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# Exploratory Study to Investigate the Influence of a Third Person on an Individual Emergency Wayfinding Decision

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**Abstract.** Disorientation is an usual issue in many situations, namely during emergency into complex buildings. It may cause a lack of crucial time mainly during early evacuation stages, increasing the chance of harming. This exploratory study aims to investigate the influence of others over a personal route-choice decision during wayfinding into a complex building. A Virtual Reality-based methodology was used and a virtual hotel was adapted from Vilar [1] in order to present six T-shape intersections with two opposite corridors. Two conditions were considered, an everyday condition, that represents the occupant interaction in an ordinary situation, and an emergency condition, in which a fire occurs into the building. Virtual character was inserted in order to investigate the influence of others over a directional choice decision. Findings point to a social influence over wayfinding decisions, suggesting that it can be an important aspect to be considered by safety planners, graphical designers, architects, managers and all those related with safety into complex buildings.

**Keywords:** Virtual Reality · Wayfinding · Complex buildings · Ergodesign · Social influence · Emergency

## 1 Introduction

Predicting people's movement within built environment is particularly important when complex buildings (e.g., hospitals, convention centers and university campus) are the focus of intervention by professionals involved in planning these structures.

According to Conroy [2], these professionals are not able to know precisely how people displacement occurs in a built environment and, sometimes, neglecting this information and replacing it by intuition. This gap in the knowledge about people's behavior regarding to their navigation indoors may contribute to increase the wayfinding problems, with which the visitors are often confronted while interacting with complex buildings, mainly during an emergency situation.

Disorientation is an usual issue in stressful situations, namely during emergency into complex buildings. It may cause a lack of crucial time mainly during early


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evacuation stages, increasing the chance of harming. Previous study [3] suggest that, during an emergency wayfinding situation into unfamiliar complex building, people tend to be influenced by some architectural features of the environment, such as illumination and corridor width, while choosing between two alternative routes to follow. Studies also point that, in stressful situations, the environmental characteristics can have more influence over emergency wayfinding decisions than the emergency directional signs, mainly during first decision points [4, 5].

The influence of others, or social influence, was also focus of study in emergency situations. In a research carried out by Latané and Darley [6], a group of male undergraduate students were placed in a room to fulfill a questionnaire in three experimental conditions, (i) alone (naïve), (ii) with more two persons who knows that it was a study (passive), and (iii) with two more naïve subjects. While they were filling out the questionnaire, some smoke was introduced in the room through a vent in the wall. In the condition with two passives, the passives were instructed to act as they were naïve, avoiding interaction, and to show indifference when the smoke started. Results shown that 75% of subjects reported the smoke in the alone condition, and only 38% of subjects reported the smoke in the three naïve condition. Only 10% of subjects reported the smoke in the two passives condition. This study is a strong evidence of the social influence in fire emergency. Authors argued that the way of the naïve interpreted the ambiguous situation may have influenced the outcomes. Thus, according to the authors, seeing other people remain passive led the naïve to decide the smoke was not dangerous.

The social influence, was also the focus of study of Nilsson and Johansson [7]. They reported that the social influence is more important when people face some degree of uncertainty, with a limited or ambiguous information, for instance, when a fire alarm is unclear or uninformative. In their study, authors selected 5 from 18 experiments previously performed, according their level of ambiguity, considering the type of alarm used (i.e., alarm bell, more ambiguous, and pre-recorded message, less ambiguous). Participants' behaviors and actions were analyzed through video recording, and the time that the behavior and action occurred, considering pre-movement time, was measured in relation to the time that the alarm was triggered (i.e., the time when the alarm started was set to zero). Three main types of behavior were analyzed considering pre-movement time, (i) look at others beside or behind oneself, (ii) start to prepare, and (iii) rise. Results suggest that people are influenced more by others who are closer than by those who are distant. So, social influence increases with decreasing distance between people.

Also, some models have been studied considering the influence of other individuals over wayfinding decisions, in both situations, during everyday activities and in an emergency. The affiliative model hypothesizes that people tend to move toward familiar places and persons during emergencies. According to the affiliative model [8], the pattern of movement both towards and away from the treat is mediated by the degree of familiarity of the individual with accessible persons or places. The affiliative model also predicts that the influence of the attachment objects (i.e. person and place affiliation) is even more likely to happen in an emergency than under normal circumstances, that is in an emergency people have higher probability to be drawn toward the familiar than in an everyday situation. In this way, Sime [8] states that the direction of movement will be related not only to the location of the fire but also to the location and degree of familiarity of the individual with the person and places. Some other studies have corroborated with the affiliative model, such as the unannounced evacuation of large retail-stores carried out by Sandberg [9]. This study investigated the emergency evacuation in two large retail-stores and main findings suggest that most of occupants (46%) started the evacuation only after the staff told them what was going on, and 33% started to evacuate by the alarm signal. Also, 100% of people stop the activity they were performing and started the evacuation if the suggestion to leave the building came from companion. Most of people which were unfamiliar with the building had help from the staff to be directed to an exit. In this way, author concludes that the emergency wayfinding might be influenced by familiarity with the building, group behavior and staff intervention. The BRE Digest 388 [10] also concludes that people in an emergency evacuation situation prefer to use familiar routes for escape.

Additionally, reports from investigations of the World Trade Center (WTC) fires [11], usually refer to the influence of others over emergency wayfinding decisions during the evacuation, such as this report from an occupant of the WTC 2: "*heard a noise that prompted me to get up and look out the window. I saw people out of the corner of my eye, grabbing their bags and leaving. I turned and got my bag, with my pocketbook and things to leave my cubicle and follow the people [to the staircase]. I didn't have to investigate; I just left [because] I saw other people leaving*".

Considering this context, the present study aims, in an exploratory way, to investigate the influence of others over a personal route-choice decision during an emergency wayfinding into a complex building. For this, a Virtual Reality - based methodology was used to overcome some ethical and methodological constraints. In this sense, as secondary goal, this exploratory study aims to verify issues related to scenario definition (i.e., VE design and development, narrative, equipment setup) to define features of best practices for VR scenario development. Based on literature review, the main hypothesis is that people will be influenced by others during their wayfinding decisions. It can occur in both, daily and emergency situations.

## 2 Method

In order to verify the main hypothesis, this exploratory study was adapted from a previous one [3, 12]. A two forced choice method was used to collect users' response about directional choices in an everyday situation and in an emergency situation. The route followed by the participants along a virtual environment (VE) was the study's main focus, with special attention to their decision-taking (i.e., path selection) at the corridors' intersection points. As such, these concerns have conditioned the architecture of the experimental virtual environment, adapted from Vilar [5] for this study.

### 2.1 Study Design

The main hypothesis (i.e., people will be influenced by others during their wayfinding decisions) was investigated considering two experimental conditions. The study used a within-subjects design (i.e. everyday and emergency conditions). The dependent variable is the percentage of choices favoring an intended in six corridor intersections. The main difference between everyday and emergency conditions was that when reaching the first floor through the elevator (beginning of the emergency condition), a fire alarm starts and smoke and fire appear near the participant, forcing he/she to escape and find his/her way out. Figure 1 shows the emergency condition, with the fire and smoke.

**Fig. 1.** Screenshot of the emergency condition showing the fire.

## 2.2 Participants

Thirteen volunteers participated in this study. They were aged between 18 and 67 years old (mean age 25.42 years, SD 11.42), being 9 male (mean age 26.54 years, SD 13.48) and 4 female (mean age 23 years, SD 4.82). All participants had normal sight or wore corrective lenses, and no color vision deficiencies were detected through the Ishihara test [13]. They also reported no physical or mental conditions that would prevent them from participating in a VR simulation.

## 2.3 Experimental Settings

Participants used a HTC VIVE™ Virtual Reality System, with a VIVE Headset and VIVE controllers. Harman Kardon™ headphones were also used by participants to listen to instrumental ambient music, the wayfinding task instructions given orally by the virtual character and the sounds of a fire alarm and fire while into the VE. The Steam VR tracking system was installed into a room with 2 m $\times$ 3 m of size allowing participants walk around while interacting with the VE. VIVE wireless controllers were used to interact with the VE in order to press buttons and moving around. The displacement method used was based on a teleportation metaphor. In this way, while pressing the trigger button on the base of the wireless controller, the avatar moves into the VE from one place to another.

### 2.4 Virtual Environment (VE)

The VE was adapted from a virtual hotel already used by Vilar [5]. In this way, six "T-type" corridor intersections were considered in a two levels building (i.e. ground floor and first floor). These six corridor intersections were mixed and randomly distributed along the floor plan.

A Virtual Human (VH) was inserted in the VE to investigate social influence during every day and emergency condition. The VH was an adult man who run in the direction of a specific corridor in two situations: a neutral, in which the opposite corridors have the same width and brightness, and a contradictory, in which one corridor is wider and brighter than the other one.

The six "T-type" corridor intersections were designed considering: (i) two neutral corridors' intersections, with two opposite corridors (i.e. left and right) with the same width (i.e. 2 m wide) without any VH; (ii) two corridors' intersections, with two opposite corridors (i.e. left and right) with the same width (i.e. 2 m wide) with a VH running in a corridor direction (i.e. for one corridor, the VH run to the left side and for the other one the VH run to the right side); and two corridors' intersections, with two opposite corridors (i.e. left and right) with different width (i.e. 2 m × 3 m wide, considering left and right corridors) and bright (i.e. the wider corridor was brighter than the narrow one), with a VH running to the direction of the narrower and darker

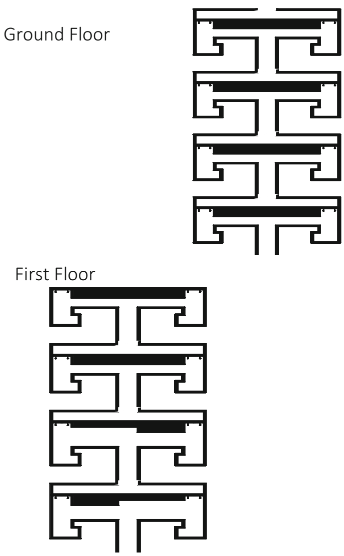


**Fig. 2.** Floor plan of the ground and the first floor of the virtual hotel with the six "T-type" corridor intersections.

corridor. Figure 2 shows the floor plan for the ground and first floors of the virtual hotel.

The VE was first designed using AtoCAD 3D® and then exported to MAYA® where all geometry was revised and UVmaps were applied onto the surfaces. Everything was exported to Unity where textures, lighting and objects were applied. The lightmap was baked. All VH were created using Adobe Fuse and the package LipSyncLite, from UNITY asset store, was used to synchronize the VH lips with the text. The camera was from the SteamVR package for UNITY (i.e. CameraRig) and the prefab was set at the floor (i.e., 0 m). The eye level into VE is the HTC VIVE HMD, so it is adjustable from person to person, depending on the participant eye level.

### 2.5 Experimental Task

**Contradictory Situation.** A situation was considered contradictory when conflicting information is given to participants. In this study, conflicting information was defined as having a VH running to the corridor that is the opposite of the one most chosen by participants in the study of Vilar and colleagues [1, 3]. Thus VH run to the direction of the narrower and darker corridors.

**Scenario and Wayfinding Tasks.** To increase participant involvement, a scenario was created. At the beginning of the experimental session, the following cover story was given to the participants: "*You were invited to give a lecture in an important conference at a hotel and conference center. The conference staff told you that you must talk with the receptionists to complete your registration at the conference and to know the location where the lecture will take place. As the city has a lot of traffic, you are late for your presentation. Please, complete your registration and find your lecture room as soon as possible*".

Participants were also told that they should behave as they would in a real-life situation. The receptionist (virtual character) would help participants to complete his/her conference registration and to know the location where the presentation will be made. When the participant reaches the second level where the presentation is to occur, he/she is informed that a fire has been detected on the premises.

It was considered a controlled navigation approach because the corridors already passed by the participant were closed by doors during everyday wayfinding and by fire and smoke in the emergency situation. Thus, for each choice point, when participants chose one of the two alternative corridors, the corridor of the path that was not chosen was closed by a door (or fire), forcing them to continue along their initial selected path.

### 2.6 Procedure

Before starting the VR-based components, all participants were asked to sign a consent form and advised that they could stop participation at any time. The VR test was divided into a training session and an experimental session. Participants were told that the experimenter's objective was to evaluate new software for VR simulation, so they ought to fulfil the tasks as accurately and as quickly as possible. Participants were unaware of the real objective of the experiment.

The VR test began with the training session which had the following main objectives: (1) to familiarize participants with the simulation set-up; (2) to allow them to practice the use of navigation and visualization devices, to bring their virtual movements closer to their realistic/natural actions; (3) to homogenize differences in the participant's performance using joystick; and (4) to make a preliminary check for symptoms of simulator sickness (participants were asked to report whether they felt any discomfort). Participants were encouraged to explore freely and navigate into the VE, as quickly and efficiently as they could, without time restrictions. Participants were further instructed to inform the experimenter when they felt relaxed and comfortable with the equipment. The researcher also monitored participants' control of the navigation device by verifying their accuracy in executing some tasks, such as circumnavigating a pillar placed in the middle of a room without bumping into this element and walking through a zigzag corridor without touching the walls. Only after verifying some of these equipment-related skills did the researcher permit the participant to start the experimental session.

No dialogue between the participant and the researcher was allowed after the simulation started.

The interaction started in the ground floor of a hotel and convention center where participants received a wayfinding task (i.e. find the elevators and go to the first floor) from a virtual character present in the VE. Once they reached the first floor, exited the elevator and walked through a room, an auditory alarm sounded. Thus, participants were faced with finding an emergency egress point by navigating through the second floor to escape from the fire. Smoke and flames always appeared behind the participants in the VE, thereby closing the corridor that they had already passed and preventing retreat in that direction.

If the participants reached a time limit of 20 min inside the simulation, the experimental session was stopped to prevent eye fatigue, or simulation sickness, or both. Simulator sickness was mainly evaluated through participants' verbalizations. However, the researcher also monitored them during the interaction for symptoms such as redness of face, nausea, dizziness and sweating [14, 15].

At the end of the experimental test, a post-task questionnaire was used to collect demographic information such as age, gender, occupation and dominant hand. Participants were also asked to answer, in seven-point scale format, questions related to their perceived hazard and overall involvement during the interaction with the simulation.

## 3 Results and Discussion

In order to verify the main hypothesis (i.e., people will be influenced by others during their wayfinding decisions), the participants' directional choices during their interaction with a VE were registered. Directional choices were left/right alternatives in "T-type" corridor intersection. Results from everyday condition (Table 1) and emergency condition (Table 2) were collected and analyzed.

Results were analyzed only considering when the VH was seen by the participants. Main results suggest that when critical situation was considered in everyday condition,

**Table 1.** Results considering social influence in six "T-type" corridors in everyday condition.

| Everyday condition | | | | | |
|---|---|---|---|---|---|
| *Corridor* | Environment characteristics | VH direction | % saw the VH | % followed the VH | Most chosen direction |
| *C1* | Right corridor - brighter and wider | Left corridor | 100 (13) | 76,92 (10) | |
| *C2* | Left corridor - brighter and wider | Right corridor | 100 (13) | 76,92 (10) | |
| *C3* | Equal brightness and width | Left corridor | 92,30 (12) | 50 (6) | |
| *C4* | Equal brightness and width | No VH | n/a | n/a | Left (7) |
| *C5* | Equal brightness and width | No VH | n/a | n/a | Right (9) |
| *C6* | Equal brightness and width | Right corridor | 92,30 (12) | 100 (12) | |

**Table 2.** Results considering social influence in six "T-type" corridors in emergency condition.

| Emergency condition | | | | | |
|---|---|---|---|---|---|
| *Corridor* | Environment characteristics | VH direction | % saw the VH | % followed the VH | Most chosen direction |
| *C1* | Equal brightness and width | Right corridor | 53,84 (7) | 85,71 (6) | |
| *C2* | Equal brightness and width | No VH | n/a | n/a | Right (7) |
| *C3* | Equal brightness and width | No VH | n/a | n/a | Left (8) |
| *C4* | Equal brightness and width | Left corridor | 100 (13) | 92,30 (12) | |
| *C5* | Left corridor - brighter and wider | Right corridor | 76,92 (10) | 50 (5) | |
| *C6* | Right corridor - brighter and wider | Left corridor | 92,30 (12) | 75 (9) | |

participants' relied more on the VH directional choice. Thus the majority of the participants (approximately 77%) preferred to follow the VH.

The same was not verified for neutral corridors' intersections. For these cases results were inconclusive.

Considering the total number of times that the VH was seen by the participants' (i.e., VH was seen 50 times, considering both critical and neutral situation), 76% of directional choices taken by the participants favored the same direction followed by the VH, in other words, 76% of the time participants preferred to follow the VH.

For the emergency condition, the environmental characteristics (i.e., wider and brighter corridors) seems to have higher impact over participants decision, decreasing the percentage of participants who followed the same direction followed by the VH.

Additionally, the VH seems to have be less seen by participants in the emergency condition than for the everyday condition (i.e., VH was seen 42 times in both, critical and neutral situations). Despite this, also about 76% of the participants preferred to follow by the same corridor followed by the VH.

Regardless of the order of appearance of corridor intersections, when the first time that the participant saw the VH was considered, 75,96% followed by the same direction as the one followed by the VH in everyday condition and 75% followed the VH in emergency condition.

## 4 Conclusion

The main motivation for this exploratory study is the influence that a third person seems to have over a personal wayfinding decision. Some studies already point to this direction and were carried out considering the influence of others [e.g. 6, 7]. However, the problem of social influence over emergency wayfinding decisions into complex buildings is still a matter to consider, namely for those responsible for planning and design.

Main results from this exploratory research point that, even in a VR setup and interacting with a VH, people seems to be influenced by the VH directional decisions, confirming the main hypothesis.

Additionally, when using VR as interaction environment, some features of the scenario (i.e., narrative, VE, equipment setup) have to be tested and validated to minimize the constraint that this type of approach may have over participants behavior. In this sense, this exploratory study aimed to test the designed scenario to be used for further studies. Thus, some features were identified as needing more attention, namely the number and order of corridor intersections should be revised. Considering previous studies [i.e., 3, 5], six "T-type" corridors' intersection in line may have been an over stimuli on the participant, and even the six corridors' intersections had been placed in a random sequence, corridors situations appeared grouped (first the two neutral, followed by the two critical situations). These facts may be influenced the results, as they could favoring random choice behavior. In this way, sample number need to be increased and VE design should be revised to avoid random choice behavior. Other point to consider was the length of the corridors. As the VH was an amination that appeared when triggered by the participant in a previous pre-defined point of the VE (i.e., on the corner of the main corridor that leads to the "T-type" corridor intersection), if the participant, for some personal reason, decided to stop, to go back, or to move slowly, he/she could not be able to see the VH wayfinding decision. This problem occurred because the main corridor was very short, so revising its length should solve it.

The number of participants need to be increased in order to have more reliable results, and it can be pointed as a limitation of this study.

For this exploratory study, the VH was a male young adult, wearing shorts and t-shirt in order to present some familiarity with the sample. For future, studies should consider other VH's status, such us fireman, boss, woman, among others, to investigate this effect over social influence in emergency wayfinding situation. Also, it would be important to explore the group effect, increasing the number of VH into the VE. Considering main results, social influence during wayfinding, mainly in emergency situation need to be more investigated. Even for a exploratory study, it is clear the influence of other over wayfinding decisions and it can highly impact buildings' use. In this way, studies considering the influence of others should be reinforced in order to define guidelines to help in the designing of complex buildings, in the definition of management strategies, and in the designing of emergency protocols and systems.

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