Study of Wayfinding Behaviours in an Outdoor Environment

Irfan Haider Khan and Saptarshi Kolay

Abstract Effective wayfinding is important for people to make their way through spaces, as it improves efficiency, accessibility, and safety. This study focusses on understanding the importance of wayfinding behaviours of people in an outdoor environment. The study area is an archaeological heritage site in the city of Delhi, India. Three navigational exercises were conducted to study the wayfinding behaviours among the users. Findings from each of the exercises are compared and evaluated. The correlation between the studied wayfinding measures is calculated and analysed to study the significant patterns in the behaviour of the participants. The results show that verbal directions for wayfinding are found to be the simplest, while directional signs and maps help in strengthening the cognitive maps of users. Users avoid unfamiliar routes, and tend to walk on the routes with more wayfinding aids, and physical structures.

Keywords Wayfinding · Wayfinding behaviour · Navigation · Outdoor environment · Cognitive behaviour

1 Introduction

Wayfinding is a part of everyone's daily life, and more so, when people experience an unknown environment, as they need to rely on the environmental cues, routes, and spatial organization of a space [1–3]. The wayfinding process, usually considered a simple and effortless task, involves complex cognitive processes [3]. Researchers of a varying field including and not limited to—cognitive psychology [4, 5], neurology [6], and architecture and urban planning [7], have therefore studied the wayfinding behaviours. The solution to a wayfinding problem is therefore, to produce a perceptible information that is easily understood by the

I.H. Khan (✉) · S. Kolay
Department of Architecture and Planning, Indian Institute of Technology, Roorkee 247667, Uttarakhand, India
e-mail: haider.irfan01@gmail.com

A. Chakrabarti and D. Chakrabarti (eds.), *Research into Design for Communities, Volume 1*, Smart Innovation, Systems and Technologies 65, DOI 10.1007/978-981-10-3518-0_15

users. In order to deliver an appreciable design, it is crucial to understand how the users behave in the given space [8]. There is still a need of research based design projects that implement the findings of wayfinding behavioural study through environmental design. The gap between the behavioural studies and design outputs is huge, and needs attention.

Wayfinding design is an integral part of a cohesive design scheme in architecture, urban design and landscape. Often misunderstood for signage design, wayfinding is much more than just signs. Wayfinding design has to take into consideration elements of architecture, landscape, landmarks and additional visual cues such as lighting, user interaction all as an interconnected scheme. The signage design is therefore only a medium to inform the users about their environment. Wayfinding research in terms of study of users' behaviour, perception and their navigational needs inform the design needs to achieve a consistent and functional scheme.

Navigation in an unknown outdoor environment is a challenging task. In a real life experience, people generally rely on pre-planned route maps and more commonly—verbal directions [9]. The comprehension of map involves the placement of self with reference to the map, reorientation, identification of the goal, and thereby remembering the way to the goal [10]. The information learned from the map is dependent on the orientation and perspective in which the map is viewed [7]. On the other hand, information received through verbal directions help in creation of mental maps in users, based on the route based directions (i.e. right, left, straight, etc.), or cardinal directions (i.e. north, south, west, etc.) and the reference points (landmarks) used by the source. An earlier study by Melinger (2008) suggest that the information received through maps and verbal directions are equally useful in wayfinding [9]. Various researchers have studied and compared the wayfinding performance of people using physical maps and GPS [7], maps and verbal directions [9] by measuring various wayfinding variables (time, distance, speed, direction, etc.) and assessing the performance. Other studies focus on the differences in wayfinding performance based on gender differences [4], culture [11] and age [12] by measuring similar wayfinding variables.

This paper aims to place wayfinding design research as a significant part in the formulation of urban design schemes. The correlations among various spatial measures forms the basis of this study, in order to study the wayfinding behaviours in users of a novel outdoor environment. This study integrates some of the existing work by other authors, and intends to build up on them. We aimed to study the similarities and differences in users' wayfinding behaviours based on information received through different means i.e. direct experience (environmental cues), map, and verbal directions through a set of three carefully designed exercises, carried out with participants in a naturalistic setting. The measurement of wayfinding variables (sense of direction, distance, time, pointing error, etc.) and the comparison between the three exercises help in evaluating the wayfinding behaviours, followed by a discussion on the translation of behavioural research into wayfinding system design.

2 Method

2.1 Study Area

The study area is a heritage site (Mehrauli Archaeological Park) in the Mehrauli region of the city of Delhi. The selected site is an outdoor space with an area of approximately 100 acres, containing several historic monuments.

2.2 Participants

Fifteen participants (7 males and 8 females) participated in the study. The participants were aged in the range of 23–30 years (Mean = 26.67, SD = 2.02). All the participants were first time visitors.

2.3 Experiment Design

In each of the exercise, participants navigated from one point to another, without taking any external help from the visitors of the area. All the pre-decided destinations were one of the monuments located within the park, chosen during a pilot. Participants were encouraged to think aloud while walking. This helped the experimenter to observe for follow-up questions and discussion.

Exercise 1 involved navigation based on direct experience, to test user's wayfinding behaviour in the absence of a map or verbal directions. Exercise 2 focussed on the study of map usage and their impact on users' wayfinding abilities. Additionally, the participants were unrestricted to refer to the directional cues (signage installed on site). Exercise 3 aimed to study the behaviour of the navigator, and mark any significant behavioural changes while navigating based on verbal directions, when compared to map based navigation, or while using environmental cues alone.

2.4 Materials

The experimenter recorded the video of the navigational exercises using the video recorder on his mobile phone device (Xiaomi Redmi 2). To measure the distance walked and the average walking speed, a pedometer was used. The time taken to reach the destination was recorded using the mobile clock application.

Self-Report Measure for Sense of Direction. The Santa Barbara Sense of Direction (SBSOD) scale was used to assess the participants' sense of direction,

Fig. 1 Map of the area, showing the extent of the park. The reference points used in the experiment are numbered sequentially 1–5

orienting abilities and their spatial understanding. The scale has an established consistency and reliability proven in earlier research works [5]. The scale has also been used by various authors in different fields, and has shown significant results [7, 10].

Map and Direction Statements. For Exercise 2, the participants were given a coloured scale map of the area (only a portion of study area) printed on an A3 sheet, showing the pathway layout, and all the structures. Figure 1 shows the map given to the participants. The reference points (starting points and destinations) used in the experiment are numbered sequentially (1–5).

In the final exercise (Exercise 3), the participants were given the directions to their destination verbally, in the form of sequential statements. This set of directions were determined in a separate pilot study, following the skeletal descriptions [13]. The instructions given to the participants were—(1) Head straight until the next intersection. (2) Turn right and follow the path until the next turn. (3) Follow the curving path and turn left. (4) *Jamali Kamali's Tomb* is on the left side, head straight from there, until *Rose Garden*. (5) Take left from the *Rose Garden*, and head straight. (6) Follow the curved path, until the next intersection. (7) Take right

from the first intersection. (8) Head straight and walk until the staircase on your left. This is the entrance to *Quli Khan's Tomb*.

Direction Estimation (Pointing) Task. In all the exercises, to measure the directional error in the pointing task, a circle of 5 cm was drawn on an A4 sheet, and divisions were marked at 1° intervals, the centre of the circle denoted the position of the participant while pointing towards the starting point of the journey.

2.5 Procedure

Prior to beginning of the experiment, participants filled out the consent forms and questionnaire relating to SBSOD. Once the participant filled up the consent form, and cleared his doubts, he was taken to the starting point of the exercise i.e. the pedestrian entry gate. Since, the gate is located outside the park boundary, on the main road; it was not possible for the participant to gain any spatial or visual information about the area while travelling to the starting point, before the actual wayfinding exercise.

Exercise 1. The participant was given the name of the first destination (i.e. *Rajon ki Baoli*), and was asked to start walking towards the goal. The participant was restricted to seek any kind of external help, from the visitors. While navigating, if the participant took a wrong turn and walked more than 5 m, the experiment informed him and corrected his direction. During the process of wayfinding, if the participant did not reach the goal within 15 min, the experimenter took him to the destination.

Exercise 2. At the starting point (*Rajon ki Baoli*), the experimenter handed the map to the participant, and gave sufficient time to find and locate the starting point on the map, and then identify the destination (i.e. *Balban's Tomb*). The participant was unrestricted to choose the preferred route based on the map (as there were primarily two possible routes). The participant was asked to make a mental note and remember the preferred route, and when the participant gave the consent to proceed with the wayfinding exercise, the map was taken from him and the exercise started.

Exercise 3. Prior to beginning the main wayfinding exercise, the experimenter gave the verbal directions to the participant. Once the participant gave the consent, the exercise started. The participant was asked to start the navigation from the origin (i.e. main entry gate) towards the destination (i.e. *Tomb of Quli Khan*).

2.6 Recording and Observations

In all the exercises, the experimenter walked about 2–3 m behind the participant while recording the video, in order to allow the participant to lead the way, and to observe the participant's behaviour. It was left to the participant's disposition to refer to any environmental cues (i.e. the signs installed on site), in addition to his

internal cognitive memory or the provided tools (i.e. the map or the set of verbal directions).

At the end of each exercise, the participant was asked to estimate the distance travelled, and to point towards the starting point, by drawing an arrow (on the paper with a circle with marked degree divisions) towards the estimated direction. At the end of the final exercise, the experimenter asked the participant to point in the direction of starting points of all the three wayfinding exercises. This was done to understand the strength of the mental map created by the participant after he had become familiar with the area.

At the end of all the exercises, participants were asked to rate the difficulty level for each of the exercise in relation to one another, on a scale of 1 (very easy) to 5 (extremely difficult).

3 Results

The different variables taken into account for the purpose of this experiment were measured and analysed to assess the wayfinding performance of the participants. The experiment did not focus on the study of gender difference as a measure of wayfinding behaviour; however, some of the findings suggest a significant difference between males and females.[1] Table 1 summarizes the findings of the experiment, with a comparison between the three wayfinding exercises.

3.1 Sense of Direction

Participants answered the SBSOD questionnaire for the self-report measure of sense of direction. To calculate the sense of direction score, the mean of the responses to the 15 questions is considered. The responses to positively stated questions were reversed, in order to calculate the sense of direction score, therefore, higher score (on a range of 1–7) refer to higher (or better) sense of direction [5].

Average score of 4.31 (N = 15, Range = 3.47–5.73, SD = 0.67) was reported through the SBSOD scale (Table 1, Row 1). A higher score was reported by the male participants (N = 7, Mean = 4.52, SD = 0.53) as compared to their female counterparts (N = 8, Mean = 4.12, SD = 0.72). Higher sense of direction in males in comparison to females has also been reported in previous studies [4, 14].

[1]A number of studies have reported noteworthy gender differences in wayfinding behaviours of males and females; however, this paper does not focus on gender differences, due to the small sample size of participants.

Table 1 Comparison between the findings of the wayfinding exercises conducted

Variable	Exercise 1 [Mean (SD)]	Exercise 2 [Mean (SD)]	Exercise 3 [Mean (SD)]
Sense of direction	4.31 (0.67)	4.31 (0.67)	4.31 (0.67)
Distance travelled (m)	966.27 (67.49)	938.67 (154.16)	750.13 (26.87)
Speed (m/s)	1.19 (0.04)	1.19 (0.02)	1.20 (0.04)
Duration (s)	882.40 (87.24)	807.67 (100.09)	651.40 (40.09)
No. of stops	3.13 (0.72)	1.60 (0.61)	1.20 (0.40)
Pointing error (°)	46.13 (19.59)	15.47 (8.50)	20.27 (7.58)
Difficulty level	3.13 (0.81)	3.07 (0.68)	1.53 (0.72)

3.2 Distance Travelled and Speed

For each exercise, the distance walked by the participant and average walking speed was measured. There were no significant differences found in the distance measurements between the readings for Exercise 1 (Mean = 966.27, SD = 67.49) and Exercise 2 (Mean = 938.67, SD = 154.16). The larger deviation in the measurement during Exercise 2 is mainly because of the longer route taken by some participants during the map based wayfinding task. However, participants walked considerably shorter distances during Exercise 3 (Mean = 750.13, SD = 26.87), as compared to Exercise 1 and 2 (Table 1, Row 2).

There were no notable differences in the speed measurements in all the three exercises. In all the exercises, female participants walked faster than their male counterparts did, the difference however, was not significant (Table 1, Row 3).

3.3 Duration and Number of Stops

The time taken by all the participants did not differ significantly in the first two exercises, however in Exercise 3 participants took lesser time (Table 1, Row 4). The exercise was considered successfully completed by the participant, if they reached the destination within the stipulated time of 15 min (900 s). To compute the quantitative relationships, the score of 1 was given to the participant if the task was a success and 0 (zero) if they failed to reach the destination within 15 min.

The number of stops made by the participants for 30 s or longer were recorded as an indicator that they were trying to orient themselves, or find their way through the space. The participants tended to make more stops in Exercise 1 (Mean = 3.12, SD = 0.72), as compared to Exercise 2 (Mean = 1.60, SD = 0.61) and Exercise 3 (Mean = 1.20, SD = 0.40) (Table 1, Row 5).

3.4 Direction Pointing

The angular difference (pointing error) between the actual direction and the direction pointed by the participant was calculated by drawing in AutoCAD. There were notable differences in pointing errors observed in all the exercises (Table 1, Row 6). Participants in Exercise 1 made greater error in pointing (Mean = 46.13, SD = 19.59), in comparison after Exercise 2 (Mean = 15.47, SD = 8.50) and Exercise 3 (Mean = 20.27, SD = 7.58). In verbal direction based exercise, the participants were asked to point towards the starting point of all the three exercises, which they had visited. The findings show a reduction in pointing error, as compared to Exercise 1.

3.5 Difficulty Level of Exercises

Participants rated Exercise 1 and Exercise 2 almost equally difficult (Table 1, Row 7). All the participants rated Exercise 3 (verbal directions) as the easiest.

3.6 Exercise Correlations

In order to assess the wayfinding behaviours in participants, non-parametric correlations (Spearman's rho) between various wayfinding measures are calculated, for each wayfinding exercise. Some of the measures of wayfinding behaviour were found to be significantly correlated.

Exercise 1. Table 2 shows the correlations between various wayfinding measures for the first exercise. Females were assigned 1 as a measure, and males as 0 (zero), for quantitative assessment. The findings suggest that—males performed better in estimating the distances and directions, and females rated the exercise more difficult as compared to the male participants. The SBSOD measure is found to be significantly correlated to the number of stops made by the participants (negative correlation, $p < 0.01$), and the pointing error (negative correlation, $p < 0.05$). Participants with higher sense of direction made significantly lesser stops during their journey, and were more accurate in direction pointing. Participants who walked greater distances made lesser error in distance estimation ($p < 0.05$). Evidently, people who walked faster were more successful in succeeding in the wayfinding exercise, as success of the exercise was dependent on time taken. Participants who made lesser stops during the exercise spent lesser time in wayfinding and therefore, were more successful in finding the goal ($p < 0.01$). Successful participants also made smaller angular errors in direction pointing ($p < 0.05$), and rated the exercises easier, compared to participants who did not succeed.

Table 2 Correlations between wayfinding measures (Exercise 1)

	1	2	3	4	5	6	7	8	9
1. Gender	1								
2. SBSOD	−0.403	1							
3. Distance	−0.371	0.568*	1						
4. Error coefficient	0.680**	−0.326	−0.521*	1					
5. Speed	0.111	0.082	−0.303	0.257	1				
6. Duration	0.062	−0.213	0.536*	−0.057	−0.528*	1			
7. Success	−0.218	0.474	−0.252	0.094	0.615*	−0.850**	1		
8. No. of stops	0.336	−0.702**	−0.080	0.269	−0.272	0.618*	−0.722**	1	
9. Pointing error	0.186	−0.550*	−0.327	−0.070	−0.138	0.250	−0.521*	0.540*	1
10. Difficulty level	0.674**	−0.407	−0.008	0.482	−0.038	0.422	−0.536*	0.539*	0.147

*$p < 0.05$, **$p < 0.01$

Table 3 Correlations between wayfinding measures (Exercise 2)

	1	2	3	4	5	6	7	8	9
1. Gender	1								
2. SBSOD	−0.403	1							
3. Distance	−0.310	0.253	1						
4. Error coefficient	0.340	−0.591*	0.161	1					
5. Speed	0.183	0.032	−0.423	0.085	1				
6. Duration	0.062	0.188	0.803**	0.196	−0.507	1			
7. Success	0.200	−0.503	−0.695**	0.000	0.456	−0.694**	1		
8. No. of stops	−0.138	0.204	0.402	0.280	−0.425	0.587*	−0.561*	1	
9. Pointing error	0.280	−0.381	0.287	0.493	−0.393	0.396	−0.271	0.401	1
10. Difficulty level	0.085	−0.354	0.123	0.106	−0.395	0.222	−0.191	−0.101	0.555*

*$p < 0.05$, **$p < 0.01$

Exercise 2. The findings in the second exercise showed similar correlations as in Exercise 1 (Table 3). The participants with higher sense of direction showed smaller error in distance estimation. Participants who made larger error in pointing task rated the task more difficult ($p < 0.05$).

Exercise 3. The observations and findings do not show many significant correlations. The significant negative correlation ($r = -0.578$, $p < 0.05$) between the speed and coefficient of error is an interesting find, suggesting participants who walked faster were much better at estimating the distances. Since all the participants successfully completed the exercise (reached the destination within the stipulated time), there were no correlations between the success of the participants or any other wayfinding measure. Female participants made greater angular errors in pointing task ($r = 0.703$, $p < 0.01$), and distance estimation ($r = 0.588$, $p < 0.05$).

4 Discussion

The study dealt with the study of wayfinding behaviours in participants who received navigational information through direct experience, maps, and verbal directions. The participants performed relatively better when given the navigational information through verbal directions. However, this may be due to the less complicated and sequentially structured directions. Verbal directions are generally considered convenient and easier to translate into actions; however, it primarily depends on the complexity, or clarity of instruction, and the reference points used to direct the navigator.

The results show that the participants faced wayfinding challenges in the absence of navigational information received via maps, or verbal directions. Since all the participants were first time visitors to the area, they did not have any prior cognitive maps formed. They primarily relied on the existing signs inside the park. However, the improper placement or the incomplete information presented by the signs affected the wayfinding experience of the participants. In the absence of wayfinding maps and carefully placed directional signs, people tend to walk longer distances and take more time, as they are trying to get familiar with the environment. One of the reasons for the differing success rate is the lack of wayfinding aids during Exercise 1, while the map-based navigation in Exercise 2 helped the participant in familiarizing with the environment. In Exercise 3, the route based verbal directions and references to landmarks helped the participants more effectively, and therefore, all the participants finished the exercise without failure.

One of the interesting find in Exercise 1 is that participants with higher self-reported sense of direction walked greater distances. This is in contrast to earlier studies [4, 5]. A possible explanation to this can be the environmental context, as the discussions with the participants suggested that participants addressed the exercise as more exploratory than direct origin-destination based experience. The correlations with the sense of direction measure with other wayfinding measures are significant for some variables, resonating with the previous studies suggesting that the participants with higher self-reported sense of direction performed better in the wayfinding exercise.

5 Design Implications

The wayfinding experiment findings, correlations and the discussions with the participants show that the wayfinding performance in users differ with each wayfinding aid i.e. directional signs, maps, information graphics, etc. The observations made during the experiment and discussions with the participants suggest that the study of wayfinding behaviours in users can help in improving the design of wayfinding elements. The findings from the behaviour study can inform about the navigational needs of the users which not only produce basic design requirements but also improve the efficiency of design. The careful placement and providing required information on signs help users to reach their goal more easily, by reducing the time spent on looking at the signs, and thereby strengthening the mental map created by the user.

This paper outlines the importance and need of an effective wayfinding solution in an outdoor environment. Wayfinding as an urban problem is not addressed, as frequently by the researchers, however, the impact of wayfinding in daily life is obvious and important. It is imperative that wayfinding design is thought of in the initial stages of any design project. The design and development of a wayfinding

system (including signs, maps, guides, etc.) can become more effective if the wayfinding behaviours are studied and evaluated properly. Further, design guidelines for the wayfinding scheme can also be formulated based on the findings of such behavioural studies.

References

1. Lynch, K.: The Image of the City. MIT Press, Cambridge, Mass (1960)
2. Arthur, P., Passini, R.: Wayfinding. McGraw-Hill Book Co., New York (1992)
3. Golledge, R.: Wayfinding Behaviour. Johns Hopkins University Press, Baltimore (1999)
4. Lawton, C.: Gender differences in way-finding strategies: relationship to spatial ability and spatial anxiety. Sex Roles **30**, 765–779 (1994)
5. Hegarty, M.: Development of a self-report measure of environmental spatial ability. Intelligence **30**, 425–447 (2002)
6. Spiers, H., Maguire, E.: The dynamic nature of cognition during wayfinding. J. Environ. Psychol. **28**, 232–249 (2008)
7. Ishikawa, T., Fujiwara, H., Imai, O., Okabe, A.: Wayfinding with a GPS-based mobile navigation system: a comparison with maps and direct experience. J. Environ. Psychol. **28**, 74–82 (2008)
8. Gibson, D.: The Wayfinding Handbook. Princeton Architectural Press, New York (2009)
9. Meilinger, T., Knauff, M.: Ask for directions or use a map: A field experiment on spatial orientation and wayfinding in an urban environment. J. Spatial Sci. **53**, 13–23 (2008)
10. Skagerlund, K.: Maps in the head and maps in the hand: the interplay between external spatial representations and individual spatial abilities during navigation in a naturalistic environment (2011)
11. Lawton, C., Kallai, J.: Gender differences in wayfinding strategies and anxiety about wayfinding: a cross-cultural comparison. Sex Roles **47**, 389–401 (2002)
12. Xia, J., Packer, D., Dong, C.: Individual differences and tourist wayfinding behaviours. In: 18th World IMACS/MODSIM Congress (2009)
13. Denis, M.: The description of routes: a cognitive approach to the production of spatial discourse. Current Psychol. Cogn. **16**, 409–458 (1997)
14. Turano, K., Munoz, B., Hassan, S., Duncan, D., Gower, E., Roche, K., Keay, L., Munro, C., West, S.: Poor sense of direction is associated with constricted driving space in older drivers. J. Gerontol. Series B: Psychol. Sci. Soc. Sci. **64B**, 348–355 (2009)