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Using Virtual Reality to Assess Young Adult Smokers' Attention to Cues

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Abstract

Cigarette smokers, when confronted with cues associated with smoking, evidence strong reactions, including increased attentional bias toward those smoking-related cues. These reactions have not been extensively studied in young adult smokers, a group that research suggests may respond differently than adults or adolescent smokers. Furthermore, the impact of olfactory cues, such as cigarette smoke, on attentional bias has not been explored in young adult smokers. In this pilot study, 20 nicotine-dependent young adult smokers were randomized to receive scent cues or no scent cues and were exposed to four virtual reality (VR) rooms containing sensory and social content, including smoking or neutral cues. Participants entered a neutral VR room, followed by two different smoking VR rooms, and closed with the same neutral room. Subjective attention to smoking cues and thoughts about smoking responses were recorded upon exiting each room. Significant increases in attention to cues and thoughts about smoking were found when young adult smokers were exposed to VR smoking environments, but the inclusion of olfactory cues did not result in significantly higher attention to cues or thoughts about smoking. Results suggest that while further research is necessary to understand the impact of olfactory cues, VR appears to be an effective methodology for cue exposure studies exploring attentional bias in young adult smokers.

Introduction

Cigarette smoking is harmful to almost every organ in the body and is responsible for hundreds of thousands of premature deaths in the United States.[1] Young adults between the ages of 19 and 24 make up a large portion of the smoking population, with over 39% reporting past month usage, according to results from the National Survey on Drug Use and Health.[2]

Although much of the existing research on smoking primarily explores issues related to adolescent or adult smokers, researchers have recently realized the need to increase research focusing on the specific issues related to young adult smokers. Arnett[3] argues that studying

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young adults is important because this population is distinctive in regard to demographics (e.g., moving or changing jobs frequently, changing educational status by beginning or dropping out of school), subjective perceptions (e.g., feeling that they are no longer adolescents but not yet adults and thus bound by neither parental control nor by societal norms dictating responsible adult behavior), and identity explorations (e.g., exercising the freedom to explore various identities in terms of love, work, and worldviews). He notes that several types of risk behavior, such as smoking, peak during the young adult years perhaps as a reflection of their desire to engage in a wide variety of experiences before settling into the responsibilities of adult life[3] or as a method of coping with the instability that accompanies this stage of development.[4] If it is accepted that young adult smokers are neither adolescents nor fully developed adults, but rather a distinctly separate population, it is appropriate to explore the unique characteristics and needs of this group.

Generally, smoking is considered to be a learned, cue-bound phenomenon by which smokers are reactive to cues associated with past smoking[5] or the availability of cigarettes.[6] The inclination to focus more attention on one type of stimuli (cue) over another is known as "attentional bias,"[7] and this bias may be a critical component of addiction.[8] Smokers have been shown to focus greater attention on smoking cues than on other stimuli[9,10] and to demonstrate enhanced approach response toward such cues.[8] Additionally, attentional bias for smoking-related cues has been associated with higher craving levels[8] and may lead smokers to observe with greater frequency and pay closer attention to smoking cues within their environment, thus increasing exposure to such cues.[11]

Although it is important from research and clinical standpoints to understand smokers' attentional bias for smoking-related cues, methods for studying this phenomenon are lacking. Research on attentional bias often involves the presentation of simple, isolated visual cigarette-related and cigarette-neutral cues, which typically are presented in a laboratory setting that is not congruent with the type of environment in which most smokers observe such cues (e.g., bars, parties, convenience stores). This presents a problem in that such methods lack ecological validity, or the degree to which the results of such studies actually mirror behaviors that occur in more naturalistic settings.[12] Indeed, Mogg et al[13] acknowledge that greater ecological validity is needed in attentional studies. Utilizing a method that provides specific cues in contexts that more closely represent the settings in which young adult smokers are confronted with such cues may provide a more ecologically valid presentation and perhaps a more accurate tool for researchers exploring young adult smokers' attentional bias in the real world. In addition, olfactory cues, such as cigarette smoke, are rarely utilized in attentional research with smokers even though studies have demonstrated that olfaction plays a distinct role in learning and in eliciting emotions and memories.[14,15]

Virtual reality (VR) cue exposure systems have the capacity to deliver complex, contextual cues through an immersive human-computer interaction that provides the participant the opportunity to actively participate in a 3D virtual environment. The sense of presence the participant derives from immersion and involvement in this environment allows more realistic cue presentation and provides exposure to complex cues in the context of realistic situations. Bordnick and colleagues developed the Virtual Reality Nicotine Craving

Assessment System (VR-NCRAS)[16] and have run several controlled trials with nicotine-dependent adults[17,18] and young adults.[19] However, attention paid to VR-provided visual and olfactory cues by young adult smokers has not been explored. It is unknown if VR is an effective vehicle for providing these stimuli in an effort to explore attentional bias in young adult smokers; thus, the purpose of this study was to explore the efficacy of the VR-NCRAS in providing contextually appropriate visual and olfactory cues that gain the attention of young adult smokers. In addition, the impact of scents on attention to cues was examined. If olfactory stimuli are shown to significantly increase young adult smokers' attention to cues, then addition of such stimuli may be warranted in future studies utilizing VR. If the VR-NCRAS demonstrates efficacy in capturing the attention of these smokers, VR may be a viable method of exposing smokers to complex cues that include social, physical, and affective interactions in an environment that incorporates contextually appropriate visual, auditory, and olfactory stimuli, thus providing researchers with a more ecologically valid picture of attentional bias among young adult smokers.

Methods

Participants

Twenty nicotine-dependent young adults, ages 19 to 24, were recruited for this pilot study through advertisements in a local free newspaper and on community college and university campuses in the Atlanta, Georgia metropolitan area. Inclusion criteria included meeting the DSM-IV criteria for nicotine dependence, being in good physical health, and being able to wear a VR helmet for approximately 40 minutes. Exclusion criteria included having a current or past diagnosis of a DSM-IV recognized severe mental illness or current DSM-IV diagnosis of dependence for a substance other than nicotine; taking medication or drugs that may have an effect on cigarette craving or mood in the past 30 days; being pregnant; engaging in smoking cessation treatment; fearing closed spaces; having visual problems that would affect viewing VR environments; having severe sinus, allergy, or other conditions that might impede olfactory performance; or having a history of seizure, seizure disorder, or other serious health problems. Participants were compensated $50 for their participation.

Design and procedures

Participants were informed about the pilot study, including rationale, risks, and institutional review board involvement. After obtaining informed consent, the researcher administered questionnaires and rating scales, including a smoking history, Nicotine Dependence Questionnaire (NDQ),[20] which is an 8-question instrument designed to measure an individual's dependence on nicotine; Questionnaire of Smoking Urges-Brief (QSU-Brief),[21] a 32-item scale designed to assess craving for cigarettes; and Attitude toward Sense of Smell Questionnaire (SoSQ),[22] a 36-item questionnaire that measures beliefs about the sense of smell, the importance of smell, and its uses.

After completion of the measures, participants were given a 15-minute VR acclimation session with an environment unrelated to the study to provide familiarity with the overall VR experience, head-mounted display (HMD) used to track head movements and provide the visual components of the VR experience (VFX-3D, Interactive Imaging Systems,

Rochester, NY), operation of input devices, and procedural aspects of the study. Next, they were asked to smoke one cigarette (ad libitum) in order to standardize the time since last exposure to nicotine. A longer latency since last cigarette was not used because it would potentially introduce nicotine deprivation confounds.

The study used a 2 – 2 factorial design with environment (neutral, smoking) as a within-participants factor and scent (scent present, scent not present) as a between-participants factor. During this time, participants were randomized into one of two paths to control for room order effects. Path 1 led participants through a first neutral room, a paraphernalia room, a party room, and a second, identical neutral room. Path 2 switched the order of presentation between the paraphernalia and party rooms. Counterbalancing, so that a smoking cue room might be presented first with a neutral cue room presented second, was not included in this design in an attempt to prevent craving and other carryover effects that might obscure differences between the conditions and to more closely follow the design used in previous studies with the VR-NCRAS.[17-19] Participants were also randomized into scent and no scent conditions. Those in the scent condition were exposed to cue-appropriate scents in each VR room through the use of a scent machine (EnviroScent Scent Palette™), while those in the no scent condition were exposed to the same visual and auditory cues in each room but no accompanying scents.

After smoking, the participants engaged in the VR-NCRAS session, spending 3 minutes in each of four VR rooms (1 neutral cue room, 2 smoking cue rooms, followed by a final neutral cue room). Participants were moved through the rooms along a timed path with pauses at various stimuli and interactions. Smoking environments were always presented after an initial neutral environment to avoid craving carryover effects. After leaving each room, participants filled out an onscreen 11-point (0 to 10) Attention to Cues Visual Analog Scale (ACVAS) using a game pad. This scale consisted of three questions, “How much did you pay attention to the sight of cigarettes in the room?” “How much did you pay attention to the smell of cigarettes in the room?” and “How much did you think about smoking when you were in the room?” Participants provided a score between 0 and 10, selecting a position along a line anchored by 0, *Not at all*, and 10, *More than ever*, on the other. Upon completing each ACVAS, participants were guided into a virtual hallway and into the next room. Participants were not allowed to smoke while engaged in the VR environments.

After the VR session ended, participants engaged in a follow-up interview consisting of a series of open-ended questions about their experiences in the VR environments. These questions were designed to gain insight into participants’ reactions to the environments as well as garner suggestions for improvements to the VR-NCRAS program.

VR cue environments

Four VR-NCRAS cue environments were utilized in this pilot study. The first and last environments presented to participants were identical neutral cue environments devoid of smoking cues, consisting of narrated nature scenes presented with a floral scent. Two smoking cue environments, a paraphernalia room and a party room (see Figure 1) were presented between the neutral cue rooms. Cues within the paraphernalia room included music and visual cues such as ash trays, burning cigarettes, lighters, cigarette packs (of the

participant's brand), and alcoholic beverages. No people were present in the paraphernalia room. For participants exposed to scent, olfactory cues in this room included cigarette smoke, coffee, and alcohol. The party room introduced a setting in which the participant engaged in social interaction with smokers and was offered a cigarette. Olfactory cues including cigarette smoke, food, and alcohol were present in this room for participants in the scent condition.

Results

Study participants ($N = 20$) were 60% male, 75% White, 15% African American, 5% Hispanic, and 5% Asian. Sixty-five percent were currently attending a 2-year community college, 30% were not enrolled in school, and 5% were attending a 4-year institution of higher education. Table 1 summarizes their smoking characteristics.

One-way analyses of variance (ANOVAs) and Chi-square tests were performed on participant characteristics, presession craving, and nicotine dependence based on group assignments (scent/no scent, stimuli order). There was a significant difference on the SoSQ between the scent and no scent groups with participants reporting lower SoSQ scores in the scent group ($p = 0.049$). The SoSQ scores were used as a covariate in all analyses comparing the scent versus no scent conditions. There were no other significant differences between groups.

Attention to the sight of cigarettes

A repeated measures multivariate analysis of variance (MANOVA) was used with attention ratings from both cigarette-related and neutral VR rooms as the within-participants factor and stimuli order (party versus paraphernalia room first) as the between-participants factor. There was neither a main effect for stimulus order nor a significant interaction between environment type and stimulus order; therefore, data were collapsed across stimulus paths.

A one-way repeated measures ANOVA was used to analyze ratings of attention paid to the sight of cigarettes with VR cue rooms as within-participants factors. There was a significant main effect of VR room on attention paid to the sight of cigarettes, F (3, 57) = 66.769, $p < 0.0001$. There was no significant difference between the group that was presented with scent and the group that was not presented with scent. Post hoc pairwise comparison analyses with Bonferoni correction revealed that attention to the sight of cigarettes was significantly greater in both smoking cue rooms than in both neutral rooms, $p < 0.000$. Within the smoking cue rooms, attention to the sight of cigarettes was significantly higher in the paraphernalia room than in the party room, $p < 0.002$. No statistically significant differences were found between the first and second neutral rooms.

Attention to the smell of cigarettes

A one-way repeated measures analysis of covariance (ANCOVA) was used to analyze ratings of attention paid to the smell of cigarettes with VR cue rooms as within-participants factors and SoSQ scores as a covariate. The assumption for sphericity was not met, so a Huynh-Feldt correction was implemented, resulting in fractional degrees of freedom. A significant main effect for attention paid to the smell of cigarettes was found, $F = (2.2, 41.8)$

17.035, $p < 0.000$; however, no significant differences were found between participants who received or did not receive scents. Post hoc pairwise comparison analyses with Bonferoni correction revealed statistically significant increases between neutral room 1 and the party room ($p < 0.002$) and neutral room 1 and the paraphernalia room ($p < 0.000$). Similarly, there were statistically significant differences between both smoking cue rooms and neutral room 2 ($p < 0.002$). Analysis revealed no significant differences between the party and paraphernalia rooms or between the first and second neutral rooms.

Thoughts about smoking

A one-way repeated measures ANCOVA was used to analyze ratings of thinking about smoking with VR cue rooms as within-participants factors, scent or no scent as between-participants factor, and SoSQ as a covariate. A significant main effect for thinking about smoking was found, $F = (3, 57)$ 19.103, $p < 0.000$. There was no significant difference between participants who received and did not receive scents. Post hoc pairwise comparison analyses with Bonferoni correction revealed significant differences between the first neutral room and the party and paraphernalia rooms ($p < 0.000$). Statistically significant differences between the party and paraphernalia rooms and the second neutral room ($p < 0.001$) also were found. No significant differences were found between the party and paraphernalia smoking cue rooms or between the neutral cue rooms.

Follow-up questions about olfactory stimuli in VR

After completing the session, participants were asked a series of questions about their experience in the VR environments. These interviews revealed that 40% of participants assigned to the group receiving olfactory cues reported smelling various scents but not cigarette smoke specifically. In addition, 30% of participants assigned to the group that did not receive olfactory cues reported smelling scents even though none were present.

Discussion

The primary goal of this study was to explore the potential of the VR-NCRAS to deliver attention-grabbing, smoking-related cues to young adult smokers. The results demonstrated that the young adults in this study reported significant increases in attention paid to the sight and smell of cigarettes and thinking about smoking in response to VR-provided smoking cues. Specifically, results show that while both the VR party and paraphernalia environments effectively elicited greater attention paid to the sight and smell of cigarettes and increased thoughts of smoking, exposure to cues in the paraphernalia room resulted in significantly greater attention to the sight of cigarettes than did exposure to cues in the VR party setting. While this may be the result of the greater prevalence of cigarettes in the paraphernalia room, it could also indicate that the VR-NCRAS environments may be capable of capturing differences in attention to cues between social and nonsocial settings for young adult smokers. Overall, however, these findings demonstrate that VR applications, such as the VR-NCRAS, may serve as a more ecologically valid method for exploring attentional bias in young adult smokers. These findings appear to be consistent with theoretical constructs often linked to cue reactivity.[23]

Of related interest were the findings related to thinking about smoking. The cues presented in the paraphernalia room were close-up representations of smoking cues such as lit cigarettes, lighters, or packages of cigarettes, while the party scenario provided more environmental cues with less focus on close-up cues. The paraphernalia room could be considered to be more like traditional cue presentation in that the cues are the central focus of the environment, while the party room provides a potentially more realistic experience focusing on the party environment with no close-up depictions of smoking cues. While one might expect the paraphernalia room cues to elicit more thoughts about smoking because of their close-up presentation and the findings related to increased attention to the sight of cigarettes in this environment, there was no significant difference in thinking about smoking between the paraphernalia room and the party room. This suggests that VR is capable of providing smoking cues in environmentally appropriate contexts without sacrificing any power to evoke thinking about smoking.

The other goal of this study was to explore the impact of scent on attention to VR smoking cues; and in this area, the results were not as expected. The addition of scent to the VR environments did not significantly increase attention to visual or olfactory VR smoking cues or thoughts about smoking among these young adult smokers. Most notable was the finding that presentation of olfactory stimuli did not significantly increase the attention paid to the smell of cigarettes in the VR environments. However, the fact that olfactory cues did not appear to contribute to any aspect of attention to cues or thoughts of smoking merits discussion as to why this may have occurred and suggestions for future research in this area.

The information gathered from the postsession interview provides some possible directions for further study. First, that 30% of participants who did not receive olfactory cues thought that they smelled cigarette smoke in the VR environments points to the possibility that participant traits may merit further examination. Some participants noted that because they filled out a questionnaire about their sense of smell (SoSQ) beforehand, they automatically would be exposed to olfactory stimuli. This suggests that individuals who are more suggestible may be better able to fill in stimuli that is not actually present but would be present in the actual setting (i.e., smelling cigarette smoke when walking past someone holding a lit cigarette).

Conversely, 40% of those who were exposed to olfactory cues acknowledged perceiving various scents in the environments but not smelling cigarette smoke specifically. Upon smelling the cigarette smoke scent used in the environments, these participants noted that they had smelled that scent in the environments but had been unable to identify it as cigarette smoke, or anything else, during the session. This may mean that piloting scents to ensure that they are recognizable to participants is necessary. In addition, development of a stringent protocol would allow greater uniformity of olfactory cue delivery in VR environments. Issues such as machine placement, air circulation, scent replacement, and room temperature should be addressed so that participants would receive the same intensity of olfactory cues, thus avoiding differences in perception that can be accounted for by external issues.

As with any pilot study, there are limits on the generalizability of these results. In order to further validate VR as a viable means of studying attentional bias, additional research, including comparison studies between VR and traditional cue presentation methods and replication studies focusing on diverse populations, is merited. In addition, this sample size of 20 young adult smokers may not have had the power necessary to detect differences between the group receiving olfactory stimuli and those not receiving such cues. Studies employing larger numbers of participants, and therefore eliciting greater power, may detect differences between the groups that were not apparent in this study. While small differences may not appear clinically relevant, it may be that the addition of olfactory cues enhances the VR experience, making it more realistic to participants, even if there seems to be no quantitative difference. Thus, qualitative studies examining how participants experience VR could provide valuable information as to what elements of VR are most critical to providing a truly realistic environment.

In summary, research with young adult smokers is needed to gain a better understanding of this population in regard to nicotine dependence. This study demonstrates that the VR-NCRAS effectively delivers smoking cues that gain the attention of young adult smokers and increases their thoughts of smoking when confronted with these complex, contextually appropriate cues. This means that the VR-NCRAS may be useful in exploring attentional bias in young adult smokers in both research and clinical settings. It also suggests that further study is needed to determine the role olfactory cues play in VR environments and the methods needed to optimize the delivery of these cues. These results are important in that, while VR appears to be an appropriate method of exposing young adults to smoking cues within a natural environment in order to study attentional bias, there continue to be areas for improving this promising new technology.

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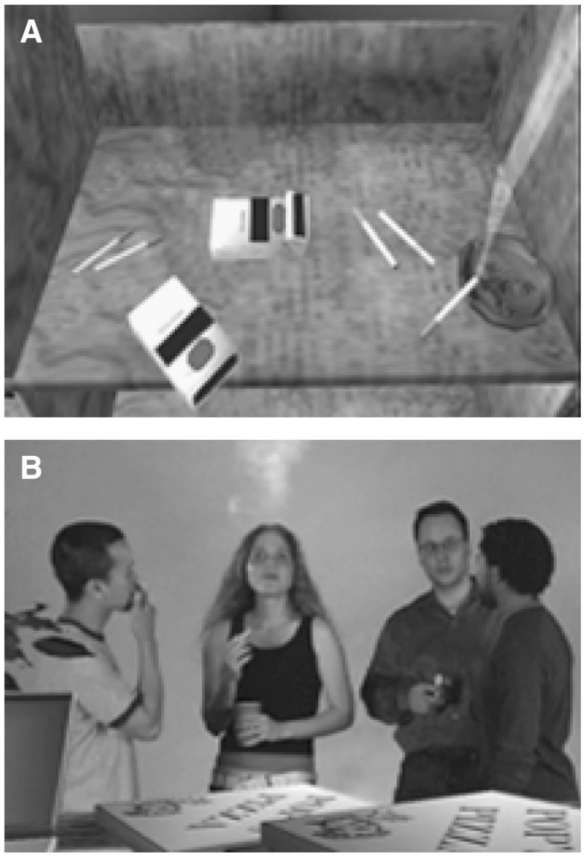

FIG. 1.
A: Smoking paraphernalia room. **B:** Social interaction room.

Table 1

Participant Age and Smoking Data (N = 20)

Variable/Label	*M*	*SD*
Age	20.9	1.4
Age of smoking initiation	14.8	2.5
Nicotine Dependence Questionnaire score	8.0	2.2
Questionnaire of Smoking Urges–Brief score	36.4	14.0
Number of years smoking	6.0	2.5
Cigarettes smoked per day	13.4	4.5