VIRTUAL SHOPPING CENTRE MODELS AND PATH CHOICE

John Zacharias
Concordia University
Urban Studies Programme
Montreal
Canada

ABSTRACT

A three-dimensional computer model of a shopping center was navigated by participants who were unfamiliar with it. In the first experiment, an orthogonal and equally spaced grid was used. It was found that the great majority of the itineraries made simple and similar patterns which were remembered by the participants, although they often mistook the precise path choices. In a second experiment, the width of the corridors was varied. Participants showed a distinct preference for wider corridors over narrow ones, resulting in a significantly different distribution of itineraries when compared with the results of the first experiment. Dimensional variation did not improve the ability of the participants to remember their itineraries, however. Also, individuals preferred to continue moving straight-ahead over turning. They also preferred to circumnavigate the shopping center, traveling along the outer edges, rather than head first into its center. The computer-based model is a low-cost way of testing preference in a dynamic way and could be mounted on multiple stations in computer laboratories as a way of increasing sample size. There remain some interface problems, however, that diminish somewhat the sensation of moving in real time. Further work will include refinements to the model and other variations in geometry and visual stimuli in the virtual shopping center, in addition to its validation in real environments.

First-time visitors to an urban environment often have limited knowledge of its layout activity structure, dimensions and level of complexity. The visitors may have a general agenda for viewing and doing, a list of items to search for and amenability to certain types of experience. In this last instance, the visitor is drawn along by a sequence of experience sets, and responds positively or negatively to the combination of visual and other-sensory effects.

The patterns of movement through certain public environments strongly suggest itineraries that vary according to visual and auditory stimuli. Studies on movement m parallel and equal paths in full-scale environments also suggest the importance of geometry.

In the present series of experiments, we are trying to isolate certain characteristics of layout that may have an effect on the succession of choices of movement that make up an exploratory itinerary into an environment . that is, a trip made by an individual for the first time and with no knowledge of the layout. This is the case of the tourist newly arrived in a city, or a first visit of an individual to a large institution or shopping center. The structure of the environment might be imagined based on prior knowledge of similar environments Book 1991]. Other information will be gleaned directly from the environment and used to make movement decisions. It is this information we are particularly interested in. Secondly, we are interested in the spatial behavior patterns of individuals in the same environment and exposed to the same information.

Studies of pedestrian environments, including shopping centers, show a shared preference for certain paths and certain corridors. Part of this preference is based on a perceived or known utility associated with those path choices. A shortest path between locations or one that provides the greatest number of choices seems a plausible explanation for much behavior in large-scale environments [Hillier and Hanson 1984; Peponis et al 1989]. There is some accumulated knowledge about preference for layout; for example, visibly accessible paths are preferred over blocked vistas [Kaplan *1985].* Also, in an "open search" of the kind we propose in this study, participants chose hallways that were more centrally located, even if the resulting routes were longer [Peponis et al 1990]. Environmental information that suggests the nature of the hidden path is also the basis of preference in shopping environments [Kent 1989].

Other efforts to isolate the reasons behind such individual spatial behavior include a few simple computer models. Plan complexity was shown to result in significant decreases in wayfinding performance using a three-dimensional computer model [O'Neill 1992]. Weisman et al (1987) showed that in *75%* of the cases, there were no significant differences in the wayfinding performance of individuals in real and simulated environments.

A previous experiment showed strong path preferences across an actual environment unfamiliar to the respondents and introduced in the form of screen images on a 17" monitor [Zacharias, 1997a]. In that experiment the angle of incidence of paths, curve of the path, topography and apparent path width all varied throughout the sample of 54 path choices and prevented us from isolating the effect of any one of these variables. A correlation between preference and scene content was demonstrated using subtractive and additive techniques. Path mystery, color intensity and contrast had a positive effect on preference.

Exploration should involve acquiring extensive knowledge that may involve sequential steps into adjacent space or alternatively jumping around, giving superficial attention to immediate surroundings. In the first instance there is an emphasis on static information-gathering, window-gazing. In the second there is a desire to know the extent of the environment as well as to be able to differentiate it by sectors. A certain differentiation by function, scale or design might be expected but an initial exploration is required to find out if and how such an environment varies.

A VIRTUAL COMPUTER MODEL

A computer model can be used to simulate the experience of traveling through a shopping environment, while controlling for the environmental variables. We expect that the experience of time friction will provoke a search for economical movement in individuals. The *friction of time and distance in walking* can be simulated by controlling the rate at which one is allowed to move through the environment.

Variations in the visual environment may also stimulate path choices. These variations may be controlled by "painting" selected surfaces with actual shop windows and frontages. In addition, the colour range can be limited or augmented depending on whether one wishes to test the content of the imagery or the colours themselves.

Lighting level and quality can be also be controlled through the use of artificial light sources set within and around the computer model. A wide variety of lighting effects and lighting intensity can be achieved over the computer model.

The *path configuration* may also have an effect on decision-making. Since the time taken to travel a given conidor acts as friction on the desire to effect such travel, a non-orthogonal plan will produce many different decisions in terms of time. Whether orthogonality is more or less important than the layout is a matter of some interest that can be tested by preserving all the characteristics of the local environment except the orthogonal arrangement of paths. In the interior of the model, all meeting paths have a unique relationship to each other. Is there a deep-seated preference for some arrangements over others? Presuming that the observed paths represent the acquisition of knowledge of the layout, do orthogonal variations actually affect the individual's performance in acquiring this knowledge?

Variations in spaciousness are also suggested as reasons for choice of path. Wide paths may attract because of associations with typical narrow-wide differences found in real environments. More often than not, relatively wide spaces are actually a confluence of paths, a gathering place or a high-capacity street, and so related to the presence of people-oriented activity and people themselves. But without other persons and the activities that accompany them, do we retain such spatial preferences in exploratory movement? Do they modify the spatial search trajectory found in uniform environments?

Variations in altitude may inspire path choice. Stairs going up and out of sight intrigue because the hidden scene is given a dramatic access. This was the case in the Montpellier shopping centre where such stairways were always preferred over the flat-terrain alternatives, regardless of other visual elements. A higher elevation also has connotations of change in symbolic and functional importance. The mysterious can also be troubling and off-putting, however.

Going up or even going down an incline also suggests an expenditure of energy and may factor into a decision to move in that direction. Of course, a computer model cannot simulate the expenditure of energy and presumably the participants are not so dupe as to resist a virtual movement of running up a flight of stairs. This model at best may suggest the relative attraction of up- and down-inclines or a sensed topographical feature.

EXPERIMENT I

A five-by-five model of identical paths was designed with sixteen identical square blocks in-between. Each block was scaled at l0m on one side with corridors at 5m in width. The three-dimensional model was created using the ceiling and wall designs and shop fronts of the Place Ville-Marie shopping center in downtown Montreal. A virtual reality modeling language (VRML) was used to construct the three-dimensional model. Color photos of shop fronts were first scanned, then the resolution and color range were reduced so that signs were unreadable but the general shop content remained evident. These shop fronts were sampled and pasted in random order onto the inside walls of the model such that frontage elements were repeated while one quadrant of the model was reserved for food-related shops. After experimenting with various levels of resolution, a lower than optimal resolution provided ambiance and information while allowing the program to run in real time.

Lighting was provided indirectly through a ceiling cowl and generally from behind the shop fronts. In this way the shopfronts were brightly lit and colorful while the corridors were more subdued in lighting level. A pattern was inserted in the floors which emphasized the intersections and configuration.

Participants were recruited at a computer graphics laboratory at Concordia University where the VRML model was loaded in Netscape v3.0. They sat at a 17" monitor and saw the opening image in the model, the corner entry point. An assistant read aloud the following introduction which the participant could also read:

> The screen you see before you is the entry point to an enclosed shopping center. We are asking you to explore it for the first time with the idea that this will be a regular hang-out for you in future. You expect to be back to shop, meet friends, have lunch or just walk around. So you want to get an idea of the place just to see what's there and so that you can find your way around the next time. You should move in any direction you like that will help you get a good idea of the layout and what's there. Afterward, we will ask you a few questions about the overall shape of the center, its layout and some landmarks. You may use the cursor keys to move around and look around. Like most people, you only have so much time and can only move so fast in this center. So after you have "walked" a certain distance, the research assistant will stop you.

Participants then began navigating the model. Motion through or near the walls was prohibited along with up-and-down motion while speed was maintained at a uniform

Figure 1**: The actual itineraries in the model are shown in the lefthandbox set while their remembered itineraries, traced on a map of the model, are shown in the boxes on the right.**

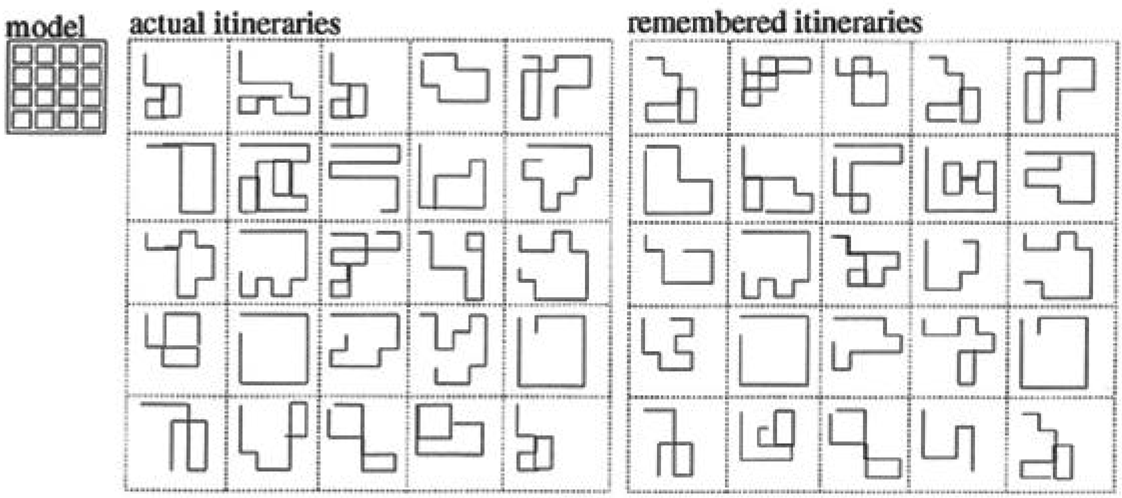
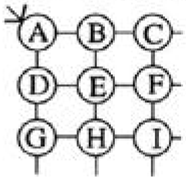


Table I: Aggregate choices at intersections (a), the direction taken at all intersection points (b) and the general configuration type of the itinerary (c).

Table I: Aggregate choices at intersections (a), the direction taken at all intersection points (b) and the general configuration type of the itinerary (c).

a. path choice proportions at decision points



	A	B	C	D	E	F	G	H	I
n	25	13	12	13	7	8	8	9	8
	0.50	0.77	0.25	0.31	0.29	0.29	0.38	0.44	0.25
	0.50	0.23	0.75	0.62	0.57	0.43	0.63	0.63	0.25
		0.00	0.00	0.54	0.14	0.43	0.00	0.00	0.38
					0.00	0.00		0.00	0.13

b. aggregate direction at intersections

straight ahead	192
left turn	102
right turn	104

c. configuration

two complete loops	7
one complete loop	17
no loop	1

walking pace. In this way we tried to simplify the movement protocol while also attempting to simulate the friction of time.

Based on previous studies of full-scale environments we expect an area-centering, traversal maneuver and a collectively preferred route over the distance-equivalent alternatives [Funihashi, 1991; Zacharias, 1997b]. A start from one corner and with similar choices in terms of distance, number of points of egress and overall content should produce a *50-50* split among the two available options.

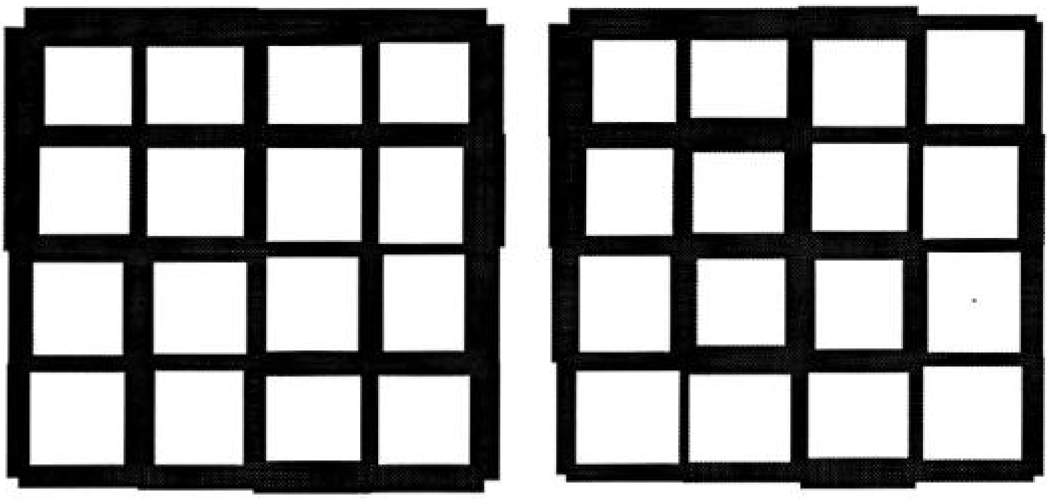
The assistant recorded the itinerary and stopped them at the fifteenth choice point. They were then shown 16 plans varying in the number of blocks and paths as well as in overall plan and block proportions, one of which was the VRML model, and were asked to identify it. Then they were asked to select appropriate descriptors from a list of twenty-three, including “brightly lit”, “confusing layout”, “narrow corridors”, etc. Finally they were asked to retrace their itineraries on a printed plan image of the shopping center and to locate the landmarks and food service area.

The Results

The itineraries are reproduced in Figure 1 along with the corresponding reconstituted paths. The aggregate choices for each path segment are represented in Figure 2 along with the aggregate remembered path segments.

The initial choice presents two paths of equal length, four openings equidistantly placed from the point of origin and with slightly varying visual stimuli in shopfronts. The distribution of choices is summarized by the first nine intersections in Table I. There is an even distribution of choices between the two options at the opening view, where the

Figure 2: The accumulated paths of the *25* participants are shown superimposed on the model's pathways on the left; the accumulated remembered paths are shown at right. Line width is proportional to the number of selections.



average expected error is 0.08. At the subsequent two intersections there is a significant preference for the straight-ahead option over the turn to the right or left (expected error is 0.10). However, at the subsequent two intersections, this preference diminishes although our sample was not large enough to know whether this preference might be significant.

Figure 3: **Individuals tend to prefer itineraries that circumnavigate the model.**

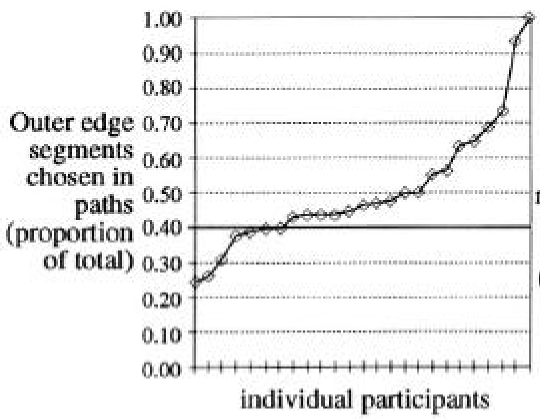
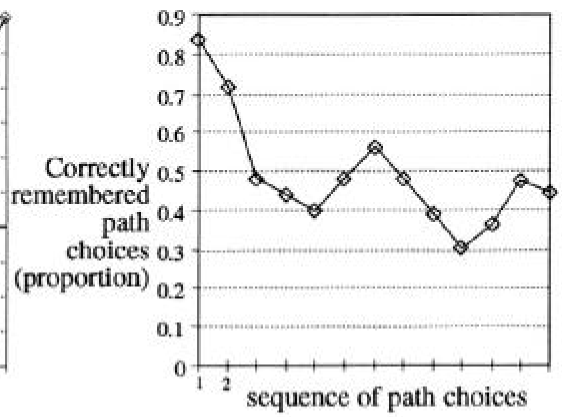


Figure 4: **Memory of the sequence of path choices declines quickly although the shape of the itinerary is generally remembered.**



If it were, it seems reasonable that visitors would seek a mid-point in the path in order to gain an idea of the interior and to be able to see all of it efficiently. In fact, overall there is a distinct preference for continuing straight ahead through the intersection rather than making a turn (Table I.b.) Reversals of direction, while possible in the model, did not occur, which explains the presence of zero-values in the table. Similarities can be detected in the configuration of paths such that a single complete loop was preferred by the majority of participants. A minority made two loops where the second loop involved a change of direction. One person performed a lateral scan of the model.

Participants tended to underestimate the extent to which they visited the sides of the center farthest from the entry point (Figure 2). They tended to remember the general configuration of their paths, recreating quite faithfully the left- and right-hand movements but often missing the correct turning point (Figure 1). Of course, those with simple itineraries could reproduce them more easily. Just a few individuals were confused with regard to left-right relationships. As a result, after mistaking a choice point they would find again the correct path and continue for some distance. The correspondence between actual and remembered itineraries by the choice sequence is summarized in Figure 4.

The outer edge segments of the center were preferred over the inner segments, even though there was less to see. One side of the path was a continuous shopfronted wall while the other offered a number of paths and subsequent intersections. This preference is not evenly distributed across individuals but is a preponderant characteristic of all the itineraries, as shown in Figure 3.

The participants were students in Urban Studies (n= 19), Geography (n=4) and other programs (n=2) whose ages averaged 24.6 years. There were just three left-handed individuals, so we unable to examine a left-right bias in choice. Most of the students had some computer experience, quickly acquired the technique and moved through the model within a period of approximately ten minutes. Three students who had greater difficulty acquiring the navigation technique took about 20 minutes to complete their circuits. It was not observed that the mechanical interface influenced the decision-making except perhaps in one or two cases.

Before retracing their itineraries on a paper map of the shopping centre, the participants were asked to identify the correct plan in a set of sixteen such plans. These plans varied

Table II: **Descriptors by the number of times they were selected by participants (n=25)**

confusing layout	8	wide corridors	3
clear layout	11	big shops	1
big	8	small shops	8
small	3	comfortable	2
average size	8	uncomfortable	5
good for clothes	5	warm	5
good for food	3	cold	6
brightly lit	2	colorful	3
dimly lit	6	drab	12
high ceilings	7	interesting	4
low ceilings	5	boring	15
narrow corridors	17		

1) in overall length and width; 2) in the number of corridors; 3) in the orthogonality of the paths within a rectangular perimeter. The correct plan was identified eight times. Those examples with fewer corridors were not chosen while 14 individuals chose plans that had a larger number of corridors. Everyone recognized the center had an orthogonal layout and was close to a square in shape; i.e. no one chose those plans where width and length varied considerably. We conclude that our participants exaggerated the size and complexity of

the center but recognized the basic layout and shape.

Finally, they were asked to freely select from a list of 23 word descriptors those that seemed to suit the shopping center they had visited. The average number of descriptions chosen was just 6.6 but opinions varied considerably about the center, as shown in Table II. There was generally greater agreement that the center was rather dimly lit, drab and boring. Of course, our intention to minimize local variation so as to draw attention to layout may have led to the generally held opinion that the center was rather uninteresting.

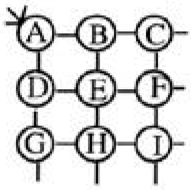
EXPERIMENT II

In a second experiment, the same model was transformed such that the corridors varied in width in three increments. The first choice offered was that of a wide hallway and a narrow one. As shown in Figure 5, the aggregated path choices are quite differently distributed when compared with the regular system in experiment I. In particular, there was a strong preference for the wider hall at the first choice point. Overall, there was a preference for the wider corridors over the narrow ones, although it will be obvious from the design that individuals were forced to take narrow hallways in order to traverse the centre. This pattern can be seen in detail in table III.

When they were asked to retrace their itineraries, the participants tended to emphasize the widest halls. They also often associated the markers in the hails (bench and location finder) with the widest halls although they were in fact not located there. As in the previous experiment, the visitors tended to cling to the outside walls and in about the same proportions as in that experiment. In other words, there was no greater tendency to enter into the centre and find its centre, even though wider corridors might suggest this visually.

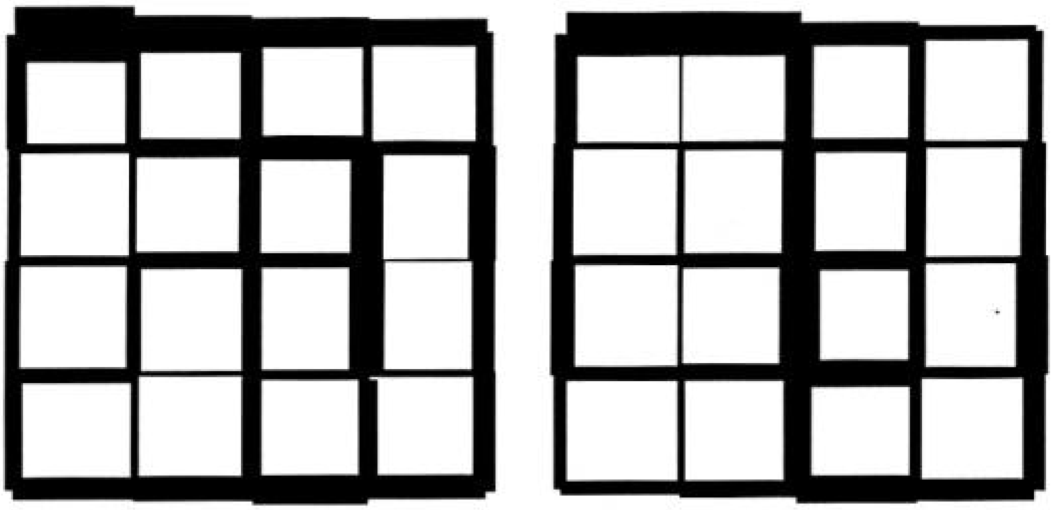
Table III: **Aggregate choices at intersections in experiment II**

a. path choice proportions at decision points



	A	B	C	D	E	F	G	H	I
n	25	13	12	13	7	8	8	9	8
	0.83	0.61	0.58	0.00	0.00	0.10	0.00	0.00	0.14
	0.17	0.33	0.42	0.75	0.00	0.00	0.00	0.75	0.43
		0.06	0.00	0.25	0.56	0.50	1.00	0.25	0.43
					0.44	0.40		0.00	0.00

Figure 5. **The accumulated paths of the 20 participants in experiment II are shown on the left; the accumulated remembered paths are shown at right.**



Finally, we asked whether individuals might remember their paths better simply because the width of the corridors was distinguishable in the three-dimensional model. This proved not to be the case. The distribution of incorrect choices in remembered paths is not signficantly different for experiment II. While some individuals remembered quite accurately their itineraries, others were much less adept.

Some problems with navigation were encountered with the second model. Narrow hallways tended to impede the individual's progress and this could be detected quite early by the participant. Calibrating the model to allow freer movement requires considerable work while the results must be tested on a number of individuals. The assistants working on the models themselves are poor evaluators of the eventual performance of participants.

Figure 6**: Individuals tend to prefer itineraries that circumnavigate the model.**

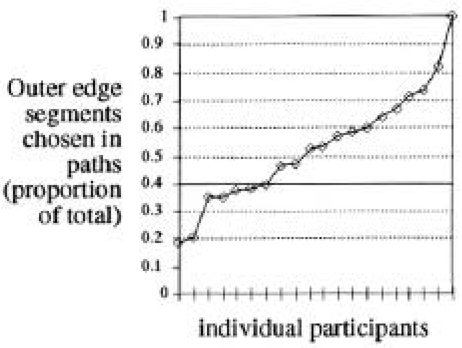
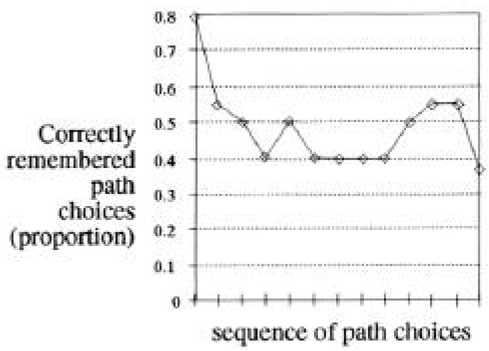


Figure 7**: Memory of the sequence of path choices in experiment II.**



CONCLUSIONS

The VRML engine is quite efficient and succeeds in simulating dynamic movement such that individuals feel they are moving through the environment and gaining a sense of **its** layout and content. It is an inexpensive way to run this kind of experiment. It has, however, a number of drawbacks at the technical level. Navigation is perhaps the chief of these. Secondly, if one wished to simulate environments at much higher resolution and with thousands or millions of colors, then the system slows down very substantially.

In a simulated environment with considerable complexity, relative to shopping environments in the real world, individuals use a simple navigation maneuver which consists of a loop or double loop. There is a clear preference for circumnavigating the center at the outset, rather than proceeding immediately to its center of gravity. Whether planned or not, the shape of this itinerary is remembered by the great majority of individuals while the specific path choices may be mistaken. Differentiating the paths by width does not improve on this performance.

On the other hand, differentiating the corridors by width has a significant impact on path choices. Wider paths are preferred over narrow ones, regardless of their position in the center itself. At least at the exploratory level, aggregated trips will be distributed differently when the path widths are different.

Other variations in the model need to be tested. In particular, we need to determine whether orthogonality has an important impact on movement patterns and whether it is more or less important than the width of the hallways.

REFERENCES

Book A. (1991) Spatial cognition as events, in Garling, T. and Evans, G. *Environment cognition and action.* Oxford University Press, New York, pp. 148-170.

Funihashi, Kunio (1991) Path choice in grid network of streets. *Journal of Architectural Planning and Environmental Engineering* 428, pp. 85-92.

Hillier, B. and Hanson, J. (1984) *The social logic of space.* Cambridge: Cambridge University Press.

Kaplan, R. (1985) The analysis of perception via preference: a strategy for studying how the environment is experienced. *Landscape Planning* 12, pp. 16 1-176.

Kent, R. L. (1989) The role of mystery in preferences for shopping malls, *Landscape Journal,* 8, 1, pp. 28-3 1.

O'Neill, Michael (1992) Effects of familiarity and plan complexity on wayfinding in simulated buildings. *Journal of Environmental Psychology* 12, pp. 3 19-327.

Peponis, J., Hadjinikolaon, E., Livieraros, C., et al. (1989) "The spatial core of urban culture." *Ekistics 56,* pp. *43-55.*

Peponis, J., Zimring, C.M. and Choi, Y.K. (1990). Finding the building in wayfinding, *Environment and Behavior* 22, pp. *555-590.*

Zacharias, J. (1997a) Virtual path decisions of visitors to the historic core of Montpellier, France, *Proceedings of the international Conference on Behaviour-Environment Studies for the 21st Century,* Tokyo, pp. 609-6 19.

Zacharias, J. (1997b) The impact of layout and visual stimuli on the itineraries and perceptions of pedestrians in a public market. *Environment and Planning B: Planning and Design* **23,** pp. 23-35.