Effect of pre-exposure to task experience on presence in a virtual grasping task

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Abstract: Virtual reality (VR) has become a popular tool in ergonomics applications, such as in system simulation, usability testing, or in task training. Performance and usefulness of such VR applications have been investigated in terms of validity, effectiveness, and efficiency. In this study, we aim to understand how task experienced performers rate presence as compared to the users who are naïve to a simulated task in a VR environment. Presence has been rated in a VR simulator by both, task experienced and unexperienced participants, performing a virtual grasping task experiment with a head mounted display (HMD). Effect of pre-exposure to task experience has been investigated based on the grasping performance of a total of 24 participants as well as their rated outcome for the presence questionnaire (PQ), the immersive tendency questionnaire (ITQ), and the simulator sickness questionnaire (SSQ). Results have revealed a correlation of the SSQ scores with the PQ scores. Correlations are in agreement with the literature and are due to binding of attentional resources caused by simulator sickness. The role of pre-exposure to task experience has been confirmed statistically by comparing the PQ scores assessed in the VR-only test condition with the PQ scores assessed by participants who have been exposed to both the real grasping task and the VR test condition. Findings of our research are relevant to the design of studies about presence in general but also specifically for reducing bias in presence caused by missing practice. When using VR in ergonomics applications, task experience should be considered in order to effectively benefit from advantages of VR over experiment in real environments.

Keywords: virtual reality (VR), task experience, simulation, presence, head mounted display (HMD), user experience (UX)

1. Introduction

Virtual reality (VR) tools have become popular in human factors engineering (HFE) and ergonomics sector, as for instance is in usability testing, virtual prototyping, measurement time method (MTM), or in training and simulation (Aromaa & Väänänen 2016). Usefulness of VR in HFE has been investigated in terms of validity, effectiveness, and efficiency. Some literature reports effects of technological factors, such as fidelity of VR (stereo image, sound, haptic feed-back, etc.) and interaction modes (tracking, gesture, etc.) on performance in completing tasks in VR (Aleotti et al. 2015,

Kronqvist et al. 2016).

Decades ago, the construct of “presence” has been established, by means of which the intensity of “being there” in VR has become quantifiable. As summarized by Witmer and Singer (1998), presence has been shown to be positively related to task performance. Also, it was found that factors affecting presence are also known to enhance learning. Presence has been shown to depend on the involvement of the user, which in turn depends on some technological factors, as well as on one’s tendency to get immersed in a VR environment. Considering the above, presence is an important variable determining usefulness of VR in HFE, in particular for usability testing, MTM, and in training. Borsci et al. (2015) assessed the user satisfaction in the era of user experience (UX) by comparing the SUS, UMUX, and UMUX-LITE as a function of product experience. Nowadays, practitioners extensively apply quick and reliable scales of user satisfaction as part of their UX analyses to obtain well-founded measures of user satisfaction within certain time and budget constraints. However, in the human-computer interaction (HCI) literature, the relationship between the outcomes of standardized satisfaction scales and the amount of product usage has been only marginally explored. Little is known about the role of pre-exposure to task experience on presence. Since naïve users lack from a comparison with a pre-exposure experience to the task, experienced users might rate presence differently from the naïve users.

VR has gained increasingly high interests in applying simulated VR scenarios of various work environments and tasks, such as a surgical simulator, assembling task, workstations, commissioning and logistics, product design and testing, sports trainings, etc. (Zhou et al. 2013, Pontonnier et al. 2014) In order to assess the quality of simulation, several measurement of performances may be applied, for instance the technical performance as well as the task performance. Other subjective estimates may be applied for evaluating the simulated VR tasks, such as the NASA TLX (task load index), System Usability Scale (SUS), Simulator Sickness Questionnaire (SSQ), Presence Questionnaire (PQ) and so on. In the present study, we aim to investigate the effects of task experience of an user performing a grasping task in a virtual environment. Participants perform a simple manual task (i.e. manipulation of a grasping task) in a real environment for gaining pre-exposure to task experience and/or perform the same manual task in a VR environment wearing a head mounted display (HMD). The research hypothesis is that the user experience about a specific task in reality (real physical world) will affect subjective estimation of presence in the corresponding virtual task.

2. Method

To test our research hypothesis, we have replicated a real manual manipulation task in a VR environment and further validated the VR scenario by means of the measurement of task perfor-mance of the users. In our experimental design, the VR task and the real task are administered in counterbalanced order.

2.1 Participants and experimental procedures

In this study, we investigated the effect of task experience in a total of 24 participants (17y-59y, mean age = 34.46y, SD = 13.28y, 13 females and 11 males). A group of 12 participants were asked to perform a simple manual task in a real

environment first and then carry out the analog task in a virtual environment using a head mounted display. The other half of the total participants were asked to proceed in a reverse order (VR condition first and then real condition). After completing the tasks, all participants were requested to rate the “presence” by means of a presence questionnaire (PQ). In addition, participants filled the questionnaires for immersive tendency (ITQ) and for simulator sickness (SSQ).

2.2 The grasping task

A Lego ® sorting experiment has been designed. Participants were asked to sort some Lego ® bricks randomly displayed on a desk into 6 corresponding boxes by its color (3 types: red, yellow, and red) and its shape (2 types: 2x2 bricks and 4x2 bricks). A time duration of 3 minutes was given to each participant for performing his/her sorting task in each test condition (VR sorting or Real sorting) as demonstrated in Fig. 1.

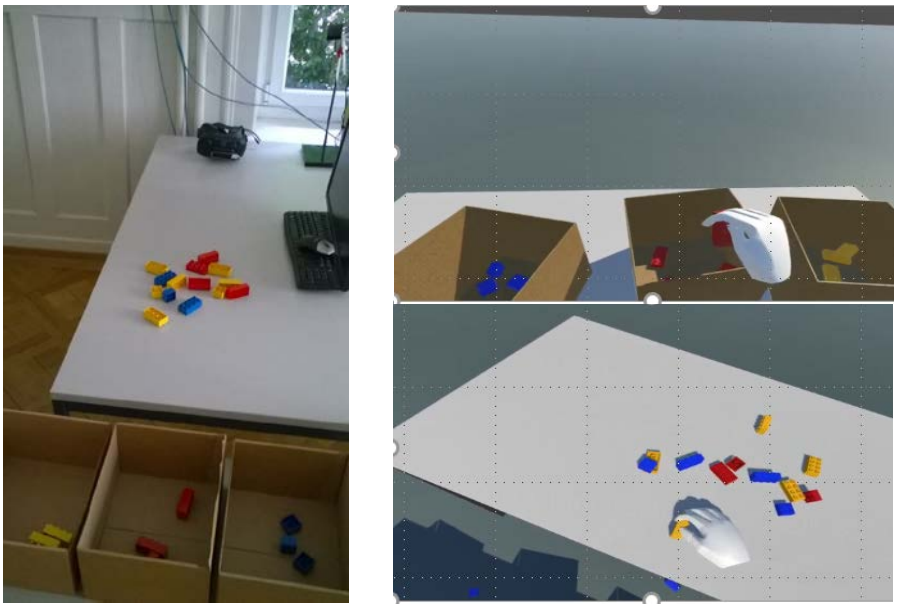

Figure 1. *The Lego ® experiment: (left) Test environment of Real sorting condition; (right) Test environment of VR sorting condition from the HMD view of the test subject.*

2.3 The questionnaires

The Motion Sickness Susceptibility Questionnaire, the Immersive Tendency Questi-onnaire (ITQ), and the Simulator Sickness Questionnaire (SSQ) have been applied via Google Forms before the VR simulation test. After the simulated tasks, participants have been requested to continue filling out the Presence Questionnaire (PQ) and SSQ to conclude the experiment (Witmer & 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

3.1 Sorting performance

The performance of the sorting task in terms of the items (pieces of Lego bricks sorted within the 3 minutes duration) in the VR condition and in the Real condition and its correlation are shown in Fig. 2.

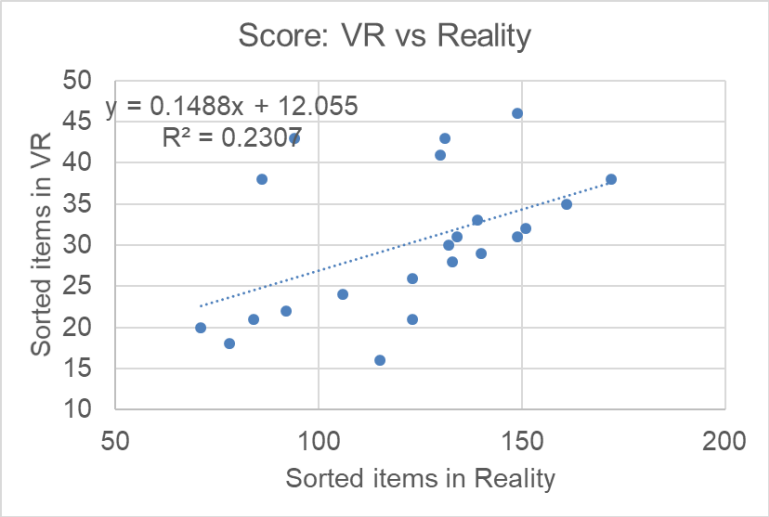

Figure 2. *The Lego ® experiment: Sorting performance – Score: VR condition vs. Reality condition.*

3.2 Presence Questionnaire (PQ)

The total score of the Presence Questionnaire outcomes are shown in Fig. 3 and the correlation with the effect of simulator sickness (the total score of SSQ) in this study.

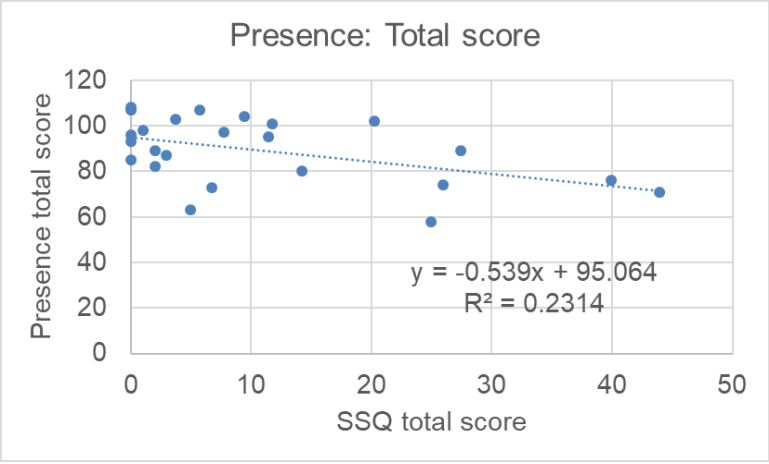

Figure 3. *The Lego ® experiment: Effect of simulator sickness on presence score (Pearson: -0.481, p = 0.017, 2-sided).*

The total score of the Presence Questionnaire and the correlation with the effect of immersive tendency (the total score of ITQ) in this study is shown in Fig. 4.

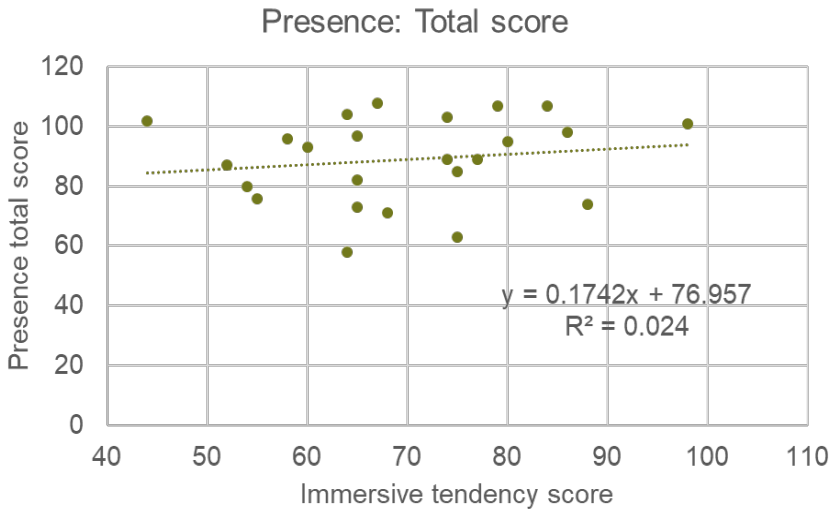

Figure 4. *The Lego ® experiment: Effect of immersive tendency on presence score (Pearson: 0.155, p = 0.470, 2-sided).*

In Fig. 5, the total scores of the Presence Questionnaire are shown in two test sequences, i.e. when the VR task was performed in the first order of the experiment or in the second order of the experiment (after pre-exposure to task experience in the Real condition).

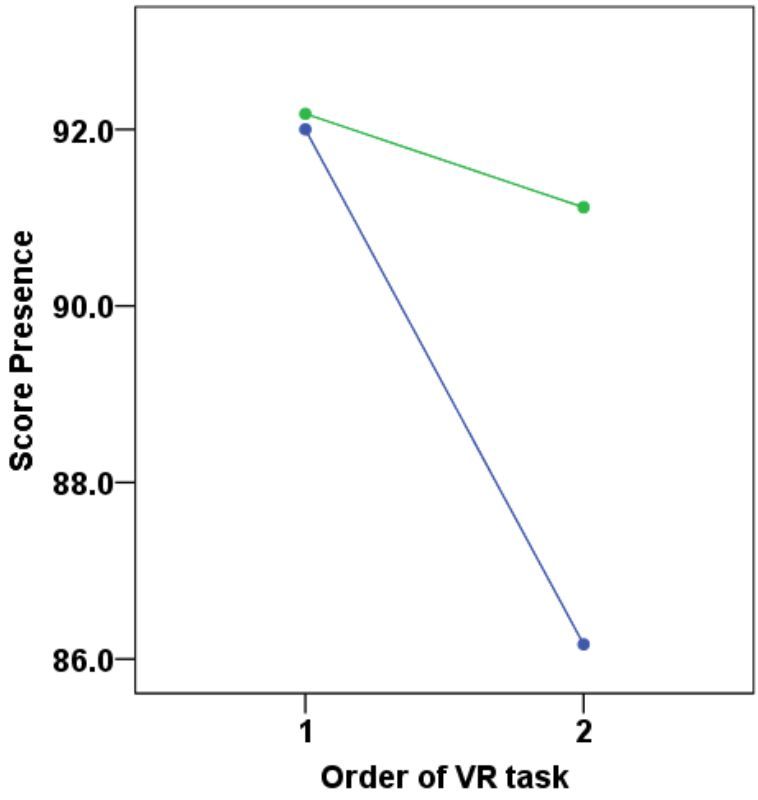

Figure 5. *The Lego ® experiment: Effect of test sequence (task experience vs. no pre-exposure to task experience) on presence score (ANOVA - order of VR task: p = 0.386).*

4. Discussion and conclusions

A correlation of the SSQ scores with the scores of the PQ was found. Correlations are in agreement with the literature, and are due to binding of attentional resources caused by simulator sickness. The role of task experience in the group of participants, which took both, the real and the virtual task was confirmed by means of an ANOVA. Additionally, the role of experience was confirmed statistically by comparing scores of the PQ assessed in the second group (only virtual task) with the PQ assessed in the first group.

In this study, the reliability of the experiment has been examined and discussed. Performances in the VR condition are proportional to performances recorded in the analog task in reality (Real condition). Findings about the effects of SSQ and ITQ on Presence are consistent with the literature. Based on our findings in this study, we have concluded some suggestions for the practice: Experience of task (or pre-exposure to task experience) in reality tends to affect negatively the Presence score of the user, although not at a significant level. A drop in Presence score is about 0-7 %. Drop in the Presence score depends on complexity of simulated task. The drop is more pronounced in simple complexity tasks. We conclude that when using VR in HFE task experience should be considered in order to effective benefit from advantages of VR over experiment in real environments.

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