Short communication

Utilizing virtual reality to standardize nicotine craving research: A pilot study

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Abstract

Traditional cue reactivity provides a methodology for examining drug triggers and stimuli in laboratory and clinical settings. However, current techniques lack standardization and generalization across research settings. Improved methodologies using virtual reality (VR) cue reactivity extend previous research standardizing exposure to stimuli and exploring reactions to drug cues in a controlled VR setting. In a controlled pilot trial, 13 nicotine-dependent participants were allowed to smoke ad libitum then exposed to VR smoking and VR neutral cues and compared on craving intensity. VR smoking cues significantly increased craving compared to VR neutral cues. On average, craving intensity increased 118% during exposure to VR smoking cues. Implications for substance abuse research and treatment using VR to assess cessation and anticraving medications are discussed.
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1. Introduction

Cue exposure research in addiction allows systematic study of reactions to drug stimuli and behavioral triggers. Cue reactivity research extends across all substances of abuse. Traditionally, laboratory cue exposure studies utilize imagery scripts, multimedia (e.g., photos and

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video), or drug paraphernalia. During laboratory cue exposure, dependent measures including physiology, endocrinology, mood state, and subjective craving are recorded. While the effects are generally robust, this methodology has not yet had the expected influence upon the behavioral treatment of addiction.

Studies of cue reactivity in nicotine-dependent persons exposed to visual, auditory, and tactile (paraphernalia) smoking cues result in increased urges and craving to smoke compared to non-smoking-related cues (Lazev, Herzog, & Brandon, 1999; Sayette, Martin, Wertz, Shiffman, & Perrott, 2001; Tiffany, Cox, & Elash, 2000). This suggests that applying cue exposure methodology clinically should have merit. However, clinical literature does not bear this out as results indicate relatively limited generalization of the effects after such treatment. We believe that there are several underlying methodological issues (e.g., the cues may lack ecological validity, tend to be presented out of context, and lack standardization across settings) that limit the application of cue exposure practices beyond the laboratory. Further, more complex cues involving combinations of social interactions, affective experiences, and physical cues need to be incorporated into cue exposure protocols in order to improve treatment generalization.

Additionally, development of a standardized cue delivery system provides a valid and reliable method to test reactivity to a variety of substance cues in both clinical and laboratory settings. Given remission rates after substance abuse treatment, new approaches using virtual reality (VR) technology to create ecologically valid, complex cues, and standardized delivery systems are clearly warranted.

VR combines computer graphics and peripheral devices including motion trackers, visual head mounted displays (HMD), vibration platforms, and audio to create immersive environments (Rothbaum, Hodges, Ready, Graap, & Alarcon, 2001), which offer opportunities to create and apply complex stimuli in drug craving research. VR expands traditional cue exposure methods by providing standardized computer-controlled exposure to stimuli and real-time assessments that incorporate inanimate and animate cues. In a controlled clinical trial, we tested a VR cue exposure system with nicotine-dependent cigarette smokers. We hypothesized that VR-based smoking cues would elicit increased craving compared to VR neutral cues.

2. Method

2.1. Participants

Thirteen (male = 4; female = 9) non-treatment-seeking, nicotine-dependent smokers (mean age = 37.1; S.D. = 12.2) were recruited for participation in this trial. Participants met the following criteria: nicotine dependence; smoked 21 cigarettes or more per day for at least the past 2 years; reported good physical health; and were able to wear HMD for up to 40 minutes. Participants who had current diagnosis of severe mental illness, substance dependence (other than nicotine), illicit drug in the past 30 days, or pregnancy were excluded.

2.2. Design and procedure

After obtaining informed consent on the first of two visits to the University of Georgia VR lab, participants were assessed for study eligibility and familiarized with procedures and equipment. Each was entered into an immersive VR environment unrelated to the craving study to familiarize them with the HMD and the hand controllers. Subsequently, each returned to the lab a second time to complete the VR craving study. After being randomly assigned to one of two standardized and timed experimental design paths through neutral and cue rooms containing smoking materials and social interactions, subjects were preloaded with nicotine (smoked one cigarette ad libitum) (see Fig. 1). Upon return to the lab, an HMD (VFX-3D, Interactive imaging Systems, Rochester, NY) was donned. Participants were instructed to relax for 5 minutes until the VRCE program began. After 5 minutes, the immersive VR program was initiated with a baseline visual analog scale (VAS) craving measure. Each participant was exposed to two neutral cue rooms and two smoking cue rooms; each room was timed at 3 minutes. The computer navigated participants through the virtual rooms with timed pauses at the various stimuli. The experimental session was completed in 26 minutes. Neutral cues included four underwater scenes arranged in a room designed to look like an art gallery, and each scene was a moving picture that ran for 15 seconds. Smoking cues included an inanimate room that contained smoking materials, burning cigarettes, cigarette packs, ash trays, a bar, and a percolating coffee pot and an animate room that consisted of a party setting, where people were smoking, drinking, and interacting with the participant by offering a cigarette (see Fig. 2). After presentation of each cue room, participants rated craving intensity on a VAS by using the hand controller to select a position along a line anchored on the left by "not at all" and on the right by "more than
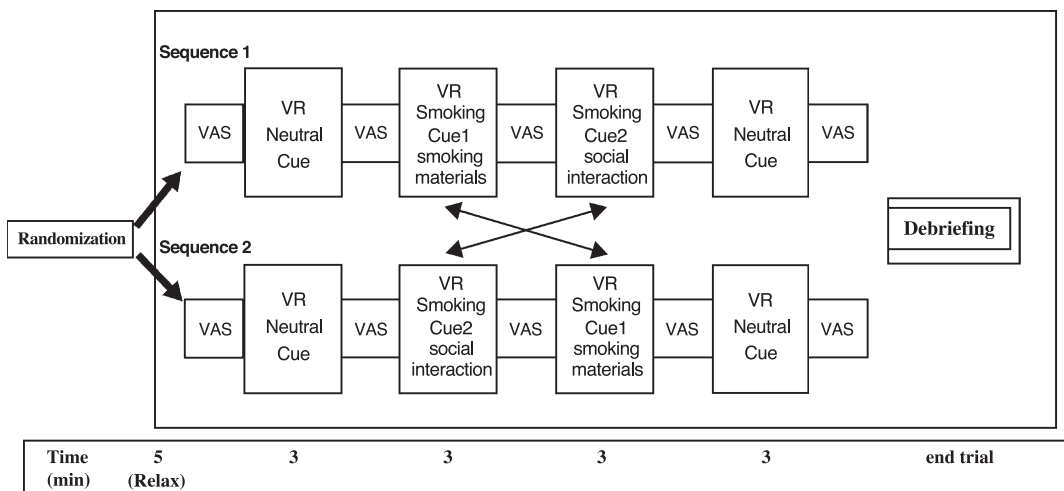

Fig. 1. Each square represents a room in the virtual world; two sequences of rooms are presented. In Sequence 2, the order of smoking cue rooms is reversed to counterbalance the effects of immersion time.
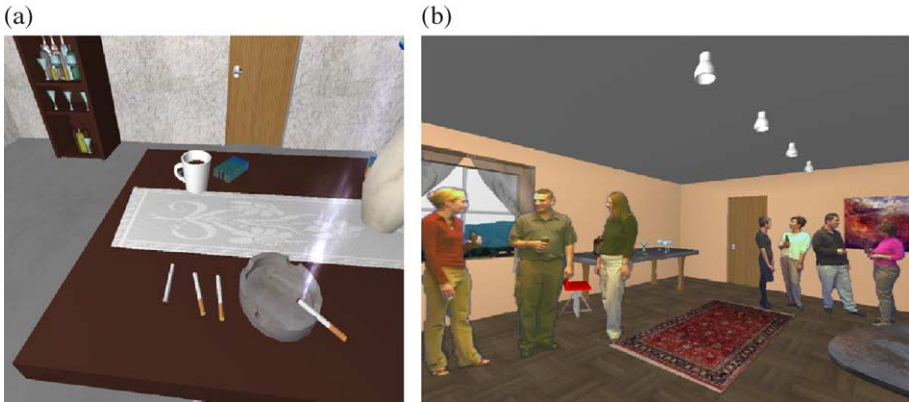
(a)   (b)

Fig. 2. Inanimate (a) and animate (b) VR smoking rooms.

ever.'' This VAS craving item has been used to measure craving for alcohol and drugs of abuse with appropriate content modification (Johnson, Chen, Schmitz, Bordnick, & Shafer, 1998; Preston & Jasinski, 1991).

3. Results

A repeated measures ANOVA resulted in a significant main effect across the baseline, neutral, and smoking VR areas ($F = 15.0$, $df = 4$, $P < .001$). Post hoc analysis indicated that
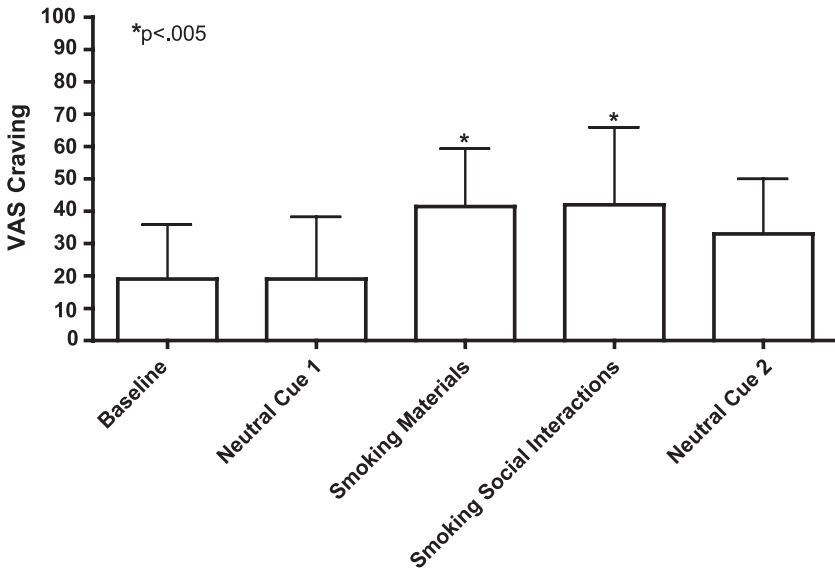

Fig. 3. VAS craving ratings across neutral and smoking rooms. Craving intensity was higher in smoking rooms compared to neutral rooms.

exposure to VR smoking cues led to significantly increased craving compared to baseline and VR neutral condition (see Fig. 3). Analyses indicated that the VR neutral cue did not increase craving and thus was a valid neutral stimuli. Final craving ratings trended toward presession levels but baseline was not recovered. On average, craving increased 118% from neutral to smoking cues.

4. Discussion

This first, controlled trial using VR cue reactivity demonstrated that VR smoking cues effectively increase subjective craving in nicotine preloaded, dependent smokers. VR allows experimental manipulation of cues in a systematic, standardized, repeatable methodology. While the second neutral cue serves to decrease subjective craving, a trend towards recovery of baseline craving levels was observed. Overall, data in this VR trial are similar to the results using traditional cue reactivity studies on smokers (e.g., Lazev et al., 1999; Sayette et al., 2001; Tiffany et al., 2000).

Demonstration of cue reactivity to VR cues represents an advance in drug addiction research by providing a standardized method to investigate addictive drug use behaviors. In addition, VR cue reactivity provides a viable method for evaluation of putative anticraving and cessation agents in addicted persons. Expanding current research using VR is clearly warranted based upon these findings. Further, success in this study leads directly to generation of hypotheses about other substance abusing populations (e.g., cocaine, alcohol), as well as defining standardized specific complex cue situations and environments (e.g., social gatherings, bars, crack house) that might be useful in research and treatment.

The results of this investigation should be viewed with caution based on limitations of the current pilot trial. The sample size of 13 is small and replication in larger samples would improve generalization. Craving intensity assessed via subjective reports could be further strengthened by adding physiological measures and/or brain imagining techniques to objectively assess of craving and urge to smoke. Future research using VR cue reactivity should include the following: larger more diverse samples, variations in levels of smoking, functional imagining techniques, and physiological reactivity measures, each of which would strengthen the case for VR cue reactivity in addiction.

Acknowledgements

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