edra 30/1999

June 2-6 · Orlando, **Florida**

The Power of Imagination

Expectation of Exploration:
Evaluating the Effect of Environmental Variables on Wayfinding

Saif-ul- Haq

Ph.D. Program, College of Architecture, Georgia Institute of Technology, Atlanta, GA 30332-0155
Phone: 404 894 6279, fax: 404 894 1629, e mail: saif.haq@arch.gatech.edu, saif.haq@alum.MIT.EDU

Keywords: Wayfinding, Hospital design, Space Syntax, Environmental Cognition

"As an amusement park employee, I am often asked for directions to specific attractions. Although detailed maps are given to each customer who enters the park, some people need more help. One exasperated guest approached me after she'd gotten lost using the map. "How come these maps don't have an arrow telling you where you are?" she asked.

J.B. Haight in Reader's Digest. June, 1997, pp. 55

Abstract

This paper reports the results of an experiment which dealt specifically with the role that environmental variables play on human wayfinding behavior. Here, 31 subjects were asked to freely explore a large urban hospital from three entry points and then were asked to walk to specific destinations within it. Their movements were transcribed into 'search patterns' which were essentially the use of each space by all the subjects in the process of performing their tasks. Environmental variables were categorized into local, relational and global kinds. Local values were derived from the spaces themselves, relational values from visual relationship to adjacent spaces and global values from relationship to the entire configurational system.

It was found that the possibility of gaining subsequent information from any space i.e. 'expectation of exploration' was an important factor in predicting its use. This was calculated with a model which considers how 'connected' a space is with adjacent areas. Also, it was demonstrated that as people get to know the environment more, they tend to attain a better understanding of its overall configuration.

Furthermore, correlational analysis of 'search patterns' with Space Syntax variables was found to be quite high and statistically significant. These results support conclusions reached from two previous studies in another hospital where Syntax values were found to be significantly correlated with 'search patterns' of wayfinding people.

Introduction

'Wayfinding' is a term that has not quite made it into the English language. Encyclopedia Brittanica (on line) does not list it, nor does the Oxford English dictionary[1]. Nevertheless, it has become an important area of focus within environment-behavior research. Although a common-sense understanding of wayfinding implies a role of the environment, yet this has been difficult to incorporate into research that has traditionally focused on behavioral and cognitive aspects such as cognitive mapping, memory, schema, decision making and information processing. When researchers do consider the environment, it is done from within a working definition of cognition and the wayfinding process. For example, Passini's model stresses processing of environmental information as an important component of wayfinding (Passini, 1984) and so he describes the environment from this point of view. Similarly, Garling et al.'s physical setting variables of (1) degree of differentiation, (2) degree of visual access and (3) complexity of spatial layout are developed from requirements for some basic cognitive processes like recognition of parts, localization of reference points, recall, selection and sequencing of destinations (Garling et al., 1986). Weisman (1981) believes that (1) visual access to cues and landmarks, (2) architectural differentiation, (3)signs and (4) plan configuration are important physical measures that effect wayfinding.

Some researchers have used the environment as predictor variables in wayfinding performance. Best reported high correlation ($r=0.93$, $p=0.03$) between 'lostness', i.e. deviations from a most direct route, and the number of choices in that route (Best, 1970). Evans et. al. (1980) found that when color-coding was added, subjects' wayfinding performance and orientation improved. Braaksma et.al. described terminal buildings as a node-link network where origins and destinations were nodes and the visibility between them, either directly or through signs, the link (Braaksma & Cook, 1980). By measuring the connectivity of such a graph, indices for visibility in a building was developed and interviews with patrons showed that wayfinding problems were associated with areas with low visibility indices. In 1981 Weisman found that 'simplicity' of floor plan configuration as rated by judges was a strong predictor of self reported wayfinding performance (Weisman, 1981). In a later study, Michael O'Neil measured layout complexity as the average number of connections per choice point in a floor plan (O'Neill, 1991). He called this 'Inter-Connection Density' (ICD). In studying buildings, he found that as ICD increased, both cognitive mapping ability and wayfinding performance decreased.

Peponis, Zimring and Choi (1990) used Space Syntax theory and methodology to examine spatial search behavior. They asked 15 subjects to explore a small hospital in 'open exploration' and then asked them to find several locations in 'directed search'. The researchers recorded their routes for both phases and found that the subject's open search patterns were strongly predicted by the space syntax measure of accessibility of a space called 'integration'. (Axial integration, as used in the Peponis et al study, measures topological accessibility by computing the number of turns necessary to reach all spaces in a system from every space, then normalizing this statistic to allow comparison among systems of different sizes.) In addition, when people were lost, they also tended to use 'integrated' paths. This research suggested that people understand and use an abstract set of global relationships within the environment when they make wayfinding choices.

Later, Zimring et.al. replicated the Peponis et al.'s study and further quantified the description of spaces (Zimring & Willham, 1998). They re-analyzed the original data to investigate if any other measures influenced the wayfinding process and also duplicated the experiment using the same building and the same methodology but with 12 older people as the subjects. Their description of interior spaces considered *local, relational* and *global* parameters. Local parameters included the characteristics of spaces themselves, relational parameters were derived from visual relationships with adjacent spaces and global parameters were calculated from relationship with all the spaces in the system. Zimring et.al.

concluded through the use of correlational research that new comers rely on the local measures for wayfinding, but as learning occurs relational and global measures become more important.

The Peponis et al. (1990) and Zimring et al. (1998) studies were suggestive that the overall pattern of layout or configuration was important for predicting the search patterns of way-finders. This seems to provide additional clarity about the role of choice and complexity in buildings. However, both studies used a single building, and it is unclear whether this finding generalizes to more complex settings.

The Research

This study was aimed at understanding the environment as a predictor variables for wayfinding performance. Furthermore, it sought both to replicate and extend the Peponis et al. (1990) and the Zimring et al. (1998) study. Specifically it dealt with exploring more local and relational values and extend the analysis between behavior and environmental variables.

Subject and setting

This research was carried out in a 21 story urban hospital in Atlanta, Georgia, a very large hospital in the state. The hospital recently completed a 318 million dollar architectural renovation and addition ; however, due to cost overruns, the entire hospital could not be refurbished and the signage was not updated.

Only the ground floor of this hospital was used in the experiment. Three entrances out of six were chosen as starting points and four locations within the hospital were chosen for the search tasks (See Figure # 1). The entry points were selected because they all had 'you-are-here' maps just inside the door. Destinations were chosen that were beside syntactically integrated and segregated corridors, were in both the new and old parts of the hospital and were both near and far from atriums and entry points,

Twelve male and nineteen female undergraduate students from the human subjects pool of the Psychology department of Georgia Institute of Technology participated[2]. They were between 18 to 25 years; one male was 32. The subjects were carefully screened so that none of them had visited a large hospital complex more than once in the previous 12 months.

Research Procedures

The subjects were individually met on Georgia Tech campus and were driven past the hospital to a parking garage. From there, they were escorted to one of the entry points of the hospital. Nine, thirteen and nine students started from entrance A, B, and C respectively (Figure # 1). They were then asked to freely explore the ground floor of the building (open exploration) and to learn about its layout and locations as best as they could, so that they would be able to carry out specific searches within the environment later. They were allowed only to go into the spaces accessible to the public; if they were confused and tried to go inside restricted areas, the researcher would stop them. They stopped when they were satisfied with their open search, or after 20 minutes. They were then taken to one of the selected locations within the building and were asked to walk to another one (directed search). For this task they were given a maximum of 15 minutes after which that task was abandoned. When they found the destination (or if their time was up they were escorted to that destination) they were asked to go to the next one. This procedure was repeated until each participant had journeyed, or had tried, to and from all the selected locations.

The four locations were each treated both as an origin and as a destination. This resulted in 12 routes for the directed search. In total, the 31 research subjects carried out 195 directed searches. The routes were counter-balanced for order. The researcher followed each subject and recorded their routes on a plan of the building. Whenever a person took more than three steps in any direction, the subject was noted as using that space.

Independent Variables: The Environment

The environment was quantified as two systems, an axial line system and an interconnected system of nodes. The layout was reduced to a set of convex spaces[3] and the longest lines connecting these spaces produced the axial system or axial map (Hillier, Hanson, & Peponis, 1984; Hillier, Hanson, & Peponis, 1987; Hillier, Hanson, Peponis, Hudson, & Burdett, 1983; Hillier, 1984). This axial map is thus composed of the fewest and longest possible straight lines of uninterrupted visibility and movement that can cover the plan. It is the most economical way of describing the layout as a pattern of potential movement, calling attention to the changes in direction and the numbers of transitional spaces that are necessary to walk from one space to another. On the other hand, nodes are basically areas where a decision regarding direction is needed by a traveler in the spatial system. In terms of this research, these are intersections of two or more axial lines. The values of axial lines and nodes were grouped into three categories depending on their relationship to other lines and nodes in the system: These are global, relational and local values.

The values of axial lines that were considered in this research were calculated by Space Syntax methodology. These are
Public Integration: This is the integration value based on *the system of corridors and spaces that are open to the public*. (This is a “global” variable.)
All Integration: This is integration value of each line which is based *on all the spaces in the hospital*. This is the spatial system which would be accessible to a staff member who had a pass key to open all the doors. (This value is also in the global scale)
Public Integration(3): Integration values of depth 3 read from the *public system only.* (Global scale)
All Integration(3): Integration values of depth 3 read from the *entire hospital configuration*. (Global scale)
Public Connectivity: This is a count of other axial lines of the *public system* which intersect the origin line. (Local scale)
All Connectivity: This is a count of other axial lines of the *total system* which intersect the origin line. (Local scale)

The part of the spatial system accessible to the public in the research setting had 39 axial lines and the *entire* hospital layout, had 377. Figure 2 and 3 show the axial lines of the public system and the entire hospital respectively.

There were 46 nodes in the public area. Since they were, by definition, a product of the axial lines, they were considered to have the average value of its producing lines. Thus, they had the same six variables. Additionally, we considered four other variables: (1) Degree, (2) DP degree, (3) Nodes recognized and (4) Isovist area. (Variables 1 and 2 was used previously by Zimring et al. (1998)).

Degree is the number of choices available at any node. This includes the approach segment, i.e. the ability of the way-finder to backtrack. This is a local variable. For example, the degree of A in figure 4 is 4.

DP degree is defined as the number of other nodes that can be seen from one node. Conversely, DP degree indicates the number of nodes from which a node can be seen. This therefore evokes the possibility of coming to one node from others. For example, the node A in figure # 4 has a DP degree 5. This measure is considered relational because it implies views through adjacent nodes.

Nodes recognized is a version of DP degree: the number of nodes that can be actually recognized from any one node. This is always equal to or less than DP Degree: from a given node, if a node was too distant or was not distinctive it was considered 'not recognized'.

Lastly, **isovist areas** are the area of the isovists drawn from each intersection of the axial lines (Benedikt, 1979). They were determined for all the 46 nodes in the part of the hospital which was open to the public.

An important distinction to note here is that while connectivity is a local measure for axial lines, it is relational for the nodes. This is because from an axial line, all connections are visible from it, but from a node, connections to corridors are seen through those corridor segments and are hence relational for this purpose.

After the axial lines were digitized into a computer, the program Axman PPC was used to generate the values of each line. This was done in two levels. They were

Considering only the public spaces (Figure 2) i.e. corridors and rooms where a visitor can go unescorted.

Considering all the spaces in the hospital floor (Figure 3)

Therefore, for each line in the publicly accessible area, we got two values for each Syntax variable i.e. integration, integration of depth 3, and connectivity. Since they were derived from the public system and the total system, they are represented with the prefix 'Pub' and 'All' respectively.

Results

Use of Axial lines in 'Open exploration'

The correlational analysis of wayfinding behavior in open exploration with axial line values are given in Table 1. The best prediction for use of an axial line during open search is given by a local value, Public Connectivity (r=0.768). The next best predictor is Public Integration(3) (r=0.744). Peponis et al. (1990) in their earlier study had reported correlations of 0.757, p<.01 and 0.617, p<.05 with Public Integration and aAll Integration respectively.

It is important to note that in open explorations, when people are trying to understand the layout, their use of a space is best predicted by a local quality, public connectivity. This is the number of publicly accessible connections in a space. This measure gives a sense of how well a space is connected to other spaces; in other words how much further exploration can be carried out. Therefore, people tend to go to such areas which offer a better sense of other spaces through visual connections.

Use of Nodes in 'Open Exploration'

The best predictor of use of nodes during open exploration is a relational value, DP Degree (r=0.723), as is shown in Table 2. Hence, during open exploration, as people are learning the hospital their search is predicted by the number of other choice points that can be seen from a node space. This is a relational value because information is gained by views through adjacent nodes and corridors. However, DP degree is analogous to 'Space Syntax' connectivity because both reflect the amount of choices available. Therefore, here too, we may safely suggest that possibilities of further exploration is a good predictor of use of a space by persons exploring the layout.

In this case, correlations with Public Integration and All Integration was 0.588 and 0.699 which also gives good support for Peponis et al. (1990) and Zimring et al. (1998) studies.

Use of Nodes in 'Directed Searches'

For each directed search we determined the topologically shortest route (i.e. the route which passes through the least number of nodes from the origin to the destination). The nodes which lie in that route were called 'path nodes'. Nodes not on the shortest route was considered redundant. Total use of redundant nodes was a measure of wayfinding difficulty. Also in terms of wayfinding, redundant node use was considered as an 'attractor index' for that node.

Redundant node use was correlated with environmental values of the nodes. The results are shown in Table 3. Here we can see that Public Connectivity, a relational quality, again has the highest correlation, (r=0.724). Also, DP degree has a similarly high correlation (r=0.719).

The preference for Public Connectivity and DP degree, like the previous finding, suggest possibilities for further movement. This is also consistent with the earlier observations that possibilities of exploration is the best predictor of space use.

As before, both Public Integration and All Integration have enough significance to support the earlier studies (r=0.602 and 0.704 respectively) of Peponis et al. (1990) and Zimring et al. (1998).

Reflecting on the repeated findings of a preference for areas with higher possibilities of exploration, it appears that people make route choices based on the extent, or presumed extent, of exploration that each unit of space offers. We have called this 'expectation of exploration'. In a situation of open search, 'expectation of exploration' of axial layout is given by public connectivity, while for nodes it is a function of its DP degree, (other) nodes recognized and public connectivity. In directed searches, considering the effect of configurational learning, an additional factor is public Integration. These can be used as parameters in a regression model to predict use of a space (See Table 5)

A linear model using these variables did produce an encouraging result (see Table 5). It was previously demonstrated that public connectivity predicts 59% (r=0.768) of the variance of axial line use in open exploration. The model to predict node use in open search, using parameters of DP degree, (other) nodes recognized and public connectivity produces r=0.780 (p=<.0001) which predicts 61% of the variance. However, collinearity problem is encountered between nodes recognized and public connectivity. On reflection it is realized that both of these variables are derived from similar considerations. Therefore a smaller model is used which considers DP degree and nodes recognized as predictors of node use in unfamiliar situations. This model gives r=0.778 which also predicts about 61% of the variance in node use. Finally to predict node use in directed search, the parameters of DP degree, nodes recognized and public Integration is proposed. But from the decrease of nodes recognized as a predictor between open exploration and directed search, it is realized that as configurational learning increase, reliance on relational variables decrease. This model therefore uses the parameters of DP degree and public Integration. This gives a r-value of .75 (p=.0000) which predicts 56% of the variation in redundant node use. We do not know exactly if this becomes a cognitive ability, but from the experiment we can propose an implicit rule: 'in search mode or in times of uncertainty, always proceed to the area which offers the highest 'expectation of exploration'.

Analysis of individual routes and Signage

The next task was to look closely at individual routes with respect to their wayfinding difficulty. For this reason the total redundant node use for each task in directed search was divided by the product of the number of subjects and the number of nodes in that task. This gave us 'redundancy' value for each route that could be used to compare them with one another. Redundancy was considered as an index of wayfinding difficulty. The redundancy values for the 12 routes are shown in Table 4.

The routes X-Ray to Emergency Care Lab (Route 5) and Snack bar to Emergency Care Lab (Route 3) stand out as having very high redundancy. The emergency care laboratory is located in the central east-west corridor whose integration value is among the highest of all spaces any way we look at the configuration. Also, these routes are the shortest in the experiment. Therefore, this finding seems extremely puzzling.

The field notes revealed two interesting patterns. First, subjects who were lost in these two tasks spent much of their time in the emergency area and in the clinic zone. They had been looking for 'Emergency Care Laboratory' in the emergency area and in the treatment areas. This suggests that they had gained a 'mental representation' of the functions of the hospital and were associating areas by function. Post-experiment conversations between the researcher and the subjects support this statement. This finding suggests that people 'mentally group' functions and activities; this warrants further research. Second, we noticed that a lot of people had walked by the emergency care laboratory, but had failed to see it. This indicates the importance of signage and of other local qualities. Although the name of the laboratory was just a small computer print (8.5"x5.5") posted to the wall nevertheless it was the only location in this well integrated corridor. Global and relational properties may feature in predicting the presence of people in an area but strong local qualities are also necessary for recognition and hence efficient destination-finding. The nature and quantification of local characteristics remains to be researched. Lynch's landmarks may be important for local recognition, but are difficult to quantify (Lynch, 1960).

Signage can have a local / 'identification' characteristic, a relational / 'directional' one and a more global 'you-are-here' kind of information. For example, in the experiment, while we were tracking the first few subjects, we noticed a good number not using 'global' signage during their tasks. This seemed odd, particularly in the light of research regarding 'you-are-here' maps (Levine, Marchon, & Hanley, 1984). Therefore in the later stages of the research, we made a careful note of the use of the three 'you-are-here' maps. Among the 15 subjects recorded, only 60% looked at the maps. Of them 11.11% used it once, 33.33% twice, another 33.33% thrice and 22.22% used them four times. It should be pointed out that the 'you-are-here' maps in the research setting are not correct. They reflect the proposed pattern of the hospital that could not be implemented. Some people may have understood it quickly and did not come again to look at the map, while others did not. That could not be determined. In a previous study, Moeser reported that plans put on walls to aid orientation was not used by the users she studied (Moeser, 1988). In this case we have seen that 40% of the subjects did not even bother to look at you-are-here maps. This could be an important pre-consideration for wayfinding 'signage' design.

Conclusions

From the different analyses that have been presented so far, a number of things can be concluded and others that need further research identified. Space Syntax tools and other measures can be used to develop a quantifiable structure of the wayfinding environment. Correlational analysis of these values with space use suggest that in unfamiliar environments, people make route choices at least partially based on what they can see ahead of them and what those spaces offer as further exploration possibilities. This is somewhat familiar to the category of 'mystery' proposed by earlier by Kaplan and Kaplan as 'promise of future information' (Kaplan & Kaplan, 1982), and also relates to Weisman's (1981) category of visual access to cues and landmarks.

This research additionally suggest that gradually, as people get to know an environment better, they seem to gain a knowledge of the overall configuration. This suggestion is graphically demonstrated in the correlation of node use with nodes recognized. Whereas in open exploration r= was 0.642, it dropped sharply in directed search to r=.317 (Compare Tables 2 and 3). Obviously the subjects were influenced by other things when they knew the environment better.

Peponis et.al have 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"* (Peponis et. al. 1990 pp. 576). This is also supported by this research. We have seen that correlation of node use with Public Integration and All Integration was .588 and .699 in open search. These by themselves are significant, but then it is pointed out that they increased to 0.622 and 0.704 in directed search. Additionally, we have seen that some subjects in the experiment did display an understanding even of the external roads as being a part of the configurational system while they were exploring the hospital interior. Therefore, not only is a sense of configuration intuitively grasped, it also increases with a short exposure to a layout. This points to a hypothesis that configuration may have a cognitive dimension.

Although 'expectation of exploration' is identified as a potentially important concept to study preference of spaces in wayfinding situations, we feel that it has not been rigorously defined. For example, nodes recognized does not have a strict and objective definition. Other factors that are potentially important in this respect may have been left out. Light and color variations are some that immediately spring to mind. Also, the unit of analysis was nodes and axial lines. Proper re-translation of these into architectural elements remain an objective for future research. Finally, decomposition of any layout into constituent axial lines has a component of subjectivity in itself that should be carefully researched. In spite of these, and because of the support by the regression models, 'expectation of exploration' appears to be a promising concept and an encouraging direction for further research.

Furthermore, this study suggests that space syntax based topological values of an environment are effective measures in understanding wayfinding problems in specific areas of complex buildings. This is substantiated by previous research

(Braaksma et al. 1980, Peponis et al. 1990, Zimring et al. 1998). Space syntax and the additional spatial measures used in this study are potentially important tools to identify wayfinding problems even before complex layouts are constructed.

Also, the study showed that everyone does not give equal value to maps. Either they do not understand it or do not notice it. In this experimental setting the you-are-here maps were very prominently displayed and the entry points were chosen because of their availability. It was highly improbable that the subjects failed to notice them. Therefore, it may be inferred that people who did not look at them did so intentionally. If that is the case, then other options should be considered in providing information.

Finally, this experiment shows the importance of all the three levels of environmental variables. Global, relational and local levels are each important in their own way and it is a complex interaction of them which produce a good wayfinding environment.

Notes

[1] Neither the 20 volume Oxford English Dictionary (1989), nor the New Shorter Oxford Dictionary (1993) list this term.

[2] This experiment was carried out with authorization dated 2/17/97 of Institutional Review Board, Georgia Tech Research Institute, Atlanta.

The authors also wish to thank all the participants who cheerfully carried out the experimental tasks and there by made the repetitive tasks of the researcher enjoyable.

[3] A convex space, according to Space Syntax definition is a space from where every point is visible from every other point in it.

Bibliography

Benedikt, M. L. (1979). To take hold of space: Isovists and isovist fields. *Environment and Planning B*, 6, pp. 47-65.

Best, G. (1970). Direction Finding in Large Buildings. In D. V. Canter (Ed.), *Architectural Psychology* . London: RIBA. pp. 92

Braaksma, J. P., & Cook, W. J. (1980). Human Orientation in Transportation Terminals. *Transportation Engineering Journal*, 106(March, No. TE2), pp. .

Hillier, B., Hanson, J., & Peponis, J. (1984). What do we mean by building Function? In I. C. J Powell, S. Lera (Ed.), *Designing for building Utilization* . New York: Spon. pp. 61-72

Hillier, B., Hanson, J., & Peponis, J. (1987). Syntactic Analysis of Settlements. *Architecture and Behavior*, 3(3), pp. 217-231.

Hillier, B., Hanson, J., Peponis, J., Hudson, J., & Burdett, R. (1983). Space Syntax: A Different Urban Perspective. *Architect's Journal*(November), pp. .

Hillier, B. H., Julienne. (1984). *The Social Logic of Space*. (Paperback Edition 1988 ed.). Cambridge: Cambridge University Press.

Kaplan, R., & Kaplan, S. (1982). *Cognition and Environment: Functioning in an Uncertain World*. New York: Praeger.

Levine, M., Marchon, I., & Hanley, G. L. (1984). The placement and misplacement of you-are-here maps. *Environment & Behavior*, 16(2)(Mar), pp. 139-157.

Lynch, K. (1960). *The Image of the City*.

Moeser, S. D. (1988). Cognitive Mapping in a Complex Building. *Environment and Behavior*, 20(1), pp. 21-49.

O'Neill, M. J. (1991). Evaluation of a conceptual model of architectural legibility. *Environment & Behavior. Vol 23(3) 259-284, May 1991.*, 23, pp. 259-284.

Weisman, G. D. (1981). Evaluating architectural legibility: Wayfinding in the built environment. *Environment and Behavior*, 13, pp. 189-204.

Zimring, C., & Willham, D. (1998). Spatial predictors of travel paths and wayfinding choices. *Forthcoming*.

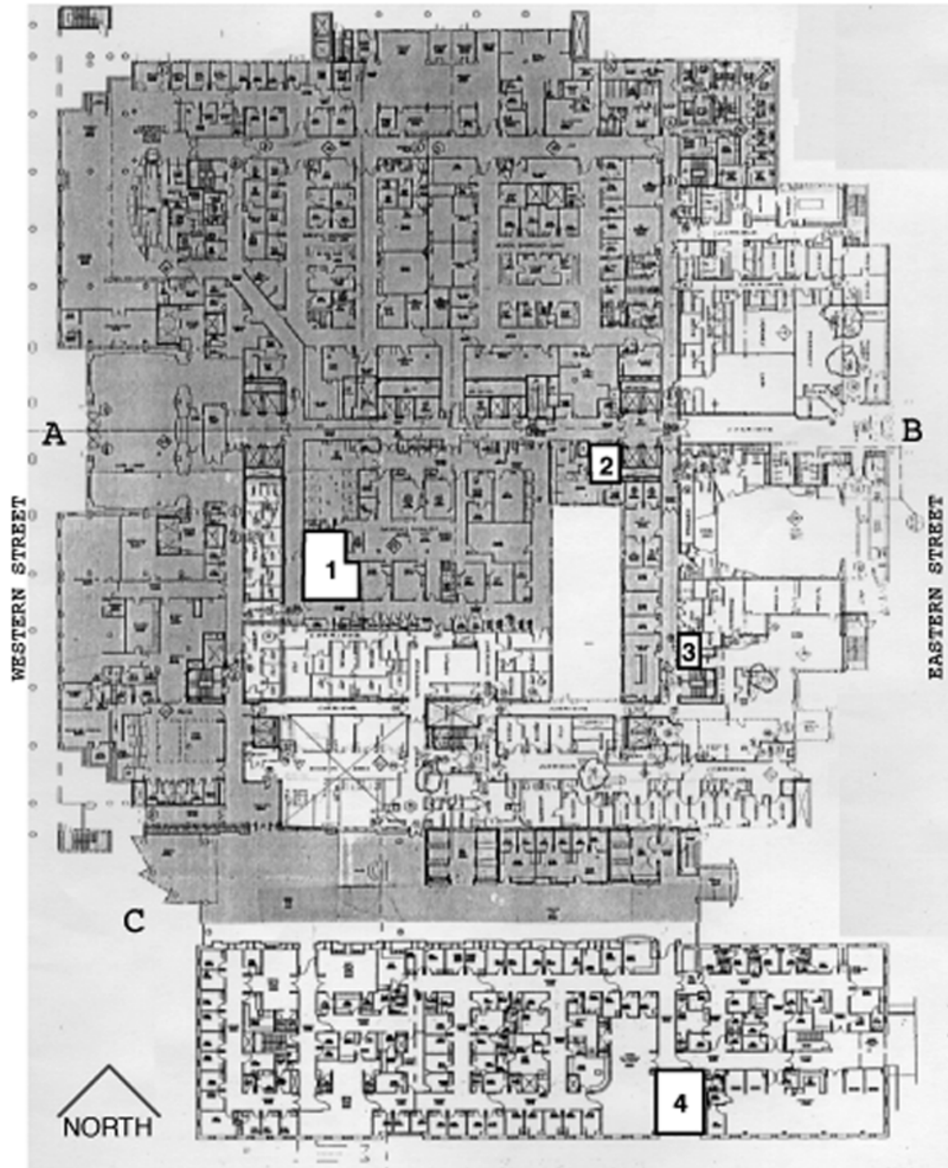

Figure 1 Plan showing areas used in the study
A, B and C are entry points for the subjects and 1,2,3,and 4 are locations for directed searches.
1=X ray, 2=emergency care lab, 3=Snack bar and 4=GYN/OB

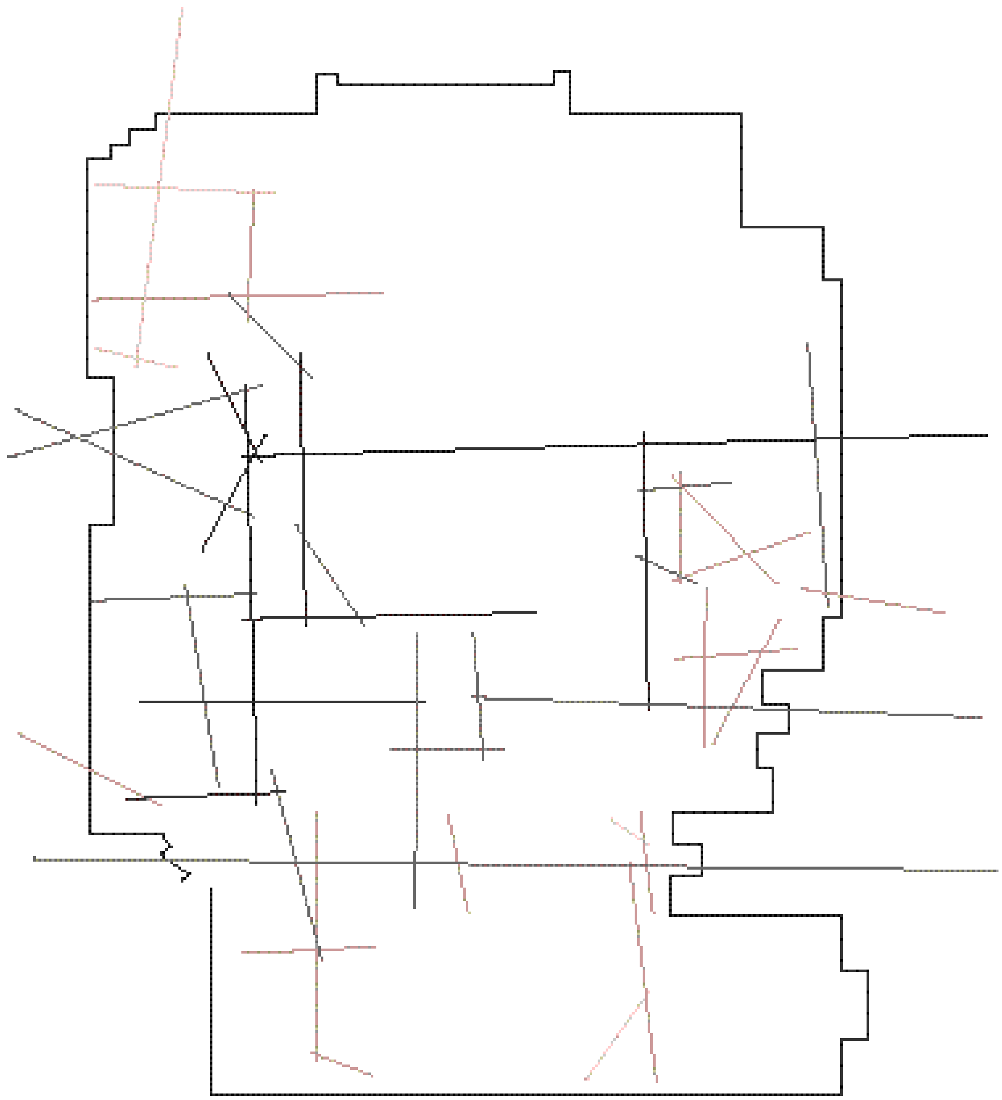

Figure 2 Axial line system of Public spaces in the setting.
(Dark lines are more integrated)

Figure 3 Axial line system of all spaces in the setting.
(Dark lines are more integrated)

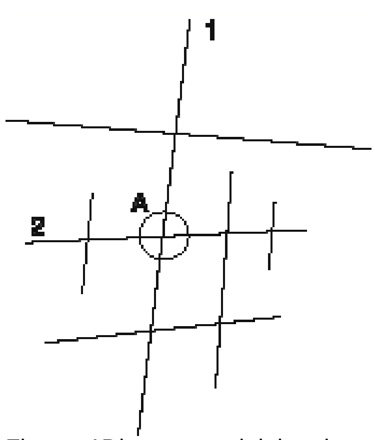

Figure 4 Diagram explaining degree and DP Degree.

Variable Type	Axial Line value	Correlation Value (r)	
		r	r^2
Global	Public Integration	.620	.38
Global	All Integration	.669	.45
Global	Public Integration (3)	.744	.55
Global	All Integration (3)	.590	.35
Local	Public Connectivity	.768	.59
Local	All Connectivity	.615	.38

Table 1 Correlations of Axial line values with their use in open exploration. (p-values are <.0001).

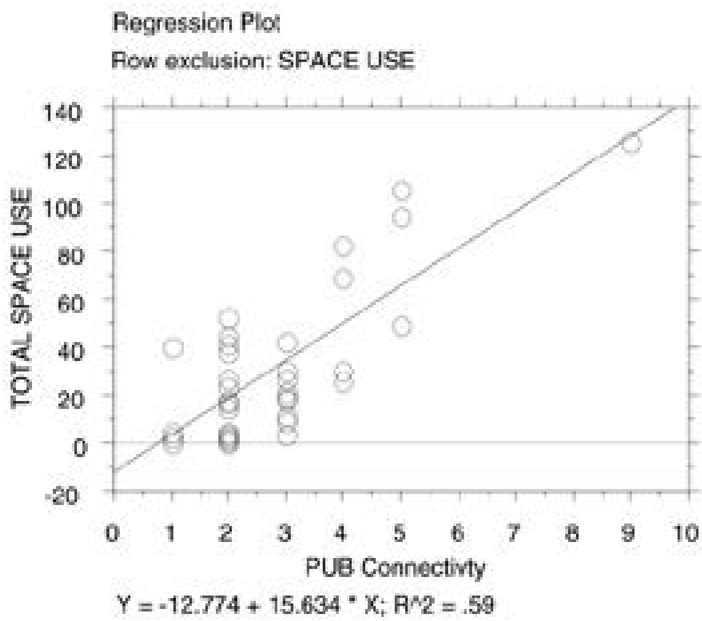

Chart 1 Regression of Public Connectivity and Axial Space use

Type	Node values	Correlation Value	
		r	**r^2**
Global	Public Integration	.588	.35
Global	All Integration	.699	.49
Global	Public Integration (3)	.652	.43
Global	All Integration	.637	.41
Relational	Public Connectivity	.605	.37
Relational	All Connectivity	.675	.46
Local	Degree	.142	.02
Relational	DP Degree	.723	.52
Relational	Nodes Recognized	.642	.41
Relational	Isovist Area	.480	.23

Table 2 Correlations of Node Values with use in Open Exploration (p values <.0001).

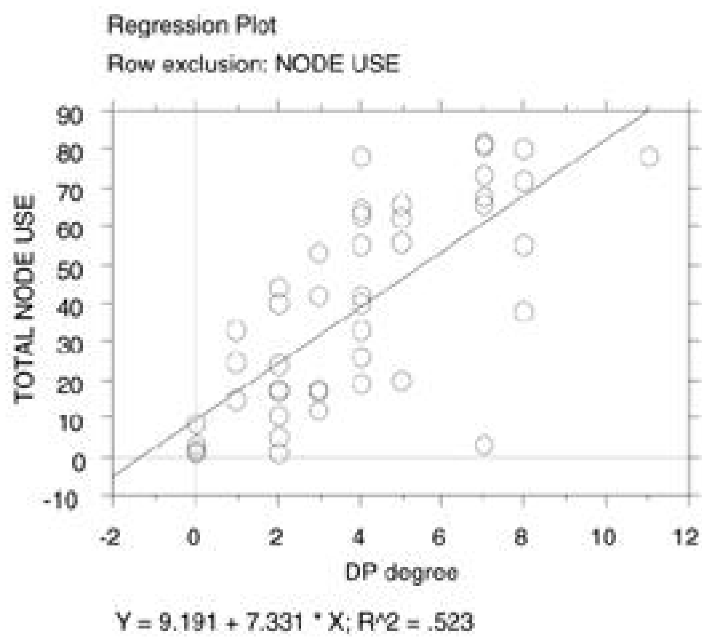

Chart 2 Plot showing regression of DP Degree and Node use

Type	Node Values	Correlation value	
		r	r^2
Global	Pub Integration	.662	.44
Global	All Integration	.704	.50
Global	Public Integration (3)	.713	.51
Global	All Integration (3)	.588	.35
Relational	Pubic Connectivity	.724	.52
Relational	All Connectivity	.600	.36
Local	Degree	.121	.02
Relational	DP Degree	.719	.52
Relational	Nodes Recognized	.317	.10
Relational	Isovist Area	.207	.04

Table 3 Correlations between Node Values and Redundant Node Use in Directed Search. (p values <.0001)

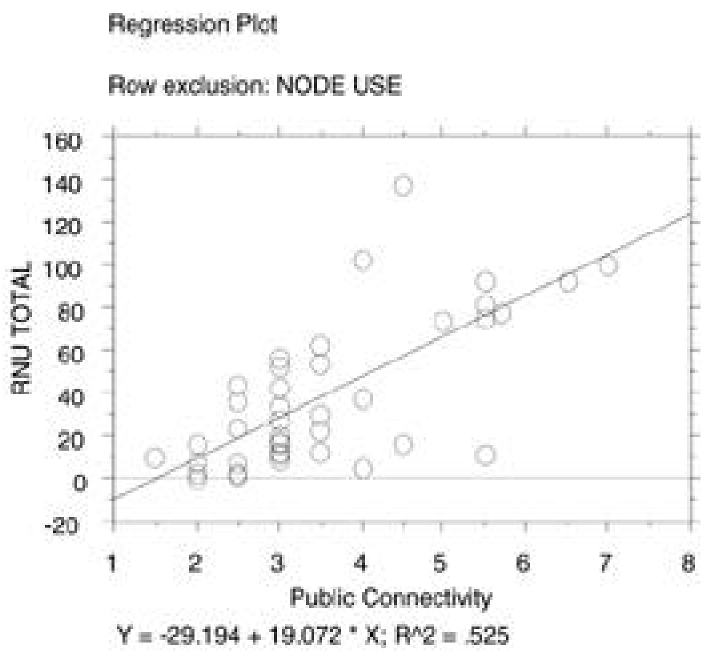

Chart 3 Plot shows regression of Public Connectivity and Redundant Node use

Routes	Route description	Redundancy
Route 5	X Ray to Lab	10.65
Route 3	Snack Bar to Lab	7.44
Route 2	Snack Bar to GYN/OB	1.21
Route 6	Lab to X Ray	1.1
Route 1	GYN/OB to Snack Bar	1.04
Route 10	X Ray to GYN/OB	1.039
Route 12	X Ray to Snack Bar	0.81
Route 9	GYN/OB to X Ray	0.8
Route 4	Lab to Snack Bar	0.73
Route 8	GYN/OB to Lab	0.68
Route 7	Lab to GYN/OB	0.57
Route 11	Snack Bar to X Ray	0.5

Table 4 Redundancy values of the 12 routes that were used in the experiment.

Use of Axial Lines in open search
y=b + (public Connectivity)x **(r=0.768)**

Use of Nodes in Open Search
y=b + (DP Degree)x1 + (Nodes recognized)x2 **(r=0.778)**

Use of Nodes in Directed Search
y=b + (DP Degree)x1 + (Public RRA)x2 **(r=0.750)**

Table 5 Regression models for ‘Expectation of Exploration’.