Teleporting in Virtual Worlds while Learning Real World Places

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ABSTRACT

Teleportation within a virtual world can be a very useful tool, as it enables the user to view many objects or points of interest in a relatively short period of time. Unfortunately, teleportation has also been known to disorient users, leading researchers to combine teleportation with navigation aids to help minimize these disorienting effects. Since virtual worlds have been used to help train users in the structure of real world places, this study investigates the impacts of virtual world travel with teleportation on the understanding of a real world place represented by the virtual world. The results of our study suggest that those who are provided with a navigation aid while using teleportation to travel in a virtual world tend to perform better than those who were not provided with the navigation aid when performing a corresponding task in the real world. However, consistent with the findings of others, we also found no significant difference on the navigation task in the real world between those who studied a conventional paper map and those who traveled the virtual world with a navigation aid to learn the real world place.

KEYWORDS: virtual worlds, teleportation, user study.

INDEX TERMS: I.3.7 [Computer Graphics]: Three Dimensional Graphics and Realism – Virtual reality; H.5.2 [Information Interfaces and Presentation (e.g., HCI)]: User Interfaces – Evaluation/methodology.

1 INTRODUCTION

Electronic devices are becoming increasingly popular as aids to assist in the travel to new or unfamiliar locations. Many automobiles today are equipped with a Global Positioning System (GPS) that can be used to help drivers find their way to specific destinations of interest. Virtual reality and virtual worlds have also been used as simulations to prepare individuals for real world travel tasks. For example, applications have been developed to help teach occupants how to evacuate from burning buildings [13]. Simulation tools have also been constructed to train pilots about the terrain they will encounter prior to combat missions [11]. Others discuss the development of virtual models of real world places that allow for the preservation and remote exploration of architecturally significant sites [9]. While research suggests that many users find it more difficult to learn about the configuration of a virtual world than in the corresponding real world place [14], the benefits of exploring a safe environment that may otherwise be inaccessible make the use of virtual worlds for teaching and training purposes still highly desirable.

In this paper, we are interested in the use of virtual worlds as training tools to help users find their way in new or unfamiliar locations; in particular we are concerned with the types of travel techniques and navigation aids that are most effective in virtual worlds to help users learn corresponding real world locations. To assist users as they travel, most modern implementations of virtual worlds, such as in gaming and social applications, provide navigation aids like maps [6][17], signs [4], route recommendations [18], and markers that point the way to destinations of interest [3]. Virtual world travel is supported through a number of means, such as walking, riding, and teleportation [1]. Teleportation allows users to travel at an infinite velocity from one virtual world location to another, allowing users to reduce the time that they spend simply traveling between destinations. However, teleportation has also been known to disorient users [2]. Previous research [5] suggests that the disorientation introduced through teleportation as a travel technique may be reduced in noncomplex virtual worlds simply by providing users with a map of the world. The remainder of this paper describes a study that investigates how teleportation in a virtual world with a map navigation aid impacts the understanding of the structure of a corresponding real world place.

2 BACKGROUND

Some of the earliest research on the use of teleportation as a travel technique in virtual worlds found that those who traveled using this technique were more disoriented than those who were provided with a sense of motion while traveling [2]. Others have found that while instantaneous travel may allow for the location of targets more quickly, this is sometimes at the cost of visiting more locations [15]. To minimize these limitations, travel techniques allowing for instantaneous movement between distant locations in virtual worlds have since been proposed that provide users with representations of, and teleport gates to, the places to which they can travel [10][12][19].

More recently, Dodds and Ruddle [8] have suggested that while users who are allowed to teleport can increase the speed at which they move, these users may lose their sense of distance and scale within the virtual world. In a previous study [5], we found that subjects who used teleportation combined with a map navigation aid were able to locate target locations more quickly than those who used a more traditional virtual free roaming technique; however, there were no differences between the groups in post-test map drawing and map labeling exercises. This may suggest that simply having access to a map navigation aid can minimize some of the disorienting effects of teleportation, while still being able to take advantage of the benefits of this virtual world travel technique.

In this paper, we consider the impacts of the use of teleportation for traveling in a virtual world that was constructed to train users about a corresponding real world place. Specifically, we were interested in determining whether the use of a map navigation aid with teleportation would serve as a desirable travel technique, or whether users were better served to travel and explore the virtual world using a more traditional virtual walking technique? We were also interested in how the use of a virtual world for learning about a real world place compared to the study

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of a paper map of the place. Others suggest that users may need to spend some amount of time in the virtual world before learning gains are realized over map study [7]. How would the use of teleportation impact these findings?

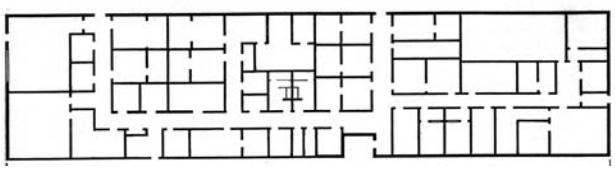

Figure 1. Floor Plan of the real world building.

3 Experimental Design

For this study, we conducted a true experiment to investigate the research questions introduced in the previous section. A virtual world was constructed to simulate the Psychology building on the campus of the University of the Pacific. The model was accurate with respect to the floor plan of the building (shown in Figure 1), but did not contain physical details such as posters or signs on the walls and doors. Figure 2 shows an image from the virtual building and Figure 3 shows the corresponding location in the real world building. The virtual world was constructed using the Valve Half Life 2 Game Engine.

3.1 Participants

Thirty-two subjects participated in the experiment and were divided into four groups: the paper map group (G1), the free roam group (G2), the teleportation group (G3), and the teleportation with map group (G4). The mean age of subjects in G1 was 22.6 (SD = 3.25) with 5 males and 3 females. The mean age of subjects in G2 was 20.9 (SD = 1.9) with 5 males and 3 females. The mean age of subjects in G3 was 22.4 (SD = 3.6) with 6 males and 2 females. The mean age of subjects in G4 was 31.8 (SD = 14.5) with 2 males and 6 females. For all groups, the majority of subjects had over one-hundred hours of gaming experience in their lives, and most were right handed. Subjects were primarily college students with the majority being from Computer Science and Engineering disciplines.

3.2 Procedure

The experimental procedure began for all subjects with the signing of an informed consent document. Subjects were then assigned to one of the four groups described in Section 3.1. Regardless of group, the procedure consisted of three tasks: task 1 (T1) was intended to familiarize subjects with the experimental procedure; task 2 (T2) was the training task; and for task 3 (T3) subjects in all groups located targets in the same real world building. The training task (T1) for subjects in G1 was to memorize the locations of three objects on the floor plan of a small university building. Subjects were then presented with a blank floor plan of the same building and asked to indicate the locations of the objects with pencil marks. The floor plan was assessed and returned to the subject with the number of errors recorded. For T2, subjects in G1 were then presented with a floor plan of a different (and larger) building and asked to memorize the locations of eight objects. Subjects were allowed to study the floor plan as long as they wanted. As before, they were then presented with a blank floor plan of the same building and asked to mark the locations of the objects. The floor plan was assessed and returned to the subject with errors noted (if any). This process was repeated four times.

Group two (G2) subjects were asked to twice locate three objects within a virtual building for T1. The virtual building was the same building whose floor plan was given to G1 subjects for T1. Using a standard keyboard and mouse, the subjects moved in the virtual space using the “WASD” keys, the W-key for forward motion, the S-key for reverse movement and the A and D-keys for side to side movement. Subjects could turn in place (or change their direction of view) by using the mouse. For T2, G2 subjects were four times asked to locate eight objects in a larger virtual building (shown in Figure 2). The targets were in the same locations each time. Errors, time, and distance traveled (in meters) were recorded for each trial. An error was defined as walking into an incorrect door. If the door the subject opened did not have a hidden object behind it, the attempt was counted as an error. Each time a participant opened an incorrect door or re-entered a door they had already opened, an error was recorded.

Figure 2. View of the virtual building modeled in Half Life 2.

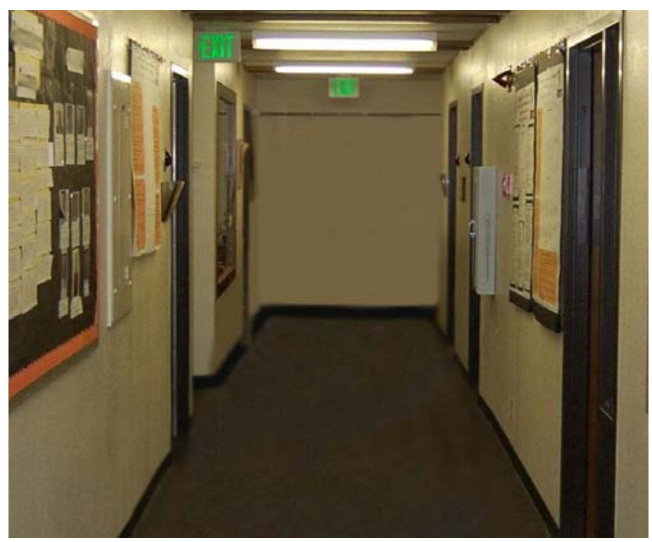

Figure 3. View of the location shown in Figure 2 of the corresponding real world building.

For group three (G3), the procedure for T1 and T2 were the same as G2. However, in addition to being able to free roam, subjects in G3 were also given the ability to teleport throughout the building. To use teleportation, subjects would move onto a teleportation pad (shown in Figure 4), face the direction they would like to go and press the 'E' key on the keyboard. They would then be teleported in the direction they were facing to the next teleportation pad. A teleportation pad was located at each door and every major intersection, (e.g. where hallways join).

Figure 4. The teleportation pads were blue squares with white line designs placed on the floor.

For group four (G4), the procedure for T1 and T2 were the same as for groups G2 and G3. However, subjects in G4 were allowed to teleport by clicking on one of the pink circles provided on the on-screen mini map (shown in Figure 5). When the user clicked on a pink circle, they were teleported to a position in front of the door inside of which a target was located. Subjects were told that the pink circles indicated the locations of the target objects.

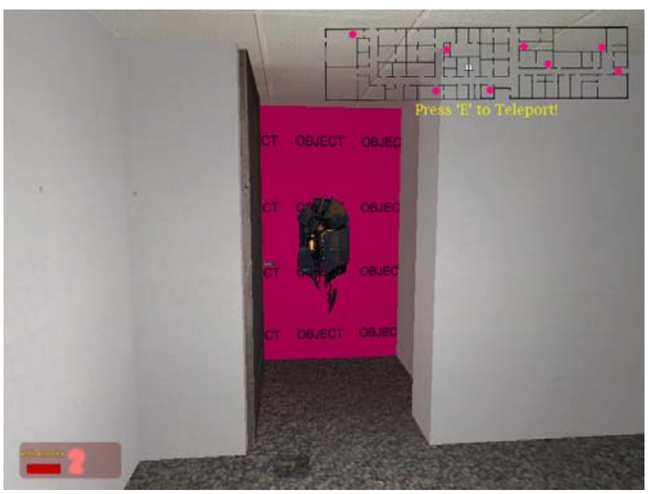

Figure 5. Teleportation with the aid of a miniature map in the upper right corner.

Task 3 (T3) was the same for subjects in all groups and was performed immediately after the completion of T2. Subjects were taken to the university building represented by the floor plan that G1 subjects had studied in T2, and the virtual building that G2, G3, and G4 subjects had navigated for T2. Subjects were asked to locate the same eight objects in the building in the same locations as the objects from T2. The objects were pink pieces of paper that had the word "OBJECT" printed on them and were clearly visible whenever the door was opened to the correct room. While roaming, the subject was followed by two researchers who noted errors and tracked the participant's distance traveled with a GPS. Once subjects completed the task by finding the eight objects, they were asked a few exit questions to determine the difficulty of the study. The questions asked were meant to give the test administrators a better idea of how the subjects learned the building. Subjects were then thanked for their participation.

After the completion of each task, subjects were asked if they had any questions or wished to quit the study. They were also given a short break if necessary. All participants completed the study within thirty to forty five minutes.

3.3 Equipment

For subjects in groups G2, G3, and G4, the first part of the testing procedure took place on a laptop computer with an Intel Core 2 Duo processor (T7200) at two gigahertz, two gigabytes of RAM, and an NVidia GeForce 7900 GS graphics card. Connected to this machine were a seventeen inch monitor and a standard keyboard and laser mouse. This setup was used to facilitate a subject's display, and a proctor's display (shown in Figure 6). The software environment was Microsoft Windows XP Professional, Service Pack 3 with current updates and Direct X release 9.0c. Half Life 2 was current and had all necessary updates applied at the time of subject testing. A native resolution of 800 pixels by 600 pixels was used for all tests.

Figure 6. Image of the experimental setup for groups G2, G3, and G4, showing administrator on the right and subject on the left.

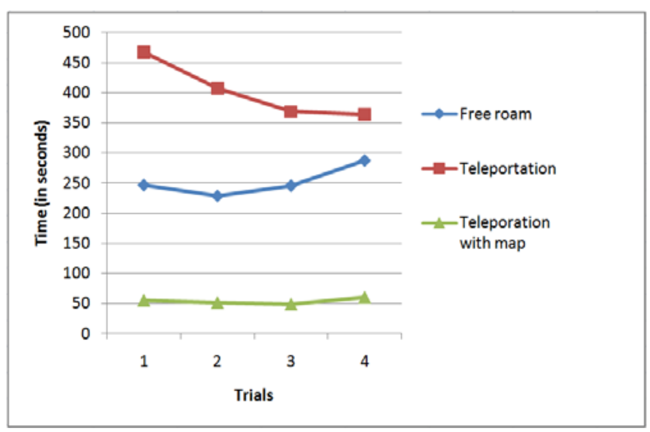

Figure 7. Time (in seconds) on the training task (T2) for the free roam (G2), teleportation (G3), and teleportation with map (G4) groups.

4 RESULTS

Since time and distance traveled were only recorded during T2 for subjects in G2, G3, and G4, separate repeated measures ANOVAs were performed for these dependent variables on these groups only. When time was the dependent variable, main effects of trial ($F(3, 63) = 2.748$, $p = 0.05$) and group ($F(2, 21) = 13.339$, $p < 0.001$) were both significant. These main effects were qualified by a significant interaction ($F(6, 63) = 4.475$, $p = 0.001$), depicted in Figure 7. When distance traveled was the dependent variable, the main effect of trial ($F(3, 63) = 3.783$, $p = 0.015$) was significant, and the main effect of group ($F(2, 21) = 3.016$, $p < 0.071$) was marginally significant. These main effects were qualified by a significant interaction ($F(6, 63) = 2.490$, $p = 0.032$), depicted in Figure 8. When errors was the dependent variable for all groups on the training task (T2), main effects of trial ($F(3, 84) = 9.504$, $p < 0.001$) and group ($F(3, 28) = 11.922$, $p < 0.001$) were both significant. These main effects were qualified by a significant interaction ($F(9, 84) = 4.009$, $p < 0.001$), depicted in Figure 9. These results are not surprising since subjects in G4 could clearly see the locations of the targets on the map navigation aid, while subjects in G2 and G3 had to explore the virtual building to locate the targets.

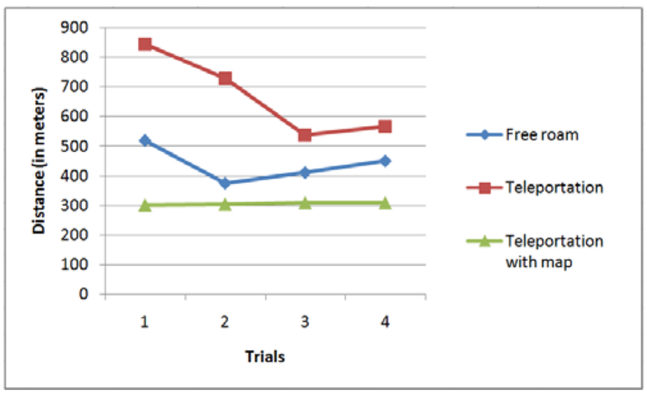

Figure 8. Distance traveled (in meters) on the training task (T2) for the free roam (G2), teleportation (G3), and teleportation with map (G4) groups.

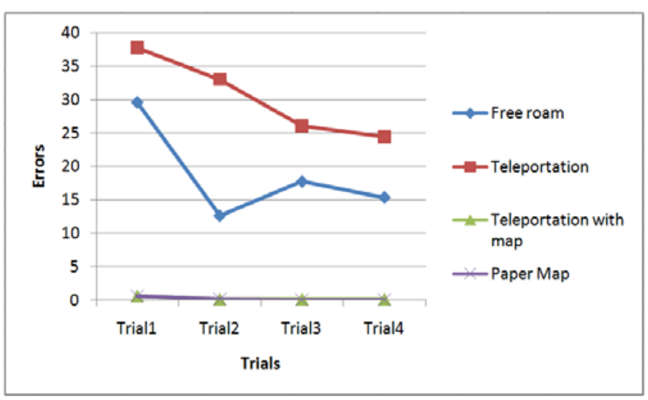

Figure 9. Errors on the training task (T2) for all groups.

Separate one-way ANOVAs were conducted for each of distance traveled and errors on the target location task in the real world building (T3). There was no effect of group when distance traveled was the dependent variable. However, there was a marginally significant effect of group when the number of errors was considered as the dependent variable ($F(3, 28) = 2.312$, $p = 0.098$). The mean errors and standard deviation for each group on T3 were as follows: paper map group (mean = 4.75, SD = 9.39), free roam group (mean = 17.63, SD = 27.10), teleportation group (mean = 21.63, SD = 20.01), teleportation with map group (mean = 2.50, SD = 2.56).

5 CONCLUSIONS

When comparing all three groups who used the virtual world for learning the real world environment, the results tend to suggest that navigating the virtual world using teleportation combined with free roam travel and the map (G4) was the most effective technique for both the training task (T2) and for learning the real world environment (T3). However, no significant differences were found between the paper map group (G1) or the teleportation with map group (G4). This result is not surprising given the previous observations of others [7]. Furthermore, as expected, the results tend to suggest that teleportation without a navigation aid (G3) is not an effective method for traveling in a virtual world or for learning the corresponding real world environment.

Future research should consider the impacts of larger virtual (and real world) environments and more complex navigation tasks on the results of such a study. It would be useful to know what size or complexity of environment, and the amount of time in the virtual world, would be required before a benefit (if any) of 3D virtual world study could be observed in our experiment over 2D paper map study. Future research should also consider the results of immersive technologies on the results of the study. Previous research suggests significant benefits for subjects who are allowed to physically walk around while traveling in a virtual world when compared to those who use other virtual world travel techniques [16][20].

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