Experimental Application of Virtual Reality for Nicotine Craving through Cue Exposure

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ABSTRACT

Research has shown that many smokers experience an increase in the desire to smoke when exposed to smoking-related cues. Cue exposure treatment (CET) refers to the manualized, repeated exposure to smoking-related cues, aimed at the reducing cue reactivity by extinction. In this study, we constructed a virtual reality system for evoking a desire of nicotine, which was based on the results of a Questionnaire of Nicotine-craving. And we investigated the effectiveness of the virtual reality system as compared to classical device (pictures). As a result, we reached the conclusion that virtual reality elicits more craving symptoms than the classical devices.

INTRODUCTION

"CRAVING" IS A TERM DERIVED FROM POPULAR PSYCHOLOGY, and is used to describe a mental state, namely, the intense desire for a certain object or experience (e.g., alcohol, nicotine, or drug).[1] The World Health Organization in 1955 made a distinction between non-symbolic craving (i.e., physiological withdrawal) and symbolic craving (i.e., loss of control, which is associated with relapse). It has been suggested that the term "craving" should be replaced by the terms "physical dependence" and "pathological desire," which refer respectively, to the two conditions described above.[2,3]

Researches have shown that many smokers experience an increase in the desire to smoke when exposed to smoking-related cues.[4,5] A strong desire to smoke, in turn, seems to play an important role in the maintenance of cigarette smoking.[5,6] According to learning-based theories, cue-induced craving might partly reflect a conditioned response (CR) established by a learned association between the cue (CS) and nicotine intake (US).[5,7] Cue exposure techniques, which try to extinguish this learned association, have been increasingly forwarded as a potential treatment of addictive behaviors, including cigarette smoking.[5,8]

Conditioned reactivity to cues is an important factor in the addiction to alcohol, nicotine, opiates, and cocaine. Cue exposure treatment (CET) refers to the manualized, repeated exposure to drug-related cues, aimed at the reduction of cue reactivity by extinction. In current CET, various stimuli are presented, such as, slides, videotapes, pictures, or paraphernalia in nonrealistic, experimental settings.[9]

Virtual reality (VR) can make a person look, feel, hear and interact in a computer-generated situation. One pilot study on addiction to cocaine

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TABLE 1. QUESTIONS

Section	Content
1	Tendency to smoke
	Amount of smoking
	Whether or not the subject had attempted to quit smoking
2	Which object induces your craving?
	Which place (or situation) induces your craving?
	Which is more attractive—the object or the place?
3	Nicotine Addiction Test (only used on experiment subjects)
	Nicotine dependence: low, high, very high

showed that immersive virtual reality (IVR) is as good or even better at eliciting subjective and physiological craving symptoms as classical devices.[9]

In this study, we designed a VR system to create desire for nicotine, which was based on the responses from a nicotine-craving questionnaire. The virtual environment is composed of craving environments, craving objects and smoking avatars. We compared this virtual reality system to photographs, and investigated the potential value of the use of a virtual reality system for cue exposure treatment (CET).

MATERIALS AND METHODS

Preliminary study

Nicotine-Craving Questionnaire. Before we designed the virtual environment for eliciting a smoking desire, we collected data about which cue would elicit one's craving by using a questionnaire (Table 1).
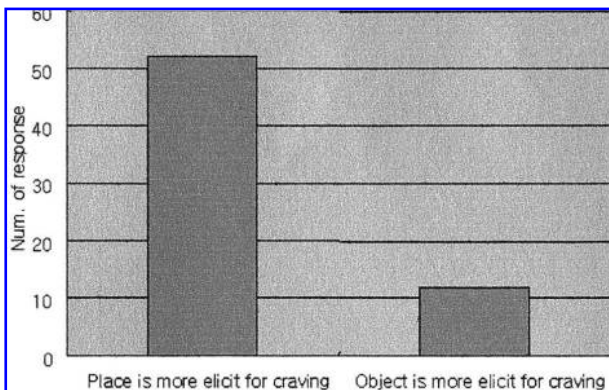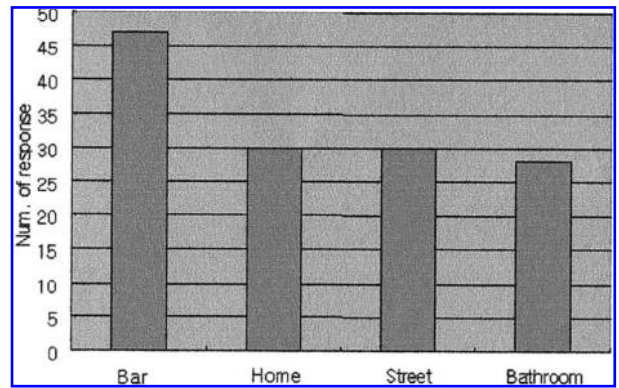

FIG. 2. What place induces craving?

Questionnaire result. Data were collected from 64 men, aged 19–38 years. The result showed that a place evokes a higher level of craving than an object; bars and tobacco were the places and objects most often cited by participants (Figs. 1–3). This result showed that the VR could be used to more strongly elicit one's desire related to smoking because the VR can provide an immersive situation. So, using the results from this survey, we designed a virtual bar environment. Objects in the virtual bar were also selected from the questionnaire results. They are an alcoholic drink, a pack of cigarettes, a lighter, an ashtray, and a glass of beer.

Main experiment

Subject. Twenty-two male smokers participated in this experiment. All subjects were free from brain injury, glycosuria, high blood pressure or medicinal poisoning, and were not handicapped mentally or neurologically. The average of amount of smoking per day was 12.64, and the average nicotine addiction test score was 4.14.
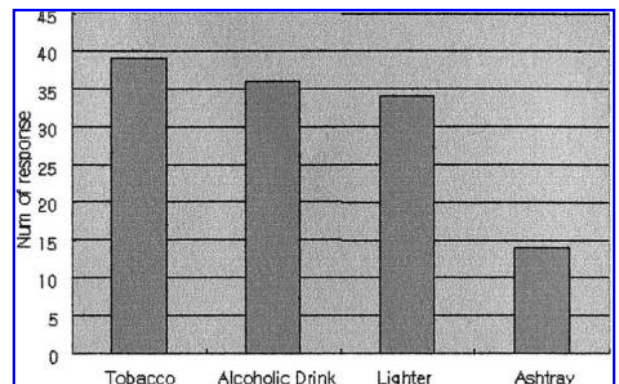

FIG. 1. Which one is more likely to elicit craving—the object or the place?

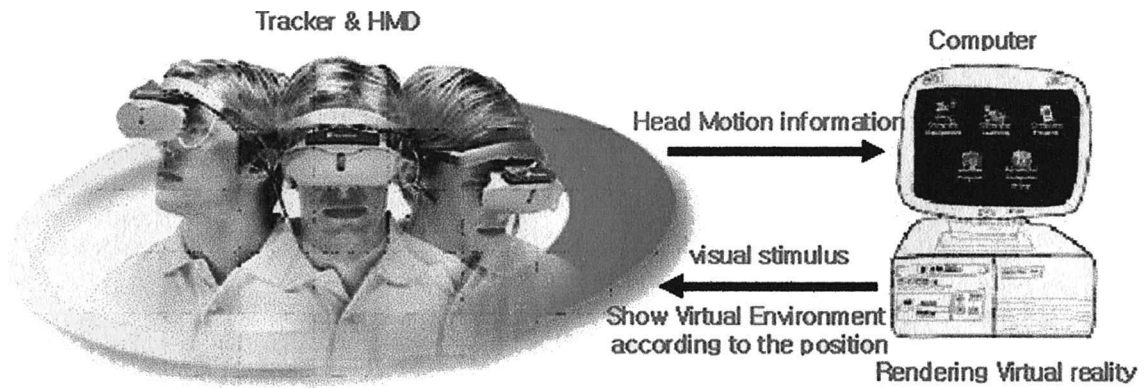FIG. 3. Which object induces craving most?

FIG. 4. System composition.

Instrument. **(1) System**. The Virtual Reality System consisted of a Pentium IV PC, OpenGL Accelerator VGA Card, HMD (i-visor DH-4400VPD), and a 3DOF Position Sensor (Intertrax2). The PC with a 3D Accelerator VGA Card generated real-time virtual images for the subject to navigate. The position sensor (tracker) transferred a subject's head orientation to the computer. The Classical Device was displayed using the same virtual reality system, but the tracker was not used in order to eliminate the difference of the display modality. Therefore, the VR system could provide a dynamic situation while the classical device provided a still picture (Fig. 4). **(2) Virtual environment.** The Virtual Environment was designed based on the nicotine-craving questionnaire. The background environment present here is a bar. The five kinds of objects were an alcoholic drink, a pack of cigarettes, a lighter, an ashtray, and a glass of beer and avatars smoking cigarettes (Figs. 5 and 6). **(3) Classical device (picture)**. Classical Device (CD) was also based on a questionnaire of nicotine craving. Therefore the CD's background was a bar with the same five object types, an alcoholic drink, a pack of cigarettes, a lighter, an ashtray, and a glass of beer. CD contained the same content as the VE.

Procedure. Before the experiment, subjects were asked for their ages, educational backgrounds and medical history, and were also asked to complete a questionnaire on nicotine-craving (amount of smoking per day and nicotine craving of individual

FIG. 5. Virtual bar and craving object.

FIG. 6.　Avatar animation in the virtual bar.

person), a Nicotine Addiction Questionnaire (from 0 to 11) and a Questionnaire on Current Nicotine craving. For the main experiment, the subjects were split into two groups randomly, a Virtual Reality (VR) group and a Classical Device (Picture) group. Subjects were to experience the VR and CD respectively for 5 min.

Measurement.　A Visual Analogue Scale (VAS) was used to subjectively measure the craving to smoke. This VAS was defined to have a range of 0–100 mm, from "none at all" to "extreme," and individual rating was decided by subjects in response to the question: How strong is your urge to smoke now?

RESULTS

Table 2 shows mean (M), standard deviation (SD) and *t*-test results, nicotine addiction test scores and the difference of nicotine craving between before and after the experiment in both the CD group and the VR group. It also shows the group difference, which means that the subjects of the two groups are

no different in terms of group. But the difference of nicotine craving (After-Before) was significantly different.

Figure 7 shows craving change before and after the experiment for the Classical Device (Picture) group and the Virtual Reality group.

Figure 7 shows that the Classical Device group's nicotine craving changed from 5.67 to 5.08, and the Virtual Reality group's nicotine craving is increased form 5.40 to 6.40. However, the difference between the before and after experiment results of the Classical Device group was not significant ($t = 1.246$, n.s.), and this difference in the Virtual Reality group was significant ($t = -2.535$, $p < 0.05$).

DISCUSSION

In the present study, we tried to determine whether VR could be used in cases of nicotine craving as a cue exposure treatment tool. Therefore, we compared a VR system with a classical device (Picture), and measured difference of nicotine-craving using VAS.

TABLE 2.　COMPARISON OF CD GROUP AND VR GROUP

	Group				
	CD		VR		
	M	SD	M	SD	t-test
Amount of smoking per day	13.17	9.63	12.0	6.85	0.321(n.s)
Nicotine Addiction Test	4.33	2.06	3.90	1.97	0.501(n.s)
Usual nicotine craving	6.08	2.23	6.40	1.65	−0.371(n.s)
Current nicotine craving before experiment	5.67	2.81	5.40	1.96	0.253(n.s)
Current nicotine craving after experiment	5.08	2.97	6.40	2.22	−1.157(n.s)
The difference in nicotine craving between before and after experiment	0.58	1.62	1.00	1.25	−2.524 (P<0.05)

CD, classical device (picture); VR, virtual reality; M, mean; SD, standard deviation.
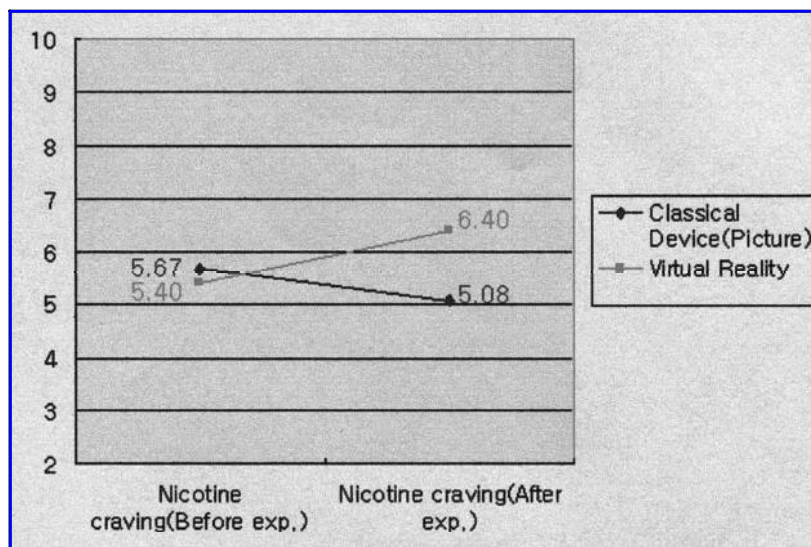
FIG. 7. Nicotine craving before and after experiment.

We found that VR is better at eliciting desire than the classical device (Picture) for CET. This result is in accordance with the results of Kuntze's pilot test for opioid dependent subjects.[9] It is because VR can present a spatial stimulus that resembles that of the real world that the VR is more immersive than Classical CET device.

As a result, the nicotine craving of the VR group increased significantly from 5.40 to 6.40. However, the CD group's nicotine craving only showed a tendency to decrease from 5.67 to 5.08. This result shows that the picture showing is not a suitable device for eliciting nicotine craving in normal subjects. Additional experimentation in 8 subjects reconfirmed that the observed CD group's decrease was non-significant. Nicotine craving, with the inclusion of additional experiments, changed from 5.50 (before experiment) to 5.45 (after experiment).

Future study is needed to investigate whether VR is superior to other classical methods at evoking nicotine craving, other sources of objective evidence by acquiring and analyzing objective evidence such as bio signals (Heart Rate, Galvanic Skin Response), fMRI (functional Magnetic Resonance Imaging) or PET (Positron emission tomography); and the possibility of a VR system for the other types of abuse and to apply the VR system to treat such abuse.

CONCLUSION

Our study demonstrates that virtual reality is probably better at eliciting craving symptoms than classical picture watching and we propose that Virtual Reality be used in Cue exposure Therapy.

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