Evaluating Spatial Presence in Image-based Virtual Reality Self-Therapy

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Abstract. Virtual reality (VR) has been used to treat various psychological disorders, including stressful conditions. It has been proven to be effective in reducing one's stress levels. Through the utilisation of VR, users can experience self-therapy without having to see an actual therapist in person. This is mainly for those who are having mild or medium stress levels. Accordingly, this study proposes an application of Image-based VR (IBVR) for self-therapy that applies the spatial presence theory and the Guided Imagery Therapy (GIT) technique. The hybridisation of spatial presence and GIT in the development of the IBVR tool for self-therapy is expected to provide calmness to users through the feeling of being in a virtual environment. Following identifying appropriate elements, a prototype was developed for evaluation purposes. This paper evaluates the level of spatial presence experienced by users through the IBVR therapy session. The results indicate that the IBVR self-therapy tool is capable of giving users the sense of being physically present in the virtual environment. This potentially supports the effectiveness of the IBVR self-therapy tool in giving calmness and thus reducing stress for the users' mental well-being.

Keywords: Virtual reality, Spatial presence, Self-therapy, Guided imagery therapy, 3D Panorama, Image-based virtual reality.

1 Introduction

Virtual reality (VR) technology is produced to provide an experience to users that generates a feeling of being genuinely present and immersed in the virtual world of the VR environment [1-2]. The sense of presence in VR that creates the feeling of "being there" in a virtual environment can be applied in many situations in various fields. [3-4]. Besides, VR has found applications in medicine and healthcare, particularly as an alternative method for addressing psychological disorders. It is done through VR exposure therapy, which provides treatment in a safe and controlled environment. It is more

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cost-effective. Stress is also classified as a psychological and physiological response that can cause a decline in health and human performance in daily activities. [5-7]. One of the traditional treatment methods implemented to overcome stress-related problems is Guided Imagery Therapy (GIT). In this therapeutic technique, the therapist assists the client in visualising and immersing themselves in a calming and serene environment or recalling a sequence of enjoyable and positive experiences to help the client feel calmer and thereby reduce stress [8]. However, there are also possibilities in which the patient misunderstood the therapist's instructions. This situation makes it possible for the patients to imagine inappropriate scenarios that will harm them otherwise [9]. So in this kind of situation, VR can be one of the alternatives to the use of imagination and memory by providing a soothing scenario in a virtual environment. This tool allows users to see the visuals provided in the virtual environment instead of using their imagination. This VR-mediated environment can also help users practice relaxation techniques to overcome stress.

Accordingly, this study proposes an application of Image-based VR (IBVR) for self-therapy that applies the spatial presence theory and the (GIT) technique. This innovative IBVR self-therapy tool provides users with the opportunity to engage in therapy independently, without the need for face-to-face sessions with a real therapist. This is especially for those who are having mild and moderate stress levels. As users navigate through the IBVR self-therapy tool, they are expected to feel calm and thus reduce stress. Nevertheless, this paper aims at evaluating the sense of spatial presence of the IBVR self- therapy tool. The following sub-topics provides elaboration on the background, methodology, result, discussion, and conclusion of the study.

2 Background

2.1 Virtual Reality and Presence

VR is a virtual environment that looks as if it is the real environment, developed with computer technology. It is an environment that can be experienced and the user can interact with it [10]. VR has expanded in various domains which include entertainment, education and health [11]. For example, in mental health, VR has been used as a therapeutic tool for managing stress and has been proven to reduce stress levels and improve task performance among people [12-13]. However, it is crucial for the user to feel present in the virtual environment and be able to act [14] to ensure the efficacy of the VR tool. Most studies on spatial presence have focused on the main form of VR application, Geometry-based Virtual Reality (GBVR). This is most likely due to the high sense of presence in the GBVR application through the provided interaction functions [15-16]. Even so, the process of developing a realistic GBVR environment with its interactive functions is time-consuming and requires high processor performance [15], [17].

Meanwhile, IBVR is a type of VR application developed using real photos or images taken from various angles. These photos are stitched together using specific software

to create a realistic and high-quality virtual environment. The IBVR has the advantage of consuming less time for development and it does not require a computer with high performance [5],[9],[18]. Even in the field of psychotherapy, IBVR has shown its capabilities through implementation in several existing studies [5], [9]. Although IBVR has some limitations in terms of interaction function, it is capable of generating a sense of spatial presence as it is important to enhance the effectiveness of the IBVR self-therapy.

2.2 Spatial Presence Theories

The theory of spatial presence by [19] was developed for applications with a high level of interactivity. It is not relevant to be adapted in this study which applies IBVR which has a low level of interactivity. Meanwhile, the theory of spatial presence by [20-23] put more focus on human psychological factors to generate a sense of presence. It is contrary to this study, which emphasizes media factors that can generate spatial presence, rather than focusing on human factors. While the theory of presence by [24-25] does not explain in depth about the direction or relationship between the variables in their theory.

On the other hand, the theoretical model of spatial presence produced by Wirth et al., [14] is composed of both media and human factor. This model is claimed to be suitable to be adapted in any type of media for the purpose of generating spatial presence. Based on the elements in Wirth's model, [26] has taken an approach to propose a specific spatial presence model for IBVR. However, [26] only emphasizes the media factor that can generate spatial presence rather than the human factor. It is a model that consists of generic components to create spatial presence in IBVR. Although the model was not meant for VR applications in self- therapy, the components and elements found in [26] can be expanded and modified to meet the objectives of this study.

2.3 Guided Imagery Therapy

Guided Imagery Therapy (GIT) is a psychological therapy technique that is proven to be effective as one of the interventions that can reduce the level of stress and anxiety of patients [27-28]. Besides that cognitive behavior is important to be adapted in the technique to reduce stress [29-31]. It uses a variety of methods such as visualization and simple imagery, metaphor and storytelling, fantasy exploration and game play, dream interpretation, drawing, and active imagination. This technique works to provide provocation to the conscious mind by bringing elements of the subconscious mind into it. Usually in GIT procedures, the patient needs to meet with a therapist who will directly guide the patient to imagine himself 'being in' a relaxed environment, preferably the patient's favourite location [9]. This method will provide a sensation of relaxation to the patient and lower the stress level. However, there is a possibility that the patient may misunderstand the instructions given by the therapist. As a result, patients are more likely to imagine scenarios that could negatively affect them. Thus, this study proposes a technology-based method with the application of IBVR as a self-therapy tool by combining GIT techniques and spatial presence theory. IBVR self-therapy allows users to view

scenarios in a virtual environment for therapeutic purposes instead of using their imagination. Users are expected to feel like they are physically present in the virtual environment. Generic components of GIT and spatial presence for the IBVR self-therapy application were obtained through the content and comparative analysis conducted on existing models and theories. A key element of GIT embedded in the IBVR is a recorded narration consisting of therapist guidance on deep breathing and relaxation exercises. The narration also contains the therapist's guide on the virtual environment experience, as well as strategies for the user to cope with stressful situations. As for the spatial presence component, it is based on three main elements, namely (i) calmness, (ii) interactivity, and (iii) perceptual realism, as illustrated in Fig. 1.

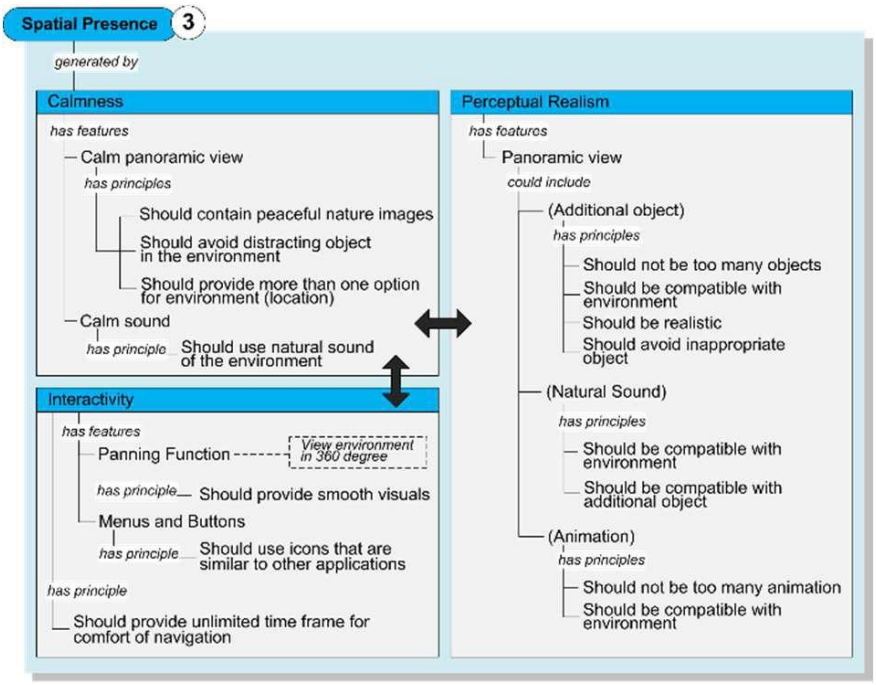

Fig. 1. Elements for spatial presence component

The calmness element refers to a calm panoramic view and sound [6]. It is outlined that the view should contain peaceful nature images and avoid distracting objects that may interfere with users' attention and emotion. While interactivity element refers to the navigation function that includes the panning function as well as menus and buttons in the IBVR self- therapy tool. With panning function, users are able to view the virtual environment in 360 degrees. The visuals for the panning function should be smooth and the icons for menus and buttons should be similar to other existing applications. Other than that, the perceptual realism element indicates that the panoramic view in the IBVR can also include additional objects, natural sounds, and animations that are appropriate and compatible with the environment. This is to increase the users' perception of the realism of the virtual environment.

The next sub-section describes the methodology of this study, followed by the results and discussion. It focuses on evaluating the level of spatial presence among users during their IBVR self-therapy experience.

3 Methodology

In this paper, the study aims to evaluate the spatial presence experience by the participants during their navigation in the IBVR self-therapy tool. This study was conducted on 100 undergraduate and postgraduate students at Universiti Utara Malaysia during the study week. As for postgraduate students, they were selected among those who will be having a viva session soon. The participants were selected on a voluntary basis. Only those who are interested are invited to be involved in this study and have the opportunity to experience the IBVR self-therapy tool. However, those with any physical disability or mental disorders were not included in the experiment. Table 1 shows the demographics of the participants.

Table 1. Demographics of The Participants

Items	Details
Age	18 to 45
Number of Male Students	50
Number of Female Students	50
Number of Undergraduate Students	62
Number of Postgraduate Students	38

The experimental session was conducted according to the diagram in Fig. 2. According to the diagram, participants were given a brief explanation of the procedures and purpose of the study, prior to the experimental session. Then, participants were required to provide their demographic information and sign a consent form.

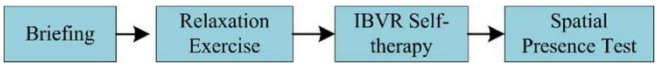

Fig. 2. Flow of the experimental session

Then, the participants were guided with a recorded narration for a deep breathing and relaxation exercise. This is to help the participant feel relaxed before experiencing the virtual environment. Then the participants were equipped with a Head-Mounted-Display (HMD) to experience the IBVR environments. In this study, there were four environments provided for the participants to select using the HMD controller, i.e. Waterfall, field, mountain and beach.

Participants were free to choose any environment based on their preference and were allowed to watch the video in any position they feel comfortable. Through the HMD, participants could enjoy every angle of the virtual environment by turning their heads

to look around and listen to the natural sounds. Participants were also allowed to end their session at any time they did not feel comfortable continuing. After the session ended, the participants were asked to fill out a spatial presence questionnaire to assess the level of spatial presence sensed by the participants during their experience in the virtual environment.

The questionnaire consists of four main variables to assess spatial presence namely (i) calmness, (ii) interactivity, (iii) perceptual realism and (iv) spatial presence. These variables were based on elements of spatial presence proposed in this study. Participants were asked to provide answers for all items in each variable based on five Likert scale, ranging from 'strongly disagree' to 'strongly agree'. The results as well as a brief discussion about the analysis of the participants' responses to this questionnaire.

4 Result and Discussion

In this paper, the evaluation is focused on the perceived sense of spatial presence by the participants. The objective is to evaluate the level of spatial presence sensed by the user during their experience with the IBVR self-therapy tool. As mentioned earlier, the measurement was done through the spatial presence questionnaire that was developed based on the proposed elements for generating spatial presence in the IBVR. The participants were required to complete the questionnaire after they navigated through the IBVR self- therapy tool in the experimental session. Having all sessions finished, the responses from the participants were analysed. Table 2 shows the mean value and standard deviation for all four variables (calmness, interactivity, perceptual realism, and spatial presence). The possible mean score based on five Likert Scales were categorized into three levels, i.e. low (1-2.33), average (2.34-3.67), and high (3.68-5.00).

Table 2. Mean and Standard Deviation of Spatial Presence Variables

Variables	Mean	Std. Deviation	Level
Calmness	3.86	.791	Average
Interactivity	3.86	.773	Average
Perceptual Realism	4.14	.516	High
Spatial Presence	3.86	.695	Average

As shown in the table2, the mean value for all variables was in the range of 3.86 to 4.14. Meanwhile, the standard deviation of variables ranged from 0.516 to 0.791. It is noted that the variable of perceptual realism scored the highest (4.14) mean value with a 0.516 standard deviation. This was then followed by the lowest score with the same mean value for the variable of calmness (M=3.86, Std. Dev=0.791), interactivity (M=3.86, Std. Dev=0.773), and spatial presence (M=3.86, Std. Dev=0.695). Based on these results, it shows that all variables appear relatively high on the scale leading to a mean of 4.00. In conclusion, it shows that the respondents gave a positive response to all the components in the IBVR self-therapy.

In other words, it can be concluded that the IBVR self- therapy tool developed based on the proposed elements of spatial presence can evoke the sense of being present in the virtual environment. Even though IBVR is less interactive compared to the GBVR, it is still capable of generating a sense of spatial presence hence giving a quality virtual experience to the user. These features support the effectiveness of the IBVR self-therapy in providing a sense of calmness to its users as they feel like being physically present in the virtual environment. It is in line with other existing studies which from [29-30] on virtual reality therapy that have shown positive relationship between a sense of presence and psychotherapy.

5 Conclusion

The main objective of this paper is to exhibit the level of spatial presence generated by the IBVR self-therapy tool. The development of the IBVR was based on the elements of GIT and spatial presence which have been extracted from existing models and theories. Participants were allowed to experience the IBVR prototype through a dedicated experimental session. Then they completed a questionnaire provided at the end of the session which aims at evaluating the level of spatial presence of the IBVR. From the results, it can be seen that the participants provided positive responses. This shows that IBVR is able to provide a sense of presence in a virtual environment to users. This value is crucial in ensuring the effectiveness of the IBVR self- therapy tool for giving therapeutic effect to users.

Nonetheless, it is suggested that a more thorough investigation be conducted to see the correlation between a sense of spatial presence and psychotherapy, specifically on the stress condition. Specific measurements can be used to assess the extent to which the effectiveness of VR therapy is proportional to the level of spatial presence sensed by the user. Above all, the IBVR self-therapy tool is expected to be able to provide calmness to users. It could be an alternative for mental health and well-being, especially in promoting a stress-free lifestyle.

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