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Effectiveness of self-training using the mobile-based virtual reality program in patients with social anxiety disorder

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ABSTRACT

Social anxiety is one of the common mental problems with relatively low treatment-seeking rate. Virtual reality exposure therapy is a promising treatment option for social anxiety disorder (SAD). Our objective was to investigate the efficacy of self-training using the newly developed mobile-based virtual reality program for the cost-effective treatment of SAD. Twenty-two patients with SAD and 30 sex- and age-matched normal controls engaged in the program, which consisted of eight self-training sessions during two weeks. Liebowitz Social Anxiety Scale (LSAS) was assessed before and after the training. Additionally, the embedded in-app performance variables were analyzed for objective performance improvements. Although the LSAS scores decreased after the training in both groups, patients showed greater degree of decrease at the marginal significance level than controls ($p = 0.053$). Overall, there were significant improvements in the total speech length ($p < 0.001$), voiced-time ratio ($p < 0.001$), and subjective self-ratings on the performance measured within the program for subjective nervousness ($p < 0.001$) and for the subjective confidence in content ($p = 0.039$). The findings provide compelling evidence that the self-training could be beneficial for reducing anxiety and improving skills. The mobile-based virtual reality program for the treatment of SAD may be the first mobile application treatment option that could be operated by the patient alone, at home.

1. Introduction

Social anxiety disorder (SAD) is one of the most common psychiatric disorders with lifetime prevalence between 7% and 13% (Furmark, 2002; Kessler et al., 1994; Ruscio et al., 2008; Wittchen & Fehm, 2003). Although neglecting to treat SAD can evolve into a chronic state, two-thirds of affected individuals do not seek treatment (Pollack, 1999; Ruscio et al., 2008). They are hesitant to even receive outpatient treatments possibly due to their fear of negative evaluation by others or because they view their condition to be untreatable (Bruch, Hamer, & Heimberg, 1995). Other reasons are the uncertainty over where to receive treatment, costs, and reluctance to go outside of their comfort zone (Olfson et al., 2000).

Cognitive behavioral therapy (CBT) has been the most researched and effective nonpharmacological approach to the treatment of SAD (Heimberg et al., 1998; Mayo-Wilson et al., 2014), in which exposure is one of the frequently used techniques (Craske, Treanor, Conway, Zbozinek, & Vervliet, 2014; Hofmann & Smits, 2008). Since *in-vivo* exposure is impractical because it is costly, time-consuming, and difficult to control for external circumstances, group therapy may somewhat compensate by allowing the group to engage in role-playing with other group members, nonetheless, this too, has its challenges (Aderka, Hermesh, Marom, Weizman, & Gilboa-Schechtman, 2011; Gledhill, Lobban, & Sellwood, 1998). One of the technologies that medicine is embracing recently is virtual reality (VR). Due to its ability to reproduce "real-like" environments, VR has been a useful tool for the management of some psychiatric illnesses such as attention deficit hyperactivity disorder (Nolin et al., 2016), eating disorder (Marco, Perpina, & Botella,

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2013), and schizophrenia (Park et al., 2011). In particular, VR exposure therapy has been employed in treating phobias including arachnophobia, agoraphobia, and fear of flying (Malbos, Rapee, & Kavakli, 2013; Rus-Calafell, Gutierrez-Maldonado, Botella, & Banos, 2013; Shiban, Schelhorn, Pauli, & Muhlberger, 2015), VR exposure therapy is as effective as traditional CBT in treating public speaking anxiety (Anderson et al., 2013; Wallach, Safir, & Bar-Zvi, 2009), and even generalized SAD (Kampmann et al., 2016).

To date, treatments using VR are only available in a clinical setting under therapist's control. The development of a VR program that can be readily carried out at home is imperative. The recent increase in the availability of mobile VR equipment and drastic decline of the cost provide a favorable environment for personalized treatments. The development of treatment options that allow patients with SAD to train alone will not only have immediate therapeutic gains but also can facilitate them to seek further treatments in clinical settings. With the pressing need for easily accessible options, we have developed a mobile-based VR program that would allow individuals to train alone. This program features various relatable environments and scenario options through interactive and user-friendly means, and includes seven in-app measures that allow objective performance evaluations and feedback recordings. To the best of our knowledge, this program is the only mobile-based VR application that offers SAD treatment curriculum without human support.

The present study aimed to investigate the efficacy of this mobile VR exposure self-training. In addition, we administered cybersickness survey in order to gauge the safety of the immersion. It was hypothesized that individuals diagnosed with SAD would show greater decreases in post-treatment survey scores relative to those in normal controls. We also hypothesized that SAD participants would exhibit greater performance improvements in in-app variables from pre-to post-treatment in respect to those of normal controls.

2. Methods

2.1. Participants

A total of 52 participants were recruited via online advertisements. Exclusion criteria included pregnancy, current use of medication for a medical or neurological illness, severe cognitive impairment, and psychotic symptoms. All participants had normal or corrected-to-normal vision. Participants were screened using the Mini International Neuropsychiatric Interview module (MINI) for DSM-IV to determine the presence of SAD (Sheehan et al., 1998). However, the diagnosis was not disclosed to the participants. Twenty-two participants were diagnosed with SAD (14 females; mean age, 23.0 ± 2.6; education years 15.5 ± 1.1); 30 participants were assigned to normal controls (16 females; mean age, 23.0 ± 1.9; education years 15.3 ± 1.2). There was no significant difference in age and education years between the two groups. All participants gave informed written consent prior to partaking in the study, and the study was approved by the Yonsei University Gangnam Severance Hospital Institutional Review Board.

2.2. Virtual environment setting

After being familiarized with the use of VR equipment, all participants executed the mobile virtual presentation task by themselves based on to the built-in instructions. The virtual environment was displayed via the head-mounted display (HMD), which consisted of a Samsung Galaxy S6 latched onto Samsung Gear VR powered by Oculus. A pair of in-ear earphones with a microphone was also utilized. Gear VR allowed a 360° view with 96° field-of-view. In addition, Samsung Gear S2, worn on the wrist, was used to measure heart rates throughout the training sessions. Instructions for the task were presented as text on the screen or by voice via the audio system.

As shown in Fig. 1, the virtual environment offered three different social situation sets: school, business, and everyday life. Each set was comprised of 4 levels, and each level included 3 topics. All levels depicted different situations that are relevant to the particular environment, and all topics within a level were appropriate to the context. As the level advanced, the difficulty also increased; and to minimize variances between the environments, components like the number of avatars, number of gestures and distractions such as nodding and yawning while the participant was speaking, and topic difficulties were tailored to be as similar across all VR environments. At the beginning of each topic, there was a listening phase, in which one or two avatars briefly introduced the topic via various means such as sharing its opinion, asking a question and giving an introductory speech (Supplement 1). In each topic, participants' task was to speak as long as possible in response to the avatars' (speaking phase) and finished it by pressing the end button.

The in-app measures were made up of 7 different variables; (1&2) Percent change in heart rate from baseline before starting the program to the listening phase (Hb-Hl) or speaking phase (Hb-Hs) of each program level; (3) eye contact percentage, percentage watching the areas of interest (AOIs) drawn around each avatar from the head to chest, and from shoulder to shoulder; (4) total speech time, the time measured from the end of listening phase until participant ended the topic; (5) voiced time ratio, the ratio of actually voiced time to the total speech time; and (6&7) two self-evaluations, level of nervousness and confidence in content answered at the end of every topic within the virtual world. The two self-evaluation questions were measured on a 3-point Likert scale (0 = “very nervous” and “not confident,” respectively; 2 = “not nervous” and “very confident in the content,” respectively). Participants could review each of the variables on the performance evaluation page. All data were instantly uploaded and made available on a cloud-based website.

2.3. Training procedure and performance measurements

All participants attended 8 training sessions (Supplement 2) over 2 weeks in the VR center. To minimize background noise, participants were in a room alone with an assistant, and were seated in a revolving chair. The assistant simply provided help to participants in the operation of the VR equipment. Once basic instructions were explained, participants chose one of the three environments, and then began the VR program. At each training session, participants completed all three topics within a level. Each level was repeatedly experienced for two sessions. Upon completing one topic and answering the two subjective questions in-app, participants were instructed to see the performance report to go through each variable for further self-reflection, and were suggested to reflect on the content, general flow, and areas they could improve in to further facilitate participants to ruminate on their performance; however, these were not recorded. This process was repeated a total of three times per session.

Participants completed a set of questionnaires at two different stages of the experiment: before treatment and after treatment. The questionnaires included the Hospital Anxiety and Depression Scale (HADS) (Zigmond & Snaith, 1983), the Liebowitz Social Anxiety Scale-Self Report (LSAS-SR) (Liebowitz, 1987), and the Social Interaction Anxiety Scale (SIAS) (Mattick & Clarke, 1998). To assess the safety, participants repeatedly reported the severity of motion sickness symptoms after every first round of each level using the