Experiencing Museum Gallery Layouts through Local and Global Visibility Properties in Morphology

Ref 094

An inquiry on the YCBA, the MoMA and the HMA

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Keywords
building morphology; museum gallery layouts; visibility

Abstract
A critical issue in art museum design is to understand how morphology influences patterns of space use and shapes our spatial experience in galleries. Focusing on layouts with interior partitions and atria, this study explores the degree to which visibility structure predicts space-usage patterns, and how this prediction varies within the morphology of museum space. This question is addressed through the examination of three case study museums: the Yale Center for British Art, New Haven (YCBA), the Museum of Modern Art-New Expansion, N.Y. (MoMA) and the High Museum of Art, Atlanta (HMA).

For this investigation, visibility properties are correlated with three groups of space-use patterns: visitors' movement paths, stopping to view displays, and stopping to survey exhibitions and/or space. These patterns of space use are considered central to visitors' spatial experience, as they refer to navigation in galleries, contact with exhibit content and cognizance of overall layout.

The results of the investigation of visitors' movement patterns suggest that exploratory movement is significantly influenced by global and local visibility relationships of the three gallery layouts; yet, the degree to which movement is predicted by global versus local visibility varies in the three museums. Furthermore, visual information of both exposed surfaces and hidden regions (described by length of real and occlusive perimeter of isovists) play a role in the prediction of movement and choice of path direction. The results of the investigation of stopping behavior suggest that stopping to view displays may be negatively linked to global visibility, unless a gallery layout is highly integrated. The results show that stopping to survey the gallery is more consistently predicted by the visibility structure than stopping to view displays. These and other results can be explained with the variation in morphological characteristics, particularly in the gallery room shape and configuration, position of the atrium in the configuration and its relationship to the gallery rooms. The results of this study show that local visual information can predict the influence of global visibility on space use patterns. These results suggest that morphological characteristics shaped by atria and room configurations can create synergy between exploring displays and experiencing architecture.

1. Introduction: Aim, Objectives and Methodology

Which aspects of morphology can potentially shape our spatial exploration in museums? The morphological characteristics of museum galleries create a network of visibility relationships. These relationships aid visitors in locating exhibitions and grasping overall layout. To identify morphological characteristics that shape our spatial exploration, this study investigates how visibility relationships shape space-usage patterns. This investigation is addressed in three illustrative museums to trace how morphological variations play a role in the effects of visibility on space-use patterns.

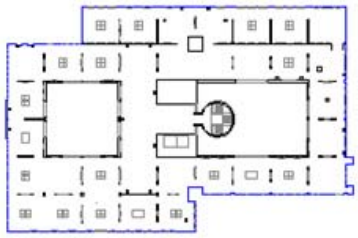
Previous studies in the museums field explore physical aspects of gallery and exhibition layouts influence on visitors' movement and orientation (Bitgood 1994, 1995, 2006; Bitgood and Patterson 1993; Falk 1993; Peart 1984; Yoshioka 1942). Previous studies using Space Syntax demonstrate that museum gallery layouts influence aggregate movement and stopping behavior through their global spatial structures (Choi 1991, 1999; Peponis et al. 2004; Psarra 2005; Psarra et al. 2007; Tzortzi 2003, 2007).

In this paper, we take a slightly different approach to the problem of understanding the effects of gallery layouts on space-use patterns. Instead of predicting aggregate space-use patterns on the basis of gallery spatial structure, this paper examines the influence of local visual cues. Therefore, we explore two key questions: (1) to what extent do global visibility relationships influence space-use patterns? (2) what can we learn about the capacity of morphology to influence space use patterns by investigating the effects of local non-syntactic visibility relationships? To explore these questions, we compare visibility properties with space use-patterns at two levels: the first level examines the link between global visibility properties and aggregate measures of spatial exploration, and this investigation takes a top-down characterization of space; the second level compares local and non-syntactical visibility properties with space-use patterns, considering a bottom-up characterization of space. The underlying hypothesis is that by exploring the effects of visibility relations on the basis of top-down and bottom-up characterizations of space, we can understand in detail which aspects of museum gallery morphology can shape our spatial experience.

We address these research questions by examining the main gallery layouts of three case study museums: the Yale Center for British Art, New Haven (YCBA), the Museum of Modern Art-New Expansion, New York (MoMA) and the High Museum of Art-with Expansion Wing, Atlanta (HMA). These museums are each characterized by gallery spaces arranged around atria. Yet, their morphologies show variations determined by the ways in which the atria spaces and gallery partitions are situated in the layouts (Fig.1).

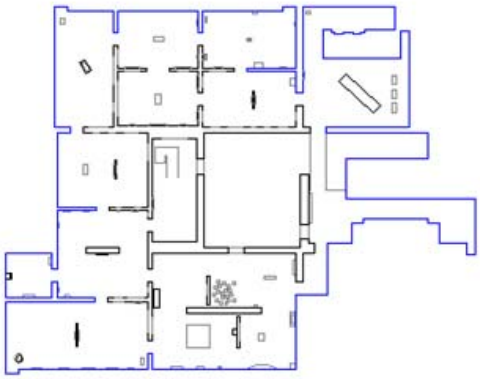
For the purpose of this study, visibility properties of the gallery layouts are described by using *Depthmap* and *Syntax 2D* applications (Turner 2004; Turner et al. 2006). Visitors' space-use patterns are obtained by tracking visitors' movement and observing them stopping to view exhibitions and to survey exhibitions and/or space. For data collection, around 25-34 visitors are tracked in each museums. Movement path data is compiled by recording the lines and direction of movement. Data on the behavior of viewing displays is collected by recording places where visitors' come to a full stop pausing for at least 1 second looking towards certain display objects. Data on the behavior of scanning galleries is compiled by recording where visitors stop for at least 1 second turning their head to survey the gallery environment. These patterns of space-use are considered central to the museum visit experience, as they refer to how people navigate in galleries, contact exhibit content and grasp gallery layouts. To investigate the effect of visibility properties on these space-use patterns, we correlate visibility properties with key measures of movement paths, counts of stops to view displays and counts of stops to survey exhibitions and/or gallery space.

We will present the findings of this study in the following order: First, we examine visibility graphs and discuss how visibility is engendered within the morphology; second, we examine how space-use patterns are distributed in the layouts, and third, we present the results obtained from correlating the space-use patterns with global syntactical and local non-syntactical properties.



(a) The Yale Center for British Art (YCBA), fourth floor gallery

(b) The YCBA's main atrium



(c) The Museum of Modern Art-New Extension (MoMA), fourth floor gallery

(d) The MoMA's atrium

(e) The High Museum of Art, skywalk (uppermost) floor of Wieland (left) and Stent (right) wings

(f) The HMA's atrium at the Stent wing

Figure 1
Floor plans to scale and interior views of the galleries showing the atria spaces

2. Visibility Structure within the Morphologies of the YCBA, the MoMA and the HMA

In the visibility graphs of the three layouts in Figure 2 [1] and the values in Table 1, we see that the YCBA is visually the most integrated building. The location of the two atria and their relationship with the galleries, as well as relations among the galleries bring about strong levels of visual integration. In the HMA, visual integration is less strong and seems concentrated on the longitudinal axis connecting the spaces to all other spaces. The MoMA has the lowest level visual integration; the atrium shifts the integration to itself reducing the capacity to be visually close to other spaces in the gallery area.

The connectivity graphs show that in the YCBA and the MoMA visual information of adjacent spaces is available through the doorways connecting the gallery rooms. Yet, in the YCBA, connectivity values are higher at the galleries adjacent to the atria openings, because the atria release the information of galleries across space, and enhance the capacity to see neighboring locations. In contrast, the atrium in the MoMA does not reveal much information and thus the

evenly distributed visual connectivity throughout the gallery rooms remain around the same levels. In the HMA, the capacity to see neighboring locations is at higher levels at the central core due to its relations with the galleries around this core.

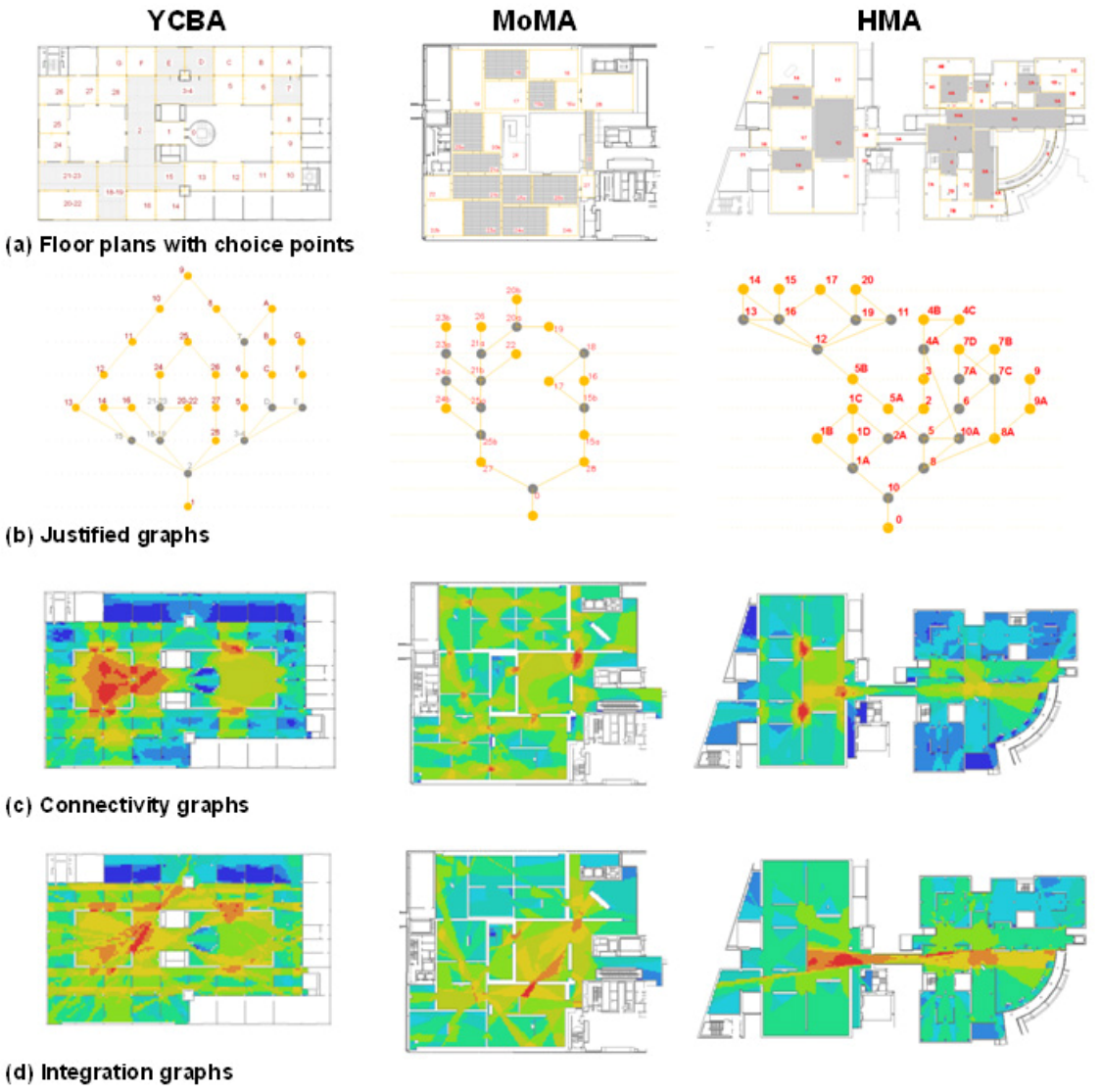


Figure 2
Comparison of Gallery Layout in terms of their Spatial Layout Properties

	YCBA	MoMA	HMA
***r* value**	0.82	0.75	0.77
R^2 value	0.67	0.56	0.59
Mean V. Connectivity	782.58	916.46	1018.46
Mean V. Integration	8.24	6.08	7.07
Number of grid cells	6466.00	11033.00	11423.00

Table 1
Comparison of Visual Intelligibility, Mean Connectivity and Mean Integration measures along with the gallery areas measured by number of grid cells

The visual intelligibility values of the three museums explain the three museums' capacity to reveal the entire layout through their local cues (Table 1). When we look at their visual intelligibility properties, we see that the YCBA has the highest level of visual intelligibility; the intelligibility values

at the HMA and the MoMA are lower in value. In Table 1, the size of the each gallery layout analyzed is indicated by the number of (equally dimensioned) grid cells measuring the gallery space. If we examine the intelligibility levels with regard to the gallery layout size, we see that the MoMA and the HMA have lower intelligibility in their larger gallery spaces. Thus, in those museums visitors would need to cover larger areas in order to grasp the entire layout through local visual cues; whereas in the YCBA, visitors will more easily learn the entire gallery through perception of local visual information.

3. Visitors' Spatial Behavior in the Three Gallery Layouts

Before comparing the space-use patterns with visibility we examine how these patterns are distributed in the three gallery layouts. To understand how visitors' movement is distributed in the gallery layouts, we focus on exploratory movement which can be described by the concentration of movement lines in space. The galleries in which a high density of movement are recorded are likely to be visited by many visitors or visited many times (indicating higher use than other parts of the museum). To obtain a measure of exploratory movement, we take the counts of movement lines entering each convex gallery space, regardless if those lines result from several visits of the same visitors. Our examination indicates that in the YCBA movement seems to be concentrated on the gallery space located in between the two atria, and the overall rate of movement is higher in this gallery and those situated around the two atria. In the MoMA, movement appears to be concentrated in the room sequence starting from the north entrance and moving towards the south galleries in a counter-clockwise direction. In the HMA, the highest number of movement lines crossing the galleries is in the galleries located along the longitudinal axis connecting the two wings of the museum (Fig.3).[2]

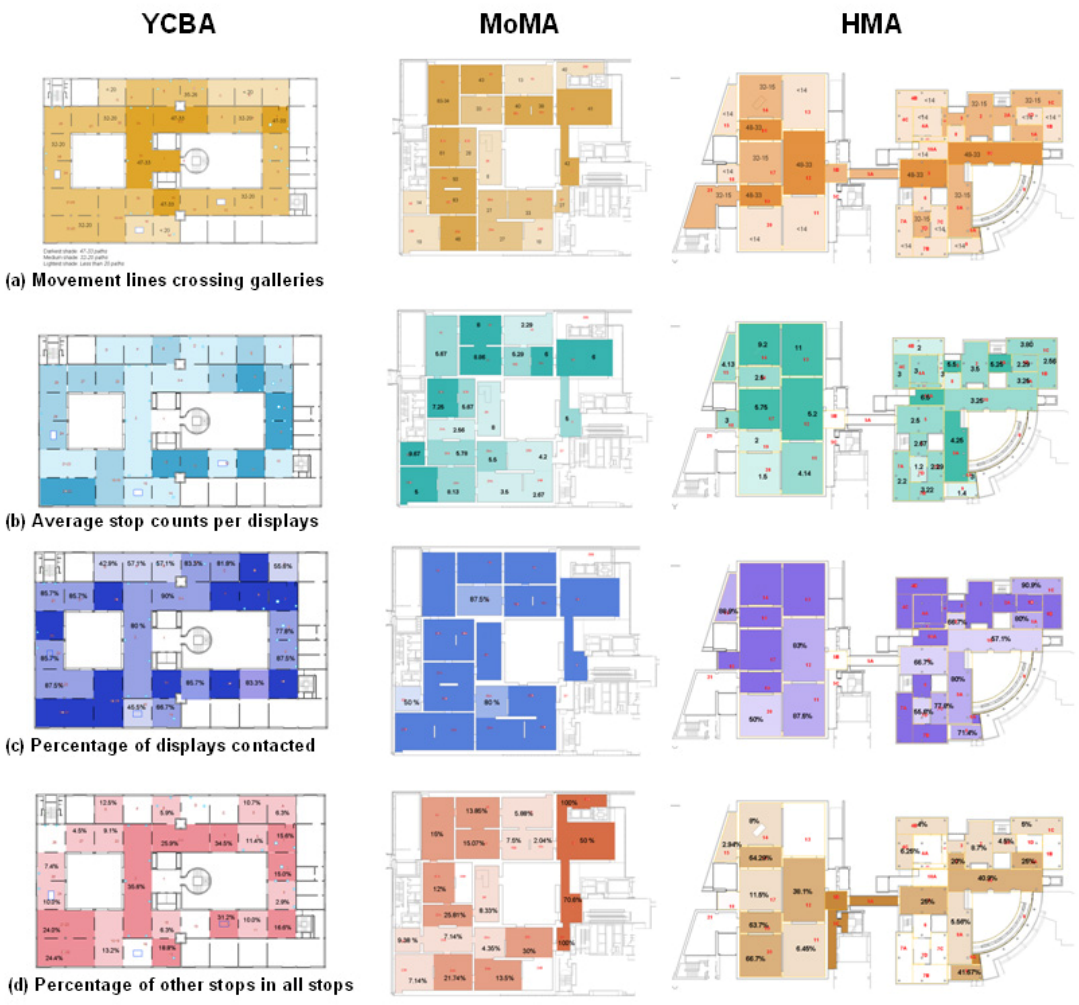


Figure 3
Comparison of Gallery Layout in terms of their Spatial Layout Properties

To understand in which galleries visitors contact displays more frequently, we examine a number of measures obtained from the stop counts in the three museums. One of these measures is obtained by counting the stops viewing each display object and taking the average of these counts in each gallery. The second way of looking at stopping behavior is through counting how many displays in each gallery were viewed by visitors. When the distributions of these two measures are examined in the three gallery layouts, the results seem greatly varied in terms of the kind of locations visitors tend to stop and view the displays. In the YCBA, the galleries where visitors stopped most frequently to view displays are located around the atria. In the HMA, visitors stopped more frequently and viewed higher numbers of displays in the galleries situated at the periphery. In the MoMA, the spaces where displays are viewed frequently do not show a particular pattern; in fact we observe that the rate of contacting displays is higher in the galleries where popular paintings are located. When we compare the stopping counts with exploratory behavior, in both the MoMA and the HMA, we see that high rates of stopping do not always overlap with high rates of movement. This disparity between the patterns of contacting displays and dynamic space use will be discussed further along with the correlation results.

To examine the patterns of stopping to survey the galleries, we look at the stops that took place as visitors scanned galleries visually or looked at the atria. We named them 'scanning stops' here for the sake of brevity. This measure refers to the relative frequency of 'scanning stops' within all stop counts and represents the rate of stopping to visually survey the gallery space within the general stopping behavior. When we examine this percentage, we realize that the rate of 'scanning stops' is usually higher in the spaces where movement is concentrated. This observation suggests that visitors' behavior of scanning galleries takes place at the same places characterized by exploratory movement.

4. Prediction of Space-Use Patterns by Visibility Properties

To investigate the prediction of space-use patterns, we correlate key space-use measures with global syntactic and local non-syntactic visibility properties in the case study gallery layouts.

4.1. Patterns of Exploratory Movement and Visibility Properties

When we correlate the number of movement lines entering each gallery with global visibility properties of those galleries, the results show that in all three gallery layouts exploratory movement is linked with the property of integration ($R^2_{int\text{-}YCBA}$= 0.58, p=0.000; $R^2_{int\text{-}MoMA}$= 0.18, p=0.047, $R^2_{int.HMA}$= 0.32, p=0.000; Table 2). The results indicate that this link varies in strength and significance throughout the three layouts. In the YCBA, the property of integration seems to predict more than half of the variation in movement lines. Integration predicts one third of the variation in the HMA, and around one fifth of the variation of movement lines in the MoMA (with much less significance). When this investigation is repeated in terms of visual connectivity, the number of movement lines is found to be associated with the property of connectivity, but again the strength of this association varies in the three layouts. The correlation results show that in the MoMA connectivity has the strongest association with movement, while in the YCBA it has the weakest ($R^2_{conn\text{-}YCBA}$= 0.36, p=0.000; $R^2_{conn\text{-}MoMA}$= 0.46, p=0.000, $R^2_{2conn\text{-}HMA}$= 0.41, p=0.000; Table 2). This result suggests that in the MoMA local visual information, described by the capacity to see neighboring locations, seems quite influential in guiding visitors' exploration. Although this property has a weaker effect on movement in the HMA and the YCBA, it still plays an important role in how people move through these layouts. If we interpret these results in reference to the three gallery layouts' general level of integration and connectivity (represented by mean integration and mean connectivity values in Table 1), we see that the extent to which exploratory movement is predicted by visibility properties is parallel to how strong these properties are in the spatial structures of the gallery layouts.

In the second step of this investigation, we correlated the number of movement lines in each room with (non-syntactic) grid isovist values of the rooms. This investigation shows that movement is predicted by local non-syntactic properties, such as isovist occlusivity, perimeter, isovist maximum radial and isovist area quite significantly (Table 2). In both the YCBA and the MoMA, the higher degree correlations were found with isovist occlusivity, perimeter and area measures. This

indicates that in these gallery layouts hidden regions (expressed by occlusivity), exposed wall surfaces (denoted by perimeter), and size of visible regions (expressed by area) are important aspects of local visual information modulating movement. In the HMA, hidden regions and exposed surfaces seem to be less important, while the size of visible regions is the most influential local aspect that predicts movement.

		Visual Integration (HH) Max.	Visual Integration (HH)	Connectivity	Visual Control	
Number of movement lines crossing each gallery	YCBA	0.77	0.76	0.60	0.38	*r*
		0.000	0.000	0.000	0.031	*p-*
		0.59	0.58	0.36	0.14	R^2
	MoMA	*No correlation*	0.43	0.68	0.66	*r*
			0.047	0.000	0.001	*p-*
			0.18	0.46	0.44	R^2
	HMA	0.44	0.57	0.64	0.54	*r*
		0.006	0.000	0.000	0.001	*p-*
		0.19	0.32	0.41	0.29	R^2
		Isovist Occlusivity	**Isovist Perimeter**	**Isovist Max Radial**	**Isovist Area**	
	YCBA	0.67	0.69	0.38	0.64	*r*
		0.000	0.000	0.033	0.000	*p-*
		0.45	0.48	0.14	0.41	R^2
	MoMA	0.64	0.72	*No correlation*	0.68	*r*
		0.001	0.000		0.001	*p-*
		0.41	0.52		0.46	R^2
	HMA	0.38	0.49	0.40	0.65	*r*
		0.017	0.002	0.014	0.000	*p-*
		0.14	0.24	0.16	0.42	R^2

Table 2

Correlation of number of movement lines with syntactical and non-syntactical VGA measures in the rooms of three gallery layouts

Another step of this investigation focuses on the paths distributed in available directions at the spaces offering choice, and investigates the extent to which local isovist properties (non-syntactic) predict peoples' choices to move towards these directions. This particular investigation aims to explore which directions visitors take based on the gradual unfolding of visual information as they move in the layout. Therefore, the visual field measures used are based upon visibility at knee-level, which in fact registers permeability. It is hypothesized that permeability is most likely to shape visitors' choices in movement direction (Wineman & Peponis).[3] For this investigation, movement lines are counted and proportioned to the total number of movement lines in all available potential movement directions leaving the spaces offering choice. The percentage values of these lines in relation to all movement lines are correlated with proportions of isovist measures in the corresponding directions. We found that in all three gallery layouts, isovist occlusivity, representing availability of hidden regions, has some effect on visitors' choice in the direction of movement. This suggests that visitors have some tendency to move towards the directions where they can explore hidden regions, and this tendency is stronger in the YCBA than other layouts (Table 3). The correlation between isovist perimeter and movement paths in the MoMA and the HMA indicates that visitors seem attracted to directions with more visible wall surfaces. The effect of area and drift in the HMA's gallery indicates that visible area extending away from the visitors' vantage points plays quite an important role in the distribution of movement in permeable directions.

		Area	Drift	Perimeter	Occlusivity	Compactness	
Movement line ratio in available directions	YCBA	*No correlation*			0.58	0.40	*r*
					0.002	0.044	*p-*
					0.33	0.15	R^2
	MoMA	*No correlation*		0.45	0.39	*No correlation*	*r*
				0.012	0.031		*p-*
				0.20	0.15		R^2
	HMA	0.57	0.63	0.56	0.40	0.57	*r*
		0.000	0.000	0.000	0.013	0.000	*p-*
		0.32	0.40	0.31	0.16	0.34	R^2

Table 3

Correlations between percentage of movement lines and visual field measures in corresponding directions at the choice locations

With these results in mind, we see that the three gallery layouts seem to guide visitors at a local level with visual attributes that become available through room configurations and display arrangements. The results imply that in the MoMA and the YCBA the extent of visible wall surfaces (and by extension their associated displays) have a role in shaping exploratory movement. In the HMA, the demonstrated effect of isovist area on movement may be affected by the larger size of the gallery spaces (in comparison to MoMA or YCBA) that may offer visitors attractive visible areas. The demonstrated link between movement and isovist maximum radial in the HMA and the YCBA may be explained by the fact that their galleries offer distant views which apparently attract visitors, whereas this characteristic is not offered in the morphology of the MoMA.

4.2. Patterns of Contact with Displays and Visibility Properties

To investigate how layouts impact visitors' contact with displays, we correlated counts of stops viewing displays with global syntactic and local non-syntactic visibility. We took the stop counts recorded in each gallery and normalized the counts with room areas and number of available displays in order to compare the results obtained from the three layouts. The investigation performed by the stop counts normalized with the number of displays demonstrates that stopping frequency in each room is linked with visibility at the global level. In the YCBA, visitors stop at integrated spaces more than other spaces. In contrast, in the MoMA, visitors tend to stop less to view displays at visually integrated spaces. Visual connectivity does not appear to influence stopping behavior in either the YCBA or the MoMA.

When this investigation is repeated with the stop counts normalized by room areas, this time we see that in the HMA stopping to view displays appear more often at the spaces with low connectivity and low integration. These results suggest that except for the YCBA, in the MoMA and the HMA visitors' contact with displays co- varies inversely with visual integration, and in the HMA there is also an inverse relationship with connectivity.[4] The varying effects of integration on viewing displays can be explained by the placement of popular displays in segregated galleries. Yet, the inverse effect of integration on viewing displays may suggest that visually segregated locations may provide visitors with enhanced opportunities to focus on the displays.

When we correlated the stop counts (normalized by displays) with non-syntactic properties, we found a positive association with the isovist maximum radial and a negative link with isovist compactness in the YCBA. Isovist compactness expresses the degree to which a visible region is convex in shape. The negative effect of isovist compactness suggests that visitors tend to stop more often in galleries where visibility is extended as one moves around in the space (in contrast, a convex shape would provide constant visual information anywhere within the shape). The

significant correlation with longer lines of sight suggests that visitors stop to view displays more often in locations that offer longer visual vistas. Perhaps, this behavior is associated with a smaller exhibition area (YCBA) whereas in a larger museum, such as the HMA, we see the opposite behavior. In the HMA, our research indicates a negative association between stopping behavior and visual field area. It is characteristic of this larger museum that visitors tend to contact displays in locations that have fairly contained views.

		SYNCACTIC		NON-SYNTACTIC		
		V. Integ. (HH) Max.	V. Integration (HH) Avg.	Isovist Compactness	Isovist Max Radial	
Stops at displays (normalized by n. of displays)	YCBA	0.38	0.45	-0.48	0.52	*r*
		0.033	0.012	0.006	0.003	*p-*
		0.14	0.20	0.23	0.27	R^2
	MoMA	-0.45	-0.51	*No correlation*		*r*
		0.039	0.019			*p-*
		0.20	0.26			R^2
	HMA	*No correlation*		*No correlation*		*r*
						p-
						R^2

Table 4

Correlations between display stop counts (normalized by displays) and visibility measures in each gallery room

		V. Integ. (HH) Max.	V. Integration (HH) Avg.	Connectivity	Isovist Area	
Stops at displays (normalized by room areas)	YCBA	*No correlation*			*No Correlation*	*r*
						p-
						R^2
	MoMA	-0.67	-0.51	*No Correlation*	*No Correlation*	*r*
		0.001	0.019			*p-*
		0.45	0.26			R^2
	HMA	-0.54	-0.57	-0.50	-0.55	*r*
		0.001	0.000	0.002	0.001	*p-*
		0.29	0.32	0.25	0.30	R^2

Table 5

Correlations between display stop counts (normalized by room areas) and visibility measures in each gallery room

These results demonstrate that local and non-syntactic properties shape in various manners stopping behavior to view displays in the three layouts. This variation may also explain the different effects of visual integration on viewing displays in the three museums. In the previous step, the effects of visual segregation on stopping behavior in the MoMA and the HMA indicate that visitors tend to contact displays more often in galleries that are segregated from the rest of the layout offering the potential for focused viewing. Furthermore, the results obtained from local non-syntactic measures confirm that in the HMA visitors tend to view displays more often in locations where views are contained, (consistent with the demonstrated link with low connectivity). On the other hand, in the YCBA, visitors tend to contact displays more often in visually integrated spaces; and local non-syntactic measures suggest that visitors view displays more often in locations with longer lines of sight and non-convex visual fields. Perhaps in the YCBA, a smaller gallery overall (see Table 1), visual information extending beyond the confines of each gallery space motivates visitors to stop and view displays.

4.3. Patterns of Contact with Galleries and Visibility Properties

In order to investigate the effect of visibility on 'scanning stops', we correlated the percentage rates of these stops (in relation to all stops) with the global syntactic and local non-syntactic visibility. This analysis shows the effect of visibility on the rate of stopping to survey galleries varies in the three layouts. In the HMA, the rate of stopping to survey the galleries is not linked either with global or local visibility properties. In the YBCA, visitors seem to survey the gallery environment when they can be well connected to neighboring locations and visually close to other spaces in the layout. Similarly, in the MoMA, the results show that the rooms' capacity to be visually close to other spaces (visually integrated) motivates visitors to stop to scan the galleries.

When the rates of scanning stops are correlated to local and non-syntactic properties, we see that different aspects of spatial layout have an effect on scanning stops. In the YBCA, isovist occlusivity and perimeter are the important spatial characteristics that have a role in shaping visitors' tendency to visually scan the galleries. In the MoMA, isovist maximum radial seems to impact the rate of scanning stops (Table 6). The results suggests that hidden regions and exposed wall surfaces in the YCBA and long lines of sight in the MoMA have a role in motivating visitors to visually scan the gallery space.

		Visual Integ. (HH) Avg.	Connectivity	Isovist Occlus.	Isovist Perimeter	Isovist Max. Rad.	
Percentage of other stops (scan + look at atria) in all stops	YCBA	0.50	0.62	0.48	0.51	*No correlation*	*r*
		0.005	0.000	0.007	0.003		*p*
		0.24	0.38	0.23	0.26		R^2
	MoMA	0.48	*No correlation*	*No correlation*		0.44	*r*
		0.025				0.042	*p*
		0.23				0.19	R^2
	HMA	*No correlation*		*No correlation*			*r*
							p
							R^2

Table 6

Correlations of rate of other stops in all stops with VGA measures in galleries

5. Discussion of the Results

These results provide us with a detailed understanding of how morphology may work in shaping the museum visit experience. First, the links we found between space-use patterns and syntactic visibility properties indicate that visitors are guided by the best available levels of visual information in the gallery layouts. Since the MoMA and the HMA have lower levels of mean integration and they are relatively less intelligible than the YCBA, it is the connectivity value that guides exploration. The property that predicts explorative movement is visual integration in the YCBA. When we interpret these results along with the morphological characteristics of the three layouts, we can see that the YCBA's morphology, shaped with two atria visually linking the galleries in multiple directions, provides global scale information that guides visitors' movement. In the MoMA, visual information is distributed predominantly at the local level and through doorways connecting rooms; thus visitors are guided locally through progressively disclosed information. In the HMA, the visual information is also distributed at the local level through links between the central axis and the gallery rooms, as well as connections among the gallery rooms. Thus, for MoMA and HMA, visitors' movement is predicted by local level visibility more strongly than global level visibility.

In addition to these interpretations, our analyses focusing on non-syntactic properties show that local visual cues shaped by morphology seem to have a role on the distribution of movement. More specifically, the effects of various local visibility characteristics, for example isovist area in the HMA versus the exposed wall surfaces in the MoMA, explain the ways in which local visual information structured through room partitions (and by extension their associated displays) guides

visitors in navigation. Interestingly, we found that it is not only the immediately available visual information (i.e. exposed wall surfaces and visible area), but also visually hidden areas that seem to motivate visitors' explorations. Especially, at the spaces offering choice, hidden regions seem to attract visitors' movement.

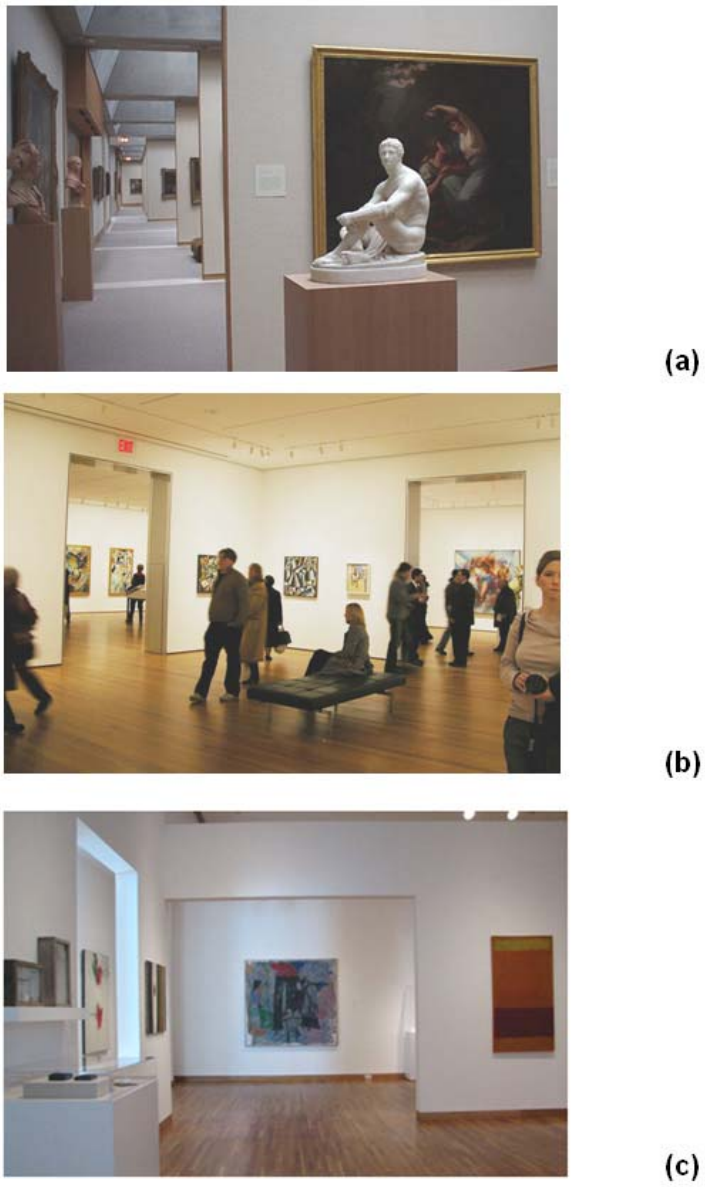


Figure 4
Interior views from the galleries of the three museums
(a) YCBA, (photo: I. K. Rohloff), (b) MoMA (S. Psarra), (c) HMA (photo: I. K. Rohloff)

Our findings concerning the behavior of viewing displays reveal some other aspects of the gallery layout morphology that shape the museum visit experience. These results indicate that the absence of strong integration levels (and/or the correlated larger size of the gallery) may shift visitor focus to viewing displays instead of exploring the layout. In the MoMA and the HMA (both larger museums as compared to YBCA) where visual integration is limited and localized, visitors stop to view displays in segregated galleries although they move through these galleries less often. This result suggests the following observations: First, since global segregation limits visual cues beyond the confines of the galleries, this may motivate visitors to contact displays by creating opportunities for contemplative experience in space. Second, morphological properties reveal or limit global level visibility. For example, the YBCA's morphology creates few segregated spaces

and renders most of the layout visually integrated. In the YBCA this capacity is afforded by room and atria configuration (in a smaller layout) allowing projecting lines of sight into spaces beyond the confines of the galleries; whereas such a potential appears to be more limited in the MoMA and the HMA. If we look at general morphological characteristics of the three museums, in the MoMA and the HMA, the room and atria configuration separates the central (visually more integrated) spaces from peripheral (visually more segregated) ones. In the YCBA, the atria and room configuration enhances visibility opportunities towards the periphery to a larger extent than in the two other museums (Fig.4).

If we compare the ways in which exploratory movement and viewing displays are predicted, we see that in the YCBA these two patterns are predicted by similar properties. This suggests that visitors stop and view displays in the same galleries where they are also often observed moving through. In contrast, in the MoMA and the HMA, visual integration impacts stopping to view displays in an opposite way than it predicts exploratory movement, and thus viewing displays and exploratory movement take place in different parts of the gallery layouts. This may be attributed to morphological properties which create a visual separation of central and visually integrated spaces from the peripheral spaces.

Other results concerning the prediction of scanning stops suggest that global visual integration seems to create opportunities for visitors to establish contact with gallery space and grasp the layout through visual scanning. If we consider this behavior as an opportunity for experiencing architecture, our findings indicate that this experience can be motivated by visibility structure. In the YCBA, integration motivates stopping to survey galleries, along with predicting exploratory behavior and viewing displays. Thus explorative movement appears to coincide with experiencing architecture as well as viewing displays. However, in MoMA global integration seems to motivate scanning behavior much more explicitly than predicting movement, while discouraging the behavior of stopping to view displays. These findings become more interesting when we demonstrate that scanning behavior is more frequent in locations characterized by long lines of sight (isovist maximum radials). This local spatial property helps visitors grasp information beyond the confines of the visited gallery rooms, and thus maintain contact with global levels of visibility. Through this local property, the MoMA's layout seems to create the opportunity for visitors to visually orient themselves in the gallery environment. By predicting scanning behavior on the basis of long lines of sight and integration, which are afforded by the few openings to the central atrium, the MoMA's gallery layout separates the experience of architecture from the experience of displays.

6. Conclusions

This discussion leads us to a number of important conclusions. First, the gallery layouts motivate visitors' exploration through the best available visual information. This effect of the gallery layouts on exploration can be explained by local visual cues and the extent to which they expose additional visual information. Second, the absence of global levels of visual information may shift attention from exploring layouts to focusing on displays. This effect may result from segregated layouts where local visual cues limit opportunities of accessing the information of neighboring spaces. Third, in smaller gallery layouts visitors are likely exposed to visual information beyond the visited galleries and have a less contained view and this might result in integration to be a factor motivating viewing displays. These conclusions suggest that aspects of morphology may motivate the exploration of layouts, viewing displays and experiencing architecture.

One of the critical issues in planning museum buildings and galleries is to enhance legibility of the layout so that it guides visitors in their exploration, while also offering opportunities for focused viewing. Shaping the museum experience is a significant priority for an art museum. Due to the synergy between the artwork and the architecture, the value of the collection is intensified by the architectural values invested in the building. The YCBA achieves high levels of synergy between the activities of exploration, viewing displays and viewing the building. In contrast, the MoMA and the HMA dissociate the experience of navigating, and viewing displays from experiencing the architecture. In these buildings, visitors stop to see artwork in segregated locations, while contact with the larger building space is through only a few openings to the atria in integrated locations. If

architecture is an integral aspect of cultural experience as is the art work (Hillier 1996), it can be suggested that architectural design should work in such a way that morphological characteristics support experiences with both art and architecture. Viewing paintings and appreciating a building are not opposite purposes but complementary aspects of a museum visit. Our work attempted to demonstrate how this capacity can be enhanced through morphology to inform architectural design decisions.

Notes

1 This study is interested in understanding how the characteristics of the gallery layout influence patterns of space-use. Therefore, only the spatial properties in those gallery layouts are taken into consideration.

2 This analysis is based on an examination of the effects of visibility on movement patterns and does not account for the influence of visitors' familiarity with the museum/exhibits. Future research could examine the percentage of visitors that visit for the first time compared to those that are repeat visitors by utilizing other survey techniques.

3 Knee-level visibility refers to permeability described based on visibility graph analysis. In their study analyzing prediction of movement in science museums, Peponis & Wineman (in press) measured permeability based on the analysis of visibility polygons (drawn at floor level). Note that, comparing how visitors' choices in movement direction are influenced by eye-level visibility and knee-level accessibility could be a focus of future research.

4 The investigation examining stop counts normalized with room area did not show significant results for the YCBA, and the correlation with stop counts normalized by display demonstrated no link for the HMA. This suggests that stop counts might be skewed by the number of displays in the HMA galleries, while the counts might be skewed by room area in the YCBA.

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