Pedestrian Navigation Aids, Spatial Knowledge and Walkability

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Abstract

This study attempts to demonstrate the impact of pedestrian navigation aids on spatial knowledge acquisition and its link to walkability in an urban environment. Spatial knowledge is important for pedestrian travel. Rich spatial knowledge contributes to a good mental image of the walking environment, which consequently increases travel confidence and potentially allows more active walking. While there are plenty of studies on walkability, little work has been done on how navigation aids influence walkability. Using a pilot wayfinding experiment, we examined the effect on users' acquired spatial knowledge of two major pedestrian navigation aids used in London in comparison to direct experience of routes.

1. Introduction and Background

Walkability has become a widely discussed topic in urban and transportation planning and gained public interest since 2005. A walkable city that provides an accessible walking environment encourages more pedestrian walking. This results in benefits to the economy, improved public health and reduced ground emissions. Existing walkability studies focus on the assessment of street pattern, land use diversity and housing density (Frank *et al*. 2010), and relate to local routes and subjective pedestrian perceptions (Ewing and Handy 2006).

Spatial knowledge is important for pedestrian travel. Better spatial knowledge contributes to richer cognitive maps and thus allows improved understanding of the walking space. Acquired spatial knowledge of an environment can be differentiated depending on whether it comes from direct resources associated with travel experiences or from indirect resources such as signs and maps. Researchers conducted several experiments to compare spatial knowledge obtained from different resources (Ishikawa *et al*. 2008). The design and placement of signage systems clearly affect pedestrian orientation during their journeys (Arthur and Passini 1992), and thus have impact on spatial knowledge.

Recently various types of pedestrian navigation aids (PNA) have been developed as aids in wayfinding. These systems assist pedestrians in gaining the ability to get from one place to another, without getting lost (most of the time). Existing work focused mostly on GPS-based mobile devices (e.g., Huang *et al*. 2012). Little work has been done on how different PNAs, digital or non-digital, static or dynamic, influence spatial knowledge acquisition of pedestrians.

In this paper, we aim to demonstrate the influences of different types of pedestrian navigation aids on spatial knowledge acquisition. A navigation aid was assessed by its support of spatial knowledge acquisition of its users. We conducted a pilot wayfinding experiment to assess the two major PNAs used in London (Google Maps & Legible London) in comparison to direct experience of routes as a base line. The Legible London system is a citywide signage system for pedestrian wayfinding initiated by Transport for London in 2007. It is designed to help visitors and local residents to easily gain local spatial knowledge and so to encourage more walking by providing time, neighborhood and transport information, 3D buildings, and heads up orientation (Transport for London 2007).

2. Method

We conducted an experiment to examine how navigation aids influence users' walking behavior and more importantly users' acquired spatial knowledge in comparison to direct experience. The two navigation aids evaluated in the experiment were GPS-based Google Maps and the Legible London signage system. The participants were split into three groups, Google Maps, Legible London and direct experience, in terms of the way to acquire spatial knowledge during wayfinding. With a similar design to Ishikawa *et al.* (2008), our experiment consisted of three tasks, namely sense-of-direction fill-out, wayfinding, and map sketching. We analyzed sketch map completeness and the accuracy of the qualitative sketch aspects (topology, orientation and order) proposed by Wang and Schwering (2015). Figure 1 gives an overview of the experiment design and workflow.

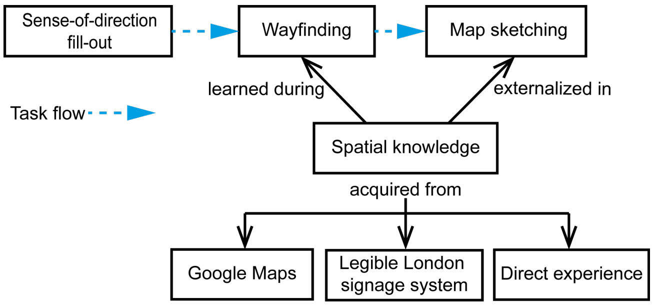


Figure 1. The experiment design and workflow.

Participants. Eight people, three men and five women, with average age of 30.3 years (*SD* = 3.58) took part in the experiment. None of them had visited the study area before the experiment. The participants were randomly assigned to one of the three groups: Google Maps (*n*=3), Legible London signage (*n*=3), and direct-experience (*n*=2).

Study area. The study area is St Christopher's Place in the West End of London. It is an open area with a mixture of shops, boutiques, restaurants and bars located just off Oxford Street. The study area is not visible when you walk along Oxford Street. So it has been described as "a hidden gem". Figure 2 (left) shows the start point (Bond street underground station) and the destination (the clothing shop called Jigsaw at St Christopher's Place) of the wayfinding task.

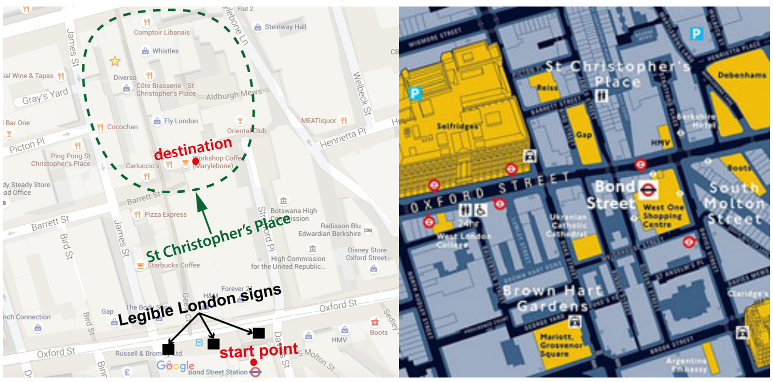


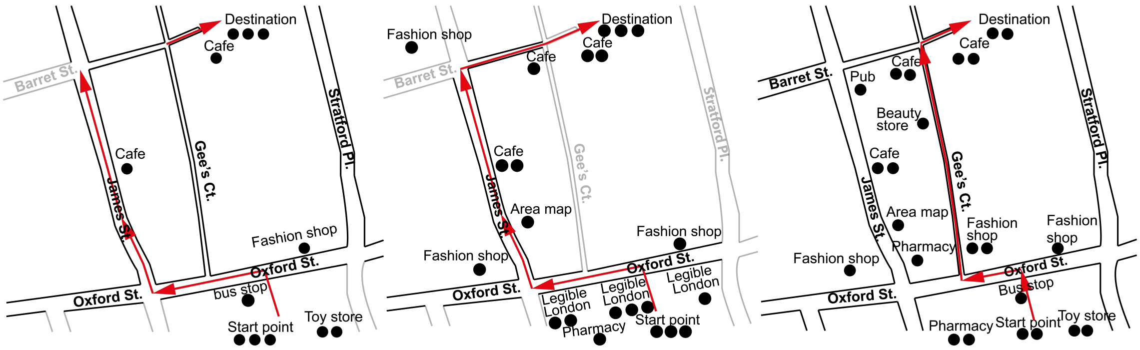
Figure 2. Study area (left) and a Legible London sign showing the study area (right).

Materials and Procedure. The first task (see Figure 1) required all participants to fill out the Santa Barbara Sense-of-Direction scale designed by Hegarty *et al.* (2002) as a self-report measure of environmental spatial ability. After filling out the scale, participants were taken individually to the start point and began wayfinding to the destination. Each participant was followed by the experimenter and their wayfinding behavior was observed and recorded by using a behavior diary. The Google Maps group used the mobile GPS-based application as its navigation aid. The Legible London group was free to check any Legible London signs positioned in the study area. The three Legible London signs located near the start point are shown in Figure 2 (left). The direct experience group first walked the study area guided by the experimenter. They were then returned to the start point and asked to walk towards the destination without any navigation aid. Finally, all participants were asked to sketch the area they had travelled in a detailed manner on a piece of paper with routes highlighted.

3. Results and Discussion

Sense-of-direction fill-out task. Following the scoring procedure for the scale (Hegarty *et al.* 2002), each participant got a score where the higher the score the better the perceived sense of direction (Google Maps: M = 4.58, SD = 0.92; Legible London: M = 3.93, SD = 1.39; direction experience: M = 4.77, SD = 1.08). We did not find significant differences in the spatial ability of orientation between groups.

Wayfinding task. Figure 3 highlights the routes (in red) taken by the participants. Google Maps users all followed the same route recommended by the application (Oxford St. - James St. - Barret St.). They checked frequently their current positions on their screens and tried to align map features with their surrounding environment. Because the destination and user's current position were not always shown together on the screen, Google Maps users sometimes needed to zoom out the map to relocate themselves in relation to the destination. Legible London users made more stops, with each stop much longer than the other two groups, so they took the longest travel time. The 'heads up' style Legible London adopts makes it easy for users to understand their immediate environment. However, it took time to mentally rotate and align the signage maps with reality when the 'heads up' direction differed from the walking direction. Routes taken by Legible London users were restricted to the placement of the signs so they all look similar to the red route shown in Figure 3. Participants in the direct experience group both took the shortcut (via Gee's Ct.) without any stop so they were the fastest to reach the destination.



Google Maps Legible London Direct experience

Figure 3. Routes and sketched buildings and streets.

Map sketching task. In general, the direct experience group created the most complete sketch maps in terms of the streets and buildings that were recalled and drawn; the Google Maps group drew the fewest buildings, and the Legible London group drew the most incomplete street network. In Figure 3, the number of black circles shows the number of participants who drew certain objects. Streets in grey were omitted by sketchers. The Legible London group included in their sketch maps the signs used during wayfinding. These signs became part of the study area and each sign played the role of a landmark – it provided orientation cues and memorable locations during wayfinding. The Legible London and Google Maps groups only drew the buildings on their routes while the direct experience group also drew off-route buildings. This suggests that the former two groups acquired route knowledge and the latter group was able to learn more complex configurational survey knowledge that is not limited to any particular route. The Google Maps group performed better in learning the street network than the Legible London group. The reason could be that the Google Maps users learned the street layout by zooming out the digital map, and the signage users learned the route by recognizing in reality the relevant streets shown on signage maps and ignored irrelevant ones. As a result, the signage users could only reflect the streets constituting their travel paths on sketch maps.

We measured sketch map accuracy by using the approach proposed by Wang and Schwering (2015). The direct experience group made the most accurate sketch maps. Sketch maps from the Google Maps group were better able to represent the street network topology but worse in orientation and ordering in comparison to the Legible London group.

4. Conclusions

The results of our study suggest that the two navigation aids affect spatial knowledge in different ways. Due to the lack of exploration of the study area, the two types of PNA users had difficult in obtaining survey knowledge and learning how streets fit together so they could not take the best route to the destination. The Legible London group needed to work out a route by learning signage maps, which on one hand provided them local knowledge about their immediate environment but on the other hand prevented them from learning about their surroundings. The Google Maps group only needed to follow the automatic route guidance, which was (most of the time) quick and reliable. However, the limited screen size made it difficult to always relate the current position to the destination. Google Maps users also paid the least attention to their routes and surroundings. These two reasons caused Google Maps users to have the worst orientation during wayfinding.

The small size of this pilot study did not allow us to conduct significance and correlation tests. The continued and expanded formal experiment will include more participants from different backgrounds and more study areas of diverse spatial layouts. The formal experiment will also show how enhanced spatial knowledge could promote more active walking. Based on the formal experiment, the goal is to suggest a new aid to pedestrian navigation that makes cities more walkable by connecting users to their surroundings through enhanced spatial knowledge.

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