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Getting Lost in Buildings

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Abstract
People often get lost in buildings, including but not limited to libraries, hospitals, conference centers, and shopping malls. There are at least three contributing factors: the spatial structure of the building, the cognitive maps that users construct as they navigate, and the strategies and spatial abilities of the building users. The goal of this article is to discuss recent research on each of these factors and to argue for an integrative framework that encompasses these factors and their intersections, focusing on the *correspondence* between the building and the cognitive map, the *completeness* of the cognitive map as a function of the strategies and individual abilities of the users, the *compatibility* between the building and the strategies and individual abilities of the users, and *complexity* that emerges from the intersection of all three factors. We end with an illustrative analysis in which we apply this integrative framework to difficulty in way-finding.

Keywords
navigation, architecture, cognitive maps, strategies, spatial abilities

Most people have a story about a building that they hate because they easily get lost in it. A compelling and public example is the Seattle Central Library that opened to great critical acclaim for its bold architectural design, named as *Time*'s outstanding building in 2004 (Lacayo, 2004) and receiving an American Institute of Architects' Honor Award for Architecture in 2005. Exterior and interior views of the library are provided in Figure 1.

However, the building has also received criticism on functional grounds. A *New York Times* review lists way-finding as a serious kink (Pogrebin, 2004), and a *Seattle Post-Intelligencer* article describes the need to install signs to assist navigation (Murakami, 2006). One user comments "I'm still not sure how I would get out if there was ever a fire, even after visiting weekly for almost two years" (http://www.yelp.com/biz/seattle-public-library—central-branch-seattle-2). While this example illustrates the tension in architecture between aesthetic and functional features, there are also buildings that are tremendously difficult to navigate despite navigability having been a primary design criterion. An example is Homey Hospital (Peponis, Zimring, & Choi, 1990), in which patients are reluctant to leave their rooms for fear that they will not find their way back. This indicates that users anticipate difficulty tracking their movements through the space, as would be required for integrating different segments of a path for their return to their rooms. Moreover, architects may include you-are-here maps to assist navigation, but these often require users to mentally rotate map content to match their current perspective, an alignment process that is complex and difficult (Levine, Jankovic, & Palij, 1982). These tensions between aesthetics and use reflect the fact that architects and laypersons judge buildings quite differently (Gifford, Hine, Muller-Clemm, & Shaw, 2002).

Why do people get lost in buildings? We concentrate on three contributing factors: the spatial structure of a building, the cognitive maps that users construct as they navigate it, and the strategies and spatial abilities of the building's users. We discuss recent research on each factor and argue for an integrative framework that characterizes how these factors intersect. We end by returning to the opening example of the Seattle Public Library, offering an illustrative analysis in which we apply this integrative framework to difficulty in way-finding.

Spatial Structure of Buildings

Weisman (1981) describes a taxonomy of features for way-finding in a building that includes (a) visual access between key locations, or the degree to which one can see other parts of the building from a given location; (b) architectural differentiation, or the degree to which different parts of an environment appear

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Fig. 1. Seattle Central Public Library exterior (a) and interior (b). Architect: Rem Koolhaas. Photographs by Bryan Chee.

unique or might be confused; and (c) layout complexity, or the number of rooms and corridors and their configuration.

A recent approach to better understanding how these features influence way-finding has involved the application of space-syntax tools to building designs (Conroy-Dalton, 2005). The theory of space syntax was developed as a means for describing the social role of spaces and capturing movement patterns of groups of people. As applied to way-finding, the key technique is to identify the locations in a building that are mutually visible (e.g., when standing at Location A, one can see Location B, and vice versa). One can then translate the geometry of the building layout into a network graph of these visual connections. Two examples of hospitals studied by Haq and Zimring (2003) are shown in Figure 2.

In controlled experimental tasks, Haq and Zimring (2003) asked new users to search for hidden targets within the two hospitals shown in Figure 2. They found substantial differences between the two hospitals in both searching and spatial learning (route retracing) that were associated with the intelligibility differences for the two settings. Applying the same space-syntax approach to a conference center, Hölscher, Brösamle, & Vrachliotis (in press) had new users perform controlled way-finding tasks. Their key finding was a systematic association between particular building features (e.g., insufficient visual access in the lobby, awkward staircase placement, and dead-end corridors) and way-finding difficulties for the study participants (e.g., disorientation, frequent stops, and substantial detours). Thus, space-syntax analysis may be a powerful way to represent the spatial structure of a building and its likely impact on way-finding. Nevertheless, as Montello (2007) points out, such an analysis needs to be augmented with information on other factors that also influence navigation, such as cognitive maps and spatial strategies and abilities of individual users.

Relevant Properties of Cognitive Maps

During navigation, users construct an internal cognitive map of their environment (Golledge, 1999). A large literature exists to show that this map is not a veridical representation. We highlight the following components, as they apply specifically to navigation in a building. First, there is a prioritization of certain features and objects. When navigating in a building, users encounter numerous rooms, corridors, intersections, and objects, and they use a subset of these as landmarks to help them find their way. It is a long-standing question in the navigation literature as to what features define a good landmark (e.g., Nothegger, Winter, & Raubal, 2004; Presson & Montello, 1988), with navigational relevance, salience, and task all influencing which features are prioritized. Second, there is a simplification of the space, with a regularization of distances, angles, and structure both within and across floors. For example, Werner and Schindler (2004) observed that, on any given floor, participants showed a preference to represent a building's layout with respect to consistent locally defined spatial reference frames. Using a virtual reality environment, Werner and Schindler systematically varied the orientation of the central elevator, either misaligning its axis relative to two connecting rooms (Fig. 3, left panel) or aligning it (Fig. 3, right panel). Way-finding performance and accuracy in a pointing task in which participants indicated the direction of particular targets throughout the building were significantly facilitated in the aligned condition relative to the misaligned condition. Third, Hölscher et al. (in press) observed that participants typically assume that the organization of a given floor extends to all floors and show considerable difficulty with way-finding and diminished pointing accuracy when this assumption is violated. Fourth, buildings are nested environments, and within the cognitive map, one can ask whether there is coherence across local and global levels. For example, Wang and Brockmole (2003) showed that participants maintained a representation of their current position, updating as they moved to a new unit and coding information with respect to this new unit but no longer maintaining their position relative to the previous unit. Thus, one's representation may be coherent locally but not globally, such as when one faces the front of a room but does

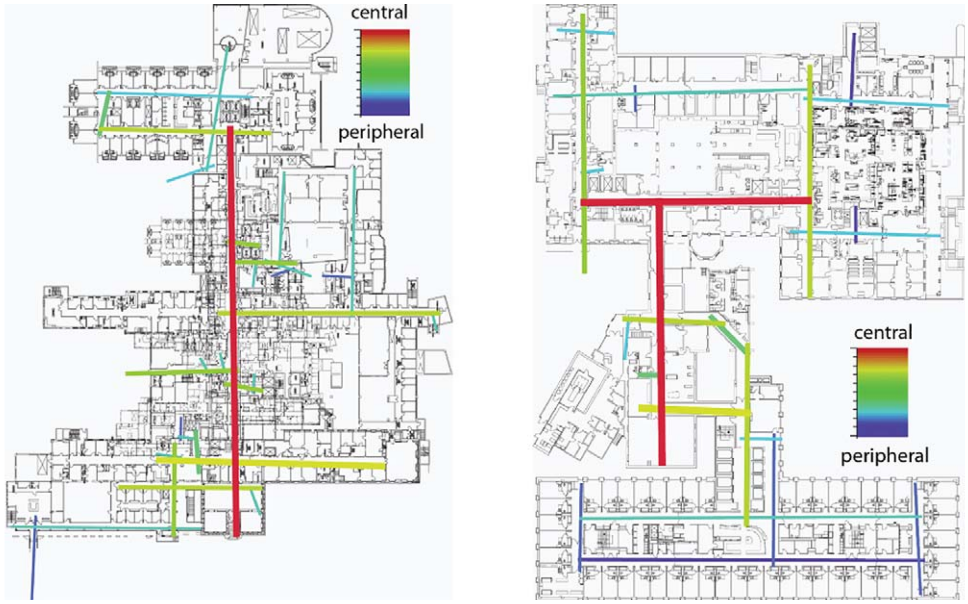

Fig. 2. Space syntax analysis of two hospitals located in a major U.S. city, studied and labeled "University Hospital" (left panel) and "City Hospital" (right panel) by Haq & Zimring (2003). Each line in each panel represents a mutually visible connection between units (rooms, corridors), with the color of the line representing how strategically important or central that unit is to the building as a whole. Warmer colors (anchored by red) indicate more central locations (the lines are also thicker), and cooler colors (anchored by blue) indicate more peripheral locations (the lines are also thinner). The resulting network can be summarized using an intelligibility index that is the correlation between the number of direct visual connections from each room or corridor in the network and the strategic importance of that room or corridor. A high intelligibility score indicates that topologically central locations are associated with more possible paths and connections. High intelligibility may be expected to facilitate navigation, because most paths lead to or across the central locations. Low intelligibility indicates that central locations only have restricted paths, making navigation difficult because users must find the limited number of correct paths. University Hospital has a high intelligibility score of .831; City Hospital has a lower intelligibility score of .557.

not know whether that corresponds to the front of the building (see also Montello & Pick, 1993).

Strategies and Spatial Abilities

Some people are more prone to getting lost in a building than are others. Successful way-finding requires effective strategies, and each strategy is subserved by particular spatial representations and reasoning processes. Two strategies are commonly discussed: a route-based strategy in which a user tracks his or her movement through a building in a viewpoint-specific manner, and a survey-based strategy in which the user constructs a viewpoint-independent representation of the spatial relations that enables reasoning about relative orientation and distance. Way-finding is likely a combination of the two strategies (Ishikawa & Montello, 2006), with some individuals in some settings focusing on one or the other (Lawton, 1996). For a given strategy to be effective, an individual must meet the representational and processing demands of that strategy. For example, consider the example of learning a route through a low-intelligibility building like the one analyzed by Haq and Zimring (2003; e.g., Fig. 2, right panel) that requires many turns to get from one place to another. With each successive turn, it becomes increasingly difficult to maintain one's sense of direction. Different people will have different thresholds

Fig. 3. A virtual environment constructed with two rooms and a central elevator, based on the town hall of Gottingen, Germany. Within the virtual environment, experimenters manipulated the orientation of the elevator (designated with an E) relative to two surrounding rooms, with different participants experiencing each orientation. The left panel shows the axes of the elevator misaligned from the axes of the rooms; the right panel shows the axes of the elevator and room aligned. (From Werner & Schindler, 2004.)

(e.g., number of turns) at which they will no longer be able to track the sequence of movements. Participants with higher thresholds may be able to maintain a route-based strategy for this building, but participants with lower thresholds who nonetheless try to use a route-based strategy may fail to learn the route. Differences in strategy selection and way-finding success have been linked to individual differences in spatial ability

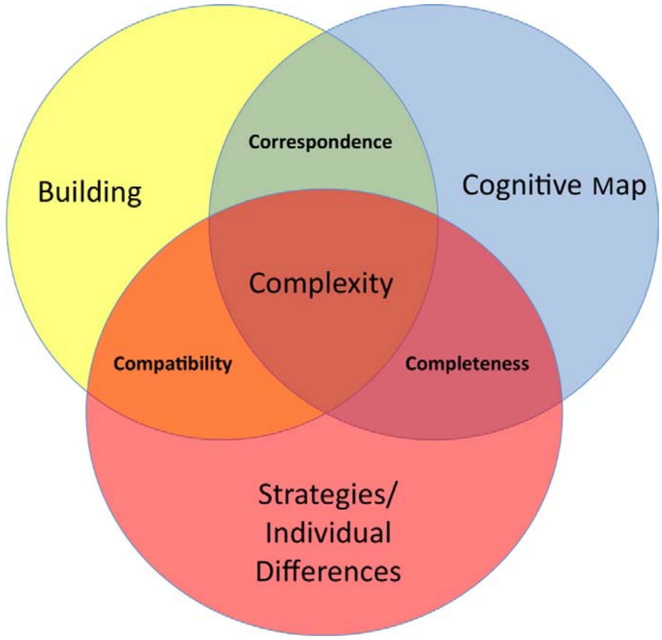

Fig. 4. Factors predicting navigation in buildings, and lines of research that fall at the intersections of these factors: correspondence between the building and the cognitive map, compatibility between strategies/individual differences and building, completeness of the cognitive map as a function of strategies/individual differences, and the complexity of the interaction between the structure, map, strategies, and spatial abilities.

(Hegarty, Montello, Richardson, Ishikawa, & Lovelace, 2006), gender (Lawton, 1996; but see Liben, Myers, & Kastens, 2008), and general way-finding experience (Siegel & White, 1975; but see Ishikawa & Montello, 2006), with these links being complex and interrelated. The key point here is that not all users of a building are at the same level in terms of ability, strategy selection, or experience (see also Hölscher, 2009); consequently, different users may find different types of buildings difficult to navigate.

Future Research Using an Integrative Framework

We argue that successful navigation in a building emerges as an integration of the spatial structure of the building, the cognitive map that is constructed during navigation, and the strategies and individual abilities of users. Figure 4 shows an integrative framework that encompasses these factors and their intersections. With respect to the *correspondence* between the building and the cognitive map, we are interested in the extent to which the map is an isomorphic representation of the spatial structure of the building in terms of the content and configuration of its units. One novel aspect of this question is the extent to which information about unexplored places in the building is inferred from spaces already explored. For example, imagine a user who enters a symmetric building with left and right wings and a central entrance. To what extent will the interior structure that is experienced with navigation through the left wing be inferred and directly represented within the cognitive map for the unexplored right wing? With respect to the *compatibility* between the building and the strategies and individual abilities of the user, we are interested in the extent to which the spatial structure of the building (as reflected, for example, in a space syntax analysis) impacts strategy selection and how this may be further mediated by spatial abilities. With respect to the *completeness* of the cognitive map as a function of the strategies and individual abilities of the users, we are interested in the extent to which the navigation strategy dictates the features and properties that are included in the cognitive map. For example, for a route-based strategy, the representation may be more akin to a sequence of familiar views with heading information, whereas for a survey-based strategy the representation may be more akin to an external map with an overhead perspective. How spatial abilities may mediate these differences is also interesting. Finally, *complexity* represents the intersection of all three factors and corresponds to the difficulty of the way-finding problem in a given structure for a given user using specific strategies and relying on a specific cognitive map. Complexity can be assessed accurately only if the three factors are assessed simultaneously.

An Illustrative Analysis of How Correspondence, Compatibility, and Completeness Impact Way-Finding

We end by returning to our opening example, the Seattle Central Library, and illustrating how a lack of correspondence, a lack of compatibility, and a lack of completeness may be associated with difficulty in way-finding within this building.

Correspondence

Users expect that floor layouts in multistory buildings will be identical on every level (Hölscher et al., in press). This relates to the correspondence between the building and the cognitive map. This heuristic is broken on the first five levels of the library, where, in some cases, the boundaries and orientations of the floors do not align. However, once the sixth floor is reached, this trend is suddenly reversed in a most dramatic manner: The next four floors form a ‘‘book spiral’’—a continuous, spiraling set of floors with poor architectural differentiation (all corners, on every level, appear identical) and users are forced to continuously reorient themselves as they navigate up or down the spiral. This runs counter to both Weisman’s (1981) findings about architectural differentiation and Conroy-Dalton’s (2005) findings that users prefer more linear routes containing few turns. There are no salient landmarks in the book spiral, and the majority of signage refers to a user’s location in the Dewey Decimal System rather than to the building (Nothegger et al., 2004; Presson & Montello, 1988).

Compatibility

It is advantageous to have unimpeded lines of sight connecting entrance spaces and other key central spaces (e.g., atria) to the means of vertical circulation: stairs, elevators, and escalators (Weisman, 1981). This relates to the compatibility between the building and the strategies that a user may adopt for navigation. However, in the Seattle Central Library there are strategic locations in the building where there is a sharp schism between where you can see (lines of sight) and where you can go, causing another user to comment, "The escalators that shoot up 3—4 floors without any off points are completely exclusionary. The lack of accessibility is bewildering" (http://www.yelp.com/biz/seattle-public-library—central-branch-seattle-2). Although the escalators are visible from the entrance lobby, this is not true of the elevators or stairs, prompting another user to complain, "It's basically a cold labyrinth . . . I can't get past the lack of functionality (or stairs)" (http://www.yelp.com/biz/seattle-public-library—central-branch-seattle-2).

Completeness

The degree to which these architectural features of the library impact way-finding may well depend upon the completeness of the cognitive maps that individual users construct. We suspect that the library user quoted in the introduction, who is not confident about finding the exit after 2 years of visiting, has an incomplete cognitive map of the building; others who frequent the building equally often and can find the exits presumably have a more complete cognitive map.

Conclusion

The Seattle Central Library represents a classic example of where the differences between users' internal representations of their environment and a building's layout are substantial and likely further exaggerated for some users by their individual strategy preferences and cognitive resources, resulting in extreme reactions like that of the library user who states, "I ... left the building as soon as I could figure out how to get out, hoping I wouldn't have an anxiety attack first" (http://www.yelp.com/biz/seattle-public-library—central-branch-seattle-2). If such experiences are to be avoided, further work needs to be conducted within our proposed integrative framework to understand how the factors we have discussed interact.

Recommended Reading

Arthur, P., & Passini, R. (1992). *Wayfinding: People, signs, and architecture*. Toronto, Ontario, Canada: McGraw-Hill Ryerson. A classic design reference for indoor signage.

Ellard, C. (2009). *You are here: Why we can find our way to the moon, but get lost in the mall*. New York, NY: Doubleday Books. An accessible book that offers a nice overview of way-finding and navigation.

Gärling, T., Böök, A., & Lindberg, E. (1986). Spatial orientation and wayfinding in the designed environment: A conceptual analysis and some suggestions for postoccupancy evaluation. *Journal of Architectural Planning Resources, 3*, 55–64. A classic paper that links architectural features to a conceptual model of way-finding.

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Supplementary Material

Supplementary materials in the form of images, floor plans, space analysis diagrams, movie clips of navigation through a difficult virtual building and comments by architects and users are provided at http://www.nd.edu/~lcarlson/Site/Supplementary_materials.html