs. smoked per day	19.44 (3.9)
CO levels	
Baseline	22.7 (8.6)
24 hours	5.3 (2.4)
48 hours	3.4 (2.1)
Previous quit attempts	3.7 (3.6)
Impulsivity**	67.02 (12.4)
Ethnicity (percent)	
Black	4.0
Asian/Pacific Islander	2.0
White	86.0
Hispanic	2.0
Multi-ethnic	4.0
Native American	2.0

Note. *Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerström, 1991). **The Barratt Impulsiveness Scale, version 11 (BIS-11; Patton, Stanford, & Barratt, 1995).

Test for Nicotine Dependence (FTND) (Heatherton, Kozlowski, Frecker, & Fagerström, 1991) and meet the *Diagnostic and Statistical Manual of Mental Disorders Fourth Edition–Text Revision* (*DSM-IV-TR*) criteria for Nicotine Dependence (American Psychiatric Association [APA], 2000). As shown in Table 1, participants were almost 23 years of age (M=22.72, SD=4.8, range=18–40) and smoked approximately a pack of cigarettes each day (M=19.44, SD=3.9, range=16–35). Potential participants were excluded at screening if they reported current use of psychotropic medications, had a psychiatric diagnosis, were nursing, pregnant, or trying to become pregnant, or reported a recent traumatic event that was noted to be distressful. All participants received monetary compensation for their participation in this study.

Procedure

Interested study candidates were screened by telephone. Eligible participants were asked to come to the laboratory for 3 consecutive days (either Monday through Wednesday or Wednesday through Friday). During the first day of the experimental protocol (baseline), informed consent was obtained and smoking status for each participant was biochemically validated using a carbon monoxide (CO) monitor (Model 2900; Vitalograph, Lenexa, KS, USA) with a value of >10 parts per million (ppm) to ensure that each participant was a regular smoker. Participants were informed that they would be asked to provide a CO measure each day that they participated in the study and it was explained that the information would be used to biologically confirm their self-reported 24- and 48-hour abstinence.

Participants were then asked to complete the study questionnaires and to abstain from any form of nicotine use for the following 48 hours. Participants were scheduled for appointments at the same time for the following 2 days. To confirm smoking abstinence at both 24 and 48 hours, a CO level of less than 10 ppm or at least 50% less than the baseline CO reading had to be obtained at the start of Day 2 (24-hour abstinence) and Day 3 (48-hour abstinence). These levels are consistent with the recommendations of the Society for Research on Nicotine and Tobacco Subcommittee on Biochemical Verification (2002). If participants had CO levels greater than this criterion on either Day 2 or Day 3, they were asked to reschedule all days for the following week. If participants had appropriate CO levels, they were asked to complete the same measures they completed at baseline. All 50 participants in this sample successfully abstained from nicotine for the full 48 hours; however 12 of these participants had to be rescheduled for the following week due to CO levels falling above the cutoff. At the end of Day 3, participants were debriefed and any questions related to the study were answered.

Assessments—screening and experimental sessions

Impulsivity. The Barratt Impulsiveness Scale, Version 11 (BIS-11) (Patton et al., 1995) provides a measure of trait-impulsivity divided on three impulsiveness subtraits: acting without forethought, being focused on the present rather than the future, and quick cognitive decision-making (Patton et al., 1995). The BIS-11 is a 30-item self-report questionnaire that asks participants to rate on a 4-point scale the degree to which a series of statements applies to them from "Rarely/Never" (1) to "Always/Almost Always" (4). Cumulative scores range from 30 (low in trait-impulsivity) to 120 (high in trait-impulsivity). The average BIS-11 score in the present sample was 67.02 (SD=12.4). The BIS-11 has three subscales: Nonplanning Impulsiveness (e.g., "spending or charging more than I earn"), Attentional Impulsiveness (e.g., "focusing on the task at hand"), and Motor Impulsiveness (e.g., "acting on the spur of the moment"). For purposes of this study and consistent with similar studies (Doran et al., 2004; Doran et al., 2006; Doran, Spring & McChargue, 2007), the overall BIS-11 score was used as a measure of trait-impulsivity. The BIS-11 has been shown to be reliable in both clinical and community samples, with Cronbach's alpha coefficients ranging from .79 to .83 (Patton et al., 1995). The BIS-11 is structured to

assess long-term patterns of behavior and has been used to assess trait levels of impulsivity across a variety of populations (Mitchell, 1999; Moeller et al., 2001; Stanford, Greve, Boudreaux, Mathias, & Brumbelow, 1996).

Nicotine dependence. The Fagerström Test for Nicotine Dependence (FTND) was used to assess level of nicotine dependence (Heatherton, et al., 1991). The FTND is a brief self-report instrument designed to correlate with physiological measures of nicotine tolerance. The FTND consists of six items rated either from 0 to 1 or from 0 to 3 (depending on the question) that can yield a total score of 10, with higher scores indicating greater nicotine dependence. The FTND has demonstrated adequate internal consistency (Cronbach's alpha=.64; Pomerleau, Carton, Lutzke, & Flessland, 1994) and strong test-retest reliability over time (r=.88) (Pomerleau et al., 1994).

Smoking status. During the screening, participants reported their average daily number of cigarettes smoked. Also, participants' smoking status, as well as abstinence from smoking, was assessed via a CO monitor (Model 2900; Vitalograph, Lenexa, KS, USA). Carbon monoxide measures provide a biological marker to validate smoking status as well as to corroborate self-reported smoking abstinence. According to the guidelines set forth by the Society for Research on Nicotine and Tobacco's Subcommittee on Biochemical Verification (2002), abstinent participants must have CO levels below 10 ppm. Due to the fact that some participants may have very high levels at baseline, a second criterion for the verification of abstinence was considered. Individuals with initial CO levels above 20 ppm must demonstrate a drop in CO level by at least 50%. This criterion has been used in other studies (Bickel, DeGrandpre, Hughes, & Higgins, 1991; Tidey, Higgins, Bickel, & Steingard, 1999).

Nicotine withdrawal and craving. The Withdrawal Symptoms Checklist (WSC) (Hughes & Hatsukami, 1986) is a 12-item self-report measure that is designed to assess the presence of tobacco withdrawal symptoms and the severity of each symptom. The severity scores are based on a 4-point scale, ranging from 0 (not present) to 3 (severe). For purposes of this study, the total score on the WSC was calculated by taking the sum of all the items on the measure minus the craving item. We omitted the "craving" item from the total score since it is not currently listed as a nicotine withdrawal symptom in the *DSM-IV*-TR (APA, 2000). The craving item, however, was used in isolation to assess cigarette craving.

Negative affect. The Profile of Mood States (POMS) (McNair, Lorr, & Droppleman, 1971) is a 65-item self-report questionnaire used to assess distinct mood states. The POMS uses an adjective checklist rated on a 5-point scale ranging from (0=Not at all) to (4=Extremely). The "right now" version was used to determine participants' mood while in the laboratory. Six factors have been derived using factor analysis (McNair et al., 1971) that correspond to the six basic moods assessed (Tension-Anxiety, Depression-Dejection, Anger-Hostility, Vigor-Activity, Fatigue-Inertia, and Confusion-Bewilderment). For purposes of this study, the Tension-Anxiety and Depression-Dejection factors were used as the primary measurement of negative affect.

Data analysis

The primary analysis in the current study included impulsivity as a continuous time-invariant variable while craving, negative affect, and tobacco withdrawal were analyzed across the three time-points (baseline, 24-hour, 48-hour) via a series of repeated measures multilevel models analyses using SAS Proc Mixed. This analysis provided a way to account for variation in the intercepts and slopes across each participant (Littell, Milliken, Stroup, Wofinger, & Schabenberger, 2006). The Proc Mixed method also allows for the ability to specify the covariance structure within a between subjects research design. The covariance structure used for this analysis was the first-order autoregressive, or AR(1) model. This covariance structure was chosen after obtaining estimates of the correlation and covariance among residuals as well as estimates for model fit, as recommended by Littell and colleagues (2006). An AR(1) covariance structure models variance within an observation caused by its relationship to the previous observation. This is appropriate when there is equal spacing between observations. Simple slopes analyses were examined using simple linear regression.

Results

Preliminary analyses

As displayed in Table 2, the relationship between impulsivity and sample characteristics was examined. Results indicated that impulsivity was not significantly related to age, number of previous quit attempts, nicotine dependence, and number of cigarettes smoked per day, gender, or race. Additional correlation analyses (Table 3) assessed the relationships between impulsivity and the outcome measures of anxiety, depression, tobacco

Table 2. Relationships among demographic variables and impulsivity.

	Impulsivity	Quit attempts	Gender	FTND	Cigarettes per day	Race	Age
Impulsivity	–	–	–	–	–	–	–
Quit attempts	−.12	–	–	–	–	–	–
Gender	.14	.11	–	–	–	–	–
FTND	−.13	−.09	.16	–	–	–	–
Cigarettes per day	.15	.16	.20	.31*	–	–	–
Race	.12	.15	−.07	−.13	.16	–	–
Age	−.15	−.12	−.004	.16	.24	−.24	–

Note. *$p<.05$; Pearson's *r*.

withdrawal, and craving. Impulsivity was not significantly associated with any of the outcome measures.

It was hypothesized that among those with increased levels of trait-impulsivity, a 48-hour period of smoking abstinence would induce higher levels of tobacco withdrawal, negative affect, and craving. Analysis using multi-level mixed modeling indicated that there were significant relationships between impulsivity, time, and the interaction of impulsivity and time on each of the outcome scores. Inspections of covariance parameter estimates indicated mostly significant Z values for all estimates. Significant parameter estimates indicate significant variability in intercepts and slopes for the model as specified.

Primary analyses

Craving. An analysis of the relationship between craving and impulsivity indicated a significant impulsivity × time interaction, $F(2, 96)=3.74$, $p<.05$. To determine the nature of this interaction, simple slopes were estimated via simple linear regression. Simple slopes analysis indicated that at 48 hours of abstinence ($\beta=.365$, $t[49]=2.72$ $p<.01$), higher levels of impulsivity predicted greater increases of craving. This relationship was not significant at baseline ($\beta=-.186$, $t[49]=-1.31$, n.s.) or 24 hours of abstinence ($\beta=-.058$, $t[49]=-.405$, n.s.). This indicates that at the 48-hour mark, but not at baseline or 24 hours of abstinence, the more impulsive smokers had increased cigarette craving compared to their less impulsive peers.

Negative affect. Analysis of the relationship between impulsivity and negative affect revealed mixed results. For anxiety, analyses indicated a main effect for impulsivity, $F(1, 48)=11.45$, $p<.01$, as well as a significant impulsivity × time interaction, $F(2, 96)=3.23$, $p<.05$. To determine the nature of the interaction, simple slopes were estimated using simple linear regression. Results indicated that for 24 hours ($\beta=.401$, $t(49)=3.03$ $p<.01$) and 48 hours of abstinence ($\beta=.430$, $t(49)=3.30$ $p<.01$), higher impulsivity predicted increased levels of anxiety during the full abstinence period. No relationship was observed at baseline ($\beta=.204$, $t(49)=1.44$, n.s.). For depression, analyses indicated a trend toward significance for the impulsivity × time interaction, $F(2, 96)=3.03$, $p=.05$. For this sample, heightened levels of impulsivity had a stronger relationship with anxiety than with depression during 48 hours of abstinence.

Total withdrawal. Analysis of the total scores obtained on the WSC indicated a trend toward significance on impulsivity, $F(2, 96)=3.91$, $p=.053$, but the impulsivity × time interaction was not significant, $F(2, 96)=2.34$, n.s. Results indicate that despite significant differences in craving and anxiety, levels of impulsivity did not predict higher levels of tobacco withdrawal during the abstinence period.

Discussion

The present study examined the effect of a 48-hour period of smoking abstinence in an attempt to clarify the role of impulsivity on smoking behavior. The primary aim was to examine the possible mechanisms of relapse that may explain why those higher in trait-impulsivity appear to relapse more quickly during a period of smoking abstinence. For this project, repeated measurements of craving, negative affect, and tobacco withdrawal were taken. As expected,

Table 3. Relationships among outcome measures and impulsivity.

	Impulsivity	Anxiety	Depression	Craving	Withdrawal
Impulsivity	–	–	–	–	–
Anxiety	.26	–	–	–	–
Depression	.07	.67*	–	–	–
Craving	−.16	−.17	−.27	–	–
Withdrawal	.04	.61*	.52*	−.20	–

Note. *$p<.05$; Pearson's *r*.

those with higher levels of trait-impulsivity experienced significantly greater increases in craving at 48 hours of abstinence. Results were mixed, however, with respect to negative affect and tobacco withdrawal. Specifically, elevated impulsivity predicted significant increases in anxiety, but only a trend towards significance was observed for depression. These results indicate that anxiety may be a better predictor of relapse in those with higher levels of trait-impulsivity than depression or more general negative affect. With regard to tobacco withdrawal, no significant differences were found.

To our knowledge, the present study is the first to assess the impact of impulsivity on the mechanisms of relapse in cigarette smokers during an abstinence period without the use of a treatment paradigm. Contrary to prior findings in the literature (Doran et al., 2004), results from this study indicate that the intensity of craving and anxiety increase at a significantly greater rate for those with higher levels of trait-impulsivity. The finding that smokers who have higher levels of impulsivity also had increased cravings for a cigarette is consistent with previous research (Doran et al., 2007). With respect to the relationship between impulsivity and negative affect during an abstinence period, research has been equivocal. The significant increase in anxiety and a trend towards significance for depression found in the present study is consistent with previous research (Emmons & Diener, 1986), suggesting that those higher in impulsivity may be more prone to affective disturbances.

The non-significant finding with respect to tobacco withdrawal raises questions about the symptoms of smoking abstinence that were measured. In a review on tobacco abstinence effects, Hughes (2007) found that three of the most valid symptoms of withdrawal include craving, anxiety, and depression. Other symptoms, such as drowsiness, fatigue, and several physical symptoms were found to be inconsistent in the literature despite their recurrent inclusion on measures of total withdrawal.

Significantly greater increases in craving at the 48-hour period of abstinence among those higher in trait-impulsivity may account for the higher levels of relapse observed among this population. These data are particularly interesting given the current sample was not prepared in advance to effectively cope with the cues in their environment that may trigger craving or withdrawal symptoms experienced during an abstinence period. These findings lend support to previous speculation that those higher in trait-impulsivity have more difficulty finding appropriate and comparable substitutes during a quit attempt (Kreudelbach, McCormick, Schulz, & Grueneich, 1993). The possible implication of this finding is that these individuals are more likely to relapse, because they find cigarettes more rewarding compared to their peers with lower levels of impulsivity.

Important limitations do need to be considered when interpreting or generalizing the findings from the present study. For instance, while all participants were dependent smokers, they were generally college-aged (i.e., 18–24 years old). However, estimates indicate that up to 25% of adult smokers initiated smoking after entering college (Everett et al., 1999) and that nicotine abuse peaks during this time of emerging adulthood (Chen & Kendel, 1995). A second limitation is that the current sample was primarily Caucasian and male, making gender and ethnic group comparisons impossible. Additionally, those who participated were current smokers who were not planning to quit smoking. The results, therefore, could be different if these individuals were not planning to resume smoking after 48 hours.

In summary, the present study suggests that those higher in trait-impulsivity experience greater levels of craving and anxiety during a period of abstinence. Additionally, the significant increases in anxiety coupled with the trend toward significance for depression, suggest that dependent cigarette smokers higher in trait-impulsivity may experience more distress when abstaining from smoking, compared to their less-impulsive peers. The current study builds upon previous research by examining the mechanisms of relapse without the use of a treatment package as part of the experimental protocol. Future research is needed to compare the effect of different cessation tools that are both accessible and rewarding to those higher in trait-impulsivity. Recent evidence supports addressing personality factors in treatment programs for substance misuse (Staiger, Kambouropoulos, & Dawe, 2007). Additionally, because those with higher levels of trait-impulsivity may be more susceptible to cues in their environment, using an ecological momentary assessment (EMA) paradigm during an abstinence period may provide valuable information about individual differences and specific environmental smoking cues that need to be addressed in treatment for those with higher levels of trait-impulsivity.

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