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Pharmacology, Biochemistry and Behavior 78 (2004) 647–652

PHARMACOLOGY BIOCHEMISTRY AND BEHAVIOR

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Cue reactivity in smokers: the effects of perceived cigarette availability and gender

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Received 17 February 2004; received in revised form 17 March 2004; accepted 22 March 2004

Abstract

We examined the effects of perceived cigarette availability and gender on smoking cue reactivity. Smokers were exposed to smoking cues (smoking paraphernalia) and control cues whilst their subjective and physiological responses were measured. Perceived cigarette availability was manipulated on a between-subjects basis before cue exposure. Relative to control cues, smoking cues evoked increases in the level of skin conductance in all participants. Cigarette craving was also increased in the presence of smoking cues, but only in female participants. Perceived cigarette availability had no effect on these responses. Participants also showed salivary reactivity to smoking cues, with males showing a decrease in salivation, and females showing an increase, but only when cigarettes were perceived as unavailable. These results suggest that perceived cigarette availability may not influence craving and skin conductance reactivity to smoking cues in minimally dependent smokers who are not nicotine deprived. In addition, the present data suggest that there are important gender differences in craving reactivity to smoking cues.

Keywords: Gender differences; Smoking; Skin conductance; Craving; Salivation

1. Introduction

Smokers' perceptions of cigarette availability can mediate their responses to smoking cues (see Wertz and Sayette, 2001; Droungas et al., 1995; Dols et al., 2000, 2001). For example, Juliano and Brandon (1998) demonstrated that exposure to smoking cues evoked slightly higher craving than exposure to control cues, but only in a subgroup of participants who expected to be able to smoke after the cue exposure session, and not in participants who were instructed that they could not smoke.

Although craving in response to perceived cigarette availability has been widely studied, there have been few investigations into physiological reactivity to perceived cigarette availability. However, patterns of physiological reactivity may be expected to differ when smokers expect to be able to smoke compared to when they perceive cigarettes as unavailable. For example, autonomic reactivity may differ when smokers are frustrated at being unable to smoke compared to when they are expecting to smoke soon and physiological systems are preparing for motor activity (Tiffany and Conklin, 2000). One aim of the present study was to examine the effect of perceived cigarette availability on responses to smoking cues, using physiological and self-report measures. We measured subjective craving, skin conductance level, and amount of salivation as our dependent variables. Cigarette craving is the most widely studied measure of smoking cue reactivity and its sensitivity to perceived cigarette availability has been demonstrated (e.g., Juliano and Brandon, 1998). Skin conductance level was measured as it has been demonstrated that electrodermal activity is sensitive to presentation of smoking cues (Drobes and Tiffany, 1997), to the perceived availability of cigarettes (Carter and Tiffany, 2001), and to frustration caused by removal of access to a reinforcer (Otis and Ley, 1993). The amount of salivation was studied as a previous study from our laboratory (Field and Duka, 2001) demonstrated that salivation was sensitive to the perceived availability of smoking.

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0091-3057/$ – see front matter © 2004 Published by Elsevier Inc.
doi:10.1016/j.pbb.2004.03.026

A further aim of the present study was to examine gender differences in smoking cue reactivity, as there is some evidence for differential patterns of smoking cue reactivity in male and female participants (e.g., Niaura et al., 1998; Morgan et al., 1999; Hogarth et al., 2003). For example, Perkins et al. (2001) demonstrated that olfactory and taste cues are an important determinant of satisfaction from smoking and of smoking behaviour in female, but not male smokers. Therefore, responses to smoking cues may be an important determinant of smoking motivation and behaviour, particularly in female smokers (see also Perkins, 1999). Gender differences in reactivity to drug cues have also been observed for users of other drugs. For example, Robbins et al. (1999) demonstrated that female cocaine-dependent participants were more likely than males to report increased drug craving in response to presentation of cocaine cues. In the present study, we aimed to examine if these results would generalise to smokers: that is, we hypothesised that female smokers would show elevated craving in response to smoking cues, compared to male smokers.

In the experiment presented here, smokers were exposed to in vivo smoking and matched control cues and their physiological and subjective reactivity to those stimuli was recorded. Participants' perceptions of cigarette availability were manipulated on a between-subject basis. We predicted that smoking cues would only evoke increased cigarette craving (relative to control cues) in smokers who perceived cigarettes to be available after the cue exposure sessions, and that physiological reactivity to smoking cues would differ in participants who perceived cigarettes to be available compared to participants who perceived cigarettes to be unavailable. We also explored the effect of gender on smoking cue reactivity, to examine whether females would show enhanced reactivity to smoking cues, relative to males.

2. Method

2.1. Participants

Thirty-six participants (16 male) were recruited from students and staff at the University of Sussex. Participants responded to a recruitment poster requesting participants for a study of smoking and mood. Participants were only permitted to take part in the study if they were over 18 years of age and smoked at least 10 cigarettes per day. Participants abstained from smoking for at least 1 h before coming to the laboratory. To explore gender differences in smoking cue reactivity, we planned to include gender as a factor in all analyses. However, gender and age were confounded as males were significantly older than females [24 vs. 21 years, $t(34) = 2.45$, $P < .05$], but this difference was due to three male participants, aged 33 and above, who were extreme outliers in age (as evident from a box and whisker plot). To maintain a homogenous sample, these three participants were removed from all subsequent analyses, which eliminated this gender difference in age ($t < 1$, ns). For the remaining participants, the mean number of cigarettes smoked per day was 14.36 (S.D. = 3.73, range 10–20), the mean number of years smoking was 5.35 (S.D. = 2.28, range 1–10), the mean score on the FTQ was 3.97 (S.D. = 1.51, range 1–8), and the mean level of expired CO at the start of the session was 7.29 ppm (S.D. = 5.97, range 0–27). Participants gave their informed consent before participating in the study, which was approved by the University of Sussex ethics committee.

2.2. Materials

2.2.1. Stimuli

Participants' own cigarettes and lighter were used as the smoking-relevant stimulus set (stimulus SMOK). The control stimuli consisted of three stationery items: a stapler, a pen, and a pencil (stimulus CTRL).

2.3. Physiological measurements

2.3.1. Skin conductance

Skin conductance level measurements (μS) were taken over a period of 1 min using an Electronic Development skin conductance instrument, which was interfaced to a PC for data processing. Electrodes were smeared with ECG paste and attached with surgical tape to the distal phalanxes of the second and fourth fingers of the nondominant hand.

2.3.2. Amount of salivation

The amount of salivation was measured over a period of 1 min by placing two 3-cm-long cotton swabs in participants' mouths, in between the cheek and lower jaw, one on each side. The swabs were weighed before and immediately after being placed in participants' mouths to calculate the amount of saliva produced.

2.4. Subjective craving

2.4.1. Questionnaire of Smoking Urges-brief form (QSU-brief; Cox et al., 2001)

The 10-item QSU-brief was administered to participants to evaluate their urge to smoke. The QSU was administered at baseline and during both periods of stimulus exposure. QSU scores range from 1 (*low craving*) to 7 (*high craving*).

2.5. Procedure

Upon arrival in the laboratory, participants provided an expired CO sample on a smokerlyser (Bedfont Scientific Ltd., Bedford, UK) and then completed the Fagerstrom Tolerance Questionnaire (FTQ; Fagerstrom, 1978) and provided information about current smoking rate and the number of years of regular smoking.

Participants were then seated in the experimental cubicle whilst baseline measurements were taken. The skin conduc-

tance electrodes were attached and participants placed the cotton rolls into their mouths. Skin conductance recording then commenced for 1 min. After this period, participants removed the cotton rolls from their mouths and then completed the QSU-brief. Participants were then given 60 s to complete a version of the Digit Symbol Substitution Task (DSST, Lezak, 1995), which functioned as a filler task.

The experimenter then read out the cigarette availability information to the participants. Group POS was told that the experiment would take up to 3 h, although they would be given a break in about 20 min time, and they would be able to smoke as much as they pleased during this break. Group NEG were given similar information, but they were told that they would not be able to smoke during the break, and they would not be able to smoke until the experiment was over. Participants were randomly allocated to group POS or NEG, with the provision that the gender ratio was identical for both groups.

Stimulus exposure sessions then began. Either CTRL or SMOK stimuli were placed on the desk in front of the participant (the order of stimulus presentation was counterbalanced between participants). Participants placed more cotton rolls into their mouths and skin conductance recording began. Participants were then instructed to handle and look at the objects, whilst thinking about the properties of the objects, for 60 s. Subsequently, participants removed the cotton rolls from their mouths, and then completed a QSU-brief. Participants then left the experimental cubicle and were seated in an adjoining waiting room, where they were given 60 s to complete as much of a DSST as possible. Participants remained in the waiting room for a further 5 min before returning to the experimental cubicle.

The skin conductance electrodes were reattached and the second stimulus exposure session began with the remaining set of stimuli (SMOK or CTRL), whilst skin conductance and salivation were recorded, as above. After this period of stimulus exposure, participants completed a further QSU brief. Participants then completed two brief computer tasks in which their attentional responses to smoking-related photographs were examined. These tasks are not described in detail and the results are not discussed. After completion of these tasks (which took approximately 10 min in total), the experimenter informed the participants that the experiment was over, despite what they had been told earlier. Participants were then debriefed, thanked for their time, and paid £5 sterling.

2.6. Statistical analysis

Amount of salivation, skin conductance level, and QSU-brief scores during stimulus exposure sessions were analysed using a mixed ANOVA, with stimulus type (two levels: SMOK/CTRL) entered as a within-subject factor, and perceived availability group (two levels: POS/NEG) and gender, entered as between-subject factors.

3. Results

3.1. Variables related to smoking status and history

Table 1 shows participants' age, number of cigarettes smoked per day, number of years smoking, FTQ scores, and expired CO at the beginning of the session, separately for male and female participants in groups POS and NEG. To ensure that there were no between-group differences in these variables that may have confounded the results obtained, a series of ANOVAs was performed on the data above using expectancy group and gender as grouping variables. There were no significant main effects or interactions (Ps>0.1). There were 7 males and 10 females in group POS, and 6 males and 10 females in group NEG. Groups did not differ significantly in gender ratio ($\chi^2 < 1$, P>.1).

3.2. Baseline responses

To ensure that there were no between-group differences in baseline responses, a series of ANOVAS was performed using perceived availability group and gender as between-subject variables. None of the main effects or interactions were statistically significant (Ps>.1).

3.3. Stimulus exposure sessions

3.3.1. Skin conductance level

Table 2 shows the mean level of skin conductance in response to SMOK and CTRL stimuli, separately for male and female participants in groups POS and NEG. Due to technical problems, skin conductance data was missing from one participant. There was a statistically significant main effect of stimulus type [$F(1,28) = 4.59$, $P < .05$], which reflects a higher skin conductance level during exposure to SMOK compared to CTRL, in all participants. All other

Table 1
Variables related to smoking status and history for male and female participants in positive (POS) and negative (NEG) perceived availability groups

Perceived availability group	POS	NEG
Age (years)	Males 21.86 ± 2.19	Males 22.17 ± 2.40
	Females 20.90 ± 1.79	Females 21.30 ± 2.50
Cigarettes smoked (daily)	Males 13.86 ± 2.34	Males 15.50 ± 4.32
	Females 12.70 ± 3.43	Females 15.70 ± 4.19
Number of years smoking	Males 5.07 ± 2.17	Males 6.17 ± 2.14
	Females 5.15 ± 2.96	Females 5.25 ± 1.84
FTQ	Males 4.29 ± 1.98	Males 4.00 ± 1.67
	Females 3.80 ± 1.75	Females 3.90 ± 0.88
Expired CO	Males 10.17 ± 4.96	Males 8.17 ± 5.71
	Females 4.00 ± 3.40	Females 8.44 ± 7.95

Values are mean ± S.D.
FTQ = Fagerstrom Tolerance Questionnaire; expired CO = expired carbon monoxide.

main effects and interactions were not statistically significant (*P*s>.1).

3.3.2. Amount of salivation

Table 2 shows the mean amount of salivation in response to SMOK and CTRL stimuli, separately for male and female participants in groups POS and NEG. The three-way interaction Stimulus Type × Perceived Availability Group × Gender was statistically significant [$F(1,29)=4.22$, $P<.05$], but all other main effects and interactions were not statistically significant (*P*s>.1). To explore the interaction, we split the sample based on perceived availability group and conducted ANOVAs with gender as the between-subjects variable and stimulus type as the within-subjects variable. The Gender × Stimulus Type interaction was not statistically significant for participants in group POS (*P*>.1), but it approached significance for participants in group NEG [$F(1,14)=4.20$, $P=.06$]. This marginal interaction occurred because females, but not males, had a higher level of salivation in response to SMOK compared to CTRL when smoking was not available (NEG condition).

3.3.3. Craving (QSU brief)

Fig. 1 shows mean QSU-brief scores after exposure to SMOK and CTRL stimuli, separately for males and females. The main effect of stimulus type was statistically significant [$F(1,29)=14.13$, $P<.01$], as was the Gender × Stimulus Type interaction [$F(1,29)=4.48$, $P<.05$]. Females had higher craving after SMOK compared to CTRL [$t(19)=4.32$, $P<.01$], whereas males did not demonstrate differential craving in response to the stimuli (*P*>.1). All other main effects and interactions were not statistically significant (*P*s>.1).

4. Discussion

The present study demonstrates cue reactivity in smokers, as participants reacted to the presentation of smoking cues with an increase in subjective craving and skin conductance level. We also demonstrated a gender difference in craving reactivity to smoking cues as female, but not male, smokers responded to the presentation of smoking cues with an increase in cigarette craving. Unexpectedly, our primary hypothesis was not supported, as craving and skin conductance responses to smoking cues were not influenced by perceptions of cigarette availability. However, we did demonstrate a marginally significant gender difference in salivary reactivity to smoking cues when cigarettes were perceived to be unavailable, as females showed an increase in salivation in response to the smoking cue, and males showed a decrease in salivation.

The observed craving and skin conductance responses to smoking cues are generally consistent with the existing literature. Smoking cues evoked higher levels of craving and skin conductance than control cues, which is consistent with existing research (e.g., Drobes and Tiffany, 1997; Carter and Tiffany, 2001; Morgan et al., 1999), yet these responses were not affected by the perceived availability manipulation. Possible limitations of the manipulation in the present study, which may explain the failure to demonstrate different patterns of craving and skin conductance reactivity in response to the perceived availability manipulation, are discussed below.

The finding that craving reactivity to smoking cues was higher in female than in male smokers is the first demonstration that females are more sensitive to nonpharmacological cues associated with nicotine. The majority of existing research does not report analyses of gender differences in smoking cue reactivity, although some studies do suggest that gender is a factor which can influence cue reactivity (e.g., Niaura et al., 1998; Morgan et al., 1999; Perkins et al., 2001; Hogarth et al., 2003). However, the

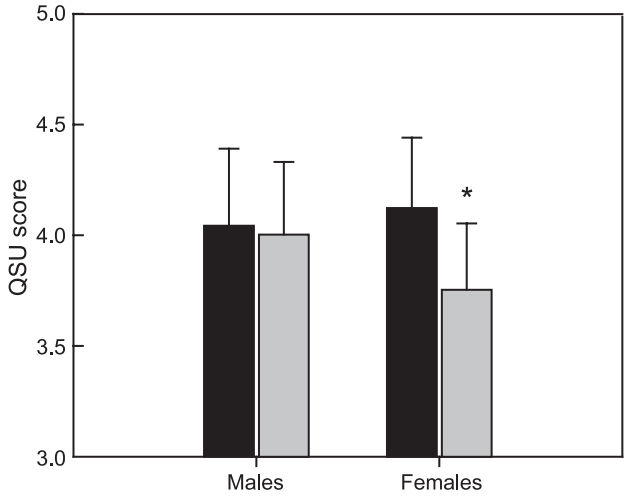

Fig. 1. QSU-brief scores after exposure to smoking [SMOK (■)] and control [CTRL (▒)] cues, shown separately for male and female participants. Values are mean±S.E.M. *$P<0.05$ compared to SMOK in females.

Table 2
Physiological reactivity to SMOK and CTRL stimuli for male and female participants in positive (POS) and negative (NEG) perceived availability groups

Perceived availability group	POS		NEG	
Gender	Male	Female	Male	Female
Skin conductance level (μS)				
SMOK	17.40 ± 8.39	21.74 ± 12.07	19.34 ± 3.42	16.26 ± 6.88
CTRL	17.54 ± 6.12	18.55 ± 7.47	16.27 ± 4.94	14.64 ± 5.63
Amount of salivation (g)				
SMOK	0.41 ± 0.35	0.40 ± 0.21	0.34 ± 0.16	0.37 ± 0.27
CTRL	0.35 ± 0.25	0.39 ± 0.29	0.39 ± 0.13	0.29 ± 0.17

Values are mean ± S.D.

present study is the first demonstration of elevated craving in response to smoking cues in female, compared to male smokers. As such, the present results are comparable to results reported by Robbins et al. (1999), who demonstrated that cocaine-dependent females had elevated craving in response to a cocaine cue, compared to cocaine-dependent males. These results suggest that females are more sensitive to drug-related cues in general, and that these effects are not specific to any one drug class.

The observed gender difference in smoking cue reactivity also complements the existing literature on gender differences in the response to nicotine and nicotine-associated stimuli. Perkins (1999) has demonstrated that females are less sensitive than males to the discriminative stimulus effects of nicotine, which are known to depend on the interoceptive effects of nicotine, such as changes in mood (Duka et al., 1998). On the other hand, females are more sensitive than males to exteroceptive stimuli associated with smoking (such as the taste of tobacco smoke and the sensations of smoke on the throat; Perkins, 1996; Benowitz and Hatsukami, 1998, Perkins et al., 1999). For example, Perkins et al. (2001) demonstrated that subjective satisfaction from smoking was inhibited by the removal of the taste and olfactory cues that are normally associated with smoking, but only in female smokers. The results reported in the present study are consistent with this literature, in that they also demonstrate enhanced sensitivity to exteroceptive stimuli related to smoking in females compared to males.

Future treatments for smoking cessation may need to recognise this gender difference in reactivity to smoking cues. For example, it may be particularly important for female smokers to formulate strategies to cope with exposure to smoking cues when attempting to remain abstinent.

There was an interaction which approached significance for a gender difference in the salivary response to smoking cues when participants thought that they could not smoke, as female participants showed elevated salivation in response to smoking cues, but males showed a decrease in salivation. There are no reports of salivary reactivity in response to 'naturalistic' smoking cues, such as those used in the present study. However, a previous study from our laboratory (Field and Duka, 2001) demonstrated that arbitrary cues which had been paired with smoking in a laboratory conditioning paradigm produced a decrease in salivation, relative to cues which had been paired with the explicit absence of smoking, but only during an 'extinction' phase of the experiment, in which participants perceived cigarettes to be unavailable. The present results suggest that naturalistic smoking cues may also provoke a decrease in salivation when cigarettes are perceived to be unavailable, albeit only in male smokers. It is unclear why this decrease in salivation was not seen in females who instead showed an increase in salivation. It is possible that the smoking-related cues were perceived as more appetitive by the females compared to males, particularly when access to cigarettes was blocked.

Several existing studies demonstrate that smoking cue reactivity can be potentiated if participants are led to believe that they will be able to smoke after the cue exposure sessions (Juliano and Brandon, 1998; Droungas et al., 1995; Dols et al., 2000, 2001). While our procedure was similar to that described by Juliano and Brandon (1998), it differed in some crucial aspects, particularly participant characteristics (the smokers in the present study were relatively moderate smokers, compared to the heavy smokers who were recruited by Juliano and Brandon) and withdrawal (participants in the present study abstained for only 1 h before coming to the laboratory, whereas Juliano and Brandon's participants had abstained from smoking for 3 h before attending the laboratory). We suggest that perceived cigarette availability may only influence smoking cue reactivity in heavy smokers who are nicotine deprived, which may account for the failure of the present study to replicate earlier results. Future studies may wish to explore the relative contributions of gender and perceived cigarette availability to smoking cue reactivity in heavily dependent, nicotine-deprived smokers to resolve this issue.

In summary, in the present study, we have demonstrated cue reactivity to smoking-related cues in a sample of young smokers, which is consistent with, and builds upon, the existing literature. Females responded to smoking cues with an increase in cigarette craving but males did not, whereas both males and females demonstrated increased skin conductance reactivity in response to smoking cues. This gender difference is consistent with the notion that females are more sensitive to nonnicotine aspects of smoking than males.

Acknowledgements

This research was supported internally by a University of Sussex Research Development Fund.

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