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# Short Paper: The Effects of Teleportation on Recollection of the Structure of a Virtual World

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**Abstract**

*Teleportation is a virtual world navigation technique that allows users to travel at an infinite velocity from one location to another. Unfortunately, teleportation is known to cause disorientation in many users. This paper reports on an experiment designed to explore the relationship between teleportation and recollection of the structure of a virtual world when users are provided with a map navigation aid. Thirty-six subjects were divided into two groups (teleportation and free roam) and asked to collect objects in a virtual world. The results of the study showed that subjects who navigated with teleportation completed the task significantly faster than those who free roamed, with no difference between groups in the number of errors. However, when the map was removed, subjects who previously teleported committed significantly more errors and took longer than those in the free roam group. There were no differences between groups on either of the post trial map drawing or map labeling exercises.*

Categories and Subject Descriptors (according to ACM CCS): 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

Virtual worlds are becoming increasingly popular for social, educational, and recreational purposes. Social worlds, such as Second Life (www.secondlife.com), allow users to meet and interact with other users online. World of Warcraft (www.worldofwarcraft.com) is a gaming application that allows players to explore vast worlds while completing quests with other users. Other worlds have been developed for teaching [Mik06] and training purposes [ZED*09].

In most modern virtual world applications, users must travel throughout the world to locate destinations of interest. However, many users find it more difficult to acquire spatial knowledge in a virtual world than in the real world [RMH99]. To help users find their way in virtual worlds a variety of navigation aids, such as maps [DC99], have been explored. To help users travel between destinations more quickly, teleportation is often implemented. Teleportation allows users to travel at an infinite velocity from one location to another. Unfortunately, teleportation in virtual worlds has been shown to leave many users disoriented [BKH97]. Modern implementations of teleportation frequently provide users with navigation aids to counterbalance the disorienting effects. However, little is known about the actual impacts of teleportation with a navigation aid on users' recollection of the structure of a virtual world. In this paper, we describe a preliminary experiment designed to explore this relationship between teleportation combined with a map navigation aid, and users' recollection of the structure of a virtual world.

## 2. Background

Bowman et al. [BKH97] were some of the first to study the impacts of teleportation, finding that subjects who traveled using this technique were more disoriented than subjects who traveled using techniques that supplied a sense of motion. Others [RHPJ00] have shown that travel techniques which instantly teleport users to destinations in a virtual world allow for the location of targets more quickly, but sometimes at the cost of visiting more locations.

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Researchers have since attempted to minimize the disorienting effects of teleportation by combining this travel technique with navigation aids. For instance, Elvins et al. [ENSK01] describe “Worldlets”, three dimensional thumbnails of virtual worlds to which users might want to teleport that provide users with a preview of landmarks present in the worlds. Pierce and Pausch [PP04] discuss a technique that allows users to teleport within a virtual world through the use of landmarks and place representations. With this approach, nearby landmarks are made visible and distant places are presented as scaled copies or symbolic representations. Other researchers have proposed the use of “teleport gates” to instantaneously travel to destinations of interest that have been located [YM05]. Dodds and Ruddle [DR08] suggest that teleportation speeds up the time it takes to explore an environment allowing users to move to points of interest more quickly. However, teleportation may cause users to lose their sense of distance and spatial relationships in a virtual world.

This paper, seeks answers to three questions. First, when a map navigation aid is provided to help users complete a navigation task, are there differences between users who teleport and those who use a virtual walking (free roam) technique with respect to speed and accuracy? Our first hypothesis (H1) is that those who teleport will be faster but commit no more errors than those who free roam when a map is provided. Second, will there be any difference in speed and accuracy between users who have traveled previously using teleportation and those who have always free roamed, when the map is removed and all users must free roam? Our second hypothesis (H2) is that there will be no difference between groups with respect to speed and accuracy when the map is removed, since users will have learned the world. Third, what is the impact of teleportation combined with a map on a user’s recollection of the structure of a virtual world? Our third hypothesis (H3) is that there will be no difference between those who teleport and those who free roam when recollecting the structure of the virtual world, if a map was provided.

## 3. Experimental Design

A true experiment was designed to explore the hypotheses proposed in the previous section. A virtual world was constructed consisting of 12 differently colored buildings; each building contained a distinct object (see Figure 1).

### 3.1 Subjects

Thirty-six subjects participated in the experiment and were divided into two groups: teleportation and free roam. Both groups consisted of 8 males and 10 females. The mean age for the teleportation group was 20.1 (SD=2.8). The mean age of the free roam group was 21.1 (SD=3.5). Subjects were run through the experiment one at a time.

**Figure 1:** *Top-down view of the virtual world showing the locations of the buildings and the objects inside.*

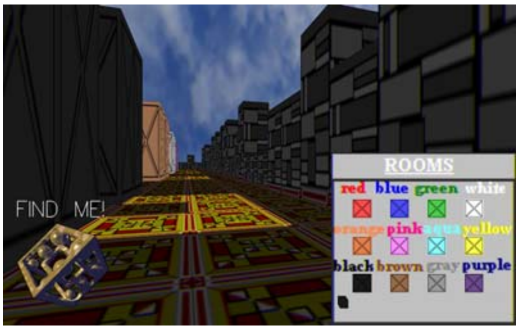


**Figure 2:** *A subject’s view into the virtual world.*

### 3.2 Test Environment

Subject testing took place on a single computer with a widescreen monitor (1.6 aspect ratio display). The geometric field of view of the virtual world was set to 90º (see Figure 2). Subjects in the teleportation condition could travel between buildings simply by clicking on a building in the map display located in the lower right of the screen, similar to the approach described in [AS95]. Subjects were then instantly teleported to the front of this building. Subjects could move into and around the inside of the building by pressing the arrow keys on the keyboard. However, subjects in this condition were not allowed to move between buildings through any method other than teleportation. Subjects in the free roam condition were also provided with the map, but always had to use the arrow keys to travel at a constant velocity throughout the world. Subjects in both conditions were provided with a “you-are-here” marker shown as a black cube on the map display.

### 3.3 Procedure

After signing the informed consent, subjects were shown how to travel throughout the world using the appropriate navigation technique. Subjects were asked to explore the world and given as much time as they wanted. When subjects indicated that they were finished exploring, they were asked if they thought they had visited all of the buildings. If subjects did not believe they had visited all buildings, they were asked to visit the buildings in which they had not yet been inside. This was to ensure that subjects were familiar with the locations of the objects in the buildings.

Subjects were then restarted in the northwest corner of the world (upper left of the map in Figure 1) and asked to collect five of the objects in the same order four times. Subjects were made aware of the next object to collect through a display in the lower left of the screen (see Figure 2). On the fourth trial, the map of the world was removed and all subjects used the free roam technique to collect the objects. Time and number of errors were recorded for each trial. An error was defined as an entrance into a building that did not contain the designated object to collect. Subjects were only allowed to commit one error per visit to a building. To commit multiple errors in the same building during a single trial, the subject would have to exit the building, enter a different building, and then return at some point to the previous building.

At the conclusion of the fourth trial, subjects were asked to draw a map of the world using twelve colored pencils (similar to the colors of the twelve buildings found in the virtual world). They were told that there would be one pencil per building. Subjects were not asked to label the locations of the objects on this map. Then, after drawing their own map, subjects were provided with a map of the world and pictures of the objects they had collected. Subjects were then asked to label the locations of the objects.

## 4. Results

To evaluate H1, time and number of errors were analyzed for subjects using a mixed 3 (trials) X 2 (condition) ANOVA. When time was the dependent variable, the main effects of trial ($F[2, 68] = 30.92$, $p < .001$, $\eta = .48$) and condition ($F[1, 34] = 31.40$, $p < .001$, $\eta = .48$) were both significant. These main effects were qualified by a significant interaction, $F(2, 68) = 13.16$, $p < .001$, $\eta = .28$ (see Figure 3). Subjects in the teleportation condition completed the task in less time relative to the free roam condition, with the greatest difference during the first trial. A main effect of trial was observed when error rates were analyzed, $F(2, 68) = 27.62$, $p < .001$, $\eta = .45$, with subjects committing fewer errors as they progressed through the trials. The main effect of condition and the interaction were not significant, suggesting that there was no difference between the teleportation group ($M = 11.63$, $SE = 1.51$) and the free roam group ($M = 11.51$, $SD = 1.51$) with respect to the number of errors committed ($F[2, 68] = 2.28$, $p = .11$). Thus, H1 was supported.

To evaluate H2, the number of errors and time to collect objects on trial four were compared using independent samples t-tests. Results revealed a significant difference in the number of errors made during trial four, $t(34)=2.37$, $p < .05$, with individuals in the teleportation condition ($M = 6.22$, SD = 5.76) making more errors than in the free roam condition ($M = 2.44$, SD = 3.55). The difference in time between the teleportation ($M = 813.5$, SD = 444.6) and free roam ($M = 576.6$, SD = 251.4) groups was marginally significant, $t(34)=1.97$, $p = .06$. Thus, H2 was not supported.

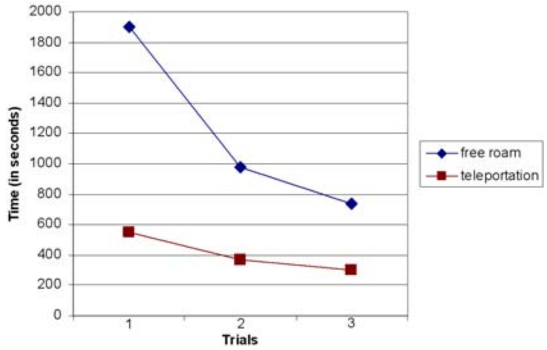


**Figure 3:** *Navigation time (in seconds) across trials 1-3 in both the free roam and teleportation conditions.*

The maps that subjects drew of the world were scored on four dimensions: buildings in the correct row (regardless of order, 12 possible points), buildings in the correct column (regardless of order, 12 possible points), buildings correctly placed next to one another (e.g., the red and blue buildings were located side-by-side, regardless of whether it was on the correct side, 17 possible points), and the buildings located in the correct order on a row or column (7 possible points). Scores across all four dimensions were added together to form a composite score with a maximum of 48 points. The composite scores across the two raters were then averaged; however, with such high inter-rater reliability *($r = .99$)*, there were very few changes in scores. No significant difference was observed between the free roam ($M = 29.58$, $SD = 11.39$) and teleportation ($M = 26.53$, $SD = 13.78$) conditions with respect to the maps drawn by the subjects, $t(34) = 0.725$, $p = .47$. When subjects labeled the map with the locations of the objects, again, no significant difference between the free roam ($M = 3.89$, $SD = 1.37$) and teleportation ($M = 3.28$, $SD = 1.45$) conditions was observed, $t(34) = 1.302$, $p = .20$. Thus, H3 was supported.

## 5. Conclusions

This research was motivated by three questions. First, when a map navigation aid is provided, are there differences in the amount of time and navigation errors made between users who teleport and those who free roam? The results of our study suggest that the answer is yes. Not surprisingly, participants in the free roam condition took longer to navigate through the environment relative to the teleportation group, especially in the first trial. However, error rates did not differ significantly between the groups.

The second question examined whether there would be a difference in speed and accuracy between those who had previously traveled using teleportation and those who had free roamed, when the map was removed and all subjects free roamed. The answer to this question appears to be yes. We found that when the map of the world was removed and subjects were forced to free roam, those who had teleported previously took longer and committed significantly more errors than those who had free roamed previously.

Finally, we examined whether there would be a difference in the recollection of the structure of the virtual world between those who teleported and those who free roamed when both groups had access to a map navigation aid. With respect to the map drawing and map labeling exercises the difference between groups was not significant. However, subjects in the teleportation group appeared to be more disoriented during trial four and ended up checking more buildings than subjects in the free roam condition (as indicated by the greater number of errors). These differences may be the result of the subjects in the teleportation group using a new travel technique (free roam). Regardless, these findings tentatively suggest that teleportation with a map navigation aid can be an effective travel technique for some navigation tasks.

There are several limitations to the study that should be noted. First, while the world was 3D in structure, navigation was essentially only 2D. Test subjects could not change their elevation. This may have ramifications in worlds that allow navigation in three dimensions as the complexity of the navigation aid would be greater which could also lead to potentially greater disorientation caused by teleportation. A second limitation is that the grid-like layout of the world may have been too easy to remember. Thus, differences between groups may exist in more complex worlds or more complex navigation tasks. Furthermore, readers are cautioned that our results do not show that performance on the map drawing and labeling exercises was the same for both groups, only that it was not significantly different. Finally, the study took place on a desktop computer and not in an immersive virtual reality environment. The impacts of an immersive environment on the results of this study are unknown.

## 6. Acknowledgements

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