Available online at www.sciencedirect.com
ScienceDirect
Addictive Behaviors 31 (2006) 1881–1894
ADDICTIVE BEHAVIORS

A preliminary report on the use of virtual reality technology to elicit craving and cue reactivity in cocaine dependent individuals

Michael E. Saladin [a,*], Kathleen T. Brady [b], Ken Graap [c], Barbara Olasov Rothbaum [d]

[a] College of Health Professions and Department of Psychiatry and Behavioral Sciences, Medical University of South Carolina, Charleston, SC, USA
[b] Neuroscience Division, Department of Psychiatry and Behavioral Sciences, Medical University of South Carolina, Charleston, SC, USA
[c] Virtually Better Inc., Atlanta, GA, USA
[d] Trauma and Anxiety Recovery Program, Department of Psychiatry, Emory University School of Medicine, Atlanta, GA, USA

Abstract

In the present feasibility study, we developed a 3-dimensional virtual "crack" cocaine environment and evaluated the environment's ability to elicit subjective craving and cue reactivity (i.e., subjective emotional responding, heart rate and skin conductance) in 11 crack cocaine dependent individuals. Each of the seven 3-D crack cocaine scenes in the cocaine environment depicted actors engaging in a range of using-related behaviors (i.e., smoking crack) whereas the neutral environment contained scenes depicted 3-D aquariums with active aquatic life (baseline measures were obtained following immersion in the neutral environment). Results indicated that craving was significantly elevated during the cocaine-related scenes as compared to baseline. Craving varied by scene content, with scenes depicting active cocaine use eliciting the highest levels of craving. Heart rate was significantly higher in four of the scenes with drug use content and positive affect (i.e., happiness) ratings were significantly lower during cocaine scenes as compared to baseline. Overall, the results suggest that a standardized and stimulus rich virtual reality environment effectively elicits craving and physiologic reactivity. Such technology has potential utility in the development and refinement of exposure-based behavioral and pharmacological interventions for substance use disorders.

Keywords: Virtual reality; Craving; Cue reactivity; Cocaine dependence

* Corresponding author. Medical University of South Carolina, College of Health Professions, Rehabilitation Sciences Department, 151 Rutledge Ave., Building B, PO Box 250965, Charleston, SC 29425, USA. Tel.: +1 843 792 5306; fax: +1 843 792 0710.
E-mail address: Saladinm@musc.edu (M.E. Saladin).

0306-4603/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.addbeh.2006.01.004

A considerable volume of empirical literature has documented that stimuli associated with drug administration (e.g., sight and smell of preferred alcoholic beverage, syringes, lighters, pipes, etc.) can elicit subjective reports of craving and patterns of physiological responding in persons who have extensive drug use histories. This phenomenon, referred to as cue reactivity, is typically studied in laboratory settings where participants are systematically exposed to a collection of cues that elicit responses presumed to relate to the motivational processes involved in relapse to drug use (cf., Drobes, Saladin, & Tiffany, 2001; Drummond, Tiffany, Glautier, & Remington, 1995b). In fact, there is growing evidence that craving occurring in the natural environment of addicted individuals is associated with substance use (cf., Robbins & Ehrman, 1998; Shiffman et al., 1997; Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996). Accordingly, there is growing consensus that research on craving and cue reactivity has substantial clinical significance.

In the study of cocaine addiction, a variety of modes of stimulus presentation have been used to elicit craving and cue reactivity. In vivo cue presentation is one of the most common modalities and involves presentation of substance related cues such as a bag of simulated cocaine, cocaine pipe and lighter (cf., Ehrman et al., 1998; Saladin et al., 2003). While one virtue of the in vivo stimulus presentation method is that participants can manipulate the cues during exposure, its primary liability is that the range and complexity of stimuli that are typically employed is somewhat limited. Other studies, in an attempt to capture some of the more complex and dynamic stimulus features of cocaine addiction, have successfully employed a video depicting the purchasing, preparation and smoking of crack cocaine (Childress, Ehrman, McLellan, & O'Brien, 1988; Childress, McLellan, Ehrman, & O'Brien, 1988; Childress et al., 1999; Ehrman, Robbins, Childress, McLellan, & O'Brien, 1992; Robbins, Ehrman, Childress, & O'Brien, 1992). Recently, our research group has used both in vivo and video cue presentation formats to elicit craving in cocaine dependent individuals and have found the video format to be superior to in vivo cues (but see Johnson, Chen, Schmitz, Bordnick, & Shafer, 1998). This informal observation led us to consider other methods of presenting stimuli that might increase and/or accentuate the breadth, salience and dynamic features of cocaine cues that can be used in cue reactivity studies.

One novel and potentially promising methodology that has not yet been used for stimulus delivery in cue reactivity studies is virtual reality (VR) technology. The most common approach to the creation of a virtual environment is to outfit the user with a head-mounted display unit. The head-mounted display consists of separate display screens for each eye, along with some type of display optics, stereo earphones, and a head-tracking device. Rather than being a passive, external observer of video images, VR allows an individual to become immersed in a computer-generated, 3-dimensional world that changes in realistic ways in response to head and body motion (Anderson, Rothbaum, & Hodges, 2001; Rothbaum & Hodges, 1999). The immersive and interactive 3-dimensional qualities provided by VR technology has led to its successful use in the exposure-based treatment of a variety of clinical disorders including acrophobia (Emmelkamp, Bruynzeel, Drost, & van der Mast, in press; Emmelkamp et al., 2002; Rothbaum et al., 1995a,b), fear of flying (Rothbaum, Hodges, Anderson, Price, & Smith, 2002; Rothbaum, Hodges, Smith, Lee, & Price, 2000; Smith, Rothbaum, & Hodges, 1999), combat-related PTSD (Rothbaum e al.,1999; Rothbaum, Hodges, Ready, Graap, & Alarcon, 2001), panic disorder (Vincelli, Choi, Molinari, Wiederhold, & Riva, 2001), spider phobia (Garcia-Palacios, 2002) and public speaking anxiety (Anderson, Zimand, Hodges, & Rothbaum, 2005). In all of these clinical applications, the VR technology was employed to provide a standardized, realistic and stimulus rich environment. Likewise, it seems possible that the use of VR could be extended to