An inclusive model of wayfinding, and the question regarding the environment

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Abstract

This paper proposes an exclusive model of wayfinding that considers three major components: behavioral component, human differences and cognitive component. Based on this model, a wayfinding experiment was conducted to investigate the role of the environment in wayfinding and cognitive mapping, measurement of wayfinding success and comparison of sketch map analytical techniques.

The experiment took place in two complex hospitals located in a major U.S. city. Ninety-six volunteers, 47 females and 49 males, performed open explorations (where they attempted to become familiar with the settings), wayfinding tasks (where they were asked to reach specific locations), sketch mapping tasks (sketch a map of the hospital's main corridors and locations), cognitive tests (distance estimation and pointing to previously visited but unseen locations), and filled in a questionnaire on wayfinding strategy use.

The results indicate that the environment in which wayfinding is carried out strongly influence both wayfinding and cognitive mapping. Furthermore, a distinction is made between wayfinding success and wayfinding efficiency, where the former may not be a corollary to the latter. The notion of layout versus configuration is introduced as an important wayfinding variable and then some suggestions are made regarding the inclusion of environmental properties in future wayfinding research.

1 Introduction

An important component of environment behavior studies is the environment. This is especially significant in wayfinding studies because in this behavioral mode a person deliberately takes cues from the environment to make travel decisions. Many researchers agree that successful wayfinding is facilitated by a cognitive map that includes certain aspects of the environment. However, there is little agreement regarding which environmental aspects or specific properties contribute to successful wayfinding. Adding to this complexity is the different operational definitions of wayfinding found in various research.

This paper suggests that consideration of environments in which the way-finder is immersed is a key element of wayfinding experimentation and wayfinding success. Indeed, we may get different experimental results in different environments. Related to this is that the cognitive tasks are directly affected by the environment in which a subject is immersed in.

The paper begins with a proposal for an inclusive wayfinding model that includes behavioral component, human differences and cognitive component. Based on this model a wayfinding experiment compares performances in two different real hospitals. In the process, a distinction is made between wayfinding success and wayfinding efficiency where one is not a corollary of the other. Additionally, the distinction between layout and configuration is introduced as the role of the environment is emphasized.

2 Wayfinding

Wayfinding is choosing paths and travel directions in order to arrive successfully at a desired destination. Some researchers have provided simplified descriptions of wayfinding. For example, Passini (1995) has proposed that wayfinding is primarily the ability to orient oneself in the environment and to successfully arrive at desired locations. Prestopnik & Roskos-Ewoldsen (2000) suggested that "… wayfinding involves the ability to navigate successfully through the environment. … (it) is the ability to identify ones location and arrive at destinations (or navigate) in the environment, both cognitively and behaviorally." (pp. 177). Other definitions are more complex. Arthur & Passini (1992) describe wayfinding as a process of spatial problem solving that includes decision making, decision execution and information processing (pp. 25). Garling, Book, & Lindberg (1986) describe wayfinding as "psychological, information processing operations, and, …, knowledge about physical setting variables that effect the successful completion of these information processing operations (pp. 55). To Darken, Allard, & Achille (1999), “wayfinding, …, involves issues such as mental representation, route planning and distance estimation”.

In general, one may conclude that there is both a cognitive and a behavioral component in wayfinding (see figure 1). It involves behavior i.e. moving from one point to another and cognitive component that includes three things: the capability of developing, referring to and taking cues from an internal ‘image of the environment’ (cognitive map), individual mental abilities[1] and mental strategies used for wayfinding. Unfortunately, the research literature is less clear about how these components predict wayfinding. After a review Prestopnik (2000) has concluded that “… there is little agreement in the literature about which factors may be most important for predicting wayfinding ability. Further, there is also little agreement on how to measure wayfinding ability itself” (pp. 177).

A model of wayfinding is developed for this paper and is described in the next section.

3 Wayfinding Model

Wayfinding involves three major factors. These are behavioral components, human differences and cognitive components (see figure 1). Behavioral component includes successful movement from an origin to the desired destination. It is visible and easily measurable. Human differences are physical ones: gender, age, disabilities etc. These too are easily measured. Cognitive component includes abilities, strategies and cognitive maps. These are harder to identify or measure. Various tests have been devised and different researchers prefer different ones.

Wayfinding is also influenced by the environment in which it takes place. Different environmental characteristics influence the process in different ways. Therefore, the wayfinding model proposed in figure 1 is situated within a box that is a representation of the environment.

The cognitive component of the wayfinding model is described below.

3.a Cognitive Component

The cognitive component includes mental abilities such as information processing, a sense of direction, sense of distance etc, strategies used and environmental information stored in the mind which is more generally

[1] Some researchers like Heft (1983) follows Gibson (1979) and supports a perceptual model of wayfinding

understood as a cognitive map or cognitive image (see figure 1). It should be noted that although wayfinding always takes place in a particular environment, cognitive components include those that are developed in settings experienced earlier. Additionally, the environment in which wayfinding takes place has an immediate influence on the process.

3.a.i Abilities

A sense of direction simultaneously allows for an awareness of location. It can refer to universal reference systems such as north, south, east or west; or local references such as the lobby, the tall building, the distant mountain etc. (Landmarks in the vocabulary of Lynch, 1960). Together, a sense of direction and an awareness of location should, at least theoretically, provide for wayfinding success. This 'sense of direction' has been experimentally measured in two main ways: self reports and pointing to unseen destinations. The first does not take into account the complexities of a layout, while the second is done within particular environments. For example, Bryant (1982) has found that there is a positive relationship between a self reported sense of direction and pointing accuracy, i.e. subjects reported as having more 'sense of direction' were typically better at pointing to locations. Because of such findings many researchers have used direction estimation test as a measure of orientation.

Although a sense of distance as a measure of cognitive ability has been used by many researchers, (Golledge, 1977) yet in many cases it is found to be untrustworthy. For example Hirtle & Hudson (1991) found no difference in distance estimation, but a substantial difference in orientation, when they were comparing between a group that studied maps and a group that looked at slides of the same environment. Garling, Book, Ergezen, & Lindberg (1981) also found a similar distinction in their work where distance estimates were less accurate than direction estimates.

3.a.ii Strategies

Mental abilities may influence wayfinding strategies. Researchers have identified three distinct types of wayfinding strategies: route strategy, orientation strategy (Lawton, 1994; Russel & Ward, 1982), and survey/map strategy. Route strategies imply a sequence of decision making that enables one to reach a destination. They involve recognition of landmarks and decision making at those locations. Orientation strategy involves remaining oriented to cardinal directions or landmarks. Survey/map strategy involves the use of an overall cognitive map of the environment. As various routes are traversed and landmarks learned, the cognitive map gets updated. A person usually employs route strategy in a completely unknown area when s/he operates from a set of instructions only. Orientation and survey/map strategy is usually employed after an environment has been 'explored' and /or learned by exploration or by other means. Typically when a person has learned enough about an environment and employs orientation or survey strategy, then s/he can usually take more than one route from any origin to any destination (provided that alternate routes exist)

Lawton (1996) has developed a self report questionnaire called indoor wayfinding scale to measure an individual's use of the wayfinding strategies: route or orientation. (Although she has used the word survey for what is described as orientation in this paper.) In this, six items measure the degree to which an individual remains oriented to directional cues during wayfinding. Four items measure the importance of routes, and three items measures the importance placed on the building layout.

3.a.iii Cognitive Image

Environmental information in cognitive maps includes both <u>tangible</u> and <u>intangible</u> factors. Tangible information has equivalent physical entities in the real world that can be identified and described. One kind of tangible information is 'element' information; nodes, landmarks, rooms, routes, signs, colors etc. are examples of this. Element information can be easily extracted from sketch maps. It is a matter of counting intersections, streets, locations etc. that has been drawn by the subject. Another kind of tangible information is layout and configuration. Layout is the overview of individual elements or spaces and configuration is the structural hierarchy that arises between these elements and spaces due to layout. A preliminary knowledge of layout is through 'routes' connecting places, and an expanding knowledge of the interconnection of various routes produce detailed layout and configurational knowledge (Evans, Fellows, Zorn, & Dotty, 1980; Hart & Moore, 1973; Siegel & White, 1975). The role of metric properties in layout and configurational knowledge is yet unresolved. Although it is argued that the ultimate cognitive map is Euclidian, yet many studies have found poor response to distance estimation abilities (Garling et al., 1981; Hirtle & Hudson, 1991). Piaget & Inhelder (1967) had suggested earlier that topological relations of local elements are understood at first and it leads to recognition of Euclidian properties. Layout and configurational information of cognitive maps may be understood through analysis of sketch maps. Unfortunately, this has always been a difficult task. The layout of elements and spaces in a sketch map may be correct when considering adjacent elements i.e. partially correct, or it may be correct overall. This refers to local and global accuracy of sketch maps. Appleyard (1970) categorized sketch maps based on their "level of accuracy that is their congruence with the objective plan of the city" (global accuracy, pp. 103). Afterwards Rovine and Weisman (1989) considered local layout information by evaluating the topological accuracy of placement of each building with respect to two immediately adjacent ones (local accuracy). This was determined by how correctly three adjacent elements (buildings in this case) were positioned with respect to their spatial relationship. Obviously, this is a case of local layout analysis of sketch maps. Later, Kim (2001), Haq (2003) and Haq & Girotto (2003) developed different techniques of analyzing sketch map configuration using Space Syntax methodology[2].

Finally, intangible information in cognitive maps may include a qualitative sense of the environment, such as 'threatening', 'mysterious', 'beautiful' etc. or may include things like procedural knowledge, action rules, decision strategies and so on. Usually, they are best gathered through interviews, protocol analysis or verbal descriptions of the environment.

3.a.iv The Environment

An important aspect that is often ignored in wayfinding research is the setting characteristics. Physical features of the environment in which wayfinding are carried out has an influence. While this is of utmost importance for designers, it has been most difficult to deal with. It requires sustained research that is carried out in multiple settings and the development of new experimental procedures that allow multiple environmental factors to be described and experimentally 'controlled'. One important aim of this paper is to demonstrate the variability of environments in wayfinding.

As seen from the model described above, many research questions can be asked. They can be about relationships between various components in one category to the role of one or a combination as a predictor of another. Architects for example, would be interested in the tangible cognitive component: element, layout and configuration and how they influence the behavioral component (navigation). They would also be interested in measurements of environmental variables and their effects.

4 Objectives of this study

Based on the wayfinding model described above, a wayfinding experiment was conducted in two real hospital buildings to evaluate the following questions: is there a difference between wayfinding efficiency and wayfinding success and, do the specific environment in which wayfinding is carried out have an influence? In the process, a related methodological focus was in the comparison of various methods of sketch map analysis.

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[2] Space Syntax aims to uncover the underlying structural hierarchy of spaces in a layout by considering topological relationships. It may be used to calculate both local and global values (Hillier, 1984).

5 Experimental method and data generation

The research uses data obtained from an experiment conducted in two complex hospitals located in a major US city (see figures 2 and 3). Ninety-six volunteers, 47 females and 49 males (mean age=19.5; S.D.=1.51), completely unfamiliar with the two environments and screened so that none of them had visited any large hospital complex more than once in the 12 months prior to the study participated. Among them, 29 volunteers participated in one hospital and 67 in the other. The total sample was 64.6% White, 10.4% African American, and the remainder other minorities. They performed various behavioral and cognitive tasks related to wayfinding. These were carried out in the public areas of the floor accessible from the main entrance.

The tasks used in this experiment were based on the wayfinding model described earlier. They were developed from a previous research undertaken by Peponis, Zimring, & Choi (1990). Some additional cognitive tasks were also performed. These were devised to gather information regarding both behavioral and cognitive components of wayfinding.

5.a Behavioral Component: Wayfinding

Before wayfinding tasks were started, the, participants were asked to explore the setting within a specified time period estimated as adequate during pilot studies. The subjects were told not to talk to anyone but to try and fulfill their tasks by making reference to environmental cues only (including signage).

Afterwards, the subjects started their wayfinding tasks. They were taken to one of four pre-selected locations within the building and were asked to walk to another one. The locations were selected on the basis of signage. Some could be found simply by following the signs, while others had no directional signage at all indicating their location. When the destination was found, they were asked to find the next one. If the participants could not find their destination in a preset time period (estimated during pretests as adequate), they were escorted to the destination by the researcher. The procedure was repeated until each participant had found, or unsuccessfully attempted to find, his/her way to and from all the selected locations. Thus all four locations acted as both origins and destinations. The searches were counterbalanced such that each task was completed in all possible orders to control for fatigue and learning effects.

This method approximates the work of O'Neill (1991a). He had asked subjects to find destinations in 'known' buildings. In this case, the open explorations done before wayfinding make the buildings 'known' to the participants. Moreover, the similar length of exposure to the building through open exploration made everyone's 'knowledge' about the building comparable.

Data regarding the paths undertaken by each subject for each task was collected by sketching, on separate maps, the path taken by each subject. Participants' wayfinding performance (behavioral component) was measured by the following: (1) *coefficient of success*, which was computed as the number of times each subject reached the required destination divided by the total number of searches that they were asked to perform; (2) *redundant intersection use*, which considers the total number of intersections not in the shortest path between origin and destination, but nevertheless used by the subject; (3) *repeat intersection visits*, that considers the number of times each subject used an intersection more than once during wayfinding (without distinguishing between required and not required ones.

5.b Cognitive component: Strategies, Abilities and Image

Two kinds of cognitive strategies, route or orientation, employed by each subject were measured by Lawton's (1996) questionnaire. The questionnaire had six questions related to orientation, four regarding routes and three about building layout. Participants were asked to rate each of the 13 questions on a five-point scale, where '1' indicates 'not at all typical', 3 indicates 'moderately typical' and 5 'extremely typical'.

Two measures were derived from the self-report strategy questionnaire: mean score for orientation strategy and mean score for route strategy. They were computed by averaging the scores given by all the subjects respectively to the items referring to Indoor orientation strategy (6 items) and Indoor route strategy (4 items).

Cognitive abilities of the subjects were tested in two ways: pointing to previously visited but unseen locations and estimating distances between them. Immediately after reaching or being escorted to a destination in the wayfinding phase, each subject was asked to point to the location or locations that he/she had visited before. This was done by using a circular cardboard with angles marked on it in 10-degree intervals and a pointer attached to the center. Each person performed 13 pointing tasks at different times and with increasing familiarity with the setting. All of them faced the same cardinal direction during this task. The angular deviations from the actual direction (as determined from a plan drawing) were recorded and then averaged as the pointing error for each person.

After each pointing task, the participants were also asked to estimate the distance between their current location and the locations they were pointing to. The difference between the real distance and the estimated distance was recorded and the average distance estimation error calculated for each person.

Cognitive image of each subject was tested by sketch mapping. This was done in 8 ½ by 11 sheet of paper. A 'normal' sketch mapping technique was used Kitchin & Blades (2002) where each subject drew the plan of the hospital where he/she performed the experiment. They were instructed to draw all the paths that they could remember and to write in the maps all the locations they could recall. These maps were analyzed from two points of view: element and layout information. Three measures were obtained for element information: (1) number of corridors drawn; (2) number of intersections included and (3) number of locations indicated. For layout information two more variables were calculated: (1) sketch map accuracy, and (2) local topological accuracy. The former provided global layout information including geometry, and the latter provided local topological information.

Sketch map accuracy was assessed averaging the grades given to each of two criteria (concept and layout) separately. Two independent researchers, not familiar with the real settings, computed the grades. This was done by comparing the sketches with an actual map. Concept grade reflected the overall perception of planning, including distribution of locations. Layout grade depended on the similarities with the actual plan. Both criteria relied on an understanding of correct layout. The scores of the two researchers correlated at .842, p=<.0001. The average value of the two scores was used for this research.

Local topological accuracy was calculated according to a method used by Rovine & Weisman (1995). They described a method of accessing local topological accuracy as ‘adjacent building score’. This was done with respect to adjacent buildings that were drawn in a map. Buildings were considered accurately placed if “it satisfied two key criteria: (1) the building was in the appropriate sequence with respect to the … buildings which immediately preceded and followed it on a sketch map and (2) the paths connecting the buildings accurately reflected any turns one might make while traveling from the preceding to the following building.” (pp. 15) The number of accurately placed buildings defined an individual’s ‘adjacent building score’ and this accounted for 62.4% of wayfinding performance in their study. Similarly, in this experiment, local topological accuracy was determined by ascertaining that the number and direction of turns to locations before and after was accurate. Three locations (as identified in a subjects sketch map) were taken and the central one was evaluated in relation to the others. Dead end spaces, exit spaces etc. were not considered.

In summary, a dataset by person was produced, containing two different sets of data: behavioral and cognitive ability data. The latter included strategy, ability and cognitive image scores.

6 Results

It is hypothesized that the wayfinding model described earlier finds specificity in the environment. In other words, the setting plays an active role in wayfinding. Therefore, before any analysis of data, a critical description of the two environments is necessary.

University Hospital has 32 corridors with 33 intersections, while City Hospital has 24 corridors and 28 intersections. Their layout is also quite different. University Hospital is a series of buildings arranged along a very long corridor (figure 2). This corridor is the heart of the complex and connects almost all important destinations that are available on this floor. On top of that, this corridor has a large number of intersections, almost double the number in the longest corridor of City Hospital. Therefore, movement can be expected to be predominant here. Also this hospital has a lot of dead ends so any small wayfinding error would force a person to retrace their steps, which would result in more use of intersections and corridors.

City Hospital, on the other hand, is a collection of three buildings with specific functions (figure 3). In reality, its central corridors are connections between buildings and do not have major locations. In general, its corridor layout is a series of ‘loops’. This avoids backtracking. Almost all the corridors in both the hospitals have bland institutional décor and lacks specificity. Signage in both these buildings is considered typical, i.e similar to what any visitor may expect in a large urban hospital.

6.a Behavioral Component

Data concerning the three measures of behavioral component (coefficient of success, redundant intersection use, and repeat intersection visits) were compared between the hopsitals. From Table 1 it can be noticed that there was a great variability in individual performance. T-tests revealed a significant difference ($p < 0.0001$) between the means of redundant intersection use, with University Hospital (mean = 61.56) greater than City Hospital (mean = 38.84). A similar result was obtained for repeat intersection visits. A significant difference ($p < 0.0001$) was found between the mean for University Hospital (44.25) and City Hospital (27.28). Both redundant and repeat intersection visits are indicators of wayfinding difficulty. That is, subjects were wandering more while finding their way to the required destination. Surprisingly, comparing the means of coefficient of success indicates that subjects were more successful in University Hospital ($p=.053$). So, even if University Hospital was difficult to wayfind in, ultimately more people were successful there. This illustrates a very important issue regarding wayfinding research. The time lost in wandering vs. success in finding destinations. In other words efficiency versus success. Both are important in real life and should be considered separately as wayfinding success indicators. From the point of view of this research, all behavioral components demonstrated marked difference between the two hospitals. At the very least, this indicates the significance of considering the environment as a variable in wayfinding research.

6.b Cognitive component: Abilities

Data for mean pointing errors was computed separately for the two settings. T-tests revealed a significant difference (p = 0.001) between the mean pointing error for University Hospital (22.91) and the mean for City Hospital (37.85, see table 2).

Average distance estimation value, however, was not significantly different between the two hospitals (p=.258). It seems that, in terms of estimating distances, the two layouts are similar, but, in terms of pointing to unseen locations, City Hospital was conceived to be more complex. In this regard literature survey provided a clue. In many cases distance estimation, a widely used procedure to study orientation was found to be untrustworthy (Golledge, 1977). For example, Hirtle & Hudson (1991), comparing a group that studied maps and a group that looked at slides of the same environment, found no difference in distance estimation, but a substantial difference in orientation. Garling et al., (1981) also found a similar distinction in their work, where distance estimates were less accurate than direction estimates. Rovine & Weisman (1989) pointed out that people do not often require Euclidean accuracy in their representation of the environment. An explanation can be found in Attneave (1983) observation: “If I wish to go from A to B, knowing how far away B is does not help me much, but knowing that it is due west assures me that if I go west I will get there eventually. Perhaps this is why we speak of a ‘sense of direction’ rather than a ‘sense of distance’.”

The results of the pointing tasks indicate that University Hospital is cognitively easier than City Hospital. Thus it relates to the previous finding that people in University Hospital had more wayfinding success. At this point, one curious result needs to be pointed out. Even if University hospital had more wayfinding success and provided better orientation, yet people here were wandering more. This issue will be discussed later.

6.c Cognitive Component: Image/Information about the environment

Tangible cognitive image/information was evaluated through sketch mapping. Number of corridors, their intersections and locations drawn provided element information. Topological accuracy and sketch map accuracy provided local and global layout information.

Comparisons between the sketch map variables in the two hospitals revealed that the average of corridors drawn and locations indicated are slightly higher in University hospital (14.63 and 18.26 vs. 13.33 and

15.24. p=.0214 and .0276, Table 2). Sketch map accuracy was also higher in University Hospital (mean 74.63 and 69.64, p=.048). However, local topological accuracy and number of intersections indicated no difference.

Since University hospital had more wayfinding success, less pointing error and produced more cognitive information, it can be assumed to be a more wayfinding friendly environment. Unfortunately, it also produced more lostness i.e. more redundant use of spaces. This can possibly be explained from an environmental point of view, especially the layout. More dead ends probably created more redundant use, but it also helped the development of the cognitive map because people were returning through the same spaces. However, the relationship between wayfinding success and lostness is an important issue that needs to be addressed through more research.

6.d Sketch map variables

The cognitive component of the model described before includes abilities, strategies and environmental image. The tangible part of the image includes element information, layout and configurational information. A linear model, regarding the development of cognitive image suggests that element information is learned first that sequentially leads to local layout information (topological and then Euclidian), to global layout information (topological and then Euclidian) and then to configuration. Figure 4 lower half gives an indication of the correlations between element information. The values are reported in the boxes along the lines. The important thing to note is that the three element information; number of corridors, intersections and locations are not only correlated to one another, but they do not change when split by hospitals. Therefore one may assume that particularities of an environment probably do not feature in the development of elementary elements in a cognitive map.

Unfortunately this does not remain the case when layout is considered (figure 4, upper half). The number of corridors drawn correlates with local layout (topological) accuracy and global (Euclidian) sketch map accuracy for the two hospitals combined. When split by hospitals, number of corridors remains correlated with topological accuracy in both cases but do not remain correlated with global sketch map accuracy in University Hospital. Therefore we may assume that cognitive developments of local elements and local topological layout information are less dependent on the particularities of the environment, but global information perhaps is.

It should be remembered that sketch map accuracy considers the entire hospital and considers geometry. Local topological accuracy considers local topological information without geometry. In City hospital, element information, local topological accuracy and sketch map accuracy are correlated. That is not the case in University hospital. In this setting more local topological accuracy did not lead to globally accurate sketch maps. One may therefore infer that the nature of the setting itself may contribute to what characteristics of a sketch map might be a reliable indicator. This suggestion, if verified, may have far reaching consequences on cognitive mapping research.

6.e Relations between cognitive components: strategies, abilities and image

Cognitive abilities is often taken as an indicator of ease in which cognitive image is developed. For example, people with better 'sense of direction' as measured by pointing abilities may be considered more oriented in the environment, produce maps with better layout information and have more wayfinding success. Figure 5 shows the correlations between pointing errors to topological and sketch map accuracy. Although pointing error is correlated with both topological accuracy ($r=-536$, $p=<.0001$) and sketch map accuracy ($r=-.656$, $p=<.0001$), and negative as expected, it breaks down significantly when analyzed by hospitals. For University Hospital, number of pointing error is not correlated with either topological or sketch map accuracy but are highly correlated in City Hospital. The subjects who had less pointing error, i.e. those who were more 'oriented' did not produce better sketch maps in University Hospital.

Bryant (1982) had suggested that a self reported sense of direction is a good indicator of orientation as measured by pointing accuracy. In this experiment self reported orientation strategy did correlate to pointing accuracy ($r=-.251$, $p=.0213$, figure 5), but this relationship broke down when the environments were considered separately. However, the self reported orientation strategy was correlated to sketch map accuracy and remained correlated even when the hospitals were considered separately. So, if sketch map accuracy is considered the indicator of orientation, then orientation may be predicted by self reported orientation strategy. Unfortunately, the relationship between number of pointing errors and sketch map accuracy remains far from clear.

7 Discussion

An important question that arises from this study is regarding the measurement of wayfinding success, or, how is wayfinding measured? Finding destinations correctly? Shortest time to the destination? Shortest length to destination? Least turns between origin and destination? Amount of lost ness or wandering? Etc. This experiment has demonstrated that depending on how wayfinding is operationally defined, the same environment may be either wayfinding friendly or wayfinding difficult. This important factor has not been dealt with adequately in the literature and each researcher develops his/her own version. Obviously, this is a serious issue in wayfinding research.

The results reported highlight another very important factor that has been acknowledged by researchers, but not dealt with adequately. This is the role of the environment in wayfinding. This puts emphasis on the background of the model proposed in figure 1. This background is the environment, and any changes in the environment will presumably change the components of wayfinding shown in the model and their interactions.

An associated puzzle is the relationship between coefficient of success and redundant use of spaces. Redundant use of spaces is an indicator of wayfinding difficulty (more lost ness). So it is reasonable to assume that more wayfinding success would be associated with less redundant space use. Yet people in University hospital had more wayfinding success but were also wandering more. So it seems that University hospital provided both wayfinding success and more lost ness at the same time. In other words, this hospital provided wayfinding success at the expense of wayfinding efficiency. In this regard, the layouts of the two hospitals may provide a clue. University hospital has more corridors and intersections than City hospital (32 and 33 vs. 24 and 28). These are arranged so that there is a strong central spine along which all the major destinations and intersections are located (see figure 2). This presumably provided longer views and a better sense of orientation. On the other hand, it also has more dead-end spaces that naturally provide more backtracking and thus more redundant use of spaces. This in turn supports the development of the cognitive map. In contrast, City hospital has shorter corridors that are arranged like a series of ‘loops’. The corridors do not provide long views and their layout prevents backtracking. Also, the corridors connecting each loop are devoid of important locations making them seem empty and isolated. In other words, City Hospital is almost like three settings connected together by destination-less corridors. From this comparison, one may assume that buildings with a well defined central spine with major intersections and long views may be a good beginning for creating wayfinding friendly layouts.

Earlier, Weisman (1981) had identified four environmental factors for wayfinding success: architectural differentiation, visual access to cues and landmarks, signs, and plan configuration. In this case, City hospital is more ‘differentiated’ than University hospital, but the ‘different’ areas do not come together as a unified whole. Also, it provided less ‘visual access to cues and landmarks’. Unfortunately, there is no mechanism to measure these qualitative environmental characteristics to provide indications of wayfinding success. This is an important need for future wayfinding research.

Sketch map analysis has shown that a linear development of element information to local topological information to global sketch map accuracy cannot be sustained in all environments. However, there is cause to believe that the development of local element information and perhaps local topological accuracy may not be dependent on environmental variations.

Another physical aspect that has been considered important is layout and configuration. Layout has been described as the relationship of individual elements or spaces and configuration is the structural hierarchy that arises between these elements or spaces due to the layout. This research has described layout only, and has considered it from its local topological and global geometrical terms. Configuration was not considered. Earlier, Haq (2001) had looked at the configurational differences in three hospitals using Space Syntax methods. The advantage of Space Syntax is that it not only provides a methodology to consider topological relationships in measuring configuration, but also allows comparison between different environments. Haq had reported good correlations between Syntax values and wayfinding use of spaces. It should also be noted that Space Syntax only deals with topological relationships. Other methods to consider perceptual, visual and other relationships need to be developed. This may prove to be a significant contribution to wayfinding research as the role of the environment and its properties will be questioned more and more.

Finally, from a methodological point of view, future wayfinding research needs to focus on identifying, measuring, and evaluating wayfinding effects of the different environment variables – element, layout and configuration along with their variations in different environments. This calls for the development of experimental methods to control the different environmental factors. Since it is difficult in real environments, focus needs to shift towards the development of virtual immersive environments with user controlled movement.

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