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Validation of smoking-related virtual environments for cue exposure therapy

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ABSTRACT

Craving is considered one of the main factors responsible for relapse after smoking cessation. Cue exposure therapy (CET) consists of controlled and repeated exposure to drug-related stimuli in order to extinguish associated responses. The main objective of this study was to assess the validity of 7 virtual reality environments for producing craving in smokers that can be used within the CET paradigm. Forty-six smokers and 44 never-smokers were exposed to 7 complex virtual environments with smoking-related cues that reproduce typical situations in which people smoke, and to a neutral virtual environment without smoking cues. Self-reported subjective craving and psychophysiological measures were recorded during the exposure. All virtual environments with smoking-related cues were able to generate subjective craving in smokers, while no increase was observed for the neutral environment. The most sensitive psychophysiological variable to craving increases was heart rate. The findings provide evidence of the utility of virtual reality for simulating real situations capable of eliciting craving. We also discuss how CET for smoking cessation can be improved through these virtual tools.

1. Introduction

Smoking is the first preventable cause of death in developed countries. The World Health Organization, in its *WHO Report on the Global Tobacco Epidemic*, reported that if current tobacco use persists, it will cause the deaths of more than 8 million people worldwide every year by the year 2030 (World Health Organization, 2009).

There is extensive clinical evidence that several psychological and pharmacological therapies used either alone or in combination are effective in the treatment of smoking (Lancaster, Stead, & Cahill, 2008; Mottillo et al., 2009). Multicomponent psychological treatments are characterized by the combined use of several behavioral techniques in order to act on the different factors that maintain tobacco use. Studies verifying the effectiveness of this procedure are numerous, and research identifies it as the first-choice approach for the treatment of tobacco addiction (American Psychiatric Association, 1996; Fiore et al., 2008; U.S. Department of Health and Human Services, 1996). However, the high rates of relapse found at follow-up (between 40% and 70%) suggest the need to incorporate more effective strategies for relapse prevention in such programs (Hajek, Stead, West, Jarvis, & Lancaster, 2009; Hatsukami, Stead, & Gupta, 2008).

Lapses and relapse to drug use are usually associated with high-risk situations characterized by the presence of drug-related stimuli (Marlatt & Gordon, 1985; Piasecki, 2006). Unlike what happens with other substances of abuse, where risk situations are highly specific and can easily be avoided, cigarette smoking is usually related to daily situations that either cannot or should not be avoided. For this reason, exposure techniques emerge as a potential solution for the treatment of tobacco use (Drummond, Tiffany, Glautier, & Remington, 1995; Ferguson & Shiffman, 2009; García-Rodríguez, Pericot Valverde, Gutiérrez Maldonado, & Ferrer García, 2009).

Cue exposure therapy (CET) involves controlled and repeated exposure to drug-related cues, aimed at reducing reactivity through extinction processes. Given that low craving levels have been linked as a predictor to success in long-term abstinence after interventions (Ferguson, Shiffman, & Gwaltney, 2006; Killen & Fortmann, 1997), craving responses have typically been selected as the main target in CET. Craving has been assessed through self-reported measures, unidimensional scales and multidimensional questionnaires (Heishman, Singleton, & Moolchan, 2003).

Additionally, some psychophysiological measures, such as heart rate, temperature, blood pressure, skin conductance or salivation have been cited as possible craving indicators (Rosenberg, 2009). Carter and Tiffany (1999) reviewed the psychophysiological changes most commonly associated with cue reactivity in different substances (tobacco, alcohol, cocaine and heroin). Overall effects indicated that substance abusers exposed to drug-related cues showed heart rate increase, skin conductance increase and reductions in skin temperature. However, the effect sizes associated with these changes are small for some substances, and significant changes do not appear consistently in all the studies reviewed (Choi et al., 2011; Conklin, Robin,

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Perkins, Salkeld, & McClernon, 2008; LaRowe, Saladin, Carpenter, & Upadhyaya, 2007; Upadhyaya, Drobes, & Thomas, 2004). More accurate knowledge of psychophysiological responses during cue exposure procedures is needed for a better understanding of craving.

Self-reported measures involve limitations as regards the validity of the measure, but the assessment of craving through psychophysiological correlates has also received considerable criticism. Such criticism mainly refers to the fact that the use of these measures implies an interpretation of these types of responses solely indicative of conditioned response, failing to take into account other processes related to drug desire (Drummond et al., 1995). More research is needed in order to clarify the nature of subjective craving and its possible correlates.

In smoking research, cues have been presented in various modalities, including photographic stimulus (e.g., pictures and slides of smoking paraphernalia), videos (Tong, Bovbjerg, & Erblich, 2007), imaginary procedures (e.g., imaging being in situation related to smoking) and *in vivo* presentations of cues (e.g., watching someone smoke, or holding a cigarette, ashtray or lighter). A key finding of these studies is that smokers exposed to smoking-related cues increased craving levels (Carter & Tiffany, 1999; Substance Abuse and Mental Health Services Administration, 2010; Tong et al., 2007; Upadhyaya et al., 2004). Nevertheless, most of these studies have used mainly isolated cues within the laboratory, overlooking the fact that craving is related not only to specific or proximal cues but also to contexts and more complex real situations.

A recent field of study that in which such limitations might be overcome involves the use of Virtual Reality (VR) as a tool for exposure procedures. VR is a computer technology that generates three-dimensional environments in which the individual interacts in real time, producing a sense of immersion similar to presence in the real world (Gutiérrez Maldonado, 2002). VR offers severals advantages compared to other exposure methods: First, the high degree of control over exposure parameters (precise degree of difficulty, repetition of the situation as many times as necessary); second, the low risk of embarrassment or an increase in overlearning and self-efficacy expectations; third, its ability to present proximal and distal cues simultaneously; fourth, it can simulate several real situations related to smoking; fifth, participants do not have the feeling of observing the situation from outside, as often occurs with conventional methods (e.g., videos); and finally, VR provides the opportunity for more ecologically valid assessments.

VR has shown itself to be a useful tool for to the assessment and treatment of several psychological disorders, including specific phobias (Garcia-Palacios, Hoffman, Carlin, Furness, & Botella, 2002), fear of flying (Rothbaum, Hodges, Smith, Lee, & Price, 2000) acrophobia (Emmelkamp et al., 2002), post-traumatic stress disorders (Gerardi, Cukor, Difede, Rizzo, & Rothbaum, 2010) and eating disorders (Ferrer-Garcia, Gutierrez-Maldonado, Caqueo-Urizar, & Moreno, 2009).

Recent studies have used VR to assess and produce craving in smokers, concluding that this technique may be superior to conventional methods for triggering and assessing craving (Baumann & Sayette, 2006; Bordnick, Graap, Copp, Brooks, & Ferrer, 2005; Lee et al., 2003; Paris et al., 2011; Saladin, Brady, Graap, & Rothbaum, 2006; Traylor, Bordnick, & Carter, 2009). However, further research is needed in order to translate basic research into clinical practice. Despite the good results of previous studies, most of them simply used virtual paraphernalia or avatars smoking at parties or in bars, selecting the situation to be recreated as a virtual environment *ad hoc*. The variety of cues related to drug use is an important practical issue for the improvement of smoking cessation treatments from a CET perspective (Garcia-Rodriguez et al., 2011). In order to reduce craving though extinction procedures, it is important to use a wide range of stimuli that help to promote generalization of responses in different contexts and real-life situations. More diverse environments that represent everyday situations where people tend to smoke are necessary for the use of this technique in treatment settings and for exploiting all the advantages VR can offer to the smoking cessation field.

The main objective of this study is to assess the validity of seven immersive virtual reality environments to produce craving in smokers that can be used within the CET paradigm. A second objective is to analyze some psychophysiological variables as possible correlates of subjective craving that may help to avoid the need for self-reported measures.

2. Materials and methods

2.1. Participants

Forty-six smokers and 44 never-smokers volunteered to take part in research on Virtual Reality and smoking. The sample comprised 47 males and 43 females with an age range of 18 to 60 (Mean age = 25.57, SD = 9.90); there were no statistical differences between smokers and never-smokers in either age or sex. In the smokers group, mean number of cigarettes smoked per day was 15.57 (SD = 5.37). Participants were recruited with the snowball sampling method starting from undergraduate and postgraduate psychology students at the University of Barcelona.

Inclusion criteria for participation were age over 18, and for smokers, a minimum smoking rate of 10 cigarettes per day. Participants were excluded if they were diagnosed with a current severe psychiatric disorder (dementia or psychotic disorders), if they were diagnosed with dependence for a substance other than nicotine, if they had a smoking-related illness or if they were currently involved in smoking cessation activity.

2.2. Instruments and variables

2.2.1. Virtual environments

Seven virtual environments were developed on the basis of a previous study about common situations and specific cues that produce smoking craving (Garcia-Rodriguez et al., 2011). The situations were as follows: *Being in a pub, having lunch at home, having breakfast at home, having coffee at a cafe, having lunch at a restaurant, waiting in the street* and *watching TV at night*. We also developed an environment without specific smoking craving cues that reproduced two rooms in *a museum* (Fig. 1).

The virtual environments were presented by means of a Head Mounted Display (5DT HMD 800 Series, Fifth Dimension Technologies Inc., Irvine, CA) with tracking sensors (InertiaCube3, Intersense Inc., Billerica, MA) that allowed users to change the orientation of viewpoints with their head movements. A standard mouse device was used for the interactions with executable objects and avatars during the exposure. Each environment had a 6-minute exposure time.

2.2.2. Subjective craving

Subjective craving was assessed by means of a visual analogical scale (VAS) built-in the virtual environments. Participants were required to rate the strength of their desire to smoke at that precise moment, from 0 (no desire) to 100 (intense desire). Craving was assessed before the start of each environment (pre-exposure) and after the six minute session in the environment (post-exposure).

2.2.3. Psychophysiological measures

Psychophysiological variables were selected based on the main correlates of craving cited in previous studies (Carter & Tiffany, 1999). The three physiological parameters most commonly associated with cue reactivity are heart rate (HR), skin resistance (SR) and temperature (T). An I-330-C2+ 6 Channel (J&J Engineering, Poulsbo, WA) computerized biofeedback system with USE3 Physiolab Software (J&J Engineering, Poulsbo, WA) was used to record these variables. After an adaptation