Wayfinding Behavior within Buildings – An International Survey

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ABSTRACT

A building wayfinding questionnaire study is presented which analyses the importance of a set of wayfinding criteria from a building evacuation perspective. The main path selection criteria tested in this questionnaire are handedness and length of the first leg of the path. The study involved 1166 participants from 36 countries. The results suggest that the handedness, a genetic factor, and the side of the road people drive on, a cultural factor, exert a significant influence on path choice. The results of this study clarify misconceptions existing in urban wayfinding studies regarding the importance of the length of the first leg of a path. Path selection criteria along with their relative rankings are suggested for inclusion in wayfinding algorithms used within evacuation models. It is not clear how large an effect these influences will have on evacuation analysis. This will be examined by introducing these factors into a new wayfinding algorithm recently introduced into the buildingEXODUS evacuation model.

KEYWORDS: wayfinding, escape routes, path selection, human behavior, human factors.

INTRODUCTION

Within the building environment, wayfinding describes the process by which an individual located within a complex enclosure decides on a path or route in order to reach a goal location. Within the building evacuation context, wayfinding describes the process in which the individual attempts to find a path which leads them to relative safety, usually the exterior of the enclosure. In most evacuation modeling tools, the process of wayfinding is either ignored or grossly simplified. In a recent review of 30 evacuation models wayfinding features were only mentioned in the context of two models [1]. On the whole, evacuation models assume that the simulated agents have complete knowledge of the structure and so follow a potential or distance map to their nearest exit – essentially selecting the path of minimum travel distance. Some models may even assume that a proportion of the occupants have partial knowledge of the structure and so are familiar with only some of the exits [2,3]. At least one model incorporates agent interaction with signage allowing agents completely unfamiliar with the structure to follow a signage chain leading to an exit [2,3]. Recently, there has been some effort to incorporate a modified form of urban wayfinding criteria within building evacuation models [4]. However, this may be questionable as the wayfinding process within buildings may be different to that within urban environments. If our computer models are to accurately represent the wayfinding process adopted by humans during building evacuation we must first understand how humans wayfind within such environments. Key to this is developing an understanding of the criteria used by humans in deciding which path to take.

The lack of sophistication in the manner in which wayfinding is treated within building evacuation models is due in part to the general lack of detailed knowledge concerning wayfinding within complex building layouts. While there are numerous wayfinding studies in urban environments [5–8], there is very little wayfinding research performed within complex building environments. Due to the difficulty in conducting wayfinding research, especially research which involves international participants, most of the research that is conducted makes use of surveys, questionnaires or virtual environments.

Golledge's urban wayfinding study [5,6] involved a sample of 32 adults, 16 male and 16 female. The sample was mostly students, with half the population being trained in geography. The participants in Golledge's study were asked to identify the path they would take on a map to get from an identified starting point to an identified end point. The maps used varied from uniform grids, to uniform grids with diagonals and grids with curved paths plus blockages. Participants were then asked to rank the criteria they used in selecting their path using a seven point scale; participants selected the criteria from a list of 10 provided. The criteria selected by the participants, in order of preference (with mean rating shown in brackets) are: shortest distance (4.2), least time (4.1), fewest turns (3.6), most scenic/aesthetic (3.5), first noticed (2.5),

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longest leg first (2.3), many curves (2.3), many turns (1.8), different from previous (1.8) and shortest leg first (1.7).

Conroy has studied route choice decisions made at consecutive road junctions over the duration of a single journey [7]. The study involved a virtual urban environment containing a variety of urban block shapes and involved 30 participants, 20 males and 10 females with a mean age of 28. The geometry was the equivalent of 650 m × 650 m and would take approximately 8.5 min to cross diagonally walking at an average pace. Participants spent on average 10 minutes immersed in the virtual world. The participants were instructed to enter the geometry at the top corner and make their way to the diagonally opposite bottom corner. From an analysis of the paths chosen, Conroy concludes that route selection is a competition between the desire to select the simplest route (i.e. straightest route to the destination) and the desire to maintain a heading closest to the direction of the destination from the origin (most direct route). Conroy goes on to suggest that the finding of Golledge in which people prefer to select the longest leg first (i.e. starting the journey by selecting the route option that has the longest line of sight) over the shortest leg first [5,6], is a result of the most direct route winning over the simplest route.

The study of Scharine and McBeath [9] investigated the choice people make in taking a left or right turn when all other conditions were equal. Their experiment involved 112 participants who were library patrons, 82 from the USA and 30 from the UK. The sample consisted of 87 % right-handed people. Participants were asked to retrieve an object which was hidden at the end of an aisle formed by a shelf of books. The participants had to walk down a 10 m long corridor formed by book shelves and then turn either into the left aisle or the right aisle to retrieve the object. They found that 66 % of the right-handed sample preferred to turn right while only 33.3 % of the left-handed sample preferred to turn right. This indicates that the handedness of the participant is a strong indicator of the direction in which the person is likely to turn. In addition, 67.1 % of the sample who drive on the right side preferred to turn right while 46.7 % of the sample who drive on the left-side prefer to turn right. This indicates that while the side of the road that you drive on has an influence, it is not as strong as the handedness. Furthermore, it appears that handedness and driving side are additive factors, with approximately 70 % of right-handed, right-side driving sample preferring to turn right, while approximately 48 % of the right-handed, left-driving sample prefer to turn right. The sample size of left-side drivers was considered too small to draw definitive conclusions. This study would suggest that there is both a genetic component to wayfinding (handedness) and a cultural component (driving side).

While these studies indicate that there are a number of factors that influence wayfinding, the studies are either drawn from too small a sample or are not directly related to wayfinding within buildings. Furthermore, the study of Golledge, conducted in the USA and Conroy, conducted in the UK, do not consider handedness or driving side of the participants and the likely impact this may have on wayfinding. To address these issues and identify the factors which impact wayfinding within building environments, the authors have undertaken two large-scale international surveys. The first survey explored factors associated with; handedness, driving side, and preference for longest leg first (LLF) or shortest leg first (SLF). The second survey was designed to explore a wider range of potential factors which influence wayfinding. The results from the first questionnaire are presented in this paper. Once the factors which influence wayfinding within building are established, they will be incorporated within the wayfinding algorithm established in [4].

THE WAYFINDING QUESTIONNAIRE

Participants were invited to complete an on-line questionnaire. The call for participation to complete the on-line survey was undertaken via several different media e.g. website link, leaflet distribution, online forums, email mailing lists, friends/family/colleagues, a national appeal broadcast on BBC radio, snow balling, etc. Whilst the survey is currently on line (http://fseg.gre.ac.uk/wayfinding/index.asp), at the time of writing this paper, the results presented represent data collected from approximately July 2009 to July 2010. The survey consisted of three sections and required approximately 10–15 min to complete.

The first part consisted of five separate wayfinding tasks where the participants were shown five different hypothetical building layouts in turn (see Fig. 1), each with two paths, labeled A and B, leading to an exit. The participant was provided with written information stating that each path was equal in length and that they were completely familiar with the building layout. On selecting the preferred path, the participant was then asked to rate both paths on a scale of 1 to 6 where 1 is highly undesirable, 2 is very undesirable, 3 is a little undesirable, 4 is a little desirable, 5 is very desirable and 6 is highly desirable. On completing this, the participant was then asked to imagine that they were now in an emergency evacuation situation in the same building and choose their preferred exit path. For the emergency evacuation option, the participant was informed that both routes were considered safe and free of smoke or other fire hazards.

Question 1 is intended to investigate the participant's preference for selecting the left-hand or right-hand path (see Fig. 1a). In the second (see Fig. 1b) and third (see Fig. 1c) questions, the building geometries either have the LLF path on the left (see Fig. 1b) or right (see Fig. 1c). The LLF path is also the most direct path having the least bearing to the exit. In order to remove 'the most direct path' factor from consideration, Questions 4 (Fig. 1d) and 5 (Fig. 1e) were designed where the start position is in line with the exit, thus both paths have an equal bearing to the exit. Initially the length of the paths in Questions 4 and 5 were kept the same. However a pilot study indicated that people perceived the angled path, Path B in Question 4 and Path A in Question 5 (Fig. 1d and Fig. 1e), to be slightly longer in spite of being reminded that both paths are of the same length. Hence the angled paths were made slightly shorter in order to compensate for this visual illusion.

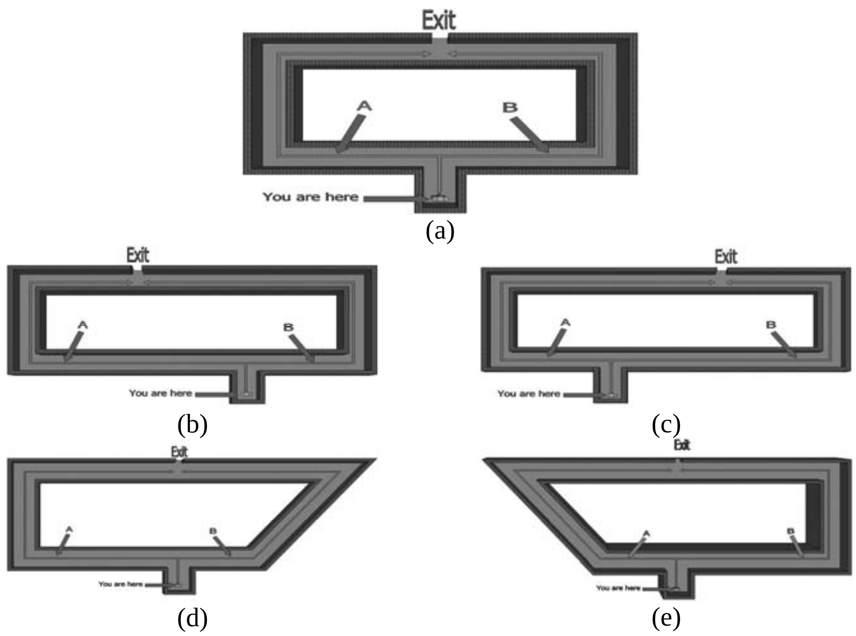

Fig. 1. Path selection tasks in the questionnaire.

In the second part of the survey the participants were given a list of factors and were asked to choose those that influenced their wayfinding decisions in the first part of the survey. Participants could select more than one option and were also given the opportunity to list other factors that influenced their decision. The list of factors provided was:

- I prefer to take the path with the longest leg first
- I prefer to take the path with the shortest leg first
- I have a preference for paths on my left
- I have a preference for paths on my right
- I have a preference to take the clockwise paths
- I have a preference to the take the anticlockwise path
- I choose the path which appeared to be the most direct
- I choose randomly

The third part of the survey involved collecting participant demographic information. Two pilot studies were conducted to check the general level of understanding of the questions. A few modifications were made to the questionnaire based on the pilot studies and this data was not included in the overall questionnaire results.

THE SAMPLE POPULATION

A total of 1200 participants from 36 countries took part in the survey of which 1166 were considered eligible to take part in the analysis. The countries with the largest response to the survey are: UK, 649 (56 %); USA, 113 (10 %); Australia, 72 (6 %); India, 62 (5 %); Germany, 46 (4 %) and Netherlands, 25 (2 %). Of this sample, a total of 336 (29 %) of the participants drive on the right-side of the road e.g. USA, Germany, Netherlands, etc, and 830 (71 %) drive on the left-side of the road e.g. UK, Australia, India, etc. Furthermore, 1010 (87 %) of the participants are right-handed while 156 (13 %) are left-handed. Our sample of left-handed people is equivalent to the world average of 10–13 % of the population being left-handed [10]. Of the sample population who drive on the left-side of the road (830), 728 (88 %) are right-handed (note, the right-handed left-driving sub-population is referred to as RHLD). Of the left-driving sample, 102 (12 %) are left-handed (note, the left-handed left-driving sub-population is referred to as LHLD). Of the sample that drive on the right-side of the road (336), 282 (84 %) are right-handed (referred to as RHRD) while 54 (16 %) are left-handed (is referred to as LHRD).

THE MAIN RESULTS AND DISCUSSION

The findings from Part 1 of the study are first presented, followed by the findings from Part 2. The Part 1 results are first summarized and then the responses to each of the wayfinding questions are examined in turn. It is important to note that the results for the path selection under normal conditions were virtually identical to those under emergency conditions and so only the results under normal conditions are presented. All the conclusions presented in this paper are statistically significant using the Chi-Square test with Yates [11] correction.

Discussion of Part 1 Results

In this section the results from the path selection tasks for Questions 1–5 are first summarized. This is then followed by a detailed investigation of the results from each path selection task. The results for each path selection exercise are examined in detail with a focus on: Question 1 – impact of the participants handedness and driving side on the path selection; Questions 2 and 3 – impact of the length of the first leg on path selection (together with participant handedness and driving); Questions 4 and 5 – as for Questions 2 and 3 but with the path directness removed as an influencing factor.

Overview of Path Selection Results

A summary of the path choice made by the entire sample population (1166) for each of the five questions is shown in Fig. 2. In the first four wayfinding tasks (Questions 1–4), the participants clearly have a preference for right-hand paths which is statistically significant at a 0.001 confidence level.

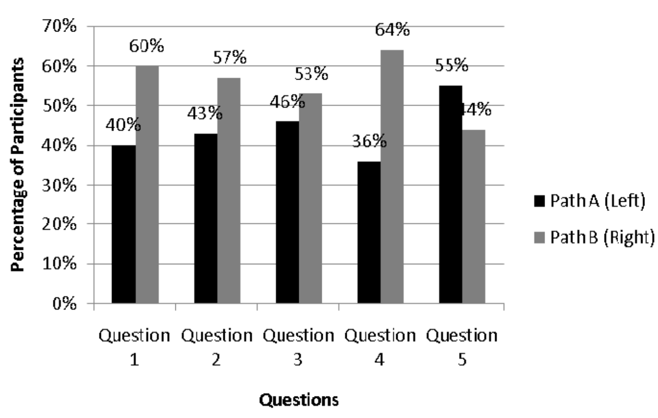

Fig. 2. Percentage of the sample population selecting Paths A and B in wayfinding tasks.

This strong preference for right-hand paths is examined in more detail in the following sections. These results suggest that on the whole people generally have a slight preference for right-hand paths. However,