Teleportation with optic flow and its effect on navigation and spatial memory in simple and complex environments

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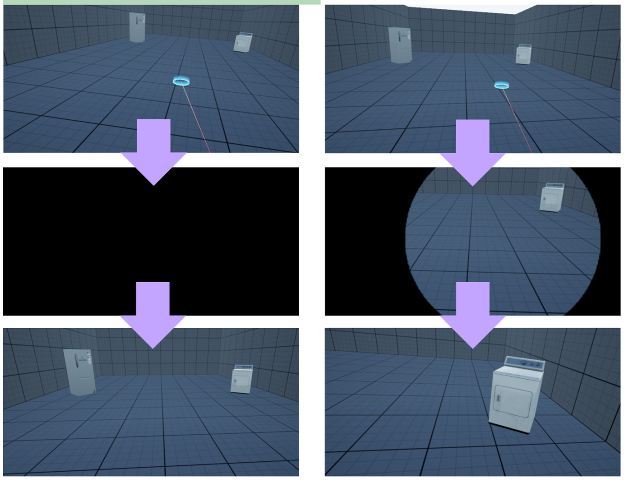
INTRODUCTION

Navigation is a significant part of most VR experiences, enabling users to explore and interact with virtual worlds. Navigation in VR is enabled by various Locomotion methods (LMs) such as Teleportation. This LM is widely used because it is safe and does not cause motion sickness, however, it can disrupt spatial awareness by removing visual cues of movement[1]. Adding optic flow can provide continuous movement cues, which could help the navigator maintain orientation and improve spatial memory without substantially increasing discomfort[2]. Environmental factors, such as the size and complexity of the environmental structure of the virtual space, also influence navigation. Environmental spaces increase the cognitive demands on spatial memory[3]. Understanding how locomotion methods interact with different environments is crucial for VR applications that rely on accurate spatial knowledge, such as architectural visualization, professional training, or educational simulations. In this project, we examined two LMs: *Teleportation* and *Teleportation with optic flow* (Figure 1).

Fig. 1 Teleportation (left), Teleportation with optic flow (rigt)



METHODS AND MATERIALS

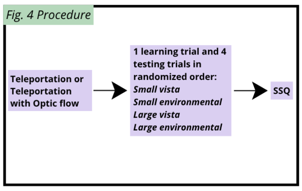
We used a within-subject VR experiment combining an object search and a pointing task. Participants completed 8 trials across environments that varied in size (small: 36 m², large: 144 m²) and spatial complexity (vista vs. environmental). They were divided into 4-trial blocks, each corresponding to one Locomotion method (Figure 4). In vista spaces, the entire environment is visible from any one point (Figure 2), while in the environmental spaces, the space is divided and not fully visible at once[4] (Figure 3), therefore requiring navigation to access all necessary information.

Each trial required participants to locate four target objects, return to the starting point (entrance doors), and then complete a pointing task from a fixed location in an empty environment. In this task, they estimated the direction and position of the objects relative to the entrance door. Performance measures included search time, traveled distance, pointing angle error, and pointed distance error. Additionally, after each block, participants filled out the Simulator Sickness Questionnaire[5] (SSQ) to compare the differences in cybersickness.

Fig. 2 View in vista space

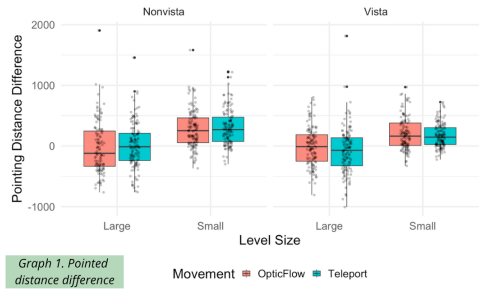
Fig. 3 View in environmental space

Fig. 4 Procedure



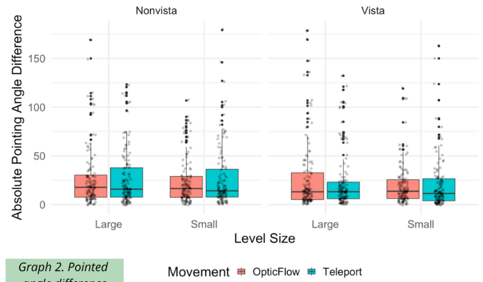
RESULTS

- N = 32
- We used mixed effects models, which included a random intercept for participants. The fixed effects were the LM, environmental size, environmental complexity, the interaction between LM and environmental complexity, and the interaction between LM and environmental size.
- No significant effect of the LM was found in our data.



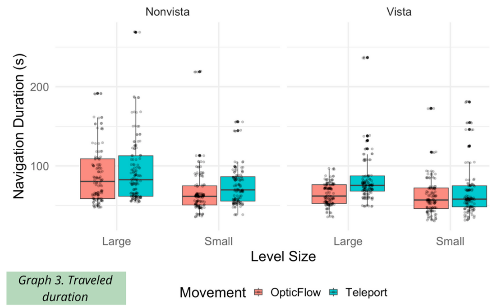
Graph 1. Pointed distance difference

- In the pointing task, participants significantly overshoot the pointed distances in small environments ($\beta = 264.6736$, $t = 10.246$, p = $p < 0.001$ (Graph 1).



Graph 2. Pointed angle difference

- The angle error was affected by the size of the environment, with larger environments leading to larger errors ($\beta = -0.21803$, $t = -2.197$, $p = 0.028$) (Graph 2).



Graph 3. Traveled duration

- Vista environments enabled quicker navigation ($\beta = -0.21901$, $t = -2.883$, $p = 0.0042$) (Graph 3) with reduced travel distance ($\beta = -0.27483$, $t = -4.477$, $p < 0.001$).

DISCUSSION

Surprisingly, the added optic flow did not seem to affect either navigation performance or pointing accuracy, even if we include interactions with environment properties. Interestingly, environmental factors played a much larger role than the navigation mode. Participants navigated faster and were more accurate in vista environments. This is likely because these environments provide immediate access to spatial information, whereas environmental spaces require exploration to gather all the necessary information about the environment. Unsurprisingly, participants navigated faster and traveled shorter distances in smaller environments. However, an interesting finding is that participants significantly overshoot pointed distances in smaller environments. From the preliminary results of the SSQ, Teleportation with optic flow seems to generate slightly more nausea and disorientation than Teleportation.

Bibliography:
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