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Up the down staircase: Wayfinding strategies in multi-level buildings

Christoph Hölscher[a,*], Tobias Meilinger[a,b], Georg Vrachliotis[a,c], Martin Brösamle[a], Markus Knauff[a]

[a]*Centre for Cognitive Science, University of Freiburg, Friedrichstr. 50, 79098 Freiburg, Germany*
[b]*Max-Planck-Institute for Biological Cybernetics, Tübingen, Germany*
[c]*ETH Zurich, Faculty of Architecture, Zurich, Switzerland*

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Abstract

The intention of this article is to create a link between human spatial cognition research and architectural design. We conducted an empirical study with human subjects in a complex multi-level building and compared thinking aloud protocols and performance measures of experienced and inexperienced participants in different wayfinding tasks. Three specific strategies for navigation in multi-level buildings were compared. The central point strategy relies on well-known parts of the building; the direction strategy relies on routes that first head towards the horizontal position of the goal, while the floor strategy relies on routes that first head towards the vertical position of the goal. We show that the floor strategy was preferred by experienced participants over the other strategies and was overall tied to better wayfinding performance. Route knowledge showed a greater impact on wayfinding performance compared to survey knowledge. A cognitive-architectural analysis of the building revealed seven possible causes for navigation problems. Especially the staircase design was identified as a major wayfinding obstacle. Finally we address the benefits of cognitive approaches for the architectural design process and describe some open issues for further research.

Keywords: Cognition; Wayfinding strategies; Architecture; Survey knowledge; Usability

> To experience architectural space truthfully it is necessary to perambulate and stride the building.
> Le Corbusier (1962, p. 30)

1. Introduction

Many people have problems finding their way around public buildings such as airports, hospitals, offices or university buildings. The problem may partially lie in their spatio-cognitive abilities, but also in an architecture that only rudimentarily accounts for human spatial cognition. We aim to make progress towards linking architectural design and human spatial cognition research. The paper begins with an overview of relevant previous work on wayfinding cognition. In the main part of the paper we report on an empirical investigation in which 12 participants solved wayfinding problems in a complex multi-level building. Half of the participants were very familiar with the building; the other half were visiting the site the first time. The results reveal distinct differences in the navigation strategies of familiar and unfamiliar participants in their strategy choice. We discuss how these strategy and performance differences may relate to route- and survey-based knowledge and to reference frames. We provide a detailed architectural analysis of the building and discuss the generalizability of our findings for architectural design, human spatial cognition research, and indoor-wayfinding.

1.1. Environmental features and wayfinding difficulties

What are the environmental features that can lead to navigation breakdowns? A pioneering study on indoor navigation was conducted by Best (1970), who first identified fundamental aspects of a building's route network, like choice points, directional changes and distances as relevant

*Corresponding author. Tel.: +49 761 203 4937; fax: +49 761 203 4938.
E-mail address: hoelsch@cognition.uni-freiburg.de (C. Hölscher).

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predictors of wayfinding difficulties in complex buildings. Numerous studies, especially in the environmental psychology community, have since investigated the reasons for wayfinding difficulties. For instance, Weisman (1981) identifies four general classes of environmental variables that shape wayfinding situations: visual access, the degree of architectural differentiation, the use of signs and room numbers, and floorplan configuration. Further studies pointed to the impact of layout complexity on both wayfinding performance and cognitive mapping (Gärling, Böök, & Lindberg, 1986; O'Neill, 1991a, 1991b). Recent studies have been conducted in airports (e.g., Raubal, 2002), shopping malls (Dogu & Erkip, 2000) and universities (Abu-Obeid, 1998; Butler, Acquino, Hissong, & Scott, 1993).

Another essential point seems to be the familiarity with the building. Gärling, Lindberg, and Mäntylä (1983) point out that familiarity with a building has substantial impact on wayfinding performance. So does visual access within the building: If large parts of the building are immediately visible and mutual intervisibility (vistas) connects the parts of the building, people have to rely less on stored spatial knowledge and can rely on information directly available in their field of vision, a notion inspired by Gibson (1979). A disadvantage of these lines of research is that floorplan complexity and configuration as well as visual access have been defined rather informally in the literature discussed above (e.g., by subjective ratings). The concept of *isovists* (Benedikt, 1979) provides a much more precise mathematical framework for capturing local properties of visible spaces as viewshed polygons, which correspond with psychological measurements of environmental perception (Stamps, 2002). The Space Syntax movement (Hillier & Hanson, 1984) has introduced formalized, graph-based accounts of layout configurations into architectural analysis. Calculations based on these representations express the connective structure of rooms and circulation areas in a building and are strongly associated with route choices of hospital visitors both in unguided exploration and in directed search tasks wayfinding behavior (Peponis, Zimring, & Choi, 1990; Haq & Zimring, 2003). Yet research along this methodology is generally based on correlations of building layout and aggregate movement patterns, thus providing no immediate understanding of individual cognitive processes (Penn, 2003).

1.2. Wayfinding in three-dimensional structures

One drawback of almost all controlled studies into wayfinding performance and building complexity is that they have limited themselves to investigating movement and orientation in the horizontal plane of isolated floor levels (with notable exceptions like Hunt, 1984; Moeser, 1988). Soeda, Kushiyama, and Ohno (1997) observed wayfinding performance in tasks involving vertical level changes. They found people losing their orientation due to vertical travel, supporting more informal results of Passini (1992). Soeda et al. (1997) identified another challenge of multi-level buildings: Wayfinders assume that the topology of the floorplans of different levels is identical, an assumption that can lead to severe wayfinding difficulties.

In Section 2.2 of the paper we provide a building analysis revealing that our setting could be similarly prone to challenges based on multi-level properties. Therefore, our investigations into both the navigation performance of test participants as well as their mental processes explicitly focus on the above-mentioned aspects. Montello and Pick (1993), although not investigating wayfinding behavior directly, present evidence that humans have trouble correctly aligning vertical spaces in pointing tasks. We also expect wayfinders to have trouble integrating survey knowledge of different floors. Properly connecting mental floorplans at transition points like staircases or elevators may also be further impaired by difficulties of maintaining one's heading due to the rapid direction changes involved in stair climbing.

1.3. Wayfinding strategies for complex buildings

Authors like Weisman (1981) or Lawton (1996) have analyzed wayfinding strategies as to what degree they rely on different types of knowledge. Spatial knowledge is commonly distinguished into three levels (Siegel & White, 1975). In the context of this study it can be assumed that finding destinations inside the building requires all three types of spatial knowledge: landmarks identify one's own position and relevant navigational choice points, route knowledge connects distinguishable landmarks, while survey knowledge integrates routes and guides high-level decisions for route selection and general direction. Pazzaglia and De Beni (2001) found evidence that people differ in their general preference for relying on different types of spatial knowledge, especially landmarks vs. survey knowledge. Lawton (1996) implies that people's wayfinding strategies gradually progress from route-based orientation to survey-based strategies, yet could not clearly tie this evolution to a performance improvement. Yet it has become clear in recent years (Montello, 1998; Montello, Waller, Hegarty, & Richardson, 2004) that strict developmental stages from landmark, to route and then survey knowledge are not realistic and that the representations rather develop in parallel, so that navigators can build up initial survey representations early on.

In a building with a complex network like in our study, the general notion of survey knowledge—in the sense of correct positional information about the metric spatial position of destinations—representing the most advanced and valuable information may not hold. In fact, knowing the routes through the maze of levels and vertical and horizontal corridors can be even more important, especially since seemingly direct routes may be blocked by dead-ends in the building, an aspect not taken into account by direction-based navigation planning.

A number of different wayfinding strategies have been described for two-dimensional (outdoor) settings. Both