Real Walking Increases Simulator Sickness in Navigationally Complex Virtual Environments

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ABSTRACT

We report on a study in which we investigate the effects of travel technique on simulator sickness in a real and virtual environment. Participants explored either a real maze or a virtual maze using either natural walking or simulated walking. Reported scores for measures of overall simulator sickness, disorientation, nausea, and occulomotor discomfort were all higher in the natural walking condition than either the simulated walking or real world conditions. This indicates that simulated walking is a better choice for reducing simulator sickness during tasks requiring a navigationally complex environment and a long amount of time.

Index Terms: H.5.1 [[Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities; I.3.6 [Computer Graphics]: Methodology and Techniques—Interaction techniques; I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Virtual reality

Keywords: virtual environments, locomotion, navigation, walking, user study

1 INTRODUCTION

Navigation is a basic task which is essential for immersive virtual environments. In this paper, we focus on travel, the motor component of navigation, to investigate differences between two different virtual environment travel techniques and the real world. In particular, we are concerned with the effect of travel technique on simulator sickness in a complex environment which requires a large amount of physical maneuvering to successfully navigate.

Various studies have been conducted to investigate the effects of travel technique on simulator sickness. Zanbaka et al. found no differences in simulator sickness between real walking and several virtual travel techniques in a small virtual room [4]. Suma et al. found no difference in reported simulator sickness between real walking, gaze-directed, and pointing-directed travel techniques in a complex 3D maze [3]. However, the amount of time spent in the maze varied by participant, and was too low to produce simulator sickness in users (1.5 - 3 minutes). Additionally, Chance et al. reported that natural walking induced less motion sickness than simulated walking in one out of two experiments involving a virtual maze [1]. The use of single self-rating instead of a validated simulator sickness questionnaire, along with the inability to reproduce this effect in a second experiment, warrants further investigation.

2 METHODS

We conducted a user study to investigate the differences between exploration in the real world and exploration in a virtual environment using either natural walking or a common virtual travel technique. To this end, we designed a navigationally complex maze to investigate the differences in navigation. A real-world maze was physically constructed in the lab space, and a virtual environment was modelled to be as nearly identical as possible. The experiment used a between-subjects design with participants randomly assigned to one of three conditions: real world (RW), natural walking in a virtual environment (VNW), or gaze-directed simulated walking in a virtual environment using a joystick (VSW).

Participants explored either the real or virtual maze for five minutes. In addition, participants in the virtual environment conditions experienced a virtual training session beforehand which lasted approximately one minute. Simulator sickness was measured using the Kennedy-Lane Simulator Sickness Questionnaire (SSQ), which was administered immediately before and after the experiment session [2]. The test yields an overall simulator sickness score as well as individual measures for three distinct physical components of simulator sickness (disorientation, nausea, and occulomotor discomfort).

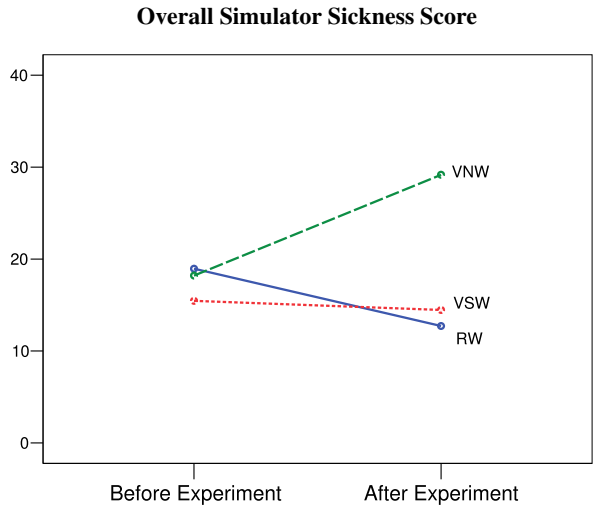

Figure 1: Mean SSQ scores in the VNW condition were greater after the experiment, but decreased in the RW and VSW conditions.

3 RESULTS

A total of 90 people participated in the study (46 male, 44 female) with 30 participants in each condition. Each of the simulator sickness scores was treated with a 3x2 mixed ANOVA, testing the within-subjects effect of time (before and after the experiment session) and the between-subjects effect of travel condition.

The analyses revealed significant interaction effects for overall simulator sickness as well as the individual measures:

- Overall Simulator Sickness, $F(2,87) = 9.78$, $p < .001$
- Disorientation, $F(2,87) = 10.33$, $p < .001$
- Nausea, $F(2,87) = 8.02$, $p = .001$
- Occulomotor Discomfort, $F(2,87) = 4.15$, $p = .019$

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Table 1. Mean Simulator Sickness Results

		Before	After
Overall	RW	18.95	12.72
	VNW	18.20	29.17
	VSW	15.46	14.46
Disorentation	RW	12.99	11.60
	VNW	14.85	37.11
	VSW	13.92	14.84
Nausea	RW	13.99	10.81
	VNW	10.81	19.72
	VSW	8.59	9.22
Occulomotor	RW	18.95	10.86
	VNW	19.96	23.25
	VSW	16.42	13.90

Table 1: Mean simulator sickness scores for each condition before and after the experiment session.

These results indicate that travel technique influenced the overall score as well as all three of the individual simulator sickness measures from before to after the experiment. None of the between-subjects main effects for travel condition were significant. Additionally, none of within-subjects main effects for time were significant, except for disorientation, $F(1,87) = 9.62$, $p = .003$. Table 1 shows the mean results and Figure 2 shows plots of each of these measures.

4 Conclusion

The natural walking technique increased overall simulator sickness, whereas this measure decreased or stayed roughly the same for the real world and simulated walking conditions. Additionally, we calculated the individual simulator sickness measures to determine the specific effects of travel technique, and found that natural walking induced greater sickness for all three measures, although the difference was most striking for disorientation. These results indicate that simulated walking is a better choice for reducing simulator sickness in tasks requiring a navigationally complex environment and a long amount of time, likely because it requires less physical motion required to move through the environment.

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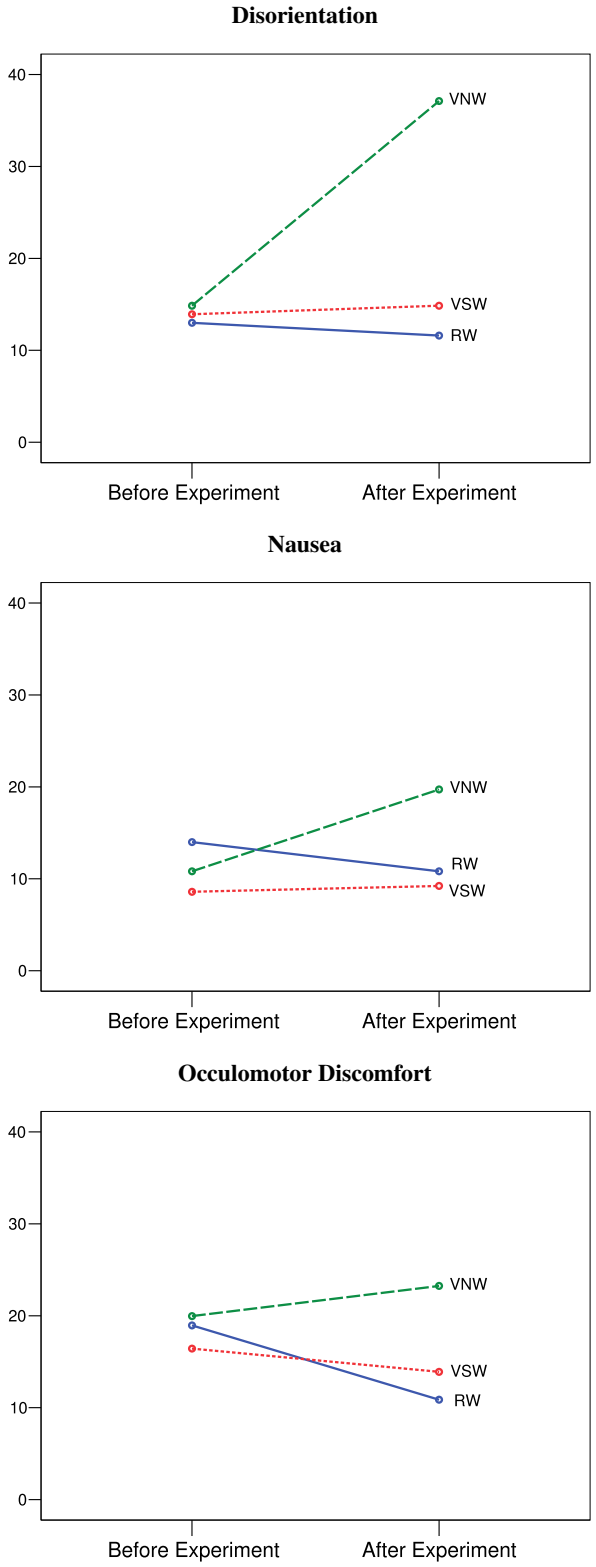

Figure 2: Individual simulator sickness measures for disorientation, nausea, and occulomotor discomfort. For all three measures, scores for the VNW condition increased from before to after the experiment. This effect was not observed in the RW or VSW conditions.