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ORIGINAL ARTICLE

The effect of virtual covert sensitization on reducing alcohol craving in heavy social drinkers

Yoon Jung Choi[1] · **Jang-Han Lee**[1]

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Abstract Covert sensitization is an imagery-based aversive treatment for decreasing craving and inducing aversion toward abused substances. In the present study, we used virtual reality to enhance the effects of covert sensitization. The aim was to verify the effectiveness of virtual covert sensitization treatment in reducing heavy social drinkers' alcohol craving. The explicit and implicit measurements included a self-report questionnaire, alcohol-Implicit Association Test, eye-tracking test, and alcohol-Stroop test. To determine the baseline, we measured the alcohol craving in heavy social drinkers ($N = 20$) and light drinkers ($N = 20$). Furthermore, virtual covert sensitization treatment was administered to each participant for 10 min. Afterward, the same measurements as at baseline were repeated. Despite the one-time nature of the administered treatment, our results confirm the effectiveness of virtual covert sensitization based on the participants' changed implicit craving and explicit, self-reported craving. Therefore, virtual covert sensitization may be an effective intervention technique for alcohol addiction treatment.

Keywords Covert sensitization · Virtual reality · Alcohol craving · Implicit cognition · Eye movement

✉ Jang-Han Lee
clipsy@cau.ac.kr

Yoon Jung Choi
choiyj2010@hanmail.net

[1] Department of Psychology, Chung-Ang University, 221 Heukseok-dong, Dongjak-gu, Seoul 156-756, Korea

1 Introduction

In many cultures, alcohol abuse is a serious and long-standing public health issue. Despite the harmful emotional and physical effects of excessive alcohol consumption, cessation of risky drinking is quite difficult. According to the dual-process model of addictive behaviors (Wiers and Stacy 2006), addictive behaviors are partly governed through automatic processes. These kinds of implicit processes correlate with alcohol craving, coming from various aspects of information processing related to the drug (Tiffany 1990).

Alcohol cravings comprise subjective experience of a powerful desire or urge to drink, as well as a motivational state of repeatedly wanting to consume alcohol (Tiffany and Conklin 2002). According to Smith and Frawley (1993), the most powerful predictor of abstinence is the absence of craving. Previous research has shown that, although abusive drinkers make an effort to control their excessive drinking, these cognitive efforts have little effect on their alcohol abuse treatment (Whitworth et al. 1996). Thus, an effective treatment for alcohol abusers should aim to reduce the automatic alcohol craving itself.

One intervention for effectively decreasing alcohol craving is aversion treatment based on the conditioning through repeated pairing of maladaptive behaviors with unpleasant aversive stimuli, such as chemical, electrical, and verbal aversion (covert sensitization) (Howard 2001; Parks et al. 2001; Smith et al. 1997). However, due to their dehumanizing effects, chemical and electrical therapies have over the years come to be regarded as improper. For this reason, Cautela developed covert sensitization (CS) based upon imagination (Cautela 1967). In the past decade, CS has proved to be an effective alternative to both chemical and shock aversion treatment in many domains

(Kearney 2006) and, specifically, in the successful treatment of alcoholism (Anant 1967; Ashem and Donner 1968; Kraft and Kraft 2005). One of the strongest points of CS is that it pairs the aversive stimulus not with the behavior itself, but with the craving for that behavior (Kraft and Kraft 2005).

While CS is a powerful method for decreasing cravings, its effectiveness, however, heavily relies on an individual's ability to imagine. This entails a reduction in the effectiveness of treatment in cases when patients have a poor imagination. One challenge of overcoming this limitation is how to offer a vivid environment providing a visually impactful scene. In order to create ecologically valid scenarios and to enhance the sense of immersion in the context, previous studies used 3D virtual reality technology (e.g., Sanchez-Vives and Slater 2005). Furthermore, it has been suggested that virtual reality can be effective in clinical treatment (Riva et al. 1999) and that it is useful for helping patients imagine vivid experiences and enhances their sensations of immersion and realism by increasing their concentration (Bordnick et al. 2008). Thus, the present study uses virtual reality, which has built up a clinical acceptance (Anderson et al. 2001).

To assess the attitudes and cognition related to alcohol craving, many studies have suggested using explicit and implicit attitude measures (Ostafin et al. 2008; Wiers et al. 2007). These measures include self-report questionnaires and the Stroop test (Williams et al. 1996) to assess attentional bias for alcohol and the Implicit Association Test (IAT) (Greenwald et al. 1998) to evaluate automatic association between alcohol and affect. Furthermore, the measurement of eye movements has been applied to evaluate psychophysiological addiction-related biases (Bradley et al. 2003). This sensitive measure was relevant to the physiological results of attentional biases (Mogg et al. 2003). Based on the latter methodology, many studies have found that heavy and light drinkers differed in their implicit cognitive X toward alcohol, such as attentional bias and alcohol–affect association (Lusher et al. 2004; Townshend and Duka 2001; Wiers et al. 2002). Importantly, implicit and physiological measures help researchers understand the indirect processing of addictive behaviors better than explicit measures do (Wiers et al. 2007).

Therefore, this study is the first to design and develop a virtual covert sensitization (VCS) technique in 3D environment and to verify its effectiveness in the treatment of alcohol problems, such as alcohol-related maladaptive attitudes. Accordingly, we focused on the differences in explicit and implicit craving levels before and after VCS treatment, measuring psychophysiological responses. In addition, we predicted that heavy social drinkers would show significantly lower craving levels after using VCS as compared to light drinkers.

2 Methods

2.1 Participants

The participants were 40 male undergraduate students selected on the basis of their Alcohol Use Disorders Identification Test in Korea (AUDIT-K) scores (Kim et al. 1999; Saunder et al. 1993). According to a previous study (Kim et al. 1999), we regarded the participants with scores of 12 points or higher to be heavy social drinkers and assigned them to the HSDs group ($N = 20$; mean AUDIT-K score = 20; SD = 2.36). Likewise, we considered the participants with scores in the range from 1 to 7 points as light drinkers and assigned them to the LDs group ($N = 20$; mean AUDIT-K score = 4.6; SD = 1.79).

On the explicit and implicit results analyses, we excluded any participant lying 2 SD above the mean as an outlier. Due to technical problems, the data from five participants were lost during the eye-tracking test.

2.2 Materials and measures

To carry out the VCS, we used a desktop PC with a GeForce 9800 GTX graphics card, an eMagin Z800 3DVisor head-mounted display (HMD), and a Logitech Cordless RumblePad 2 game controller. The VCS environments—a virtual hospital and a virtual subway—were created using the Direct X, Pentium IV PC, with an Open GL Accelerator VGA card. We created these after asking 13 alcohol dependence inpatients (mean age 39.10, SD = 10.60) and light drinkers (all undergraduate students, mean age 23.10, SD = 1.92) through open-ended questionnaires. The hospital scenario was a health-risk diagnosis situation where personnel advise the user to stop drinking alcohol. In the subway scenario, the user incurs the criticism of other passengers for vomiting on a subway. In each scenario, the avatar has been situationally moving in 3D environment made by the VR software which is developed in VSTEC (Software Company in Korea). The tasks were presented in a dim room with a 17-inch LCD monitor. The participants were seated at a desk and were instructed to look at the avatar on the monitor and to listen to the sounds and the experimenter's voice. Then, they controlled the avatar pressing the keypad (go or stop) following the routes.

To measure explicit attitudes toward alcohol craving, we assessed each participant's subjective alcohol craving using the Alcohol Urge Questionnaire (AUQ) (Mehrabian and Russell 1978), which has a 7-point Likert scale (8 items). To calculate the AUQ mean score, we summed up the eight items.

We assessed implicit alcohol craving using three psychophysiological measures, namely: (a) the alcohol-IAT, (b) eye-tracking test, and (c) alcohol-Stroop test.

The alcohol-IAT was presented on a desktop computer with the Inquisit software (Draine 2004). It comprised two target categories (alcohol and soft drink) and two attribute categories (positive and negative). The participants were instructed to categorize stimuli from each category. The alcohol-IAT stimuli consisted of six alcohol-related words: *hof*, *beer*, *Soju* (Korean rice wine), *liquor*, *alcohol*, and *Chameesul* (a type of Soju); six soft drink-related words: *coke*, *coffee*, *juice*, *milk*, *Sprite*, and *Fanta*; six general positive words (label "positive"): *best*, *pleasure*, *joy*, *wonderful*, *beautiful*, and *adorable*; and six general negative words (label "negative"): *pain*, *tragedy*, *awfulness*, *terrible*, *fear*, and *dirty*. If the participants made an error during practice trials, they received feedback as an error message and were required to re-enter the correct response. The alcohol-IAT was presented in seven blocks: (a) a 14-trial target discrimination block (e.g., left = beer, right = water); (b) a 14-trial attribute discrimination block (e.g., left = approach, right = avoid); (c) a 20-trial combination block (left = beer + approach, right = water + avoid); (d) a 40-trial combination block of the same combination as in (c); (e) a 14-trial target discrimination block with the reversed target categories (left = water and right = beer); (f) a 20-trial reversed combination block (left = water + approach and right = beer + avoid); and (g) a 40-trial combination block of the same combination as in (f). Target and attribute stimuli were always presented in the middle of the computer screen, and trials alternated between presenting target items and attribute items. During the task, the labels of the categories were assigned to the "D" and "K"; response keys were presented in the corresponding upper corners of the computer screen. We calculated each IAT score according to the D-measure algorithm (Greenwald et al. 2003).

Our eye-tracking test was based on Mogg and Bradley (2002). For the main test, we presented each participant with paired alcohol-related or neutral scenes (30 trials in total, 20 critical trials). The participants' eye movement data were recorded with the iView X^{TM} RED-III system from SensoMotoric Instruments (SMI), and only the data from critical trials only were analyzed (pairings of alcohol-related and neutral pictures). The eye movement parameter, i.e., the eye-tracking measure that revealed attentional bias toward alcohol cues, was dwell time [fixation duration (ms) for alcohol-related pictures − fixation duration for neutral pictures].

To carry out the alcohol-Stroop test, we used E-prime 2.0, with 63 trials grouped into three colors (red, blue, and green) and eight alcohol-related and neutral words. A practice trial was followed by the main task consisting of 48 trials. The alcohol-related words were *Soju*, *beer*, *hof*, *Chameesul*, *whiskey*, *Cass* (a Korean beer), and *wine*. The neutral words were *dust*, *necklace*, *shoes*, *signal*, *floor*, *carpet*, and *clock*. The participants were instructed to name the color of each word, while ignoring the word meaning as quickly and as accurately as possible by pressing the appropriate colored key on the keypad that corresponded with the color in which the word was printed. To evaluate the results, we utilized mean response time (RT) scores, in milliseconds, to calculate bias scores (RT for alcohol-related words − RT for neutral words).

2.3 Procedure

To evaluate the participants' baseline alcohol craving, the AUQ was administered. This was followed with the alcohol-IAT, eye-tracking test, and alcohol-Stroop test. Following these baseline measurements, we administered the VCS treatment, exposing each one to the VCS situation for 10 min. To increase the realism, each participant put on an HMD and stereo headphones. In addition, the experimenter read a related script at an appropriate time. First, the participants were exposed to the virtual hospital environment, this scenario was as follows: "*Can you see this white circle on your X-ray results? You have liver cancer. You have to stop drinking… If not…*" (see Fig. 1). Next, the participants were exposed to the virtual subway environment, namely: "*You drank alcohol with friends. Now it's time to go home. You feel dizzy and uncomfortable…You get on the subway…You puke. You vomit all over your hands, the subway, and the person next you. People are blaming you…The subway would never stop…*" (see Fig. 2). Finally, after the VCS treatment, we repeated all the baseline measurements again, following the same procedure as before.

2.4 Data analysis

We used a mixed repeated-measures analysis of variance (ANOVA) to examine the effects of Group (HSD vs. LD) as the between-subjects factor and Trial type (before vs. after) as the within-subjects factor.

3 Results

3.1 Explicit attitudes toward alcohol

Regarding subjective craving, these analyses revealed a significant main effect of Group and Trial [$F(1,35) = 21.93$, $p < .05$, $\eta^2 = .39$; $F(1,35) = 26.53$, $p < .05$, $\eta^2 = .43$] and Group × Trial interaction [$F(1,35) = 7.44$, $p < .05$, $\eta^2 = .18$]. HSDs showed a greater reduction in subjective alcohol craving after VCS than the LDs did [$t(18) = 5.11$, $p < .01$] (see Fig. 3).

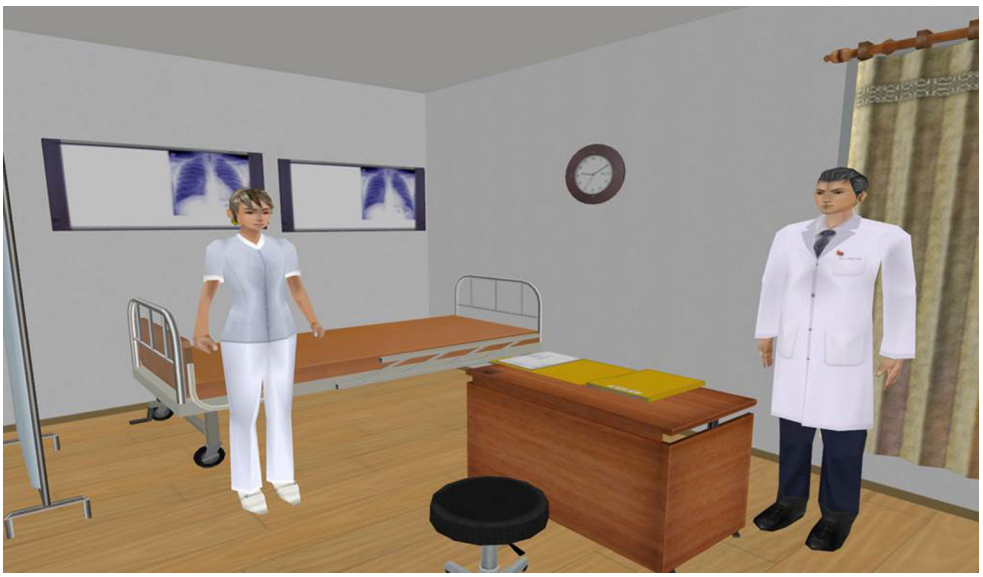

Fig. 1 Virtual hospital environment

Fig. 2 Virtual subway environment

3.2 Implicit attitudes toward alcohol

To evaluate implicit attitudes toward alcohol, we calculated the effects of alcohol-IAT, eye-tracking, and alcohol-Stroop test results. Regarding the alcohol-IAT effect, statistical analysis revealed a significant main effect of Trial [$F(1,36) = 4.82,\ p < .05,\ \eta^2 = .12$] and Group × Trial interaction [$F(1,36) = 9.00,\ p < .05,\ \eta^2 = .20$]. HSDs

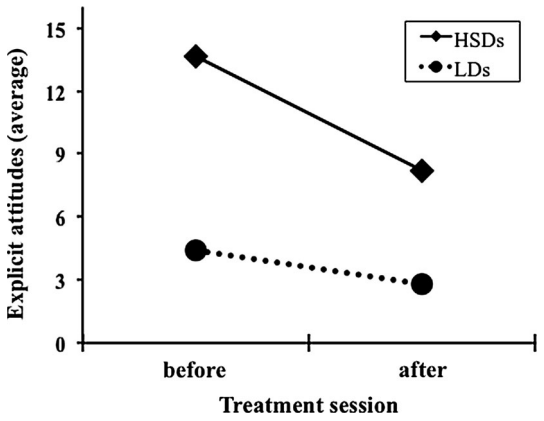

Fig. 3 Mean subjective alcohol cravings scores, for the HSD and LD groups (*HSD* heavy social drinkers, *LD* light drinkers)

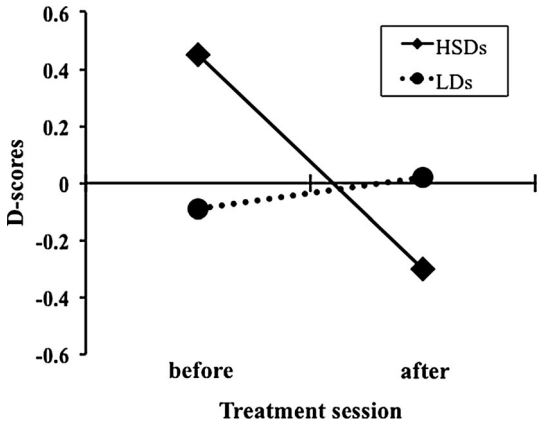

Fig. 4 Mean IAT scores for the HSD and LD groups (*HSD* heavy social drinkers, *LD* light drinkers)

showed a weaker positive association with alcohol after VCS than the one shown by LDs [$t(17) = 3.84$, $p < .01$] (see Fig. 4).

Regarding dwell time, only a main effect of Trial type [$F(1,29) = 4.71$, $p < .05$, $\eta^2 = .14$] was observed. Dwell time bias scores decreased significantly after exposure to VCS in both groups. Finally, similarly to the results on dwell time, for the alcohol-Stroop bias scores the only significant main effect was Trial type, $F(1,35) = 5.57$, $p < .05$, $\eta^2 = .14$. Thus, participant reaction times for alcohol-related stimuli decreased after VCS exposure in both groups.

4 Discussion

For several years, the role of craving as a factor in controlled drinking (Robinson and Berridge 1993) and relapse of alcoholism (Anton 1999) has been widely discussed in the literature. The purpose of this study was to investigate the effectiveness of aversive treatment in the reduction in craving in heavy social drinkers. Specifically, to overcome existing CS weakness, we first developed "virtual" covert sensitization. Furthermore, we found that both HSDs and LDs show treatment effects on these multimodal measurements after VCS.

As expected, explicit and subjective self-report craving for alcohol in HSDs decreased more after VCS than LDs. Similarly, on implicit craving, cognitive distortion for alcohol-related implicit attitudes of the HSDs, that is, having higher craving than LDs, marginally decreased after the VCS treatment. This result suggests that there was some effectiveness in decreasing the automatic association between alcohol and pleasant attitudes in the HSDs. Previous studies have found that self-report measures, based on self-report responses, have limitations of social reliability and validity of measures (Maria and Reiko 2008). Thus, beyond self-report measures, it is critical to identify further response domains including implicit cognitive experience and psychophysiological experiences. In this context, the results of the present study are meaningful, especially the change of implicit attitude to negative attitudes, because stronger association between alcohol and positive attitudes is a prediction factor for drinking (Houben and Wiers 2007), and these associations are closely related to automatic, or impulsive, cognitive processes (Pieters et al. 2010). In the VCS situation, we speculate that, through providing realistic, negative experiences in 3D virtual reality, the alcohol-related aversive environment had salient negative effects on the participants. A previous study by Maiano et al. (2011) successfully used VR technology to manipulate the participants and activate negative effects. Therefore, the implicit attitude change possibly caused negative reaction toward the alcohol-related scenario in the present study. In addition, indirect measures were safe from the participants' response sets (Rosenberg 2009). Thus, our results show that the VCS technique effectively reduces a HSD's unconscious, as well as subjective craving.

However, our results confirm only the main effects in the results of the eye-tracking and Stroop test, and no interaction effect was observed. These results are inconsistent with our hypothesis. Previous research results have shown differences in alcohol-related craving in both groups (Cox et al. 1999; Ryan 2002). In our study, however, the participants in both groups showed similar attitudes toward alcohol. Although we selected and divided the two groups according to AUDIT-K, almost all of them belong to social drinkers with past drinking experiences. Therefore, as exposure aversive virtual environments, VCS effect might manifest itself similarly in the two groups.

A number of researchers propose that substance abuse behavior may begin as a function of controlled processes and, with continued use, become more a function of automatic processes (Tiffany 1990; Wiers and Stacy 2006). That is, controlled regulatory processes are weakened by the acute effects of alcohol, whereas automatic approach processes become stronger for drinking behaviors. To identify dual-processes of addiction, recent studies have started to use more indirect or implicit measures. Within implicit measures, measurement issues are broadly distinguished between two classes: attentional biases and implicit memory associations. In an effort to investigate implicit craving, several measurements have been used, such as the modified alcohol-Stroop task, the Alcohol-IAT, and eye-tracking. Therefore, from the results of our study, it can be concluded that implicit measures are an important part of understanding the cognitive processes of addiction and addictive behaviors.

The present findings regarding implicit measures could be explained with a cognitive neuroscience theory of addiction, specifically the incentive sensitization theory of addiction (Robinson and Berridge 1993). When a drinker is repeatedly exposed to alcohol, the interaction of neural sensitization with associative learning makes the objects and stimuli associated with alcohol a powerful incentive. Exposure to alcohol-related words in alcoholics could mediate the maintenance of their addiction by producing craving—that is, making a drinker want to drink alcohol by being shown stimuli that capture attention and remind him/her of drinking. For these reasons, a reduction in attention levels for alcohol-related stimuli in after receiving VCS is identical to a decrease in automatic craving. Therefore, from a clinical perspective, this decrease may be able to help reduce relapse for alcoholics.

The present study also demonstrated the effectiveness of a virtual environment for addiction treatment. Addiction researchers have recently created and validated alcohol VR drug cue systems (Bordnick et al. 2008; Cho et al. 2008). Nowadays, researchers have access to unprecedented tools for creating realistic virtual environments to manipulate human behavior in a laboratory. Also, because of the characteristics of personal clinical treatment in CS, much experimental research has been single-subject and small group studies, rather than larger-group experiments, such as those conducted with covert modeling. Compared to replying only on their imagination, being able to experience a virtual scene seems to be an effective treatment method in reducing craving, as it can make up for an individual's limited imagination by offering a vivid experience. In addition, it can help experimental research for large groups by providing the same experience to all participants. Therefore, it is possible that VCS treatment will have an influence on many other addiction treatment methods.

This study has several limitations. First, despite the one-time treatment effect, the present findings cannot ensure that the participants experienced lasting reduced alcohol craving, as the treatment session was too short. Thus, further research is needed for a definitive answer by follow-up. Second, the participants were a nonclinical sample, and their number was too small. Future research should more accurately examine the participants' individual characteristics. Also, VCS should be provided to a larger clinical group of alcohol abusers. Finally, the present study confirmed only VCS effectiveness. Therefore, further study should compare VCS with the original CS technique. This research may provide more evidence of aversive treatment effectiveness in virtual reality.

In conclusion, this study is the first to demonstrate covert sensitization effectiveness, in the virtual environment, as an aversive addiction treatment for heavy social drinkers. Specifically, we found that a VCS technique-based aversive treatment has significant implications for the treatment of alcohol dependence. Due to offering a visual and auditory experience that can make up for an individual's limited imagination, to complement the existing verbal covert sensitization procedures, a VR within 3D environment may be more effective than verbal covert sensitization. To determine the validity of VCS treatment, further studies should not only consider the effectiveness of VCS treatment in reducing craving, but also compare VCS with other treatment methods, such as CS.

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Conflict of interest No competing financial interests exist.

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