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The effect of user's perceived presence and promotion focus on usability for interacting in virtual environments

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ABSTRACT

Technological advance in human–computer interaction has attracted increasing research attention, especially in the field of virtual reality (VR). Prior research has focused on examining the effects of VR on various outcomes, for example, learning and health. However, which factors affect the final outcomes? That is, what kind of VR system design will achieve higher usability? This question remains largely . Furthermore, when we look at VR system deployment from a human–computer interaction (HCI) lens, does user's attitude play a role in achieving the final outcome? This study aims to understand the effect of immersion and involvement, as well as users' regulatory focus on usability for a somatosensory VR learning system. This study hypothesized that regulatory focus and presence can effectively enhance user's perceived usability. Survey data from 78 students in Taiwan indicated that promotion focus is positively related to user's perceived efficiency, whereas involvement and promotion focus are positively related to user's perceived effectiveness. Promotion focus also predicts user satisfaction and overall usability perception.

1. Introduction

In 2010, Microsoft's market release of the XBOX Kinect ushered in a new stage in the development of virtual reality and the application of cognitive psychology, particularly with human–computer interaction (HCI). The realm of Virtual reality (VR) has captured considerable research attention (e.g., Wilson, 1999; Cobb, 1999; Duarte et al., 2014; Lin et al., 2015; Lawson et al., 2015; Kinateder et al., 2014). For example, Lawson et al. (2015) examined several methods combining virtual reality and physical tools within vehicle development to optimise ease of entry and exit. Kinateder et al. (2014) have found that in a virtual tunnel fire scenario, actions of a virtual agent affected participants' evacuation destination choice and travel paths. Chang et al. (2011) demonstrated that students were enthusiastic about a therapy system using Kinect with full-body control interaction and were willing to use it for physical therapy during experiments. Bruin et al. (2010) employed VR for a simulation that aided seniors in maintaining their balance, which allowed the seniors to stay healthy by avoiding accidents, reducing fatigue, and increasing happiness. Meanwhile, playing games in VR was found to be effective in encouraging participation in sports and developing team spirit. Pan et al. (2006) presented an in-depth discussion of VR in terms of its application and purpose in education, training, and entertainment, as well as how it can enhance the motivation for both traditional and digital learning. Yahaya (2005) discovered that VR learning significantly improves student achievement, enhances their problem-solving ability, and fosters interaction with peers. Vora et al. (2002) found that VR training system was preferred over PC based system for aircraft visual inspection training. Jackson and Fagan (2000) confirmed that VR can be successfully integrated into the school curriculum, enabling students to enhance their performance and learning ability.

Overall, prior research has focused on examining the effects of VR on various outcomes, for example, learning and health. It is clear from extant literature that VR systems are conducive in facilitating learning and maintaining physical health. However, which factors affect the final outcomes? That is, what kind of VR system design will achieve higher usability and help users to benefit most from the system? This question remains largely . Furthermore, when we look at VR system deployment from a human–computer interaction (HCI) lens, do users attitude play a role in achieving the final

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outcome? This research aims to answer the two questions. Based on presence theory (Lee, 2004; Vora et al., 2002), we identified immersion and involvement, two primary characteristics of presence, to be important system factors that will enhance user's experience in a VR environment. Presence captures the user's feeling of "existence" in a VR environment. Presence has two characteristics: immersion and involvement. Immersion plays an important role in a user's gaming playing experience (Brown and Carins, 2004). Immersion can also explain how students experience educational contexts and how this experience influence learning performance. Li (2009) proved that immersive digital learning can better motivate a student compared with traditional learning. Hanson and Shelton (2008) reported that in an immersive environment, users are motivated to be more proactive in constructing their own knowledge. Sherman and Craig (2003) reported that immersion in VR created a successful personal experience with the users' auditory, visual, and tactile experience or actions fully immersed in the VR environment. Brenton et al. (2007) proposed that VR technology that is interactive, immersive, and imaginative will characterize the next generation of medical instructional designs and VR learning systems. Involvement is an experience that describes an individual's personal psychological state, energy focus, and attention on their own set of stimuli (Witmer and Singer, 1998). Sylaiou et al. (2008) reported that the respondents in a virtual museum experiment correlate the degree of impact between involvement focus with the sense of time extended. Blascovich et al. (2002) proposed that in an immersive VR, sensory messages are more akin to psychological perception and experiences. Sylaiou et al. (2008) found that the sense of presence is a crucial issue in virtual environments and can enhance effectiveness and user engagement. Thus, we argue that the two presence factors, immersion and involvement, are positively related to usability.

Does user's attitude play a role in achieving final outcomes such of satisfaction, efficiency and effectiveness? Regulatory focus, a widely used theory in virtual environment-based, computer-mediated communication, has the potential to explain how user's attitudes affect system usage outcomes. Regulatory focus is considered to be one of the most important theories among manipulation approximation theories (Jin, 2011). Regulatory focus refers to people's tendencies in moving from their current state toward their desired state, as viewed through the perspective of self-regulation. There are two tendencies: "promotion focus" tendency focuses on the positive presence, whereas "prevention focus" tendency focuses on the negative presence (Higgins and Spiegel, 2004). Regulatory focus can apply not only to people's state of mind, but also to systems. For example, a system can be either promotion focus, with the goal being "enhancing your health", or prevention focus, with the goal being "preventing disease". Jin (2010) found that the fit between user's regulatory focus state and the goal of the system in computer-mediated communication (CMC) within 3D VR increases users' enjoyment, feelings of presence, and post experimental healthy eating intentions. Does regulatory focus fit, i.e., the alignment of a user's regulatory focus state and that of the system enhance user experience and performance in VR environment? This is what we would like to find out with this research.

To test theories of presence and regulatory focus, the present study designed a 3D VR digital learning system with tasks that are based on promotion focus. In the task planning scenario, the user's desire to succeed is emphasized upon, thus, the intrinsic cognitive state is a state of hope. The mission of this system is to develop the required knowledge the subject will need, comply with the ideal of the subject, enable the subject to acquire several skills, and demonstrate positive results. The subjects should be willing to assist the system in order to acquire knowledge or a skill. Success in the task results in feelings of joy, whereas failure results in frustration. As such, we predict that promotion focus, with aligns with the system goal, can drive users' learning usability. We further tested the effects of immersion and involvement, two important system characteristics, and examine their effects on VR system usability. Through extensive literature review, we summarized three most commonly used dimensions of usability: effectiveness, efficiency, and satisfaction. Efficiency refers to the learning curve of the subjects and the rate of incidence or error occurrence. Effectiveness is the decision of the subjects to complete the learning task or not, as well as whether the system meets their requirements. Satisfaction involves whether users enjoy using a somatosensory device to learn and whether somatosensory manipulation is conducive to learning, capable of kindling interest, and is convenient and satisfactory. To summarize, our hypotheses are:

H1: User's involvement is positively related to his/her perceived usability of the system
H2: User's immersion is positively related to his/her perceived usability of the system
H3: User's promotion focus is positively related to his/her perceived usability of the system

Fig. 1 below summarized our research model.

2. Methods

2.1. Participants

Eight-four students from a university in Taiwan were recruited to participate in the experiment. A final usable data of 78 surveys were returned. The respondents comprised 42 males and 36 females. 71 respondents were undergraduate students, 7 were graduate students. As for the age of the respondents, 4 respondents were under 18 years old, 71 were from 18 to 24 years, and 3 were above 25 years old. The majority of the respondents have not had any simulated boxing experience (69) while 9 had boxing experience using Nitendo Wii. In terms of the control unit somatosensory experience, the majority of the users (50) had used somatosensory control devices, whereas others (28) had not used any. For the respondents who had used control unit somatosensory devices, the average usage time was more than two hours for 23 subjects, 1–2 hours for 18 subjects, and an hour or less for 9 subjects.

2.2. Environment implementation

In this study, the experimental environment (boxing training) that was built on the computer's operating system is the

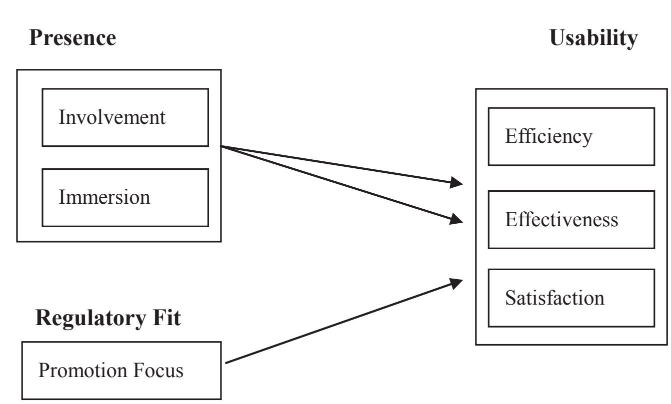

Fig. 1. The research model.