Visibility, movement paths and preferences in open plan museums: An observational and descriptive study of the Ann Arbor Hands-on Museum

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1. Introduction

Since the time museums first emerged, their social roles retain the same and enduring behavioral structure: bringing visitors together with objects on display and allowing them to engage with the knowledge that these objects convey. Throughout the visitors' exploration of museum space, the architectural design plays a critical role in facilitating visitors' encounters with the displays, because the museum experience cannot be separated from its physicality (Sirefman, 1999). This paper particularly concentrates on open plan museums and investigates whether visibility establishes the link between physical design and visitor's movement patterns.

The role of building and exhibition design in facilitating visitors' encounters with people and objects in the museum has been analyzed in several studies of environment behavior and Space Syntax research in the field of architecture. Among these, Peponis and Hedin (1982) investigated the ways in which the spatial representation of knowledge was reflected in and transmitted through the morphology of exhibition layout. Later, Choi (1991) investigated patterns of exploration and encounters in eight museum settings. His findings suggest that both deterministic and probabilistic models modulate and structure visitors' exploration patterns. Another study by Peponis and his colleagues (2003) has concentrated on open plan science exhibitions and the effect of exhibition layouts on visitors' spatial behavior. This study focuses on the effects of accessibility and visibility on visitor movement paths and engagement with display objects. Another group of studies refers to the research conducted in the field of museology, focusing on visitors' behavior, in order to understand the ways in which learning is facilitated in a visitor's encounter. Among these, Falk (1982), Serrel (1995) and Sandifer (1997) have suggested that the length of time visitors spend involved in an exhibition element predicts a visitor's engagement, and thus learning. The result of this study has been used later as a convention for measuring learning by visit duration (or stop time), in Peponis (2003).

Although previous studies on museums established that there is a link between visitors' patterns of exploration and physical design, how and through which means this link is predicted needs to be well understood. This paper argues that visibility is a critical aspect of physical design that influences visitors' spatial behavior.

This paper presents a case study of the Ann Arbor Hands-on Museum (AA-HoM), located in downtown Ann Arbor Michigan. The research focuses on visitors' spatial behavior in museums as patterns of path choice and exhibition element engagement. This question of path choice is particularly critical for open plan museums where visitors' spatial behavior is less determined by partitions or other physical constraints, but where some implicit boundaries are recognized through visibility. For this study, a visibility graph convention (isovists) and the digital tools for generating and analyzing these visual fields (Depthmap, Syntax 2D) are used to evaluate visibility patterns. These visibility results are then compared to observations of visitors' spatial behavior.

2. Museum Design and Circulation

A museum adds cultural and social value to communities. Exhibitions in a museum present knowledge through represented themes of art, history, science and technology, natural history, and music, among other fields. These themes are introduced to visitors through narratives structured in exhibition layouts with spatial arrays of display objects. An exhibition layout may show the intentions of a curator in presenting narratives in a particular viewing sequence, which implies a path visitors are expected to follow. A visitor's contact and engagement with objects in the museum occur along the path. Museum circulation and galleries also provide an environment for social encounters, introducing an aspect of museum visits as collective social experiences.

The manner in which museum architecture and the layout of the exhibitions constrain visitor circulation may determine visitors' patterns of interaction with display objects. Therefore, the way in which circulation constraints are structured is the central question of museum design.

2.1. Museum architecture and design prototypes

Examples of museum design in twentieth century architecture vary in ways of providing constraints on circulation. This variation reflects the different stylistic interpretations of the museum as a modern cultural institution.

Museums of the modern movement reflected the 'modern' ideals, such as "form follows function", and "transparency" in materials and functional boundaries. These ideals have re-introduced museum design by suggesting that an interior be merely defined with circulation space (form follows function), or be divided by only a few partitions in a rectangular volume (transparency). Two examples of modern designs, the "Museum of Unlimited Growth" (1939) by Le Corbusier (Figure 74), and the New National Gallery (1942) by Ludwig Mies van der Rohe in Berlin, illustrate these attempts (Montaner, and Oliveras, 1987). Le Corbusier's project illustrates a design in which continuous circulation dominates the museum's spatial organization. This scheme later appeared as a basic idea for the Guggenheim Museum (1945) by Frank Lloyd Wright, presenting restricted circulation around a central core. It has been argued that Le Corbusier's project is a modern re-interpretation of classical museum designs occurring in the nineteenth century with restricted/controlled circulation. Mies van der Rohe's building, on the other hand, suggests a museum environment in a rectangular volume, in which spatial organization barely implies a circulation path and vaguely divides gallery spaces with a few partitions. This building houses a volume that would have only a little influence on possible circulation paths that visitors may choose. Mies' museum design is noted as having some need for additional restrictions which could be created through the exhibition layout (Searing, 1986). Architectural historians argue that this building is a complete break with traditional museum design, and introduces a modernist flexibility in circulation with open plan organization (Quetglas, 1988).

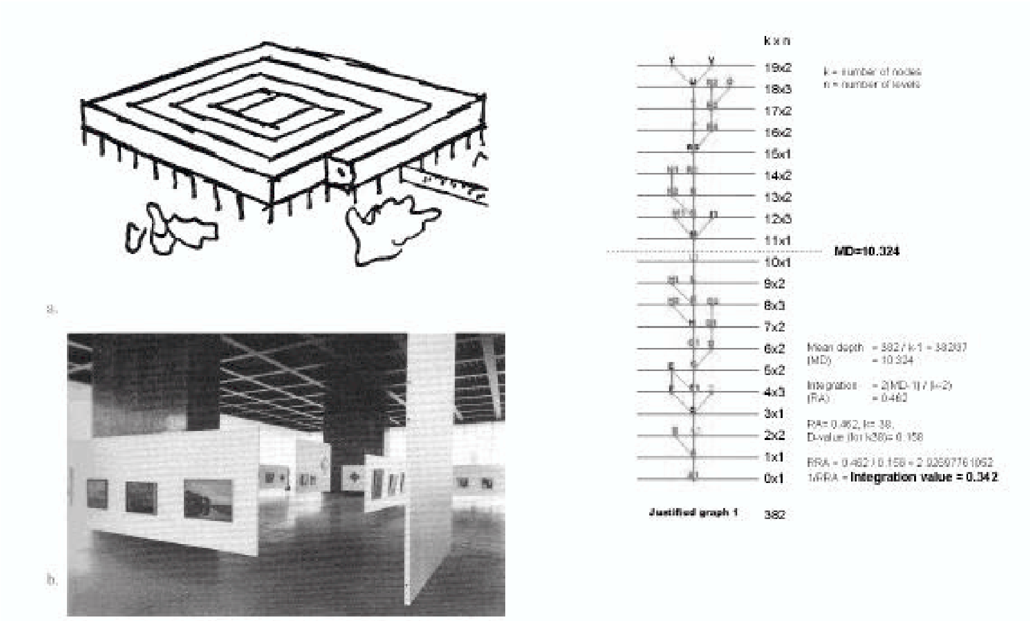

Figure 74: LEFT: (a) "Museum of Unlimited Growth" (1939) by Le Corbusier, sketch (source: Montaner, Oliveras, 1987); (b) New National Gallery, Berlin by Ludwig Mies van der Rohe, 1962-68; plan (source: Searing, 1985). RIGHT: Justified graph 1 of the AA-HoM, with Mean depth and Integration values calculated.

3. Museum with Open Plan Organization

Reviewing Le Corbusier's and Mies van der Rohe's designs implies two primary attitudes to museum design: restricted circulation, and open plan organization. These attitudes present two different sets of logic in museum design. In a museum with restricted circulation, visitors' accessibility to exhibitions would be limited to relatively few alternative paths of exploration. Thus, the visitors' museum experience follows a planned viewing sequence. Open plan organization, on the other hand, motivates more changeable circulation patterns and modulates more varied and distributed patterns of occupation. This results in visitors' choosing individualized paths and therefore individualized encounters with exhibit elements. This raises the question of how a curator can modulate the exhibit viewing sequence of visitors in an open plan exhibition.

3.1. Movement patterns in open plan museums: visibility?

Bill Hillier argues that "buildings are fundamentally about movement and how it is generated and controlled" (Hillier, 1996). Open plan museums provide an opportunity to investigate the effect of spatial layout on movement patterns, since visitor movement involves both circulation through spaces and stopping at particular display objects.

Physical boundaries connect or separate spaces, and reflect 'structures' in a building program. Thus, the "disposition and arrangement of boundaries" structure permeability in space and organize accessibility patterns in a building configuration (Peponis et. al. 1997). However, in open plan museums, physical boundaries are less prominent. The question that arises is the role of visibility in modulating visitor movement. First-time visitors tend to explore museum space to get an overall orientation to the space and to enjoy certain exhibit elements. The visual continuity in an open plan museum provides access to environmental information at a glance. Thus, it is proposed that this exploratory movement is influenced by visual access to environmental information.

A recently published study notes that "(T)he greater the limitations upon movement, the more movement patterns are distributed according to the layout" (Peponis et al., 2003). In open plan exhibitions, this observation prompts other questions: what are the critical aspects of visibility that motivate movement patterns to be more distributed? Which measures of visibility affect visitors' preferences? In fact, visibility in a building space, a three dimensional physical environment, is a more elusive variable than accessibility. Therefore, it is still an open problem as to whether visibility can be measured and strategically planned in open plan museums in order to motivate visitors' engagement within exhibitions. This problem can be investigated through analyses of an example.

4. An Observational and Descriptive Study of the Ann Arbor Hands-on Museum (AA-HoM)

4.1. The building, museum configuration and exhibition layout

The Ann Arbor Hands-On Museum is housed in a historic building in Ann Arbor, and serves as a children science museum with hands-on displays. Galleries and the main hall are spread out within the first and second floors. Administrative offices and rooms with special functions such as the science-experiment room are also located on the first and second floors next to gallery spaces (Figure 75).

The galleries hold temporary and permanent exhibitions consisting of interactive elements. Elements of the exhibitions are generally free-standing interactive kiosks and cubes. Some of these kiosks are designed in coordination with others to represent themes, such as “How things work”, “All about you”, “World around you”, “Media works”, “Light and Optics”. For this study, observations were conducted in the galleries of the first and the second floors, and analyses mostly concentrated on the first floor, where the temporary exhibition “Microbes”, and the permanent exhibition “How things work” are located.

On the first and second floors, the AA-HoM building has a partially open plan organization, with the gallery spaces usually in direct physical or visual contact to each other. After the entrance spaces (A1, A in Figure 74 right), a half-floor staircase (A2) allows visitors immediately to reach the main hall (C, F1) and two galleries (E and F). The main hall connects these two galleries (E and F) to the pre-school gallery (D and D1), and a corridor (G, and G1) that gives access to another gallery (H), or immediately to the second floor through C and the staircase S. Visual contact between parts of the building makes this accessibility noticeable for visitors, and allows them to adopt their own circulation path for exploring the exhibitions (Figure 74 right and figure 75).

4.1.1. Descriptive spatial analysis of the configuration

Studying the physical accessibility pattern of a building may imply how potential movement is distributed, and which local parts of a configuration may have a stronger effect on potential movement. Therefore, the justified graph of the first two floors the AA-HoM is created by defining convex polygons and their connections to each other in the open plan organization. Here, the boundaries of the convex polygons are defined to register the functionally distinguished units with non-physical boundaries.

Justified graph1 (Figure 74) right illustrates the global and local features of the building. The global measures of integration and mean depth indicate descriptive features of configuration relating to its capacity to distribute potential movement. As shown in Figure 74 right, the mean depth value is at a middle level and Integration-RA and Integration-1/RRA values indicate that the configuration shows a high level of (global) integration. On the other hand, local relations between spaces illustrated in Justified Graph1 help to discover parts of a configuration which may predict potential movement. For example, some segments of the justified graph represent the parts of the building that work as loops and create rings in circulation. Rings are described as circuits consisting of nodes and links in a configuration. Nodes in a ring have a higher number of links to other spaces than other nodes in a graph may have. The number of links that connect one space to the others is described by a local measure, “control”. The number of links, or the control value of a node represents that space’s position in controlling accessibility to other spaces. This character of a space or system is assigned with the term “distributedness”, suggesting a higher integration in that part, which also influences the overall configuration (Hillier and Hanson, 1984). Thus, rings are indicators of “distributedness” in a part or in the whole of a configuration, and this part or whole can be considered as places in which movement patterns are likely to grow (Hillier and Hanson, 1984). In this context, justified graph 1 of the AA-HoM illustrates some segments that may motivate the potential movement mentioned above. Particularly, the ring occurs through spaces C, F1, F, and E implying a greater potential to attract this movement than other segments. These spaces are further investigated within the observation results.

For instance the side of a window that may be partially obscured by a tree is considered to be a continuous line, while the top of a row of timber battens of the same height will similarly form a line. All potential lines or edges are graphed as points in an accumulator array, each with a specific magnitude provided by the number of pixels within the line, an example is shown in figure 74 right.

4.2. The Observations and data collection in the AA-HoM

4.2.1. Methods and objectives

As a method of observation, sixteen individuals' paths are tracked in the first thirty minutes of their visits and recorded on the plans with stop places, times and direction. Tracking records are basically treated to establish the portions where paths are more distributed. In addition, the records of stop locations are processed to determine the portions where the most frequent visits occur, and stop times (or visit durations) are noted to indicate the portions where visitors' engagement with the display objects is motivated in the museum. Qualitative observations were also recorded to describe observable behavioral patterns of the visitor groups and individuals in the AA-HoM, which were then used to understand quantitative results.

4.2.2. The observations in the AA-HoM

In the AAHoM, the science exhibitions with interactive kiosks attract school groups and families with children ages three to seventeen. Thus, the museum visitors are seen mostly as groups of children with adult guidance. The adults' need for watching and guiding the children increases the importance of visual connection within these groups of visitors, and, between visitors and display objects. This motivates a spatial pattern in which the adults are often static, keeping a visual connection to the children for whom they are responsible. On the other hand, children usually show dynamic patterns of wandering and discovering objects. These observations suggest that visibility has a critical role in the ways in which visitors explore and experience the museum interior.

Figure 75 illustrates the collected data on movement paths and stop locations. The collected data presents descriptive information about gallery spaces, display objects and visitors' preferences. Movement patterns predict the gallery spaces that have the highest number of visitors and the most distributed movement paths, and display objects that have the most frequent visits and the longest stop times. Accordingly, spaces labelled as M, F, E, D, and U show the highest number of visitors. The number of visitors in the galleries is directly proportional with the size of the galleries and the number of display objects contained in that space.

4.3. Visibility and the movement patterns

Observing the need for visual connection between visitors, adults and children in the museum suggests that visitor's behavior could be affected by the visibility patterns of the building design and exhibition layout. To explore this further, potential correlations between a visitor's movement patterns and visibility in the museum are investigated. This investigation focuses on selected locations within the building plan. These are galleries shown with convex polygons C, E, F, F1, G and G1 in Figure 74 right and Figure 75. Visibility graphs of these galleries are generated with Dephtmap and Syntax2D (developed by Turner, Taubman College of Architecture of Urban Planning, University of Michigan).

Figure 75: An accumulator array from Scape, the brighter points indicate significant boundaries within the image

Figure 76 displays some descriptive results of the visibility graph analyses generated for these spaces. Figure 76 also indicates that the main hall (C and F1) has the highest value of neighborhood size, which indicates highest inter-visibility.

4.3.1. Correlation between visit frequency and visibility, and visit duration and visibility

The display objects with the highest visit frequencies are associated with a strong interest in these elements, and this interest may be related to the features of the display objects that attract visitors or the syntactic properties of their locations (Figure 77). On the other hand, the display objects with the longest visit duration are associated with a high level of engagement, and this engagement can be explained by the appealing features of display objects or the syntactic features of the locations. The correlations between the syntactic measures of these locations and the visit frequency or stop time may indicate a spatial influence on visit patterns.

The display objects 2, 2a, 6a, 10, 12 and 8 (Figure 77-a) with the highest visit frequencies are superimposed on the visibility graph representation (shown earlier in Figure 76). It can be seen that these exhibition elements are located in the regions which have high visibility (high integration values). The visibility graphs of point isovists at the locations of these elements, demonstrate that the shape of the isovist polygons are mostly 'spikey', characterized by big differences between the measures of maximum and minimum radials of the isovist. This may suggest that these elements are visually accessible from many directions, far distances, and adjacent locations. This may motivate visitors to stop by these elements more often, which gives higher visit frequency. A measure called circularity is used to measure the shape of isovist polygons in terms of spikey-ness. However, there is no correlation found between circularity and visit frequency results and between other isovist measures such as area, perimeter, occlusivity, maximum-minimum radials and visit frequency. This may be due to the small observation sample that fails to reflect realistic variations in visit frequency. On the other hand, there may be no definite link between visibility and visitors' preferences for particular objects.

At the locations of display objects 21, 22, 20, 16 and 8, (Figure 77-a) with the longest (in average and total) stop duration isovist polygons are spikey (Figure 77 right). Yet, there is an insignificant correlation found between average visit duration and the circularity measure. This means longer visit duration occurs where environmental information is more indeterminate. The graphic interpretation of the link between longer stop duration and spikey isovists implies that variation and indeterminacy of visual information at the location of display objects may motivate visitors to spend a longer time at those locations.

4.3.2. Path choice, movement paths and visibility

Another spatial pattern of visitors' exploratory movements can be seen in path choice or, in other words, in change in the direction of a movement path. To investigate this, first the locations where path choice occurs most often are located in the tracking results, and second, a convention of detecting a change in the direction of a movement path is applied by measuring angularity of paths at the location of change. Accordingly, if the angle between the segment of a path entering the location and the segment of the same path leaving this location (denoted with a ninety-centimeter-circle on the plan) is less than 135 degrees, it is accepted that there is a direction change in this path. On the basis of this convention, locations C0, C1, C2, C3, C4, C5 and C6 are established as having

Figure 76: Visual representations of visibility graphs on the first floor (a) Neighborhood size graph, (b) Neighborhood size with superimposed paths

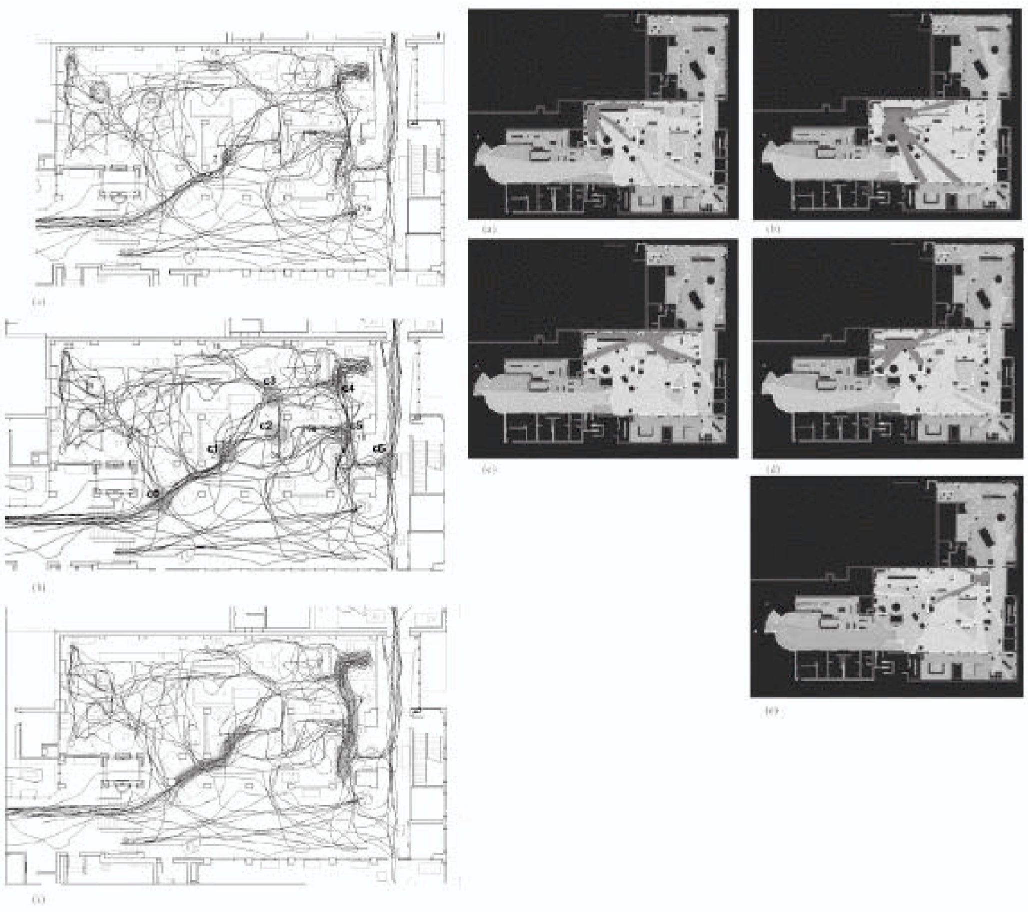

Figure 77: LEFT: (a) Tracking results in the galleries E and F, display objects with high visit duration and visit frequency marked. (b) Locations where path choice most obviously occurs. (c) Confluences in paths. RIGHT: Point isovist visibility graph at the display objects being visited for longest stop times (or visit duration).

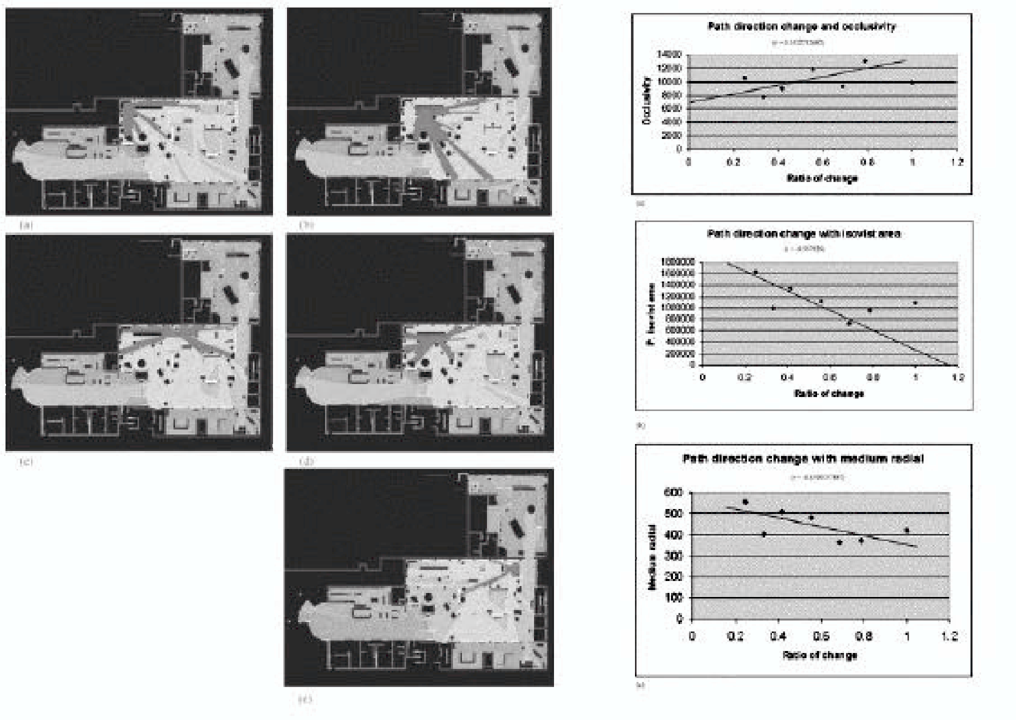

Figure 78: LEFT: Point isovist visibility graphs at the path choice locations. RIGHT: Correlations between ratio of change in direction and visibility graphs measures.

high direction change (Figure 77-b).

The potential of these locations in creating multi-directionality of the paths may be connected to the amount of visual information that visitors would have at these locations. Therefore, this connection is investigated in relation to the point isovist measures such as isovist polygon area, occlusivity and the ratio of direction change detected in each location. An isovist (polygon) area associates the amount of area seen from the vantage point of that isovist. This area also measures the area of first degree visibility, since it denotes the regions that are seen from a vantage point without any obstruction. Occlusivity, on the other hand, measures occluding radial boundaries which are, in fact, boundaries of an isovist polygon different than physical surfaces (measured by perimeter). This implies the potential of discovering the areas adjacent and beyond first degree visibility. Occlusivity of an isovist polygon, therefore, is associated with perceptual uncertainty of that isovist, which is determined by the occluding radial surfaces and the areas unseen within the first degree visibility. The point isovist polygons generated from the locations of change illustrate the first degree and second degree visibility with red and orange zones (Figure 78). Second degree visibility zones are generated by projecting visibility from occluded surfaces.

The correlation found between occlusivity and ratio of change indicates that perceptual uncertainty or the larger amount of unseen areas adjacent to an isovist polygon motivates variations in the direction of a path, and then modulates more distributed movement patterns. The negative correlation found between point isovist area and the ratio of change (Figure 78 right) also indicates that the bigger the area seen from these locations increases the amount of visual information and eliminates visitor's need for changing direction along a path, and in turn modulates less distributed movement patterns.

The tracking results also show that the two sets of movement paths in galleries E and F create confluence (Figure 77-c). Since no physical boundary (like walls of a hallway) creates this pattern in these galleries, other aspects of the layout may predict these confluences. When the tracking records are superimposed on the neighborhood size visibility graph (Figure 76-b), it is observed that the confluence mostly occurs in the regions with relatively low inter-visibility. This may indicate that the parts of a spatial layout that have access to the least visual information create an effect of channeling upon movement patterns, because visitors prefer to keep to the initial direction of a path.

The results mentioned above and the graphical interpretation of confluence can be further interpreted with cognitive theories on perception and preference suggested by Kaplan. His research on the characteristics of most preferred environments suggests that there is usually a positive response to views with larger areas of "mystery" or portions hidden from view. In other words, mystery, or visual uncertainty tends to attract visitors (Kaplan, 1992).

5. Conclusion

The effect of spatial layout on visitors' movement patterns in museums has long been discussed and validated in previous research. This study explores the ways in the spatial layout predicts visitors' movement patterns through a study of visibility. The contribution of this study is promising in suggesting a detailed understanding of the effect of visibility described with certain measures of visibility graphs.

This paper focuses on a study of an open plan museum, the Ann Arbor Hands-on Museum. The descriptive analysis includes understanding the museum configuration 'globally' on the basis of justified graph analysis. Portions of the museum are examined as a more detailed analysis of the effects of visibility on visitors' movement patterns.

The quantitative data of observations are compared with graphical and quantitative results of visibility analyses (by Depthmap and Syntax2D). Among the results of this investigation, there is no significant correlation between frequency of visit to display objects and visibility at their contact locations, although visual integration values graphically coincide with the locations of frequently visited objects. In the search for a link between longer visits to display objects and visibility at their contact locations, no correlation is found between visit duration and isovist measures such as area, perimeter and occlusivity. The insignificant correlation between visit duration and circularity, which implies a measure for spikey-ness, indicates that deformed circularity or spikey-ness of an isovist polygon motivates longer visit duration. This interesting result may be explained by the notion that when the accessibility to environmental information is less determinate, visitors' attentions are directed to the display objects.

On the other hand, the effect of visibility is stronger on path choice patterns. From observational data, locations that create path choice are identified. It is confirmed that there are correlations between the ratio of change at these locations and visibility graphs measures, such as point isovist area, occlusivity and mean radial. These results indicate that abundance in visual information modulate less distributed movement patterns. However, if the visual field includes larger areas of accessible, but visually obscured (occlusive) boundary, we observe more deviation among paths. This suggests more distributed movement in areas that provide opportunities to discover new visual information. It is also interesting that visibility graphs indicate that there is a confluence of movement paths in spaces which have very limited visual connection. This suggests that when visual choices are extremely limited, we see little variability among movement paths.

The results of this study suggest that visibility is a spatial feature through which spatial layout influences visitor movement patterns in open plan museums. In other words, open plan museums still structure and control visitors' movement patterns, but through more subtle features of spatial layout, such as visibility. In future work, it is expected that one can obtain more precisely confirmed results with a larger sample size and improved spatial analysis applications.

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Literature

Bafna, S. (2003) Space Syntax, A Brief Introduction to Its Logic and Analytical Techniques, *Environment and Behavior*, 35 (1), p. 17-29.

Benedikt. M. (1979) To take the hold of space: isovists and isovist fields, *Environment and Planning B: Planning an Design*, 6, p. 47-65.

Choi, Y K. (1999) The morphology of exploration and encounter in museum layouts, *Environment and Planning (B): Planning and Design*, 26 (2), p. 251-264.

Conroy Dalton R. (2001) Omnivista: An Application for Isovist Field and Path Analysis, *Proceedings, 3rd International Space Syntax Symposium*, Atlanta, Georgia Institute of Technology.

Falk J. H. (1982) The use of time as a measure of visitor behavior and exhibit effectiveness, *Roundtable Reports: The Journal of Museum Education*, 7(4), p. 10-13.

Gibson, J. J. (1966) *The Senses Considered as Perceptual Systems*, Boston, MA: Houghton Mifflin.

Hillier, B. and Hanson, J. (1984) *The Social Logic of Space*, New York: Cambridge University Press.

Hillier B. and Penn A. (1991) Visible Colleges: Structure and Randomness in the Place of Discovery, *Science in Context*, 4(1), p. 23-49.

Hillier, B. et al. (1993) Natural movement: or, configuration and attraction in urban pedestrian movement, *Environment and Planning B: Planning and Design*, 20, p. 29-66.

Hillier, B. (1996) *Space is the machine: a configurational theory of architecture*, New York, Cambridge University Press.

Ittelson, W. H. (1976) Environment perception and contemporary perception theory, in: *Environmental Psychology, in Proshansky, H M. et. al, (eds)*, New York: Holt, Rinehart and Winston, p. 141-154.

Kaplan S. (1982) Perception of an Uncertain Environment, in: *Kaplan, S. and Kaplan, R. (eds.) Humanscape: Environments for People*, Ann Arbor, Ulrich's Books Inc.

Kaplan, S. (1992) Environmental Preference in a Knowledge-Seeking, Knowledge-Using Organism, in: *The Adapted Mind: Evolutionary Psychology and the Generation of Culture, Barkow, J. H., et. al (eds.)*, New York, Oxford University Press.

Kaplan, S., and Kaplan R, (1982) *Cognition and Environment*, New York, Praeger (Republished by Ulrich's, Ann Arbor, MI, 1989).

Montaner, J. M., and Oliveras, J. (1987) Introduction, *The Museums of Last Generation*. Zurich: Karl Kramer Verlag.

Newhouse, V. (1998) *Towards a New Museum*, New York, Monacelli Press.

Ohno R. (2000) A Hypothetical Model of Environmental Perception: Ambient vision and layout of surfaces in the environment, in: *Wapner, S. et al., Theoretical perspectives in environment-behavior research*, New York, Kluwer Academic/Plenum Publishers.

Peponis J. (1993) Evaluation and formulation in design: The Implications of Morphological Theories of Function, in: *Nordisk Architekturforsking*, 6, (2), p. 53-62.

Peponis, J. (2001) Interacting Questions and Descriptions; How do they look from here?, *Proceedings,3rd International Space Syntax Symposium*, Atlanta, Georgia Institute of Technology.

Peponis, J. and Hedin, J. (1982) The layout of theories in the natural history museum, in: *9H*, (3), London, p. 21-25.

Peponis, J. et. al. (1997) On the description of shape and spatial configuration inside buildings: convex partitions and their local properties, *Environment and Planning B: Planning and Design*, 24, p. 761-781.

Peponis, J., and Wineman J. (2002) Spatial Structure of Environment and Behavior in: *Handbook of Environment and Behavior, Betchel, R. and Churchman, A. (eds.)*, New York, John Wiley and Sons.

Peponis, J. and Stravroulaki, G. (2003) The spatial construction of seeing Castelveccio, *Proceedings, 4th International Space Syntax Symposium*, London, University College London (UCL).

Peponis, J. et al. (2004) Measuring the effects of layout upon visitors' spatial behaviors in open plan exhibition settings, *Environment and Planning B: Planning and Design*, 31, p. 453 - 473.

Rosenblatt, A. (2001) *Building Type Basics for Museums*, New York, John Wiley & Sons Inc.

Quetglas, J. (1988) Fear of Glass: The Barcelona Pavilion in: *Architecture production, Colomina, B. and Ockman, J. (eds.)*, New York, NY, Princeton Architectural Press, p. 123 - 151.

Sandifer, C. (1997) Time-Based Behaviors at an Interactive Science Museum, *Science Education*, 81, p. 689-701.

Searing, H. (1986) The Development of a Museum Typology, in: *Building the New Museum, Stephens, S. (ed.)*, New York: Architectural League of New York.

Serrell, B. (1995) The 51% solution research project: A meta-analysis of visitor time/use in museum exhibitions, *Visitor Behavior*, 10(3), p. 6-9.

Serrell, B. (1997) Paying attention: the duration and allocation of visitors' time in museum exhibitions, *Curator*, 40 (2), p. 108-125.

SIREFMAN, S. (1999) Formed and forming: Contemporary museum architecture, *Daedalus*, 128(3), p. 297-320.

TURNER, A. AND PENN, A. (1999) Making isovists syntactic: isovist integration analysis, *2nd International Symposium on Space Syntax*, Universidad de Brasilia, Brazil.

TURNER, A., ET. AL. (2001) From Isovist to visibility graph: a methodology for analyzing the architectural space, *Environment and Planning B: Planning and Design*, 28, p. 103- 121.

TZORTZI, K. (2003) An Approach of the Microstructure of the Gallery Space: The Case of the Sainsbury Wing, *Proceedings, 4th International Space Syntax Symposium*, London, University College London (UCL).