

## Cultural aspects in simulation of work environment in virtual environment

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**Abstract.** With the advance and fast growth of virtual reality (VR) and augmented reality (AR) technology, simulation in virtual environment (VE) has been applied in many fields for various purposes, such as business, commercial, entertainment, gaming, training, workplace evaluation, etc. The demand for virtual scene construction will be different for every fields. One common point is that the detailed content of the virtual scene is a very important factor for the immersion of its users in the simulated environment. This study aims to investigate the potential influence of background familiarity and cultural differences in the virtual workplace environment. Eastern Asian participants (Taiwanese) are recruited in this study. Participants performed a manual picking and sorting task of bricks in three different virtual background environments: basic background, Asian style background, and Western style background. Several questionnaires were applied to the participants before the main VR experiment and are used to evaluate some relevant experience of the participants. At the end of each VR experiment, participants are asked to fill out the SSQ (simulator sickness questionnaire) and PQ (presence questionnaire) questionnaires in order to estimate the degree of presence and simulator sickness after the VR experiment. Finally, the task performance, i.e. operating speed, SSQ and PQ scores were collected and analyzed. Experimental results are used to clarify whether Asians would have performed differently in the three types of workplace environment design. The purpose is to allow and enable virtual space designers to design a proper and better simulated workspace.

**Keywords:** virtual environment (VE), culture, presence, simulator sickness, workplace, simulation, usability

### 1. Introduction

Recently, augmented reality (AR) and virtual reality (VR) have been applied in various fields for education and training purposes. Such modern and innovative technology has been facilitating fast growth and advances in the industry as well as in usability

and ergonomic research. An adequate AR/VR education and training system developed based on users' profiles and subjective preferences could be a key value and is supposed to enhance the quality of our work life.

VE is becoming a very popular tool in the practice nowadays. The design and implementation of high-quality VE requires intense knowledge of various disciplines, such as behavioral and social sciences, computer science, physics, art, philosophy, and much more. Presence is a sense of "being there" inside any specific space even when one is physically located in a different location. It can also be described as the way the user subjectively experiences the immersion. Immersion is the real objective degree to which a virtual reality system and application projects stimuli onto the sensory receptors of users in a way that is extensive, matching, surrounding, vivid, interactive, and plot informing (Slater and Wilbur 1997). Presence level of a VE user is an important indicator for the design quality of a VE system. The most frequently used method for measuring presence is the Presence Questionnaire (PQ) developed and revised by Witmer (1998, 2005). Another important evaluation key factor of a VE system is the sickness level induced by the simulated activities of a VE user. Questionnaires or symptom checklists are the common means of measuring VE sickness. The Simulator Sickness Questionnaire (SSQ) is one of the most common tool for estimating simulator sickness. A total of 16 discomfort symptoms were established and validated (Kennedy et al. 1993). The SSQ has become a standard for measuring simulator sickness, and the overall severity factor may reflect the best index of VE sickness.

Users of a VE system may come from different cultural backgrounds. Diverse cultural characteristics could be considered based on various races, languages, politics, etc. Researchers have found cultural differences in cognition of visual background (Evans et al. 2009, Chua et al. 2005, Nisbett 2001) – Chinese participants focus on background information or the overall structure of the visual environment more than American participants, while the Americans put more attention on the target objects. Goh et al. (2009) observed cultural differences in scene perception. They reported that Westerners have fixated on either the objects or the background for longer time durations in comparison to Asians. Asian participants in their study showed more frequent fixation alternating between the objects and the background with shorter time durations. Bucolo (2004) investigated the presence experience of Chinese and Australian participants in immersive virtual environment. Their study found that both cultural groups recognized the visual stimuli better in their own cultural visual background settings, i.e. Australians identified the target information better in the simulated Australian scene than in the simulated Chinese scene.

In this study, we focus on the design concept in simulation of work considering the cultural aspects. The nature of users can be quite diverse due to their cultural backgrounds. Under different design settings of the AR/VR work environment, e.g. visual fidelity, complexity, familiarity, etc., the AR/VR users might perceive various scales of presence, immersion, task familiarity, and simulator sickness. Such effects could further affect the user performance and simulation effectiveness in the work training. In the experimental design, we have constructed three different scenarios of a work simulation with various environmental parameters. A pre-evaluation on the cultural objects (i.e. virtual items demonstrated in the work simulation) was conducted applying our customized item choice questionnaire (Xu 2018) in interviews with participants coming from different cultural backgrounds. The evaluation results were used to identify virtual items for various cultural categories. The final virtual items used to decorate the work environment are selected based on the cultural familiarity as well as the subjective preference. The three scenarios have been set up as one controlled condition and two

cultural levels (Asian vs. Western). A total of 50 participants coming from different cultural backgrounds (i.e. nationality and living region) performed the work simulation.

## 2. Method

### 2.1 Participants

In the pre-experiment session, a total of 20 participants were recruited for the item choice questionnaire and follow-up interviews. The results were analyzed and used for selecting the virtual objects used in the main experiment. 10 were Taiwanese (5f, 5m, mean age: 23y, SD: 1.49y) and 10 were Westerners (3f, 7m, mean age: 24.5y, SD: 2.99y). A total of 30 Taiwanese participants took part in the main VE experiment (19f, 11m, mean age: 23.46y, SD: 2.06y).

### 2.2 VE experiment

Before designing and constructing the virtual rooms for the main VE experiment, a pre-evaluation experiment was conducted. Participants were invited to wear a HMD and view various virtual objects (e.g. decoration items and furniture pieces) for rating the objects for later purposes. A LEGO® sorting experiment has been designed in the main experiment. Participants were asked to sort some LEGO® bricks randomly displayed on a desk into 6 corresponding boxes by its color (blue, yellow, or red) and its shape (square or rectangular). A time duration of three minutes was given to each participant for performing the sorting task in each test condition (three virtual rooms) as demonstrated in Fig. 1.



**Figure 1.** (Left) The Basic room. (Middle) The Asian-style room. (Right) The Western-style room.

### 2.3 The questionnaires

The Item Choice Questionnaire (ICQ) was applied for measuring the cultural background of participants, as well as their familiarity scale of virtual items was used. This ICQ asked participants to classify the cultural category and rate the familiarity scale of 205 virtual items of 15 object types using a 5-point Likert-Type scale (1: not at all familiar, 5: extremely familiar). It also asked about participants' necessary demographical information and their decoration preference of virtual workspace.

The Simulator Sickness Questionnaire (SSQ) have been applied before the LEGO task. After the simulated tasks, participants have been requested to continue filling out the Presence Questionnaire (PQ) and SSQ to conclude the experiment (Witmer and Singer 1998, Kennedy et al. 1993). The original PQ consists of 32 items considering factors of control factors, sensory factors, distraction factors, and realism. In this study, we have adapted to an alternative version of the original PQ using 24 items of the original 32 items with subscales with slightly different combination of items (realism,

possibility to act, quality of interface, possibility to examine, self-evaluation of performance, and excluding “sounds” and “haptic” items which are not applicable in this study design) (Robillard et al. 2002).

### 3. Results

The data collected from the ICQ was analyzed in order to find out the cultural characteristics and familiarity scales for the different virtual rooms of participants. Table 1 demonstrates the results of ICQ for each object types (e.g. table, chair, shelf, calendar, etc.). A virtual object was classified as either Western-style or Eastern-style or neutral for later use.

**Table 1.** Results of cultural categories identified by the participants, for “table” objects. A: Western-style, B: Eastern-style, C: Not sure.

NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	6	5	7	8	9	0	1	7	9	2	1	0	7	0	1
B	3	5	2	0	0	10	7	2	1	6	7	10	2	9	8
C	1	0	1	2	1	0	2	1	0	2	2	0	1	1	1
Sort	A	C	A	A	A	B	B	A	A	B	B	B	A	B	B

Table 2 shows the familiarity level of each item. Only items with clear identification of its cultural representation and sufficient familiarity were considered to be used for the final construction of the VE rooms.

**Table 2.** Results of familiarity level perceived by the participants, for “table” objects. Scale: 1 (not at all familiar) to 5 (extremely familiar).

NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sort	A	C	A	A	A	B	B	A	A	B	B	B	A	B	B
AVG-Asian	3.1	3	<b>3.6</b>	3.6	2.9	3.7	3.2	2.7	2.5	3.8	3.1	<b>4.2</b>	3.6	3.8	4.1
AVG-Western	3.4	2.8	<b>4.3</b>	3.5	2.9	2.4	2.2	2.2	3.1	3.4	3.2	<b>2.8</b>	3.1	3.2	2.8

The effect of cultural background on sorting speed reveals no significant difference. ( $F(2, 25) = 1.819, p = .172$ ). Participants ( $N = 27$ , all Taiwanese, mean age: 23.46y, SD: 2.06y) sorted 9.531, 9.494, 8.605 LEGO® pieces per minute in Eastern-room, controlled-room, Western-room respectively. The cultural background shows significant effects on the presence level ( $F(2, 25) = 5.175, p = .014$ ). Participants’ presence level is higher in own cultural room (mean PQ = 4.959) than the Western-room (mean PQ = 4.774). The effects are significant in the PQ sub-dimensions of CF (control factors) ( $F(2, 25) = 6.770, p = 0.002$ ) and RF (realism factors) ( $F(2, 25) = 3.995, p = .024$ ).

The simulator sickness questionnaire (SSQ) was used to measure and score simulator sickness level every time immediately after participants finished the sorting task in each virtual room. The mean simulator sickness score is the highest in the controlled-room (mean SSQ = 1.11), and then is in the Eastern-room (mean SSQ = .93), and is lowest in the Western-room (mean SSQ = .93). There is no significant effect of cultural background on SSQ ( $F(2, 25) = .219, p = .804$ ).

#### 4. Discussion and Conclusion

In this study, the effects of cultural aspects on simulator sickness level and presence level in a simulated workspace are investigated to provide advice for future simulated workspace design. The results showed that the participants generally have a higher presence level in a simulated workspace with own cultural background design. Increasing background familiarity scale also increased the richness of the virtual environment, this hypothesis might be confirmed by the analysis of the PQ RF sub-dimension ( $p = .024$ ). Cultural background plays an important role in a simulated work environment. Despite no significance in the task performance, we could notice the higher performance and tendency in own-culture simulation. Outlook – we should consider users' cultural background fulfilling one's expectation in the simulation.

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