Comparing Human Wayfinding Behavior in Real and Virtual Environment

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Abstract
This paper builds on a previous research comparing wayfinding behavior in virtual and real environments in order to reveal the theoretical basis for comparison while simultaneously producing applicable implications for designers and architects. The chosen site is a complex office building. Its virtual equivalent was first modeled using standard design tools available for most practicing architects. The design of the virtual environment [VE] mimicked the parallel real environment and included more latent physical characteristics crucial for wayfinding such as signs, lighting, colors and doors. The methodology used combines both previously used and new methods, implementing quantitative and qualitative approaches. The unfamiliar users randomly assigned to two experimental conditions were asked to find the same destination point. They were accompanied by the researcher and videotaped. After the task completion, the recordings were co-analyzed with the participants, which was then followed by a short interview about the wayfinding characteristics of the environment.

The initial data yield different results on the performance level and dissimilar behavior metrics (namely movement patterns) but the cognitive rational and evaluation of the designs proved to by comparable across the two conditions. Participants were using similar environmental cues and the same strategies across the two groups. The RE and VE designs were similarly evaluated and assessed, especially the ease and difficulties it presented in terms of orientation. The space's functions and affordances were read in the same way. However, the wayfinding patterns in VE were not prognostic of movement behavior in the RE. This paper draws on the results of that study and, by using the Space Syntax tools, is attempting to analyze and seek possible explanations for the differences in the movement patterns between the VE and the RE.

Introduction

The underpinning assumption for this research is that various forms of virtual environments (VE) are widely used in the architectural practice and could perhaps serve beyond presentational purposes. The aim of this study was to research if a particular type of VE could be used for testing the building's wayfinding systems, including both architecture and the signage. In other words, the study aimed to reveal whether one could assess the building in terms of its wayfinding characteristics in the design phase before the building is actually built. If the wayfinding behavior and navigation in virtual and real environments was shown to be similar, one could conclude that VEs can be used for assessing the future building's wayfinding system.

A number of studies have used VE in research on orientation and wayfinding. Ruddle et al. (1996, 179) for example, replicated Thorndyke and Hayes-Roth's (1982, 560) experiment from a real environment in which participants were estimating relative distances. Other studies have looked at the usefulness of VE for learning environments and training purposes (Darken et al 1993, 157; Richardson et al. 1999, 741). A few studies have also focused on the same issue that this study has addressed, namely the comparison of wayfinding in a VE and a RE, addressing the ecological validity of research on wayfinding in VE (Pramanik 2006, 78; Haq, 2005).

Why address the same issue if a number of studies have already demonstrated that the patterns of movement are comparable between a VE and real environment (RE) (Conroy 2001, 249; Ruddle, et al. 1996)? A closer review of the literature revealed three strong tendencies in the research on wayfinding in virtual settings. First, a possible limitation of the existing research – often acknowledged by authors – is that such studies do not consider salient characteristics of the environment such as ambient light and landmarks (see for example Conroy 2001, 249; Haq and Girotto 2003). Second, often the virtual environments do not fully account for signage, focusing instead on the structural elements of the environment. Lastly, the bulk of the research on wayfinding in VE employs a quantitative approach, and only a few studies take a qualitative approach (for a comprehensive review see Ruddle and Lessels 2006, 637). This study confronts these issues by including more detailed physical characteristics in the VE that have been shown to be relevant to wayfinding in the RE, along with the use of a mixed-method approach involving both qualitative and comparable quantitative methods. Additionally drawing on the results of that study this paper is using the Space Syntax to attempt to analyze and seek possible explanations for the differences in the movement patterns between the VE and the RE.

Research Design and Methods

Participants

For the study, 34 participants – 24 females and 10 males – were recruited from undergraduate schools within the CUNY system. The participants had reported varied experience with VEs (mainly gaming environments) and had made no prior visits to the building.

Settings/Environment

The chosen setting is a floor of a complex office building, namely the Graduate Center of the City University of New York in midtown Manhattan. This site was selected because it is often described by users as confusing and difficult to navigate and its size and layout are representative of typical office buildings in New York.

The virtual equivalent was first modeled using standard design tools available for most practicing architects - AutoCAD, 3ds Max Studio, and SketchUp. The model mimicked the parallel real environment and included more latent physical characteristics crucial for wayfinding such as signs, lighting, colors and doors. The model was next imported to and edited in an Unreal Game Engine Editor which allowed for game-like movement in the modeled space. The accuracy of the model with actual space was consulted with the users and their feedback was incorporated. However, because this research was aimed toward the application of evaluating designs prior to their occupancy, it was decided not to include elements in the VE that would indicate that the space is actually in use. Therefore personal items or virtual representations of other people were not included in the VE. Each participant was given the same horizontal field of view (85 degrees).

Methods

The methodology used combines both previously used and new methods, implementing quantitative and qualitative approaches. Users were randomly assigned to two experimental conditions (VE and RE) and given the same task. They all started from the same point is space (the main elevator lobby) and were asked to find the same destination point (another elevator). Their wayfinding efforts were timed and videotaped on a hand-held camera. In the actual building, an investigator followed the participant and, in the VE group, the investigator videotaped the monitor of a computer standing a few feet behind the participants conducting the task. This choice was dictated by the need for keeping the experimental conditions between the groups relatively constant. After the task completion, the recordings were co-analized with the participants. As participants watched their walkthroughs, they were asked to comment on their thoughts and behavior while conducting the task. This method allowed gathering detailed information on the wayfinding process (retrospective think aloud protocols) without impeding their performance which is often pointed to as a limitation of a congruent think aloud protocol method (Van Den Haak et al. 2003, 339; Jonassen 1999, 275). This was followed by an interview about the participants' experiences of wayfinding in the building.

Findings

Following Ruddle and Lessels' (Ruddle and Lessels 2006, 637) classification of metrics used in wayfinding research, this study produced data on all three levels used for evaluating wayfinding: (1) performance, (2) physical behavior, and (3) cognitive rationale. The more detailed findings for (1) and (3) have been presented elsewhere (Skorupka 2008, 21). In this paper only final findings are referred for these two dimensions and the physical behavior level (2) gets analyzed in the context of space syntax analysis.

Performance

The performance level was evaluated based on the time taken to complete the task. The measures indicate that the time taken by the users in VE was significantly longer than in real environment. Participants in the RE group took on average 2 min 48 sec, while in the virtual environment the mean time taken was 6 min 27 sec. The average time taken to find the elevator proved to be significantly different between the two groups ($t(32) = -3.111$; $p = 0.004$).

Cognitive rationale

The qualitative methods allowed for comparison at the cognitive rationale level. The interviews and retrospective think aloud protocols were transcribed in full and coded. The codes used fall into the following categories: human, environmental, and specific differences between performing the task in the VE and the RE. These were developed based on existing literature on wayfinding and spatial orientation in built environment (Weisman 1981, 189; Golledge 1999, 191), as well as derived from the data gathered. The analysis of qualitative data has been conducted based on the categories across the two experimental groups.

The cognitive rationale and evaluation of the designs proved to be comparable across the two conditions. Participants were using similar environmental cues and the same strategies across the two groups. The RE and VE designs were similarly evaluated and assessed, especially the ease and difficulties it presented in terms of orientation. The space's functions and affordances were read in the same way (Skorupka 2008, 21).

Physical behavior

The physical behavior level was assessed by cumulating paths taken in both environments into two composite maps. The cumulative paths yield from both conditions differ diametrically, which contradicts the studies demonstrating that movement patterns in virtual and real conditions correlate (Conroy 2001, 249).

The layout of the floor, including more silent characteristics of the environment (such as glass doors) was analyzed using the Space Syntax tools. The initial analysis show that the predominant paths chosen by both groups (northern half of the floor for the VE group and southern hallway for the RE group) share the same visual step depth while the northern parts of the floor, chosen more often by the VE group, have higher connectivity values.

It can be concluded from the visual step depth analysis that in principle both groups have chosen equally visually accessible paths. The question remains, why the patterns differ so substantially. One possible answer can be provided by a more detailed analysis of the nodes, and in particular, hallways divided by glass door.

Even though the affordances of spaces behind glass door were read in the same manner (Skorupka 2008) and the visual depth has not been significantly influenced by the glass door, they constituted a barrier in RE, causing the participants in the real environment backtrack. Often, in the same point the VE went straight. These results are consistent with other studies showing that in a VE, people tend to travel in paths that are generally straight (Ruddle and Jones 2001), a pattern that is not persistent in RE navigation. It was also informally observed that the participants conducting the task in the VE were not looking around as often as in the real setting. As the available video data do not allow for quantitative comparison (due to the fact that, in the RE the researcher was following the participant and thus was not always able to record the participants eye movement), a preliminary analysis of this issue has also been conducted from the description of the behavior delivered by participants. Those in the RE reported looking around more often than VE. This finding is also confirmed in existing literature. For example Ruddle et al. (1999, 157) shows that participants in a non-immersive VE tend to look less around than when navigating in an immersive VE.

Figure 1

Movement patterns in the real (top) and virtual environment (bottom). All participants started in the elevators lobby. Their goal was to find the 7th elevator, located in the bottom right corner of the floor plan.

Figure 2
Visual step depth from the lobby

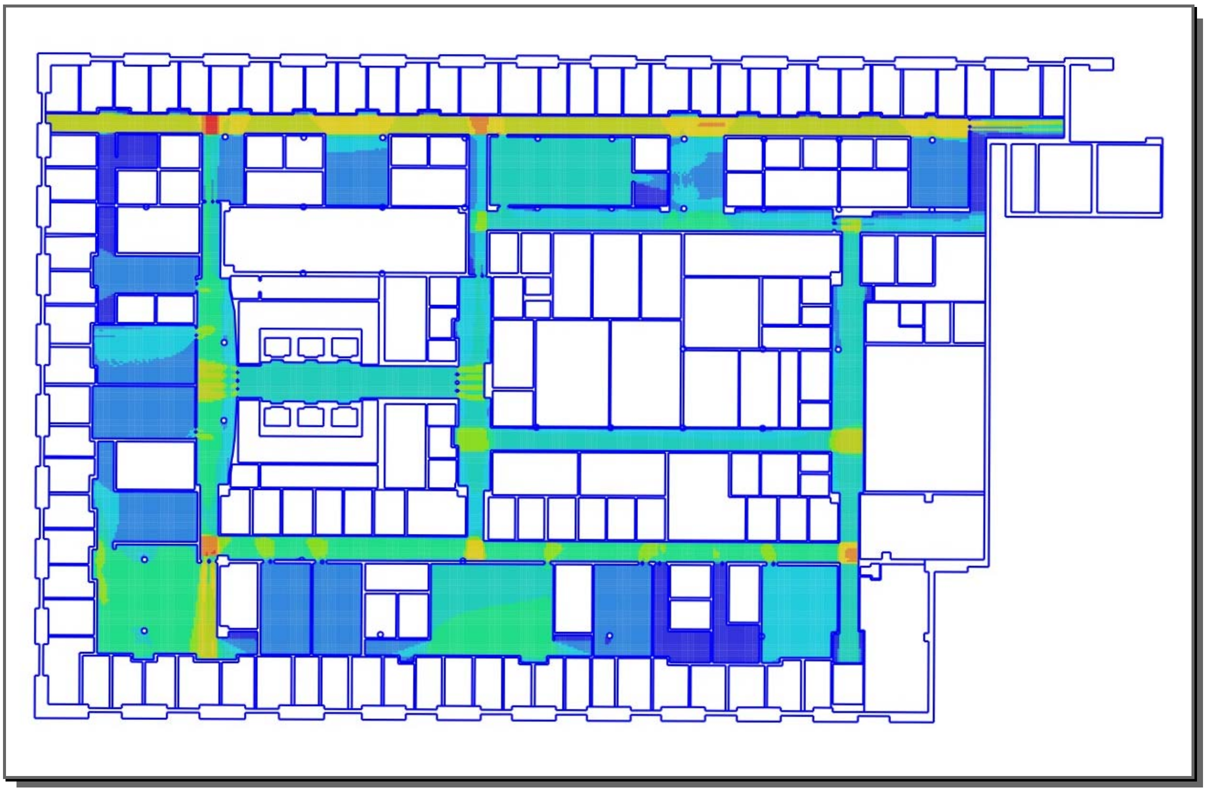

Figure 3
Connectivity analysis. The more connected northern hallway was almost only used by the VE group

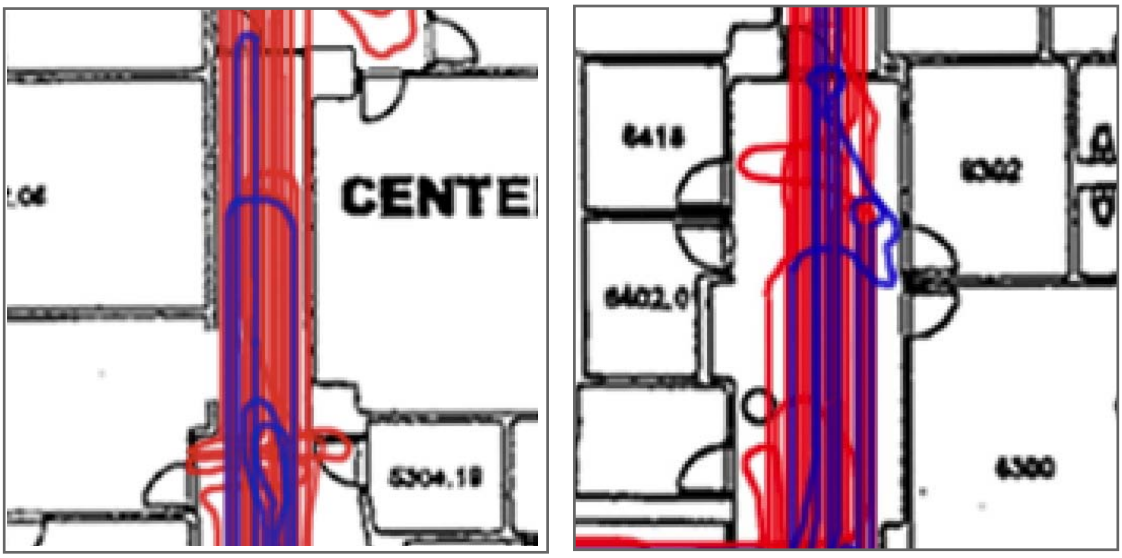

Figure 4
Patterns of backtracking at the glass door in RE (blue) and walking straight in the VE (red)

Discussion and Conclusion

The preliminary findings are partly consistent with existing research. The performance measures indicate that the time taken by users in the VE was significantly longer than in the real environment. The cumulative paths yielded from both conditions differed considerably which contradicts studies demonstrating that movement patterns in virtual and real conditions correlate. Movement in this study was task oriented while for example, Conroy's research (2001) looked at a non-task oriented behavior in an art gallery. This might be one possible reason for the differences in the findings between the two studies, yet further investigation of this issue is necessary.

Finally, the qualitative analysis of think aloud protocols and interviews demonstrates major similarities in the cognitive rationale behind the wayfinding behavior in both conditions. These findings allow for a tentative implication that virtual models could be used for assessing wayfinding systems of future buildings. Even though the virtual environments might not prove to be useful in predicting wayfinding performance and movement patterns in quantitative terms, qualitative data that can be gained through using VE in the architectural programming phases of a project seem to be sufficient for evaluation purposes and useful for redesigning buildings before they are constructed. It remains to be seen if this will be the case in more interesting, differentiated environments.

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