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Psychophysiological reactivity to environmental tobacco smoke on smokers and non-smokers

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ABSTRACT

Environmental tobacco smoke (ETS) is an air pollutant with a relevant impact on public health. In addition, ETS is a significant stimulus that may elicit different responses depending on previous experience and current status regarding smoking. Exposure to cigarette cues has been shown to be a reliable method for inducing subjective and physiological responses. However, the role of ETS as a stimulus has not received, to date, enough attention in the research literature. This study aimed to analyse both the autonomic and subjective responses of smokers and non-smokers to exposure to ETS. To that end, 41 non-smokers and 57 smokers were exposed to ETS, in a controlled laboratory setting. We measured the subjective perception of smoke, unpleasantness, heart rate and skin conductance to compare the reactions of smokers and non-smokers to ETS. Additionally, subjective tobacco craving after exposure was assessed for current smokers. We found different psychophysiological responses to ETS exposure for smokers and non-smokers. Smokers showed a generalised increase in autonomic activity, significantly greater than that of non-smokers. In addition, heart rate increase during exposure to ETS was positively correlated with subjective craving. Our data suggested that ETS was an important stimulus and acted as a relevant cue for smokers; it induced both psychophysiological reactions and subjective craving. Hence, this kind of stimulus within the cue-reactivity research paradigm may be useful for studying the effect of ETS on smokers' reactions, craving, quitting attempts, or relapse probabilities.

1. Introduction

Exposure to cigarette cues has been shown to be a reliable method for eliciting subjective and physiological responses among smokers (Carter et al., 2009; Field, Mogg, & Bradley, 2004; Lee, Lim, Wiederhold, & Graham, 2005; Miranda, Rohsenow, Monti, Tidey, & Ray, 2008). The typical reaction includes an increase in subjective craving and, physiologically, an alteration in autonomic responses. For example, exposure to smoking-related cues appeared to increase an electrodermal response or skin temperature (Carter & Tiffany, 1999; Carter et al., 2006; Doran, McChargue, & Spring, 2008; Field et al., 2004; Miranda et al., 2008; Tong, Bovbjerg, & Erblich, 2007). This exposure also appeared to affect cardiovascular reactivity (e.g., heart rate or blood pressure); however, these results are inconsistent (Tong et al., 2007). Both subjective and physiological responses seem to be affected by several other variables, including gender, nicotine deprivation, presence of environmental stressors, induction of a negative affect, impulsivity, alcohol intoxication, or smoking availability (Bailey, Goedeker, & Tiffany, 2009; Doran et al., 2008; Perkins et al., 2001; Tong et al., 2007).

Cue reactivity studies are typically conducted in a laboratory setting with a variety of stimuli. Most stimuli are 2-dimensional images (Attwood, O'Sullivan, Leonards, Mackintosh, & Munafò, 2008; Carter et al., 2009; Lochbuehler, Peters, Scholte, & Engels, 2010; Mogg, Field, & Bradley, 2005; Tong et al., 2007; Upadhyaya, Drobes, & Thomas, 2004) but some groups have used in vivo cue exposure, where the deprived subjects are shown objects like cigarettes, lighters (Bailey et al., 2009; Doran et al., 2008; Miranda et al., 2008; Naqvi & Bechara, 2006; Payne, Smith, Adams, & Diefenbach, 2006; Tidey, Rohsenow, Kaplan, & Swift, 2005; Upadhyaya, Drobes, & Wang, 2006), or even virtual reality scenarios (Lee et al., 2005; Paris et al., 2011; Traylor, Parrish, Copp, & Bordnick, 2011).

Olfactory perception has specific value as a cue for smoking that is not applicable to drugs like cocaine or heroin. The aroma of tobacco differs from that of alcohol because it can be perceived at a relatively long distance. The aromas of cigarettes and smoke have an important evocative value for smokers because they trigger the urge to smoke (Grüsser, Heinz, & Flor, 2000). Nevertheless, olfactory stimuli have not received enough attention in the cue-reactivity literature on smoking. For instance, Grüsser et al. (2000) specifically analysed the effect of nicotine aroma and concluded that it increased craving in deprived smokers. However, they measured only subjective responses. Smoking-related olfactory stimuli may also be present within a more general context of in vivo exposure used in other studies. Procedures included allowing the subject to manipulate cigarettes; light a

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cigarette, but not touch it to the mouth; or watch someone else smoke in the same room (Carpenter et al., 2009; Collins, Nair, & Komaroff, 2011; Doran et al., 2008; Miranda et al., 2008; Payne et al., 2006; Sayette & Parrott, 1999; Tidey et al., 2005; Upadhyaya et al., 2006; Watson, Carpenter, Saladin, Gray, & Upadhyaya, 2010). All of these procedures could involve cigarette or smoke aroma, but as a by-product, or secondary stimulus, and in a mixture with other visual or contextual cues simultaneously. Those that recorded psychophysiological responses found increases in electrodermal activity (Carpenter et al., 2009); reports of cardiovascular response (e.g., changes in heart rate or blood pressure) have been inconsistent (Doran et al., 2008; Erblich, Bovbjerg, & Sloan, 2011; Miranda et al., 2008; Payne et al., 2006; Tidey et al., 2005; Upadhyaya et al., 2006). Nevertheless, in all these studies, the stimulus-exposure condition was nonspecific and there was no measure of olfactory perception. Hence it is not possible to determine how the smoke aroma contributed to the measured responses, or even whether it was actually perceived. Thus, to our knowledge, no study has measured specifically both subjective and physiological responses of smokers to a tobacco-related olfactory stimulus, like ETS.

It is well known that exposure to environmental tobacco smoke (ETS) is associated with increased morbidity and mortality for smokers and non-smokers. ETS appears to affect cardiovascular activity (Dietrich et al., 2007), but it also has a relevant stimulus value. ETS is associated with smoking behaviour and previous experience, and it has been suggested that sensory cues like ETS may acquire incentive value through a learned association with drug reward mediated by the central nervous system (Megerdichian, Rees, Wayne, & Connolly, 2007). Additionally, it provides a small dose of the addictive substance, which might enhance a craving for smoke. In many countries, recent regulations regarding smoking in public places have considerably reduced the exposure to ETS; however, ETS has not been completely eliminated, and it remains a controversial issue for some socio-economic sectors. On the other hand, ETS as a stimulus may have different effects on smokers (current and previous) and non-smokers; acting to increase craving and the probability of relapse for the former and as an aversive stimulus for the latter. Therefore, an analysis of the response to ETS may offer relevant information for understanding the immediate response of both, smokers and non-smokers, to ETS, the impact of ETS on attempts at quitting, and the necessity of retaining public smoking regulations.

The present study is a preliminary analysis of autonomic and subjective responses elicited by ETS. We exposed subjects to tobacco smoke in a controlled laboratory setting and compared measures of heart rate (HR), skin conductance, and subjective perceptions of smokers to those of non-smokers. Additionally subjective craving after exposure was assessed for current smokers in order to test whether laboratory exposure to ETS is appropriate for eliciting craving and the utility of this procedure in studying cue-reactivity responses. Taking into account the common findings in cue-reactivity literature, we hypothesised that subjects exposed to ETS would experience an increase in autonomic responses (i.e., SCL and HR), and that such increase would be higher for smokers than for non-smokers. We also hypothesised that exposure to ETS would cause an associated increase in smokers' subjective craving.

2. Methods and materials

2.1. Subjects and overview

Subjects were undergraduate university students who volunteered to participate. They provided basic demographic data and responded to health and smoking questionnaires. Exclusion criteria were the current use of medications known to affect cardiovascular reactivity (e.g., anxiolytics), report of current or past drug/alcohol abuse, having been diagnosed with major psychiatric or unstable medical conditions, and presence of allergies or diseases of the respiratory or olfactory system.

After the selection process, the sample was formed by 98 subjects (78 females and 20 males) with a mean age of 19.1 (SD = 1.92). Forty-one (85% females) had never smoked and 57 (75.4% females) smoked at least once per week. The age distribution did not vary between groups. The average number of cigarettes smoked per day by smokers was 10.1 (SD = 6.61; range 1 to 35).

All participants were asked to avoid caffeinated beverage intake on the day of the laboratory session. Additionally, smokers were required to abstain from smoking for at least 3 h before arriving at the laboratory. Observance of deprivation instructions was assessed using an expired carbon monoxide (CO) monitor. A cut-off value of CO ≤ 15 ppm was used to verify compliance.

2.2. Stimulus materials

The study was conducted in a darkened, sound-attenuating chamber. The data acquisition system and computers were located in an adjacent room. In order to avoid threat or surprise reactions upon perception of ETS, which could alter the subjects' responses, they were previously informed that they would attend to a series of smoking-related stimuli. Hence, an introductory set alternating neutral and tobacco-related images was prepared. This set was intended to introduce the session and minimise the effect of expectancy on the subjects' responses to ETS, while not inducing significant reactions per se. It consisted of 14 images that represented low-arousing smoking-related scenes (i.e., a group of people smoking, a pack of cigarettes, an ashtray, etc.), alternated with 15 neutral (non-smoking related) and low-arousing images selected from the International Affective Picture System (IAPS) (Lang, Bradley, & Cuthbert, 2008). The whole set had been tested previously in our laboratory and it did not produce any significant long-lasting physiological change in either smokers or non-smokers. Its effect was limited to an initial non-significant decrease in HR, characteristic of an attentional response to a novel stimulus, followed by a quick return to baseline levels. Subjects were first exposed to the introductory set. Images were presented on a 21-inch colour TV monitor. Following the introductory set, the TV screen remained blue for 20 s and then exposure to ETS began.

Tobacco smoke was introduced into the experimental chamber through a silicone tube (6 mm diameter) that communicated with the adjacent room. The tube was fixed to the back of the chair in which participants sat, out of sight. In the other room, the end of the tube had a plastic fitting that could be coupled to a syringe for inoculating the smoke into the chamber. To fill the syringe with smoke, we developed a system with two mouthpieces joined by a short tube. A cigarette was attached to one mouthpiece, and the syringe (60 ml) was fitted to the other. The cigarette was lit, and smoke was drawn into the syringe. The filled syringe was removed, attached to the end of the tube that connected to the chamber, and smoke was inoculated. This process was repeated four times at 20-s intervals.

The smoke inoculation system was tested on a different sample of volunteers ($N = 15$). In this preliminary study, results indicated that the olfactory stimulus appeared to be adequate for eliciting subjective and psychophysiological responses in the subjects.

2.3. Apparatus and physiological recordings

The physiological signals were acquired, amplified, and filtered with an A.D. Instruments PowerLab 8/sp data acquisition system, with a ±10 V range. The system was controlled by a 32-bit 68340-intern microprocessor set to 16 MHz and had a maximum speed acquisition of 100,000 samples/s; this was connected to a PC through a USB port (data transfer of 500 kb/s). The system converted analogue signals to digital with a 16-bit A/D converter. Control of the