Landmarks and Time-Pressure in Virtual Navigation: Towards Designing Gender-Neutral Virtual Environments

Elena Gavrielidou and Maarten H. Lamers

Media Technology M.Sc. program
Leiden Institute of Advanced Computer Science (LIACS)
Leiden University, The Netherlands
elegav@gmail.com, lamers@liacs.nl

Abstract. Male superiority in the field of spatial navigation has been reported upon, numerous times. Although there have been indications that men and women handle environmental navigation in different ways, with men preferring Euclidian navigation and women using mostly topographic techniques, we have found no reported links between those differences and the shortcomings of women on ground of ineffective environment design.

We propose the enhancement of virtual environments with landmarks – a technique we hypothesize could aid the performance of women without impairing that of men. In addition we touch upon a novel side of spatial navigation, with the introduction of time-pressure in the virtual environment.

Our experimental results show that women benefit tremendously from landmarks in un-stressed situations, while men only utilize them successfully when they are under time-pressure. Furthermore we report on the beneficial impact that time-pressure has on men in terms of performance while navigating in a virtual environment.

Keywords: virtual environments, navigation, gender, landmarks, time-pressure.

1 Introduction

There exists a recurring argument of male superiority [1], portrayed as the prominent finding in the field of spatial cognition in virtual environments. Nevertheless, research also shows an innate difference in the ways that men and women understand and navigate through their environment. While men utilize mostly Euclidean navigation strategies [2] women show an inherent preference towards the use of landmarks [3].

Although a difference in navigation strategies between the sexes has been reported, we wonder why this reported inability of women to navigate, is not (partially) linked to the shortcomings of these experiments' [1,2,4,5,6,7] respective virtual environment designs. We share the opinion of Caplan and Caplan [8] that, when gender differences in spatial cognition exist, this is not due to biological inferiority [3,5] of one gender, but rather, we suggest that to some extent this is the result of men and women having different skills, suitable to handling different aspects of the environment most important to their own sex.

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This becomes especially important when designing virtual environments. Even subtle differences between the sexes' navigation techniques have the potential to be magnified in a virtual environment that does not take their respective needs into consideration [7].

Virtual environments should take into account this difference in spatial perception between the sexes. This study could act as the foundation for designing practical applications that compensate for the inadequacy of previous virtual environments to facilitate a balance in the performance of both sexes. Such a balanced navigation design framework would allow women to perform to standards equal to those of men, and weaken the argument of male spatial cognition superiority in virtual environments, on grounds of ineffective environment design.

The experiments we present study two different approaches in the alteration of the virtual environment. The first is the introduction of landmarks in the unfamiliar virtual environment as a way to directly manipulate the local perception of the participants. The second is the application of a timed deadline to the virtual way-finding task, which, to the best of our knowledge is a novel introduction in the field of human spatial cognition.

We hope to discover which virtual environment design aids the performance of both the sexes, thus establishing a framework for designing virtual training environments (and possibly GPS-based navigation systems) that successfully comply with the both sexes, without impairing the performance of either one.

2 Related Work

2.1 Landmarks as a Navigational Aid

Even though great emphasis has been put on the usefulness of landmarks in navigation of real environments [9,10], and while evidence suggests that navigation through virtual environments is problematic and often unsuccessful in the cases where supplementary information such as landmarks are not provided [11,12], a connection has not yet been made between the preference of women to landmarks in navigation [3] and the previously reported superiority of men in spatial cognition. Nor has there been evidence specifically targeting the performance of women in virtual environments where landmarks are present. Furthermore, Ruddle *et al* [10] proposed that concrete and recognizable landmarks could enhance the performance of participants in relation to abstract landmarks, but no significant improvement has been reported in the performance of the subjects, whether with, or without landmarks. We suggest that perhaps making distinction in the performance of men and women could indicate whether improvement of performance is significant in one of both genders.

2.2 Time-Pressure and Spatial Cognition

The second parameter we address is that of a timed deadline. In its more general applications this is a much-debated issue, and opinions vary on the impact it has on a presupposed task. Research shows that in general, when time-pressured, people become more anxious and energetic and adopt a number of different strategies to cope

with a deadline. Processes underlying judgment and decision-making undergo change when the time available is limited [13,14].

Svenson and Benson [15] suggested an increase in the quality of decision-making in stressful situations created by deadlines. Others, however, showed that time-pressure reduced the quality of decision-making [16] and the inclination to take risks [14].

Within these opposing views, we have not come across any evidence to show either a positive or a negative effect of time-pressure on human spatial cognition, or specifically on the spatial cognition of either males or females. Hence we propose to study the impact of a time-limit on subjects in a virtual environment navigation task, both with and without landmarks, and for men and women.

3 Methodology

3.1 Virtual Environment, Task and Subjects

A 'DOOM-like' maze (as used in [17]) of 8 rooms was created with Blender3D authoring software [18]. Subjects were required to navigate through it in a task design similar to that of Cutmore et al [19]. To collect a golden ring, subjects had to find a route from the first to the last room of the maze through a predefined route and then return to the initial room along precisely the same route. Only doors that lay on the correct route were unlocked, all other doors were locked, effectively creating a single possible route through the maze. The correct route through the maze was shown before three subsequent tries by each subject. An example route through the maze is illustrated in Fig. 1. For automated time recording the task was completed when the subject walked into the red door at the initial position, as instructed by the researchers.

Subjects were aged 15-50 and selected to have no more than 3 hours per week of experience on 3D video games. Performance of 10 males and 10 females was measured on two parameters: the participants' way-finding skill, namely the number of errors (attempts to open a locked door) while navigating through the maze, and the time taken to reproduce the route.

3.2 Introducing Landmarks and Time-Pressure

There were four different states of the experimental virtual environment. Every subject performed the described task in each of these states. Different maze layouts were randomized over the different states to ensure equal distribution of states over maze layouts. The four states were:

In the Neutral Environment (*E1*) there was no time limitation to the task and the rooms had no identifiable characteristics.

The Landmark Environment (*E2*): An environment and task similar to E1 with the addition of specific identifiable real-life landmarks situated inside the rooms (plant, lamp, kettle, and various other objects).

The Countdown Environment (*E3*): An environment and task similar to E1 with the addition of a 60 seconds time constraint (slightly under the average time of completion for the task, as found in the building/testing phase of the mazes). A countdown timer was visible on-screen.

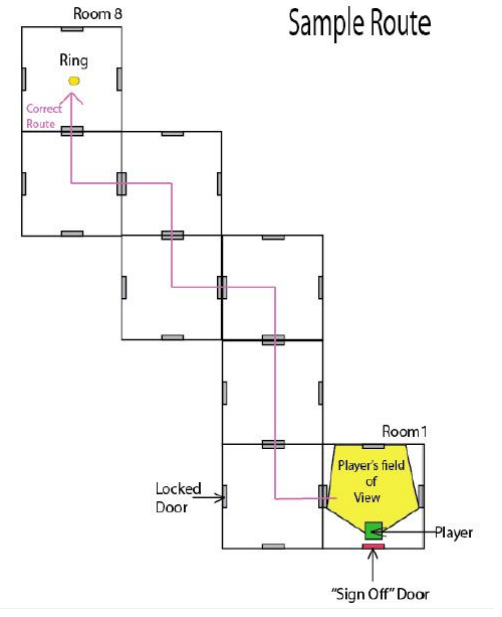

Fig. 1. Bird's eye view of an example route through 8 rooms within the virtual environment. Displayed are the subject's starting position (*Player*), the example route (*Correct Route*), the destination (*Ring*) and the return position (*"Sign Off" Door*).

Fig. 2. Screenshot of a room used in the navigation task's environment E4, including an example landmark (potted plant) and the countdown timer at the center of the screen (*29*)

The Combination Environment (*E4*): An environment and task with both landmarks as in E2 (but objects ordered differently over rooms) *and* time constraint as in E3 (illustrated in Fig. 2.)

3.3 Data Recording and Analysis

Both the order in which a subject would experience the four environments and the route for each task were chosen random and independent. It was ensured that no two subjects experienced the same order of routes or order of environments on any of the 20 experimental samplings.

Each time a subject comes in contact with a locked door, this was recorded as one error. In virtual environments E1 and E2, the time taken to complete the task was recorded for each route. In environments E3 and E4, a binary indication (pass/fail) for completion of the task within the time-limit was recorded for each route. Statistical analyses of the collected data were performed using one-way ANOVA and paired t-test methods.

4 Conclusions

In review of the experimental results and statistical analyses we conclude that:

(i) The introduction of landmarks in a virtual environment is significantly beneficial for time to complete the navigation task by females (statistically significant, $p < 0.01$), without impairing that of men (Fig. 3.) It also dramatically decreases female error counts when no time-pressure is applied, whilst also decreasing male error counts (Fig. 5.) Landmarks are therefore an addition we propose to make in designing gender-neutral virtual (training) environments and GPS-based navigation aids.

(ii) The introduction of time-pressure benefits men immensely (Fig. 4), as it dramatically raises their success rate to complete the task within 60 seconds (statistically significant, $p < 0.05$). Although female task completion rates appear to benefit from time pressure (environment E3), their lowering in the combined environment E4 remains unexplained (Fig. 4.)

(iii) Although introduction of landmarks does not increase men's task completion success rate under time pressure (Fig. 4, male bars E3 and E4), the number of errors made decreases substantially (Fig. 5.) Men appear to make use of landmarks when time-pressure is introduced. The decrease in number of errors made in E4, when compared to no landmarks and no time-pressure (E1), is statistically significant.

Most importantly, we believe that our findings contribute to the design of gender-neutral virtual environments through which users navigate. This is achieved by demonstrating the need for distinguishable landmarks and its effects on both males and females. Furthermore, inclusion of visual landmarks in car navigation systems, for example, could greatly benefit use by females without impairing use by males. Also, our study sheds light on a novel aspect of virtual environments, by examining the effects for both sexes of time-pressure on the spatial cognition in such environments. We are fully aware of the small sample sizes and its effect on statistical significance. Since greater sample sizes were not feasible in the short time-range of this student project, further study with larger subject groups is recommended.

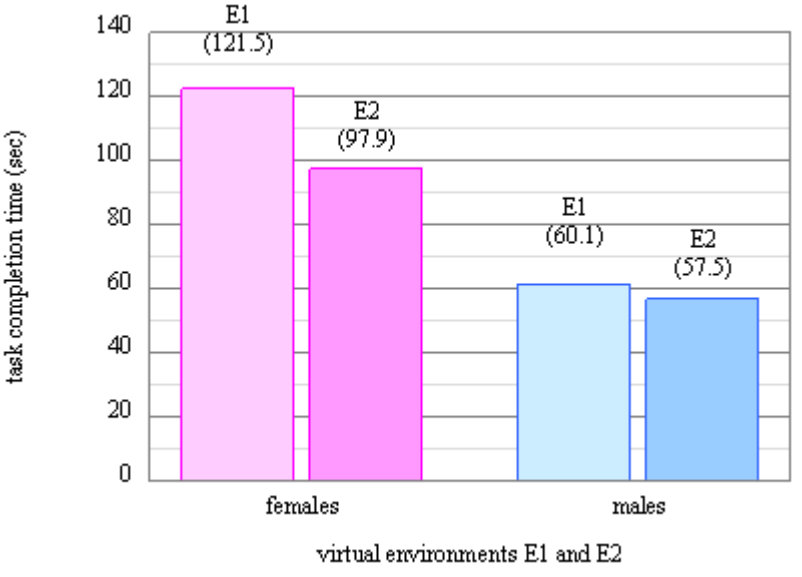

Fig. 3. Average task completion times (in seconds) for females and males, in virtual environments without landmarks (E1) and with landmarks (E2)

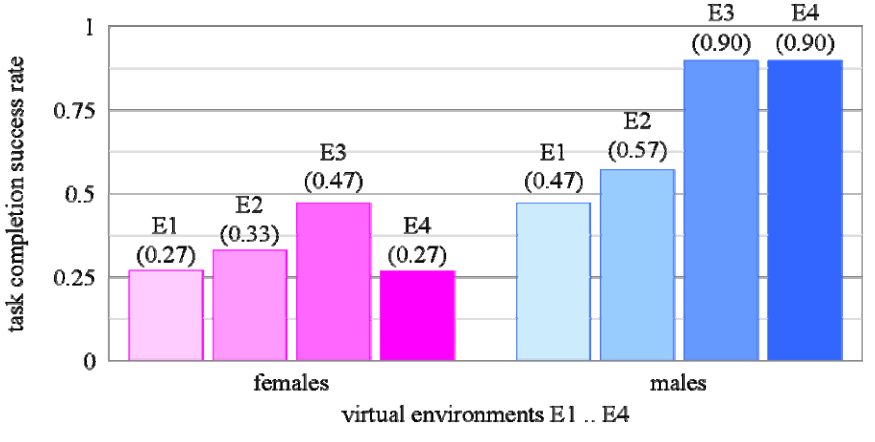

Fig. 4. Female and male task completion success rates for the different virtual environments (E1 ... E4). Shown vertically are average ratios of successful task completion under 60 seconds.

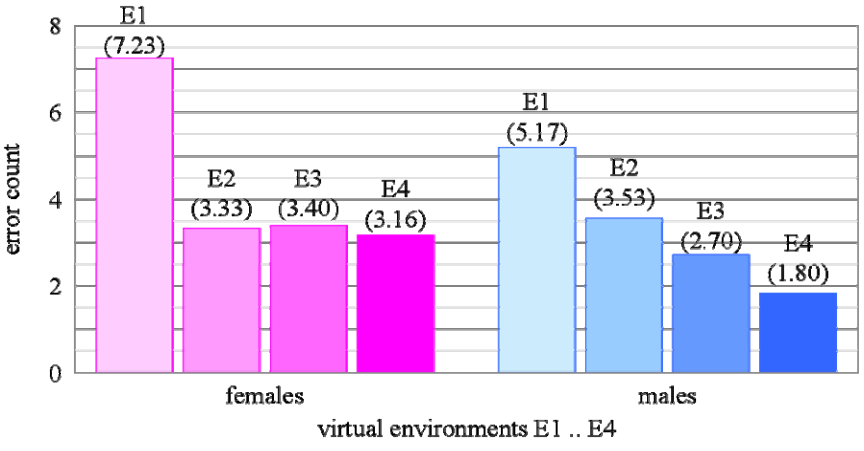

Fig. 5. Average female and male error counts for the different virtual environments (E1 ... E4). Errors are counted as attempts to enter locked doors in the maze.

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