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JUST DOWN THE ROAD A PIECE
The Development of Topological Knowledge of Building Layouts

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ABSTRACT: This study explores whether people's topological knowledge changes as they get to know a setting. Volunteers (*n* = 128) performed open and directed searches in three large hospitals. In open searches the participants attempted to become familiar with the hospital; in directed searches they sought specific locations. The participants also performed various cognitive tasks such as pointing and sketch mapping. During initial exploration, they relied more on local topological qualities, such as how many additional nodal decision points could be seen from a given node. As they got to know the setting better, their wayfinding behavior was better predicted by more global qualities such as the space syntax integration of a node. This suggests that people rapidly move from a local to a more global topological understanding as they learn a setting. In addition, space syntax measures were good predictors of the participant's ability to point to out-of-sight locations and of their sketch maps.

As people get to know a setting, their mental representation of it changes. Initially they may know topological relationships—that the shopping mall is before the turn-off for the office, for instance—but may not be able to accurately represent precise direction or distance. Later, this *route map* might be replaced by a *survey map* that has more accurate Euclidian properties (Evans, 1980; Golledge, 1999; Hart & Moore, 1973; Kuipers, 1983). Kaplan and

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Kaplan (1982) noted that topological information is a natural by-product of the human learning process, and this allows humans to assemble a usable representation of the environment from many small and incomplete pieces or views. And, accurate topological knowledge appears to be important for good wayfinding. Rovine and Weisman (1995) reported that the topological accuracy of building placement in sketch maps accounted for 62.4% of the variance in wayfinding performance.

Yet it is not clear how topological knowledge develops. Appleyard (1969) did not find any large differences in sketch maps between new and old urban residents. In addition, Garling, Book, and Ergenzen (1982) demonstrated that configuration could be learned in a short period and that it is done during or even instead of route learning in the initial contact with an environment.

Perhaps part of the problem is a lack of precision in describing topological knowledge. Environmental cognition researchers tend to consider configurational knowledge as one of two types: topological or Euclidian. Space syntax theorists have viewed topology as nested where spatial relationships are viewed in relationship to local subsystems or as part of entire systems (Hillier, Burdett, Peponis, & Penn, 1987). Our interest in this study is to see if the more nuanced view of topology represented by space syntax theory helps clarify the ontology of configurational knowledge. In particular, in a small study for a master’s thesis, Willham (1992) found that people appeared to shift from a focus on local characteristics to more global relationships as they learned a setting. In this study, we examine how a group of 128 volunteers explored and found their way in three large urban hospitals.

RESEARCH CONSIDERATIONS

This research explores the following hypothesis:

Hypothesis 1: If simple topological relationships are learned first as people get to know a setting, then in space syntax terms, spatial connectivities will be learned first followed by knowledge of spatial integration and then possibly a coordinated metric overview of the environment.

It is assumed here that people learn about the environment as they move through it. In this diachronic process, the spatial information that is obtained is of a sequential nature, and therefore a certain kind of mental activity is required to process this successive input into a comprehensive understanding of the environment. From such a position it follows that movement can be taken as one indicator of cognition and that wayfinding can be an important tool in this research. This assumption has roots in the work of Kevin Lynch. Although not expressed as such, he tapped into the mental knowledge of cities of its inhabitants by considering their everyday movement (Lynch, 1960).

THE EXPERIMENT

This research was part of a doctoral dissertation and included empirical experiments in three complex hospitals located in a major U.S. city (see Figures 1, 2, and 3). These settings will be called Urban Hospital, University Hospital, and City Hospital, respectively.

In the three settings, 128 participants carried out a variety of tasks related to wayfinding behavior and cognitive understanding. The participants consisted of 62 male and 66 female students mostly aged from 17 to 25 (mean = 19.5). They were carefully screened so that none of them had visited a large hospital more than once in the 12 months prior to the study.

Behavioral Variables

This study described the paths taken by the participants in two ways. First, the paths were described in terms of the participants' use of visibility lines and nodes in a search condition called *open exploration*, where participants were asked to choose their own route to become familiar with the setting. Second, the researcher recorded the use of *redundant* nodes during directed search—the use of the intersections of line that were not on the shortest path when participants were asked to find specific locations. These tasks were initially developed by Peponis, Zimring, and Choi (1990). To explore the effect of task order, some participants did not do the open exploration but immediately started the directed searches. Also, the order of directed searches were randomly assigned.

Open exploration was started from one of the preselected entry points of the hospital, and the participants were told not to talk to anyone but to try and fulfill their tasks only from the environmental cues, including signage. For the directed search, the participants were taken to one of four preselected locations within the building and were asked to walk to another one. When they found the destination they were asked to go to the next one. (If participants could not find their destination in a preset time period—shown during the pretest as adequate for even the slowest walkers—they were escorted to the destination.) This procedure was repeated until each participant had journeyed or had attempted to find their way to and from all the selected locations.

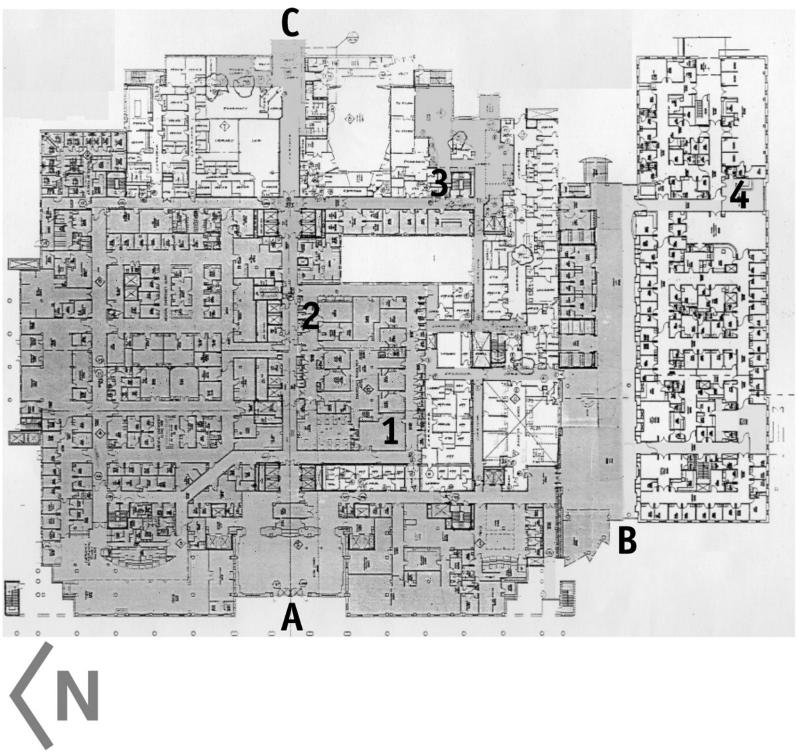

Figure 1: Plan of Urban Hospital
NOTE: The entries used are marked A, B, and C. The locations used for directed searches are marked 1 to 4.

The four locations in each hospital that were used are marked 1 to 4 in Figures 1, 2, and 3. They were each treated both as an origin and a destination. This resulted in 12 routes in each setting. In total, the 128 research participants carried out 508 directed searches. The searches were counterbalanced such that each task was completed in all possible order to control for fatigue or learning effects. Table 1 shows the number of participants and the various tasks in the three hospitals.

Cognitive Variables

Cognitive variables were collected in the second and third hospital used in this experiment, generating data for 95 participants. The participants carried

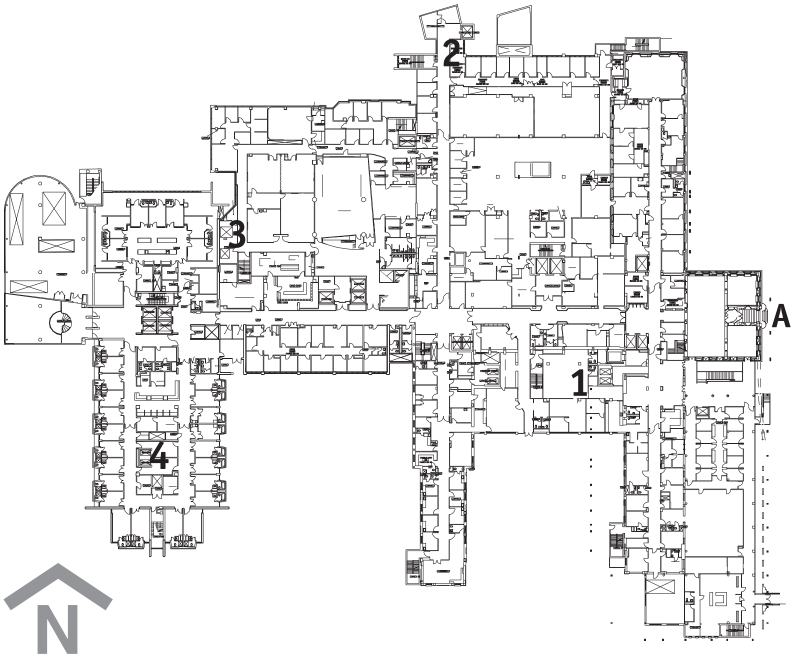

Figure 2: Plan of University Hospital
NOTE: Although different buildings form an interconnected mass, a central corridor creates a strong sense of orientation. The locations used for directed searches are marked 1 to 4.

out two tasks: pointing to “out-of-sight” locations and sketching the environment in which they had operated.

After each directed search, the participants were asked to point to the location(s) that they had started from. Each person performed 13 pointing tasks at different times and with increasing familiarity with the setting but facing a common direction. This was done by using a circular cardboard with angles marked on it in 10-degree intervals and a pointer attached to the center. The angular deviations from the actual location, in degrees, were recorded. In University Hospital and City Hospital, the participants performed 377 and 871 pointing tasks, respectively (see Table 1).

In addition, each participant was asked to draw the plan of the hospital they walked in. They were instructed to draw all the paths that they remembered and to put all the locations they could recall beside those paths. The number of times each corridor appeared in sketch maps was counted. Also by comparison with an actual plan of the setting, a value was given to the overall correctness or configuration of the sketches.

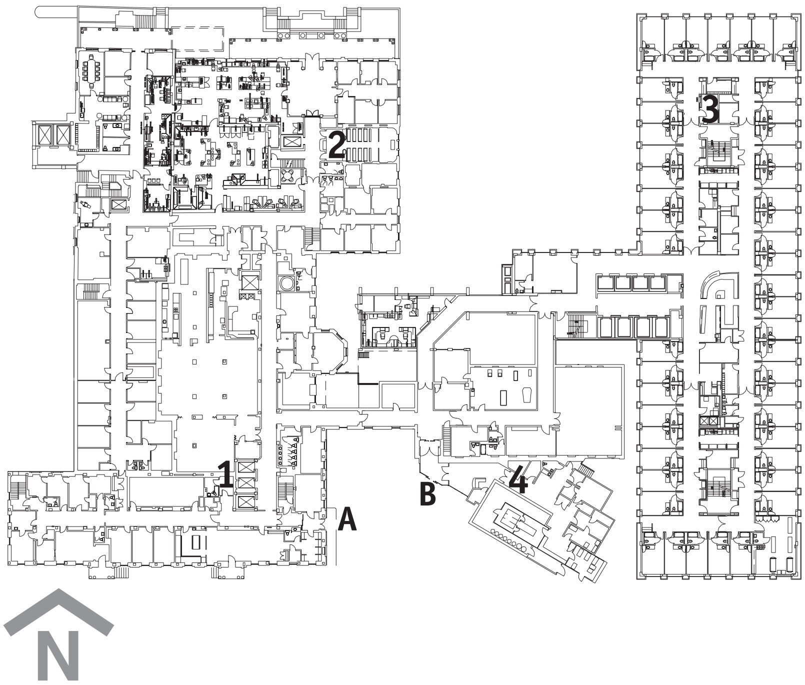

Figure 3: Plan of City Hospital
NOTE: Three buildings are connected together to form a continuous mass, a northwestern part, a southwestern part, and an eastern wing. The connecting central part also houses various functions. The entries used are marked A and B. The locations used for directed searches are marked 1 to 4.

To make sure that the occurrences of nodes and lines in the maps were correctly accounted for, two independent raters in each hospital judged a sample of the sketch maps. The researcher judged all of them. In University Hospital, two raters and the experimenter rated 10 maps; namely, each rater had to judge 320 axial lines. They totally agreed 239 times, or 74.69%. Average agreement per map was 23.9 times (out of 32)—maximum 31 and minimum 15. In City Hospital, two raters and the experimenter judged 25 maps that included 600 axial lines. Here they agreed 499 times, or 83.16%.

Environmental Units

Two kinds of environmental units were considered in this study: uninterrupted visibility lines and decision points.

TABLE 1
Comparison Between the Various Tasks in the Three Environmental Settings

	Urban Hospital	*University Hospital*	*City Hospital*	*All Hospitals*
Number of male students	13	13	36	62
Number of female students	19	16	31	66
Total students	32	29	67	128
Number of entries used	3	1	2	6
Participants doing open exploration from A	10		45	
Participants doing open exploration from B	13		22	
Participants doing open exploration from C	9			
Time given for open exploration	20 minutes	15 minutes	15 minutes	
Time given for directed search	15 minutes	10 minutes	10 minutes	
Number of participants started with open exploration	32	14	42	88
Number of participants started with directed search		12	12	24
Number of judges for nodes recognized	1	3	13	17
Number of pointing tasks		377	871	1,248
Average distance estimation error		167.855	152.026	
Average pointing error		23.303	37.854	
Number of directed searches	124	116	268	508
Number of distance estimation tasks		116	268	384

First, it is fairly easy to understand that visibility is an important issue in movement: It is easier to find a destination one can see. The extent to which one has an uninterrupted view is important. Second, places in which one needs to make a decision regarding direction are consequential because those spaces are usually areas where wayfinders pause and take in new information.

The techniques of space syntax were used to calculate some values of the environmental units. Space syntax deals with the relational aspects of linear space, and these are represented as axial lines. It takes into account those properties of space that are derived from the relationship each linear space has with all the other spaces in a system. The relationship that it considers is topological, for example, the number of steps or turns one needs to take to go from one space to all others or vice versa. With this premise, space syntax researchers have used graph theory to define spatial measures and have produced computer tools to quantify those relational properties of spaces and to provide numerical and display values for each. These measures are also called *configurational values*. The more important ones are *integration-max* and *connectivity* (Hillier & Hanson, 1984). Integration-max is a global measure that takes into account all the spaces and hence all the steps or turns required to go from one space to all others in a spatial system, thus describing the relationship of each space to the system as a whole. Connectivity is a local measure that describes the relationship of each space to its immediate neighbors. In addition, *intelligibility* is a higher-order variable that refers to the entire system. It is measured by the correlation between immediately available relationships to neighboring spaces as measured by connectivity and the relationship of the pattern as a whole, as measured by integration-max (Hillier et al., 1987). A higher correlation between connectivity and integration means more intelligibility of the entire system of spaces under consideration. From the point of view of the immersed person, intelligibility can be said to index a person’s ability to make judgments about one space’s relationship to the entire system based on the observations of the number of local connections. Because space syntax axial lines are particular instances of uninterrupted visibility lines, they were taken as one environmental unit.

Decision points or nodes, on the other hand, were defined as intersections of corridors. For many of the variables that were considered in this experiment, they were further operationalized as intersections of axial lines.

The various measures that were calculated for these two kinds of environmental units are given next.

Axial Line Values

Connectivity (pub) is the count of other axial lines in the public system that intersects the origin line. The public system is the set of corridors available to the visitor.

Connectivity (all) is the count of other axial lines in the total system that intersects the origin line. This is the spatial system that would be accessible to a staff member who had a passkey to open all doors (see Figures 5, 7, and 9).

Integration (pub) is the integration value that is calculated from the system that is open to the public only (see Figures 4, 6, and 8).

Integration (all) is the integration value calculated from all the spaces in the hospital.

Figure 4: Urban Hospital, Syntax Analysis of Public Lines

Decision Point or Node Values

Because nodes are the intersections of axial lines, the average values of these lines, as obtained from line analysis, were used. However, other variables were also considered. The different variables for nodes are described next.

Degree is the number of choices available at any node and was easily obtained by examining the plans of the settings. Degree includes the approach segment of any node; namely, it considers the ability of the wayfinder to backtrack. For example, the degree of node A in Figure 10 is 4.

Connectivity (pub) and connectivity (all) are the average connectivity values—both for public system and entire system—of the axial lines that form the node.

Figure 5: Urban Hospital, Syntax Analysis of All Lines

DP degree (decision point degree) is the number of decision points that theoretically can be seen from one node, not counting itself. Conversely, DP degree indicates the number of other nodes from which a node can be seen. Therefore it evokes the possibility of coming to one node from others. This is either equal to or greater than the degree value of the node. For example, node A in Figure 10 has DP degree value 3. This measure is considered relational because it implies views through adjacent nodes. This variable was initially defined by Willham (1992).

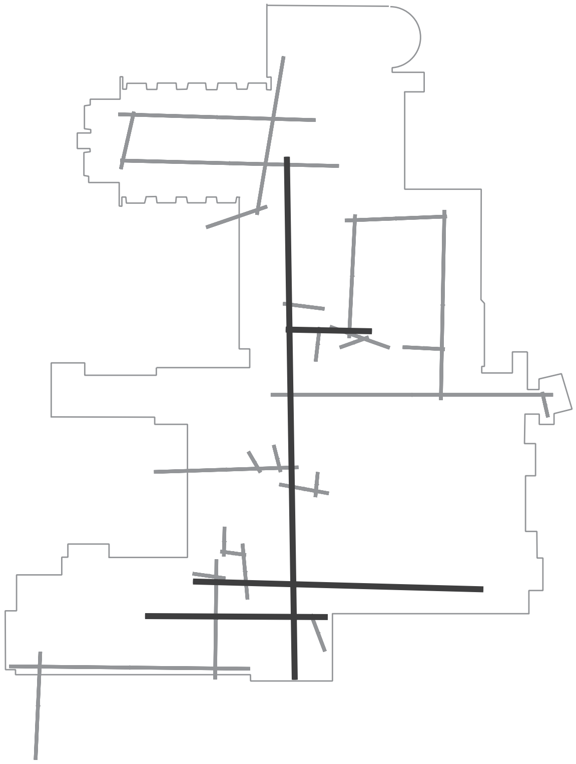

Figure 6: University Hospital, Syntax Analysis of Public Lines

Nodes recognized expresses the number of other nodes that can be recognized from any node. This is contrasted to the number of nodes that lie on an axial line and theoretically can be "seen." In reality however, because of distance and/or lack of distinctiveness, some of these nodes cannot be recognized. As the name implies, nodes recognized only considers those nodes that may be recognized from any node. This is considered important because it takes human sensibilities into consideration while describing environmental variables.

Calculation of nodes recognized was done by having a group of independent judges stand in the nodes of the various hospitals and estimate how many other nodes they could identify. The researcher was the only judge in Urban Hospital, whereas in University and City hospitals there were 3 and 13 judges, respectively (see Table 1).

Integration (pub) is the average of the integration (pub) value of the axial lines that form the node.

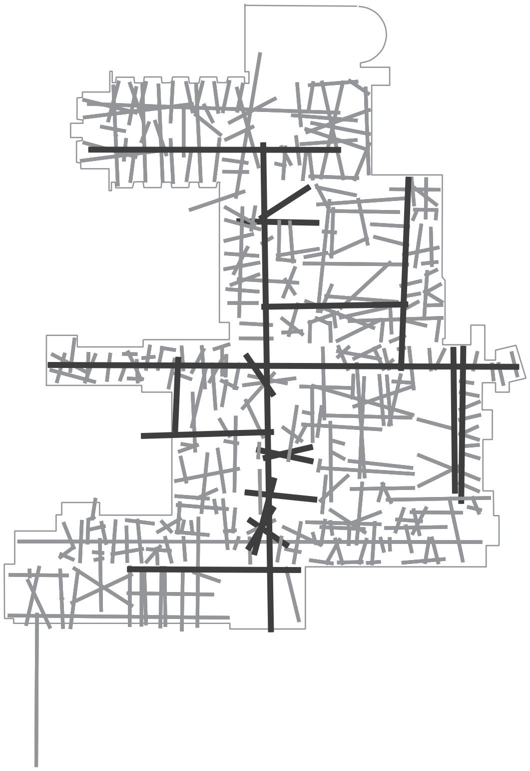

Figure 7: University Hospital, Syntax Analysis of All Lines

Integration (all) is the average of the integration (all) value of the lines that form the node.

In contrast to the average value of lines being used as a substitute for node values, the variable actual node integration was the actual integration of the nodes as they relate to the public system. It was calculated by considering the direct connections of each node to all other nodes in the public system. The calculating formula was the same as proposed in space syntax theory. Because AxmanPPC or Spatialist software only work with axial lines, a separate program was used to calculate the actual node integration.[1] Unlike syntax programs, this does not produce any colored representation, and so they were manually drawn. These are shown in Figures 11, 12, and 13.

Figure 8: City Hospital, Syntax Analysis of Public Lines

COMPARISON BETWEEN THE SETTINGS

A comparison of the hospitals in presented in Table 2, and the axial analyses are shown in Figures 4 to 9.

In terms of line intelligibility of the public axial system, University Hospital had the highest value, followed by Urban Hospital, and then City Hospital. The values were .831, .664, and .557, respectively (see Table 2; higher values are more intelligible). When node intelligibility was calculated from node values taken as average of axial lines, a similar hierarchy was seen. University, Urban, and City hospitals have values of .935, .789, and .483, respectively (Table 2). If, however, node values were computed by their own interrelationships, namely, the actual node values, then Urban Hospital had

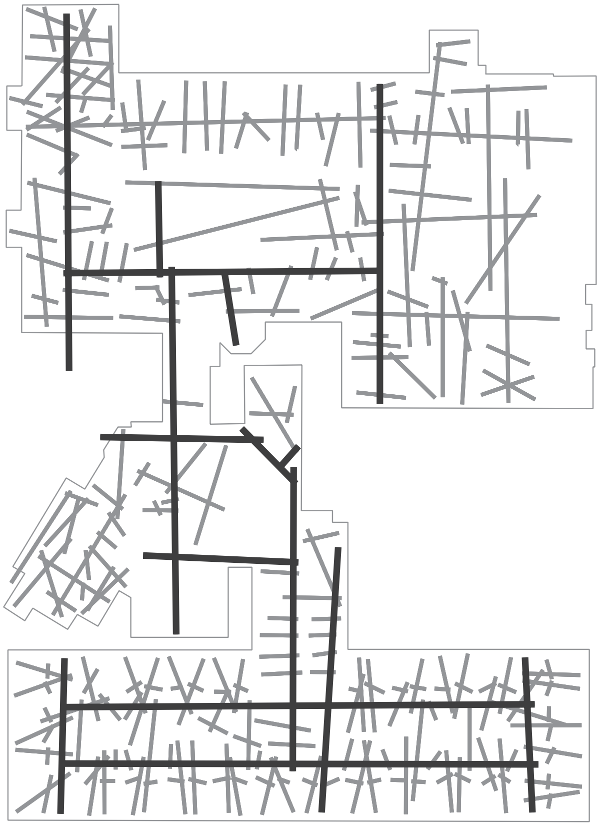

Figure 9: City Hospital, Syntax Analysis of All Lines

intelligibility value of .660, followed by University and City hospitals at .534 and .320, respectively. City Hospital had a low intelligibility in both cases.

Consideration of the total axial system gave a slightly different result. In this case, there was much less variation between the intelligibility of the three settings. The values were .435, .428, and .412 for University, Urban, and City hospitals, respectively. Thus, the overall axial complexity of the three settings can be said to be similar, but they vary in the manner in which their public spaces are laid out. This of course attests to the validity of these three hospitals being chosen as experimental settings. Also, it demonstrates that settings with similar characteristics in its overall configuration may indeed present a different property to its visitors who are restricted to the public

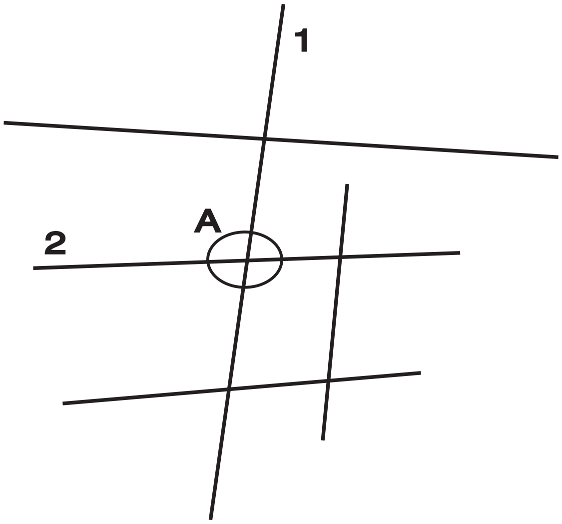

Figure 10: An Example of Connectivity

NOTE: Axial lines 1 and 2 have connectivity 3 and 2, respectively. But connectivity of node A is the average connectivity of axial lines 1 and 2, namely, 2.5. For node A, connectivity is relational because it takes into account visually connected adjacent nodes. Degree of A is 4, but decision point (DP) degree is 3.

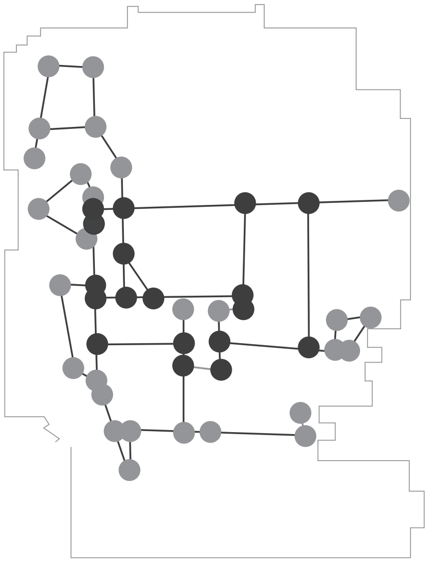

Figure 11: Urban Hospital, Actual Node Integration

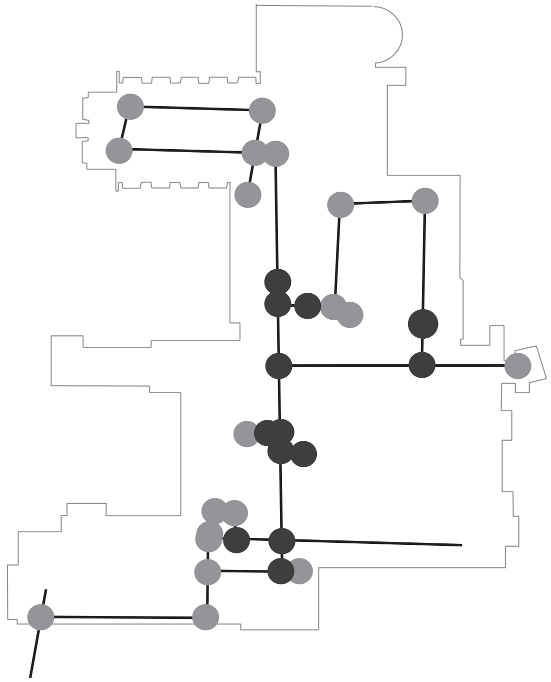

Figure 12: University Hospital, Actual Node Integration

system only. Therefore, any study should distinguish between these two systems.

Node intelligibility for the entire systems, using average of the line values, was .771, .696, and –.045 for Urban, University, and City hospitals, respectively.

The very poor intelligibility for City Hospital was cause for further investigation of its layout. This hospital was actually composed of two spatial clumps that were connected together by a third piece (see Figures 3, 8, and 9). These two parts corresponded to one building in the east and two in the west. Functionally also these two zones were dissimilar. Whereas the eastern building was exclusively patient rooms, the western two buildings housed administrative functions and laboratories. Because there was little need to commute between the two zones, there were very few people in the connecting part. Syntactically, however, this connecting corridor had the highest integration value.

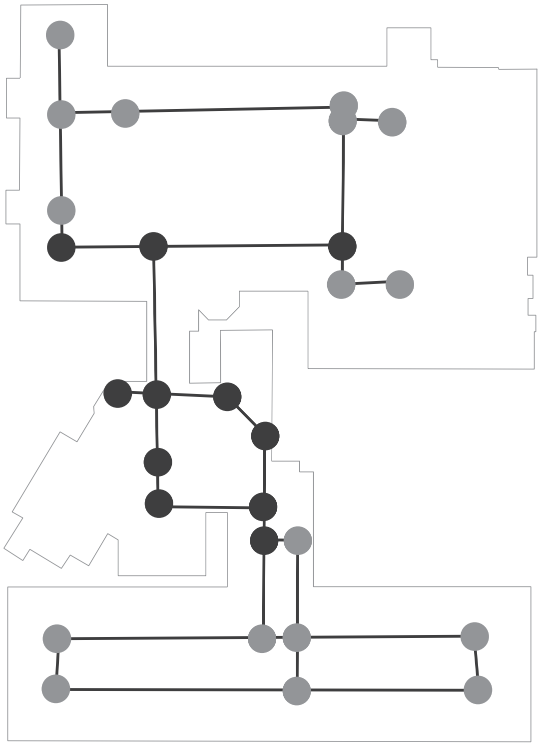

Figure 13: City Hospital, Actual Node Integration

Because of this complexity, City Hospital was later considered as two separate systems. In this case, public line intelligibility increased to .923 and .674, all line intelligibility to .840 and .747, all node intelligibility to .735 and .814, and public node intelligibility to .911 and .711 for Segments 1 and 2, respectively. Also, actual node intelligibility became .807 and .556 for the two systems (see Table 2 and Figures 14, 15, and 16).

BEHAVIOR AND THE ENVIRONMENT

The effects of the environmental variables, lines and nodes, on behavior were modeled by correlating use of spaces with their environmental values. In all the cases reported here, unless otherwise mentioned, *p* is significant at .05 or less.

Open Exploration: Axial Line Use and Line Variables

In the condition of open exploration, the best prediction for total use of axial lines was given by public connectivity (*r* = .768, .884, and .786 for Urban, University, and City hospitals, respectively) (see Table 3). Public connectivity also correlated significantly with line use in open exploration when City Hospital was considered as two independent systems (*r* = .798 and *r* = .792 for Systems 1 and 2 of City Hospital, respectively) (see Table 3).

Public connectivity is the number of publicly accessible connections that are available in a corridor. This measure gives a sense of how well a space is connected to other immediate spaces. From the point of view of the situated observer, it gives a sense of how much further exploration a space will allow. Therefore, it seems reasonable that in the initial stages of exploration, people tend to go to such areas that offer a better sense of other spaces through visual connections. This also attests to the idea that topological properties are picked up in the beginning stages of environmental learning.

Open Exploration: Node Use and Node Variables

The best predictor for total node use in Urban and University hospitals was DP degree (*r* = .723 and .848, respectively) (see Table 3).

In the case of City Hospital, node use gave very poor correlations with DP degree when the layout was considered as one system. However, when the layout was considered as two independent systems, nodes recognized became important in Segment 1 (*r* = .629) (see Table 3).

At this point, a comparison should be made between public connectivity of axial lines, DP degree of nodes, and nodes recognized. Public connectivity is a measure of how many other public corridors are connected to one and by definition may be seen from any location within one axial line. DP degree is a measure of the other nodes that can be seen from one node, and nodes recognized takes into consideration the other nodes that are actually recognized from one. Thus, all these units are similar because they provide a sense of gaining more information or possibilities for exploration.

It is not surprising that in the case of open exploration, namely, when participants were trying to understand an unfamiliar setting by walking within it, those values that provided opportunities for more exploration turned out to be the most significant across three hospitals and two kinds of environmental units. This also makes the most intuitive sense.

TABLE 2
Comparison of Environmental Variables Between the Settings

	Environmental Variables	*Urban Hospital*	*University Hospital*	*City Hospital*	*City Hospital Segment 1*	*City Hospital Segment 2*	*All Hospitals*
Number of public lines		39	32	24			95
Number of total lines		377	348	280			1,005
Number of public nodes		46	33	28			107
Axial lines							
Public system							
	Intelligibility (pub)	0.664	0.831	0.557	0.923	0.674	
	Maximum integration (pub)	1.548	2.317	1.263			
	Minimum integration (pub)	0.506	0.601	0.498			
	Mean integration (pub)	0.93	1.052	0.78			
	Maximum pub connectivity	9	8	4			
	Minimum pub connectivity	1	1	1			
	Mean pub connectivity	2.844	2.188	2.333			
All system							
	Intelligibility (all)	0.428	0.435	0.412	0.840	0.747	
	Maximum integration (all)	1.869	3.177	1.9			
	Minimum integration (all)	0.787	0.834	0.561			
	Mean integration (all)	1.16	1.513	1.138			
	Maximum connectivity (all)	28	40	35			
	Minimum connectivity (all)	1	1	1			
	Mean connectivity (all)	3.607	3.218	2.586			

Nodes						
Public system						
	Actual node intelligibility	0.660	0.534	0.320	0.807	0.556
	Node intelligibility pub	0.789	0.935	0.483	0.911	0.711
	Maximum node intelligibility (pub)	1.7069	1.954	1.234		
	Minimum node intelligibility (pub)	0.5604	0.687	0.493		
All system						
	Node intelligibility (all)	0.771	0.696	–0.045	0.735	0.814
	Maximum actual node intelligibility	0.993	0.976	0.846	1.1047	1.1098
	Minimum actual node intelligibility	0.436	0.392	0.375	0.475	0.412
	Maximum node intelligibility (all)	2.05	2.979	1.881		
	Minimum node intelligibility (all)	1.16	1.289	1.093		

Figure 14: City Hospital as Separated Systems, Syntax Analysis of Public Lines

DIRECTED SEARCH: REDUNDANT NODE USE AND NODE VARIABLES

For Urban and University hospitals, redundant node use correlated with actual node integration at *r* = .561 and .817 (see Table 4). In City Hospital, node use produced extremely low correlations. However, when the hospital was considered as separate systems, then actual node integration gave the highest and the only significant correlation (*r* = .633 for both the systems) (see Table 4).

Figure 15: City Hospital as Separated Systems, Syntax Analysis of All Lines

Actual node integration is a configurational variable that takes into account how the nodes are connected to one another in the public system. In directed search, when subjects had already some experience of their setting, they tended to use nodes with a higher integration value. This signifies a greater understanding of the configuration and one that supports a comprehension of the global properties of the environment.

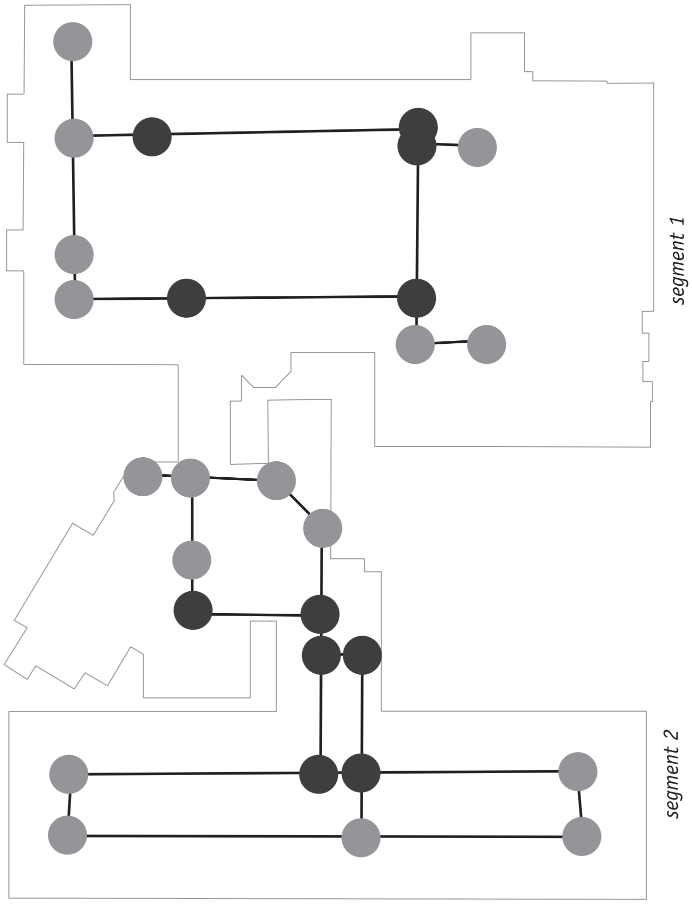

Figure 16: City Hospital as Separated Systems, Actual Node Integration

ENVIRONMENTAL COGNITION AND THE ENVIRONMENT

Environmental Elements in Cognition

One of the preliminary questions regarding cognitive data was: What properties of the environment are expressed in the mental representations? As was discussed earlier, public connectivity of axial lines was an important predictor of wayfinding. Therefore, one may expect it to be an important predictor in cognitive maps also.

TABLE 3
Correlations of Total Use With Environmental Variables in Open Exploration

	Environmental Units		
	Lines	*Nodes*	
	Public Connectivity	*Decision Point (DP) Degree*	*Nodes Recognized*
Urban Hospital	.768	.723	.642
University Hospital	.884	.848	.795
City Hospital	.786		
City Hospital Segment 1	.798		.629
City Hospital Segment 2	.792		

TABLE 4
Correlations of Node Use and Actual Node Integration

	Actual Node Integration	
	Node Use in Open Exploration	*Redundant Node Use in Directed Search*
Urban Hospital	.494	.561
University Hospital	.788	.817
City Hospital	.369	
City Hospital Segment 1	.478[a]	.633
City Hospital Segment 2	.656	.633

a. $p = .117$.

To test this hypothesis, axial line values were correlated with their appearance in the sketch maps of the participants. As expected, public connectivity correlated strongly with line appearance in cognitive maps in all three settings ($r = .556$, .678, and .817, respectively in University, City, and Segment 1 of City hospitals).

This is a significant result. The environmental variable that correlated strongly with wayfinding behavior was also found to predict 31%, 46%, and 67% of the variance of sketch map elements. This illustrates the connection between cognitive maps and wayfinding behavior. From the point of view of the environment, those units that provide opportunities for more information both predict in wayfinding performance and feature prominently in cognitive maps.

TABLE 5
Correlations of Node Use and Nodes Recognized

	Node Use in Open Exploration	*Redundant Node Use in Directed Search*
Urban Hospital	.642	.317
University Hospital	.795	.571
City Hospital		
City Hospital Segment 1	.629	.553
City Hospital Segment 2		

Configurational Learning

It has been hypothesized in this study that the way spaces are connected to one another, namely, their topological configuration, is an important predictor of spatial behavior and cognitive mapping. Also, people learn more and more about configuration as they have more experience with a setting. In the open exploration phase of this experiment, the participants were experiencing the environment for the first time, and so they did not have any conception of its layout. It was therefore expected that they would rely more on local cues, namely, those that they could see around them and recognize. In the later stages of this experiment, in directed search, when the participants have had some knowledge of the setting, their cognitive maps would have developed. At this stage, they should rely more on these cognitive representations that would include global relationships. The results reported in the previous section support this idea.

To elaborate on this, a comparison of the use of nodes recognized and actual node integration in open exploration and directed search was conducted. Whereas the first depends on local information, the second considers the relationship of each element to all others in a system. Hence, it cannot be directly perceived.

Table 4 shows that during open exploration, node use correlated with actual node integration at levels of .494, .788, .369, .478, and .656 for the three locations, Urban, University, City, and City Segments 1 and 2, respectively. The table also shows that in directed search, correlations of redundant use with actual node integration increased in all cases to .561, .817, and .633.

On the other hand, correlations between node use and nodes recognized decreased from values in open exploration to values in directed search, namely, from .642, .795, and .629 to .317, .571, and .553, respectively for the three hospitals (See Table 5).

Thus, when participants were new to the environment, they depended more on nodes recognized and less on actual node integration. As they became more familiar, the situation was reversed. This comparison demonstrates that as a person moves from open exploration to directed searches, namely, becomes more and more familiar with a setting, his or her reliance on what can be immediately seen and recognized decreases on one hand, and understanding of the configuration of the setting increases on the other. Therefore, it can be said that cognitive understanding had progressed from local variables to more global ones.

Cognition and Configuration

This study points to the possibility that topologically constructed configurational knowledge may be something that people pick up quite quickly as they learn a new environment. It was demonstrated that initial reliance on local topological properties quickly shifted to higher order or global topological properties with the change from open explorations to directed search in a time gap of about 10 to 15 minutes.

This follows a series of tentative suggestions by various researchers. For example, Appleyard (1969) did not find any large differences in sketch maps between residents who had lived in a town from 0 to 6 months and those who had lived more than 60 months. Garling et al.'s (1982) research hinted at a much shorter period of acquisition of configuration—as he suggested, perhaps during or even instead of route learning in the initial contact with an environment. Later, Peponis et al. (1990) suggested that "some knowledge of configuration develops independently rather than by somehow aggregating the knowledge of specific routes, at least where cognitively competent adults are involved" (p. 576).

This study supports the notion that less intelligible settings are harder to understand. An unpaired *t* test on pointing errors revealed a substantial difference between University and City hospitals ($p = .0042$, $t = 2.934$). In terms of line intelligibility of the public axial system, University Hospital had an intelligiblity of .831, and City Hospital was .557 (see Table 2). When node intelligibility was calculated from node values taken as average of axial lines, a similar hierarchy was seen. University and City hospitals have values of .935 and .483, respectively. The actual node values for University and City hospitals were .534 and .320, respectively.

The fact that topological configuration was considered here and that this featured prominently in the sketch maps of the participants is important. Rovine and Weisman (1995) reported that the topological accuracy of building placement in sketch maps accounted for an exceptional 62.4% of the variance in wayfinding performance. Later, Peponis et al. (1990), Willham (1992), and Haq (1999) found the syntax variable integration was an important predictor of wayfinding tasks. This research result, supported by previous ones, builds up to the argument that even before the development of survey knowledge based on metric properties, a strong sense of global relationships is developed. This is a higher order of topological information. This understanding of relationships gradually considers larger and larger systems as well as connectivities of greater and greater depth in its scope. In this manner, local information is assimilated into a global understanding.

SPACE SYNTAX AND ENVIRONMENTAL COGNITION

This study has perhaps served to establish that consideration of topological configuration plays an important role in wayfinding and environmental cognition. Topics such as layout and configuration have been discussed in wayfinding and in cognitive representation studies earlier (e.g., Evans, Marrero, & Butler, 1981; Rovine & Weisman, 1995). However, both these research areas have lacked precise ways to measure topological relationships especially to be used as predictor variables in experiments. From these considerations, space syntax is a very effective tool.

If, as was seen in this experiment, topological and visual relationships are indeed important, then the syntax ideas of natural movement proposed in space syntax theory can be expanded. Whereas natural movement is often portrayed as a result of the confluence of all trips to and through a setting (Hillier, 1993), it seems that movement itself rapidly helps create a cognitive representation of the most paths for natural movement. Therefore, a cycle can be proposed. Configuration creates movement, which in turn promotes an understanding of the configurational properties. This then will contribute to more accurate movement and wayfinding.

In addition, this experiment points to the value of connectivity rather than integration for new users of a building. Syntax researchers have emphasized that many empirical findings support a correlation between human movement and integration. From this data, integration was proposed as a significant measure of the environment. “The configurational correlates of movement patterns are found to be measures of the global properties of the grid with the Space Syntax measure of ‘integration’ consistently found to be the most important” (Hillier, Penn, Hanson, & Xu, 1993, p. 29). Intelligible layouts by definition are those that have a good correlation between local connectivity and global integration. However, in this study connectivity has proven to be a better predictor of space use.

In terms of applicability, space syntax analysis may be a good way of testing for possible wayfinding difficulties in buildings and projects, and the role of local and relational qualities for new users potentially helps fine-tune these methods.

In conclusion, topological values of an environment are effective measures in understanding wayfinding difficulties in specific areas of complex buildings. This is substantiated by previous research (Braaksma & Cook, 1980; Haq, 1999; Peponis et al., 1990; Willham, 1992). Because space syntax deals primarily with topological information, it has been found to be a potentially important tool to test wayfinding problems, perhaps even before complex buildings are constructed.

NOTE

1. Sonit Bafna, a faculty member in the College of Architecture, Georgia Institute of Technology, wrote this.

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