BRIEF REPORT

Breath Holding Duration and Self-Reported Smoking Abstinence Intolerance as Predictors of Smoking Lapse Behavior in a Laboratory Analog Task

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ABSTRACT

Introduction: Distress intolerance (DI) is elevated in smokers and confers increased risk for relapse following a quit attempt. Intolerance of respiratory distress and of nicotine withdrawal may be particularly relevant predictors of smoking cessation outcomes. However, no studies to date have examined the association between smoking relevant DI and smoking lapse behavior in a laboratory setting. The current study examined whether DI was associated with the risk of initiating smoking in a laboratory-based lapse analog task.

Methods: This study is a secondary data analysis from a study of the impact of alcohol administration on smoking behavior. Ninety-six cigarette smokers completed measures of DI and a smoking lapse analog task. Breath holding (BH) duration and self-reported intolerance of smoking abstinence were analyzed as predictors of smoking initiation in a survival analysis model.

Results: Shorter BH duration was associated with greater risk of smoking initiation, controlling for nicotine dependence, nicotine withdrawal symptoms, and demographics. Self-report measures of smoking abstinence DI were not associated with BH duration or time to smoking initiation when controlling for nicotine dependence severity.

Conclusions: BH captures a domain of DI that is specifically associated with a higher risk of initiating smoking in this analog of smoking lapse. The prediction of smoking in an analog lapse task adds to the extant literature identifying an association between DI and smoking lapse and may enable further research to understand and address the mechanism through which BH affects smoking lapse risk.

INTRODUCTION

Distress intolerance (DI)—the perceived inability to manage negative somatic and affective states—is elevated among smokers relative to nonsmokers (Hajek, 1991; Steinberg et al., 2007; Zvolensky, Feldner, Eifert, & Brown, 2001), and high levels of DI predict early lapse following a quit smoking attempt (Brandon et al., 2003; Brown, Lejuez, Kahler, & Strong, 2002; Hajek, Belcher, & Stapleton, 1987). Prospective data suggest a 3 times higher risk of relapse among smokers with elevated versus low DI (Brown et al., 2009). However, much remains to be understood about these associations.

Self-report (e.g., Sirota et al., 2010) and behavioral measures (e.g., Brown et al., 2002; McHugh & Otto, 2011) of DI vary across domains of distress (e.g., frustration and pain), and intolerance of certain domains may be differentially relevant to specific behavioral outcomes. In smokers, behavioral measures of respiratory discomfort intolerance (breath holding [BH] and tolerance for breathing CO_2-enriched air) appear most robustly related to smoking outcomes (Brown et al., 2009; Hajek et al., 1987), although frustration tolerance tasks also are predictive (e.g., Brandon et al., 2003; Brown et al., 2002). With self-report measures, measures of nicotine withdrawal intolerance are more strongly associated with nicotine dependence and quitting history than measures of general intolerance of emotional and physical discomfort (Sirota et al., 2010). Few studies have examined DI and smoking utilizing domain-specific self-report and behavioral measures, and none have used behavioral laboratory analog models to understand how DI impacts lapse behavior under standardized conditions.

The current study tested the hypothesis that shorter BH duration and higher self-reported intolerance of smoking

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abstinence would predict increased risk of initiating smoking in a laboratory-based lapse analog model in which participants were reinforced monetarily for delaying smoking. Data were drawn from a study of the effects of alcohol on smoking lapse (Kahler et al., 2012). We also examined whether the association between DI and initiating smoking would be moderated by nicotine withdrawal severity and motivation to abstain. At very low levels of motivation, all smokers may be likely to smoke regardless of their DI. Likewise, in the absence of nicotine withdrawal, DI may be less relevant to decisions to smoke. Therefore, DI may be more predictive of smoking lapse when there is greater motivation to abstain and greater nicotine withdrawal.

METHODS

Participants

Complete details on study design are presented in Kahler et al. (2012). Participants had to meet the following inclusion criteria: 21–65 years of age, smoking 10–30 cigarettes a day, carbon monoxide (CO) level >10 ppm, current heavy drinking (>5 drinks per occasion for men; >4 drinks for women) at least twice a month, and no history or intent to seek alcohol treatment. Exclusion criteria were current use of nicotine replacement or tobacco products other than cigarettes, plan to quit smoking in the next month, significant alcohol withdrawal symptoms, current affective disorder or psychotic symptoms, current pregnancy or nursing, illicit drug use more than weekly, medical conditions or medications contraindicated for alcohol consumption, and weighing greater than 250 lb. The study was approved by the Brown University Institutional Review Board.

Ninety-six participants completed the study. The sample was 43.8% female with a mean age of 38.6 (*SD* = 11.1) years, and mean education of 13.2 (*SD* = 2.1) years. The sample was 65.3% White, 24.2% African American, 1.1% American Indian, 2.1% Asian, and 7.4% multiracial with 4.2% identifying as Hispanic/Latino. Participants smoked an average of 17.3 (*SD* = 6.0) cigarettes/day.

Procedure

Participants completed a baseline interview and self-report assessments prior to an experimental session. They were instructed to abstain from alcohol for 24 hr prior to study sessions and to abstain from smoking overnight before the experimental session. Compliance was confirmed with a CO reading less than 50% of baseline and a zero breath alcohol concentration.

Participants were randomized to alcohol administration conditions in a 2 × 2 balanced placebo design crossing alcohol administration (Receive Alcohol [0.4 g/kg] vs. Receive Placebo) with instructional set (Told Alcohol vs. Told Placebo). Participants completed self-report measures before alcohol administration began at 3:00 p.m. Those in Told Alcohol were instructed that their beverage contained alcohol, whereas those Told Placebo were instructed that their beverage did not. Those receiving alcohol were provided a weight and sex-adjusted alcohol dose (0.4 g ethanol/kg; 90% of this dose for women) in a beverage containing tonic and vodka mixed in a 5:1 ratio with lime juice. The placebo beverage contained only tonic and lime juice. Participants consumed their beverage in 15 min. Research assistants were unaware of the beverage alcohol content. Prior analyses found no significant effect of beverage condition on smoking lapse behavior and a significant interaction between instruction condition and gender in which women, but not men, showed reduced ability to resist smoking when Told Alcohol versus Told Placebo (Kahler et al., 2012).

Smoking Lapse Task

Fifty minutes after starting drinking, participants were presented with eight cigarettes of their preferred brand and an ashtray (McKee, Krishnan-Sarin, Shi, Mase, & O'Malley, 2006; McKee et al., 2011). Participants were instructed they could initiate smoking at any point over the next 50 min, but that for each 5 min they delayed smoking, they would earn $1 (total of $0 to $10 based on how long they delayed). They were instructed the session would end at 7:00 p.m. regardless of whether they chose to smoke. The time at which participants chose to smoke was the primary dependent variable (range 0–50 min), coded into 5-min intervals for analysis. Following the first cigarette (or the end of the delay period if smoking not initiated), participants were provided a $4.00 "tab," which they could save or use to smoke additional cigarettes at $0.50 each.

Measures

Severity of nicotine dependence was assessed using the Fagerström Test for Nicotine Dependence (FTND; Heatherton et al., 1991). Nicotine withdrawal was assessed with the 7-item Minnesota Nicotine Withdrawal Scale (Hughes & Hatsukami, 1986). Responses ranged from 0 (*none*) to 4 (*severe*). Total score is the mean of the 7 items. Motivation to remain abstinent during the task was assessed indirectly with a single item that asked participants to rate on a 0 (*not at all*) to 10 (*extremely*) scale the importance of maximizing payments on study tasks.

BH (Brown et al., 2002; Hajek et al., 1987) was assessed at baseline with a stopwatch by asking participants to hold their breath for as long as they could. BH duration (seconds to exhalation) correlates positively with ability to tolerate exposure to CO_2-enriched air (Brown et al., 2002, 2009), duration of maintaining a grip (Hajek, 1989; i.e., physical distress tolerance), a behavioral measure of frustration tolerance, and self-report measures of tolerance for both frustration and anxiety (McHugh & Otto, 2011). Self-reported smoking-specific DI was assessed at baseline with the Intolerance for Smoking Abstinence Discomfort Questionnaire (IDQ-S; Sirota et al., 2010), a psychometrically validated 17-item questionnaire. The IDQ-S has two subscales: Withdrawal Intolerance (e.g., "I can't stand that restless, jittery feeling I get if I go too long without a cigarette") and Lack of Cognitive Coping (e.g., "To get through a day without a cigarette, I think to myself 'no pain, no gain'"—reverse scored). Items are rated on a scale of 1 (*strongly disagree*) to 5 (*strongly agree*), with the scale scores being the mean of these items.

Data Analysis Plan

We first ran correlations among background baseline characteristics, BH, IDQ-S subscales, and nicotine withdrawal at the experimental session. We then ran Cox proportional hazards analyses to predict risk of initiating smoking. Models controlled

for sex, FTND, experimental conditions, and the interaction between female gender and Told Alcohol. Each measure of DI was entered individually as a predictor of initiating smoking along with severity of nicotine withdrawal symptoms at the start of the session and motivation to maximize payment. In the second step of these models, interactions between the DI measure and both withdrawal and motivation were added.

RESULTS

Table 1 shows the means and correlations among key study variables. Women had significantly shorter BH duration than men. BH was positively associated with having ever had a 24-hr quit attempt but not with the FTND. Additional analyses indicated that BH was not correlated significantly with years of daily smoking ($r = -.07$) or baseline CO level ($r = .09$). BH showed very low, nonsignificant correlations with both IDQ-S scales. IDQ-S scales were not significantly correlated with each other, but both correlated significantly and positively with the FTND and negatively with having a past 24-hr quit attempt. IDQ-S Withdrawal Intolerance was significantly positively correlated with withdrawal severity, but they shared only 4% of variance. Withdrawal significantly increased from baseline to the experimental session, $t(95) = 6.55$, $d = .67$, $p < .0001$.

In the proportional hazards models, there was a significant effect of BH when controlling for experimental conditions, gender, FTND, nicotine withdrawal, and motivation. For each additional second of BH, the risk of initiating was reduced by 2% (see Table 2). Main effects of IDQ-S scales (tested in separate models along with the covariates) were nonsignificant for both Withdrawal Intolerance (hazard ratio [HR] = 1.18, 95% *CI* = 0.81–1.73, $p = .38$) and Lack of Cognitive Coping (HR = 0.86, 95% *CI* = 0.56–1.30, $p = .47$). When interactions between indices of DI and both nicotine withdrawal and motivation to maximize payments were added to the models, none were significant, $ps > .20$. Given that FTND and nicotine withdrawal both correlated with Withdrawal Intolerance, we reran a model removing these covariates. In that model, Withdrawal Intolerance was significantly associated with greater risk of initiating smoking (HR = 1.49, 95% *CI* = 1.02–2.16, $p = .038$). The effect of Lack of Cognitive Coping was not altered by removing FTND and withdrawal from the model.

CONCLUSIONS

This study provides additional evidence that BH duration predicts the ability to resist smoking, extending previous studies by showing this association in a laboratory analog model. The effect of BH on smoking initiation risk was not moderated by motivation to avoid smoking or nicotine withdrawal, was present despite proximal monetary reinforcement for abstaining from smoking, and remained when controlling for individual differences in the importance of this reinforcer. The mechanisms through which BH affects the ability to resist smoking, however, remain unknown. Prior research indicates that the effects of BH on smoking outcome are independent of lung function (Hajek et al., 1987), and BH was not correlated with years of regular smoking, CO level, or level of nicotine dependence. However, it was positively correlated with having a past 24-hr quit attempt, replicating prior research (Brown et al., 2002). BH was not significantly correlated with self-report measures of smoking-specific DI in this study, highlighting the fact that behavioral and self-report measures of DI can often diverge (McHugh & Otto, 2011).

Self-reported inability to tolerate and cognitively cope with smoking abstinence was associated negatively with having a past 24-hr quit attempt but did not predict risk of initiating smoking in our primary model. The effects of these variables also were not significantly moderated by motivation or level of nicotine withdrawal. However, when severity of nicotine dependence and withdrawal symptoms were removed from the model, greater Withdrawal Intolerance significantly predicted greater risk of initiating smoking. Self-reported withdrawal intolerance may affect lapse risk primarily through its association with greater tobacco dependence.

Limitations

Participants were not intending to quit smoking in this laboratory study. Motivation to avoid smoking could only be inferred from self-reported motivation to maximize payments, and DI may have more limited predictive power when motivation to abstain is very low. Only one behavioral measure of respiratory DI and one self-report measure of abstinence-related DI were included. The relative performance of other measures of DI could not be examined. Despite limitations, results show

Table 1. Correlations Among Distress Intolerance and Background Variables

Variable	*M*	*SD*	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Age	38.57	11.10	–								
2. Female gender	43.8%	–	.07	–							
3. Importance of payment (motivation)	8.32	2.04	.18	.25*	–						
4. FTND	5.29	2.11	.18	−.04	.09	–					
5. Ever had 24-hr quit attempt	64.6%	–	.21*	.08	−.17	−.24*	–				
6. Minnesota Nicotine Withdrawal Scale	0.99	.72	.01	.19	.08	.23*	−.05	–			
7. Breath holding duration (s)	40.12	19.72	−.14	−.35**	−.10	−.05	.21*	−.16	–		
8. IDQ-S Withdrawal Intolerance	3.17	.76	−.01	−.08	.10	.26*	−.23*	.21*	−.02	–	
9. IDQ-S Lack of Cognitive Coping	2.80	.79	−.13	−.002	−.16	.23*	−.26*	.01	−.05	−.09	–

Note. FTND = Fagerström Test for Nicotine Dependence; IDQ-S = Intolerance for Smoking Abstinence Discomfort Questionnaire (possible score range = 1–5). Importance of maximizing payments on study tasks (motivation) ranged from 0 (*not at all*) to 10 (*extremely*). Minnesota Nicotine Withdrawal Scale, assessed prior to alcohol administration, ranged from 0 (*none*) to 4 (*severe*).
*$p < .05$; **$p < .001$.

Table 2. Hierarchical Cox Proportional Hazards Regression Model Predicting Risk of Initiating Smoking During the 50-min Delay Period (*N* = 94)

Variable	Hazard ratio	95% *CI*	*p* value
Received alcohol vs. placebo	1.28	0.73–2.27	.39
Told alcohol vs. placebo	1.27	0.73–2.20	.40
Female	0.82	0.45–1.50	.52
Female × told alcohol	4.34	1.36–13.71	.01
FTND	1.27	1.09–1.48	.002
Importance of payment (motivation)	0.82	0.71–0.95	.008
Minnesota Nicotine Withdrawal Scale	1.03	0.97–1.10	.28
Breath holding duration (s)	0.98	0.96–0.99	.03

Note. FTND = Fagerström Test for Nicotine Dependence. In this analysis, time to choosing to smoke was divided into 10 discrete 5-min segments representing the possible time periods in which participants could choose to smoke. Female gender and experimental conditions were centered. Importance of maximizing payments on study tasks (motivation) ranged from 0 to 10.

that measures of DI can be examined in laboratory analog lapse models, which can facilitate examination of the mechanisms through which DI impacts smoking outcomes and tests of procedures to enhance DI to improve the ability to resist smoking.

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DECLARATION OF INTERESTS

None declared.

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