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Increases in Impulsivity Following Smoking Abstinence are Related to Baseline Nicotine Intake and Boredom Susceptibility

Jasmine Pettiford, **Rachel V. Kozink**, **Avery M. Lutz**, **Scott H. Kollins**, **Jed E. Rose**, and **F. Joseph McClernon***
Duke University Medical Center, Durham, NC 27707

Abstract

Trait impulsivity and response inhibition have been shown to be related to smoking behavior. One measure of response inhibition—antisaccade performance, or the ability to inhibit looking at a novel stimulus—has been shown to be worsened by smoking abstinence, improved by nicotine administration and predictive of smoking cessation outcomes. However, relations between antisaccade performance and measures of trait impulsivity have not been extensively evaluated in smokers. In the present study, twelve dependent smokers (n = 12) completed an eye tracking task following smoking as usual and overnight abstinence; and they completed baseline measures of trait impulsivity, smoking history and provided biological samples. As expected, overnight abstinence significantly increased antisaccade errors ($p < .002$) while having no effect on prosaccade performance. Abstinence-induced increases in antisaccade errors were positively correlated with baseline plasma cotinine and Sensation Seeking Scale Boredom Susceptibility, and negatively correlated with IQ. These results suggest that smoking abstinence significantly increases errors of response inhibition and that the magnitude of this increase is related to trait impulsivity and nicotine intake variables.

Keywords

smoking; impulsivity; antisaccade; sensation seeking; IQ; nicotine

INTRODCUTION

Impulsivity, which has been conceptualized as a dysregulation of inhibitory processes (Evenden, 1999), has been shown to play a role in smoking (Mitchell, 2004) and smoking relapse (Doran, Spring, McChargue, Pergadia, & Richmond, 2004;Powell, Pickering, Dawkins, West, & Powell, 2004). For instance, Doran et al. (2004) found that among participants asked to quit smoking for 48 hrs, those who were higher in trait impulsivity relapsed more quickly than other participants. This relation was not mediated by other potentially important variables (e.g., craving).

One performance based measure of inhibitory processes—the antisaccade task—has been used to study relations between smoking and impulsivity. The antisaccade task measures response inhibition by requiring subjects to inhibit looking at a novel stimulus (Pierrot-Deseilligny, Muri, Ploner, Gaymard, & Rivaud-Pechoux, 2003). Performance on this task has been shown

*Corresponding Author: Dr. McClernon, DUMC 2701, Durham, NC 27708; Tel.: 919-668-3987; Fax: 919-668-5088; mccle011@mc.duke.edu

to reliably differentiate healthy controls from individuals who are higher in trait impulsivity, such as individuals with ADHD (Feifel, Farber, Clementz, Perry, & Anllo-Vento, 2004;Munoz, Armstrong, Hampton, & Moore, 2003) and drug dependence (Rosse, McCarthy, Alim, & Deutsch, 1994). Overnight abstinence from smoking has been shown to result in worse antisaccade performance (Powell, Dawkins, & Davis, 2002). Moreover, the administration of 4 or 6 mg nicotine gum was shown to significantly decrease antisaccade error rates compared to placebo gum (Larrison-Faucher, Matorin, & Sereno, 2004). Additionally, Powell et al (2004) found that the degree to which nicotine (4 mg lozenge) improved antisaccade performance in overnight deprived smokers was correlated with self-reported nicotine dependence and predicted relapse during the first week after quitting (Powell, Pickering, Dawkins, West, & Powell, 2004).

Despite studies showing relations between measures of trait impulsivity and smoking, and antisaccade performance and smoking; relations between trait impulsivity and antisaccade performance among smokers has not been thoroughly evaluated. Therefore, the goals of the present study were to address this question by evaluating relations between abstinence-induced changes in antisaccade performance and measures of smoking behavior and trait impulsivity.

METHODS

Participants

Participants were 14 adult smokers recruited from the community. These participants were part of a larger study examining individual differences in tobacco withdrawal for which antisaccade data was available. Potential participants were required to smoke ≥ 15 cigarettes per day and have an afternoon CO level ≥ 15 ppm. Two participants' data were not analyzed due to missing or incomplete data. The study was approved by the Duke University Institutional Review Board.

Procedure

Following a baseline session, participants completed two 2.5 h experimental sessions—each scheduled to start between 7 and 9 a.m. Prior to one of the sessions, participants were required to maintain abstinence starting at 10 p.m. the previous night (abstinent session). Prior to the other session, participants could smoke freely and they were also allowed two smoke breaks during the session (satiated session). Otherwise, the experimental sessions were identical. The order of sessions (abstinent first vs. satiated first) was randomly assigned.

Smoking and Personality Measures

Expired air carbon monoxide (CO)—Verification of smoking status and overnight abstinence was obtained using expired air CO concentrations (BreathCo, Vitalograph, Lenexa, Kan. USA). The criteria for CO following overnight abstinence was individually determined using a previously validated formula (Rose & Behm, 2004) based on each smoker's baseline afternoon CO level.

Baseline cotinine—Plasma cotinine concentrations were determined from samples taken at screening. Cotinine concentrations were assayed using gas chromatography (Jacob, Wilson, & Benowitz, 1981).

Smoking history—Smoking history was assessed using a 14-item questionnaire.

Nicotine dependence—The 6-item Fagerström Test for Nicotine Dependence (FTND) was administered (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991). FTND scores ranged from 0 to 10.

Kaufman Brief Intelligence Test (KBIT)—General cognitive functioning was assessed using the KBIT (Kaufman & Kaufman, 1990) which yields estimates of verbal, nonverbal and overall functioning.

Barratt Impulsivity Scale (BIS)—The Barratt Impulsivity Scale version 11 (BIS-11; Patton, Stanford, & Barratt, 1995) is a 30-item measure of three domains of trait-impulsivity: attentional, motor and non-planning impulsiveness. The reliability of the scale in clinical and community samples is adequate (Cronbach's α = .79 to .83; Patton, Stanford, & Barratt, 1995).

Sensation Seeking Scale Form V (SSS-V)—The SSS-V (Zuckerman, 1993) contains 40 forced-choice items yielding a Total Score and four subscales: Thrill and Adventure Seeking (TAS), Experience Seeking (ES), Disinhibition (DIS), and Boredom Susceptibility (BS).

The Tridimensional Personality Questionnaire (TPQ)—The TPQ (Cloninger, 1986) is a 100-item true-false questionnaire. The self-report personality inventory measures three major personality dimensions: Novelty Seeking, Harm Avoidance, and Reward Dependence.

Eye Tracking Measures

Eye Tracking—Eye movements were measured using an ASL EYE-TRAC 6000 eye-tracking system (Applied Science Laboratories, MA). A near-infrared light was used to illuminate the pupil and corneal reflection, from which pupil diameter and line of gaze was extracted (sampling rate = 60 Hz). Visual stimuli were displayed on a computer screen 77 cm from the participants' eyes. At the beginning of each trial, a central fixation circle that was either gray or white was presented on a black background for a random duration between 1250 and 1750 ms. The fixation circle disappeared 200 ms prior to the presentation of a white target asterisk. The target was displayed for 1750 ms, 6.8° from center. If the fixation circle was gray, participants were instructed to look in the opposite direction of the target (antisaccade). If the circle was white, they were instructed to look towards the target (prosaccade). Each task consisted of 110 trials—30 prosaccade and 80 antisaccade—presented in random order.

Analysis Saccades were classified as artifactual, correct, or incorrect. Trials were marked artifactual if the direction of the saccade initiation could not be distinguished due to excessive noise, loss of pupil-corneal reflection, excessive head movement. Both pro- and anti-saccades were classified as incorrect if all of the following conditions were met: 1) saccade initiation was in the wrong direction, 2) the incorrect saccade generated was more than 2.3° (one-third) in the wrong direction, and 3) the incorrect saccade was not corrected by an eye movement in the correct direction within 150 ms. All other saccades were classified as correct.

RESULTS

Sample Characteristics

The sample was 58.3% female (n = 7). Reported racial/ethnic group membership was 83.3% Caucasian (n = 10), 8.3% African American (n = 1), and 8.3% Other/Unspecified (n = 1). Mean age was 32.08 years (SD = 6.10). Two participants (16.6%) completed high school or equivalent (n = 2), 8 had some college/technical education (n = 66.6%), and 2 were college graduates/post-grads (16.6%). Mean FTND score was 4.40 (SD = 1.4).

Smoking behavior

Participants smoked a mean of 18.75 (SD = 4.33) cigarettes per day, and reported smoking a mean of 13.17 (SD = 6.62) years. Six (n = 6; 50.0%) reported smoking menthol cigarettes.

Mean cotinine level at screening was 187.57 ng/mL (SD = 66.61). Pre-session CO levels were indicative of satiety and overnight abstinence (see Table 1).

Task performance

Participants exhibited a significantly higher percentage of antisaccade errors on the abstinent day, $F(1,11) = 16.20$, $p < .002$, Table 1. In contrast, prosaccade performance was unaffected ($p > .05$). Abstinence did not affect percentage of artifactual trials (p's > .05).

Correlates of antisaccade performance

A change score reflecting the effects of abstinence on antisaccade performance was calculated (% incorrect on abstinent day - % incorrect on satiated day). As can be seen in Table 2, this change score was significantly positively correlated with baseline plasma cotinine and SSS Boredom Susceptibility and negatively correlated with IQ. Of these three variables, only IQ and SSS Boredom Susceptibility were correlated with each other ($r = -.705$, $p = .01$).

DISCUSSION

The results of the present study show that smoking abstinence results in significantly increased impulsive responses as measured by the antisaccade task, while not affecting prosaccade performance. Anti-saccade change scores were significantly correlated with higher baseline plasma cotinine levels, Boredom Susceptibility scores from the SSS, and lower IQ estimates.

Consistent with earlier research (Powell, Dawkins, & Davis, 2002), our results show that smoking abstinence increases response inhibition errors among smokers—a finding with important implications for understanding smoking withdrawal. Smoking has been viewed as a behavior that becomes highly automated over time (Field, Mogg, & Bradley, 2006), and that can be triggered by any number of both internal (e.g., withdrawal; stress) and external triggers (e.g., conditioned smoking cues)(Beckham et al., 2005;Krukowski, Solomon, & Naud, 2005;Shiffman et al., 2002). From this viewpoint, maintaining abstinence would require the inhibition of a prepotent reponse (i.e. smoking) in the face of cues that previously automatically led to smoking behavior. The findings of the present study, along with others (e.g., Powell, Pickering, Dawkins, West, & Powell, 2004), suggest that smoking abstinence results in poorer response inhibition that likely exacerbates attempts to remain abstinent.

We also observed a significant positive relation between abstinence-induced decrements in response inhibition and baseline plasma cotinine levels, an index of nicotine intake. This suggests that smokers who administer higher levels of nicotine experience greater disturbances of response inhibition during abstinence. This finding may account for previous observations that smokers higher in nicotine dependence exhibit greater improvement in antisaccade performance by nicotine following abstinence (Powell, Pickering, Dawkins, West, & Powell, 2004).

Lower IQ and greater Boredom Susceptibility were also correlated with worsening of response inhibition by overnight abstinence. Individuals who are high in Boredom Susceptibility and have lower levels of intellectual functioning may require higher levels of environmental stimulation to achieve the same levels of arousal as individuals who do not share these traits. As such, smoking may serve to increase arousal in these individuals and smoking abstinence may therefore cause greater disruptions in this process. Very little work has been done examining the relationships among Boredom Susceptibility, IQ, and response inhibition, so interpretation of this interesting finding will require additional research. In any case, given the high correlation between IQ and Boredom Susceptibility, these are likely to be measuring a comparable underlying construct.

The present study provides additional evidence of the effects of smoking abstinence vs. smoking satiety and relates abstinence-induced worsening of response inhibition to important individual difference variables. Future studies will examine the effects of nicotine replacement and treatments designed specifically to reduce abstinence-induced disinhibition on antisaccade performance and smoking cessation outcomes.

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Table 1

Carbon monoxide levels and percent incorrect on prosaccade and antisaccade trials in the satiated and abstinent conditions.

	Satiated		Abstinent	
	Mean	**SD**	**Mean**	**SD**
CO (ppm)	28.25	12.64	9.58	5.66
Prosaccade	2.96	2.85	2.12	1.66
Antisaccade	19.24	10.61	27.50	12.04

Table 2

Correlations between IQ, smoking behavior and personality variables with change in % antisaccade errors in the Abstinent – Satiated conditions.

	Abstinent – Satiated % Antisaccade Errors
IQ	
KBIT Score	−.630*
Smoking Behavior	
Cigarettes per day	−.037
Baseline expired CO	−.081
Baseline plasma cotinine	.656*
FTND	.099
Personality Measures	
BIS	
Motivational Impulsiveness	−.316
Non Planning Impulsiveness	−.221
Attentional Impulsiveness	.047
Total	−.225
SSS	
Total Sensation Seeking	.310
Thrill And Adventure Seeking	.272
Experience Seeking	−.265
Disinhibition	.118
Boredom Susceptibility	.583*
TPQ	
Reward Dependence	−.101
Novelty Seeking	−.352
Harm Avoidance	−.230

All *n*'s = 12 except FTND (*n* = 10)

* $p < 0.05$ (2-tailed)