The Interactive Relationship between Spatial Conditions and Visitors' Behaviour of Knowledge Cognition within Large and Small-Sized Museums

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Keywords: Museum, Spatial Conditions, Knowledge Cognition, Visitors' Behaviour, Space Syntax

Abstract: Museums primarily aim to convey social knowledge through their social conditions. The interpretation of knowledge amongst Museum visitors varies depending on spatial use and layouts designed to reflect contemporary social circumstances. Our study investigates the relationship between visual-spatial conditions (spatial size, use and layout) and visitors' behaviour within a museum, from a social-spatial standpoint. During the study, two London museums (The Victoria & Albert Museum and The Design Museum) with differing the spatial conditions were subject to the linear and multiple regression tests using Visual Graph Analysis (VGA) and by monitoring Visitors' viewing behaviour. The results are as follow; It was found that the size of a museum, in relation to its complexity affected the pattern of visitors' circulation and spatial distribution in terms of spatial information and knowledge cognition. Consequently, the behaviour exhibited by visitors changed in relation to spatial use and layouts of the museums. Furthermore, the linear and multiple tests revealed this relationship creates different patterns within the behavioural-spatial network of visitors in relation to the spatial-information system within the museums. In light of the study, it's plausible that museums create fixed and deterministic network in a rational way or interrelated and probable network in a natural way based on the aforementioned relationship from the social perspective. In other words, a Museum achieves varying levels of social education in a closed or opened way, is determined by its spatial-behavioural network with visitors reflecting the shape of the public's social experiences in a modern society.

1. Introduction

1.1. *The purpose of the research*

The primary function of a museum is social education through a spatial organisation. The spatial organisation that exists within museums resembles contemporary social characteristics. Museum visitors are affected by the spaces and act in varying ways depending on their spatial conditions; the characteristics of such behaviour can be interpreted from a social perspective. This study explains how visual-spatial characteristics affect people's movements within a museum, and how this experience can impact on the amount of knowledge visitors can garner. Architecture is defined as a combination of unifying or coherent forms of space and is a complex

DOI 10.36158/978889295356747
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object that socially integrates users visually with their singular and multiple spaces; therefore, this study will concentrate on the relationship between spatial conditions and visitors' behaviour within museums, socially, to understand museum visitors' knowledge cognition from an individual and multiple standpoint.

1.2. *Research questions*

This study aims to collect in-depth knowledge on the correlation between visitor behaviour and spatial conditions within museums, treating it as an information system. In this sense, the study aims to compare visitor behaviour within two museums, which are differentiated in terms of their spatial conditions: 1) size, 2) spatial function, and 3) spatial layout. The research questions are as follows:

- a. How do spatial conditions differ in spaces providing museum information and acquired knowledge? To answer this question the study investigates how spatial size in large- and small-scale museums provides information through systems such as signs and displays.
- b. How do people gain knowledge depending on the spatial conditions within museums? To address this question, the study looks at how visitors use information systems according to spatial functions and layouts in exhibition spaces as well as throughout small and large layouts.
- c. How do spatial conditions impact visitor behaviour within museums? To elaborate on this, the study considers how individual and multiple spatial features affect and interact with visitors' behaviour in the small- and large-sized museums.

1.3. *Literature review*

This study aims to identify the patterns of interaction between spatial conditions and visitors' behaviour within museums. To understand the purpose of museums, this study uses the knowledge of museums (functions and spatial structures), society (social organisation, network, interaction), and human behaviour (information and communication) to identify visitor behaviour from the perspective of knowledge transfer and acquisition within museums. Space syntax theory was also introduced for quantitative analysis from a social perspective.

Firstly, this study inspects the prevailing academic theory that identifies different types of museum spatial conditions from a professional perspective. A museum's size significantly affects visitors' satisfaction (Jung, 2005). Thus, the efficiency and purpose of a museum's spatial use depend largely on its size (*Ibid*: 54). Furthermore, it has been observed that visitor behaviour is affected by the spatial layout in a museum. In research on museum spatial layouts, it has been argued that the movement of visitors is governed by the spatial layout and, as such, can be manipulated by adjusting the characteristics of those spatial structures (Choi, 1996). The various spatial types in a museum can help us to understand movement patterns from the viewpoint of spatial development and the connections that exist between different spaces. This phenomenon has also commonly been seen in circulation and exhibition spaces. A museum's spatial attributes can help to explain how spatial characteristics are related to function, layout, and subsequent visitor behaviour.

Secondly, this study uses organisation theory, network theory, and interaction theory to interpret the meaning of interactions between spaces and museum visitors from a socio-spatial viewpoint. A spatial organisation can affect a visitor's decision making. In 1998,

Scott introduced organisation theory, the purpose of which was to identify the types of communication among workers in the workplace. He suggested three organisational systems: rational, natural, and open systems based on how people generate information within a given type of communication system. He argued that the type of an organisational system can be defined by the pattern of people's communication in that group that is related to the pattern of their spatial use. Social networks and organisational structures can be used to explain the interaction between people and buildings in causal terms (Kurogawa, 1994). The spatial structure within a building can show the pattern of people's behaviour from a social perspective because the buildings are built with the needs of society and people of the same age in mind.

Moreover, this study refers to previous information and communication theories to identify visitor behaviour from the perspective of knowledge transfer and acquisition within museums. Altman and Rogoff (1987) classified the philosophical approach of theories on psychological and behavioural studies and commented on interactionism. In interactionism, the units of analysis can be categorised into *individual psychological characteristics* and *environmental characteristics*. From the physical environment of society, however both units interact with each other. The action of individuals is related to its environment, and the behaviour can be a symbol of the society (Blumer, 1962). These theories relate to how people learn according to their environment within a museum layout. A person's behaviour is a product of the communication that exists between that person and their surrounding environment, and people tend to offer feedback on knowledge recognition from their environment (*ibid.*).

Lastly, to explain how the quantitative research method is applied from the social standpoint to this study, space syntax theory is introduced. The theory was developed by Hillier and Hanson (1984). They argued that people could understand social attributes through patterns in spatial structures. The attributes of spatial structure can explain how people use spaces. They said that just as sentence spaces are combinations between unit spaces based on regulation, spatial combinations can constitute a pattern of spatial use that would produce social meaning (*ibid*: 209). The spaces can be a channel to deliver information; the process mimics the process of interpersonal communication to gain information in a society (Moon, 2004). Therefore, by utilising space syntax theory from a social viewpoint, we can answer many of the questions on people's movement in relation to spaces.

1.4. *Case studies*

To analyse the relationship between spatial conditions and visitor behaviour within museums, the study considered the size, spatial function, and layout as spatial conditions. To maximise our ability to observe the impact of size on visitor behaviour, only small – and large – sized museums were considered. Spatial layout encompasses spatial form as well as object layout. With respect to the research criteria, art and crafts museums which vary in size and spatial layout and with many signs and exhibition displays were selected.

Furthermore, since London is one of the birthplaces of the museum and one of the most renowned cities for studying museum architecture, it was selected for the case study. The Victoria and Albert Museum (a large-sized museum, LM-1) and the Design Museum (a small-sized museum, SM-1) were selected for the study.

To understand how visitors in museums garner knowledge and information, the spatial functions were categorised into circulation and exhibition spaces within both museums. Fur-

thermore, according to the number of signs and exhibitions, there were four spatial layouts: halls, passages, irregular exhibition layouts, and regular exhibition layouts.

The museum spaces looked at in the study can be categorised as follows:

- (1) circulation spaces: halls and passages
- (2) exhibition spaces: exhibition spaces with regular layouts, and exhibition space with irregular layouts

Table 1.

Classification	LM-1	SM-1
Floor plan (study area)		
Name	Victoria and Albert Museum	Design Museum
Type	Art and Craft	Art and Craft
(re-) Opening year	2006	2016
Location	London	London
Size	Large size (over 60,000 public area)	Small size (under 4,000 public area)
Sign (n)	74 (40 in circulation space, 12 in exhibition space)	45 (25 in circulation space, 20 in exhibition space)
Exhibition (n)	215 (34 in circulation space, 181 in exhibition space)	99 (12 in circulation space, 87 in exhibition space

2. Research Methodology

2.1. *Space syntax methodology: Visibility Graph Analysis (VGA)*

Observation study: movement snapshot, following people

From the observation study visitors' behaviour was derived into eleven behaviour types: Moving and static individuals, movement speed, visit rate, viewing rate of signs and exhibitions, viewing sign and exhibition attention rate, re-visiting, re-viewing sign and exhibition rate.

Table 2. *The factors of Visibility Graph Analysis (VGA).*

Visual connectivity
Visual connectivity measures the number of spatial elements, which are connected to a certain element. The visual connectivity is a local measurement, meaning it only takes into account the direct neighbours of a spatial element.
Visual clustering coefficient
The visual clustering coefficient measures people's decision making by considering all possible lines of sight in the neighbourhood of a location in a visibility graph. If most locations are mutually visible from a specific location, then the coefficient will approach 1. Many locations are not mutually visible from a specific location, then the coefficient will be closer to 0.
Visual control
Visual control picks out visually dominant areas. Each location is first assigned an index of how much it can see; the reciprocal of its connectivity. Then, for each point, these indices are summated for all the locations it can see. It should be apparent that if a location has a large visual field, it will pick up many points to sum, so initially, it might seem to have a high level of visual control.
Visual controllability
People dominate the visual controllability of a location. It would seem to operate similarly to visual control. Each of the cells is highly controllable, as the area of the visual field is small compared to the area viewable from the centre to which it connects, while the centre is less controllable, as it links only to the cells within its field, and they add a little extra visual field.
Visual integration
Visual integration is the value that reflects how entire spaces are related to certain spaces within them. It has the same approach with mean depth that calculates the arrival time to other spaces from a certain space in order to connect the entire space together. When moving, people tend to use spaces with a high integration value and thus the extent of encounters between people can be predicted with the integration value. Here, Integration is a global measure.
Visual step depth
Visual step depth calculates the steps necessary to get from one single element to all the others. When a point is chosen, it becomes the starting point to measure the visual step depth. The starting point is adjustable, so it is a flexible rate from an analysis viewpoint. The concept of step depth is a relational value. On the other hand, controllable spaces are locations that can be easily seen from other locations, but themselves cannot see much.

Intelligibility and Isovist
Intelligibility is the ratio between visual connectivity and integration, a value used to understand the difficulty in recognising a spatial structure. If intelligibility within buildings is low, people cannot recognise the spatial structure. This can cause unpredictable patterns of movement. An isovist is a 2-dimensional measurement used to calculate visual accessibility. It starts from the location of the target people or gates.

Correlations: Linear and Multi-regression analysis

Linear regression analysis is used to correlate the linear relationship between an independent variable and a dependent variable, one by one. A multi-regression analysis is used to correlate multiple relationships, between various independent variables and a dependent variable. The independent and dependent variables were consistently used in linear and multi-regression analysis, categorised in terms of circulation and exhibition spaces: to measure the impact of spatial structures on visitor behaviour and the relationship between the parameters, the value (average) and the R^2 (average, between 0,3 and 1)were respectively looked at.

Table 3. *The definition of Visitors' behaviour.*

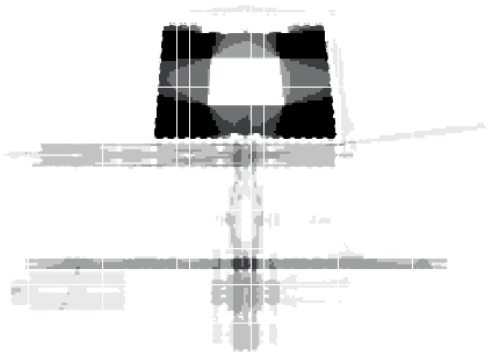
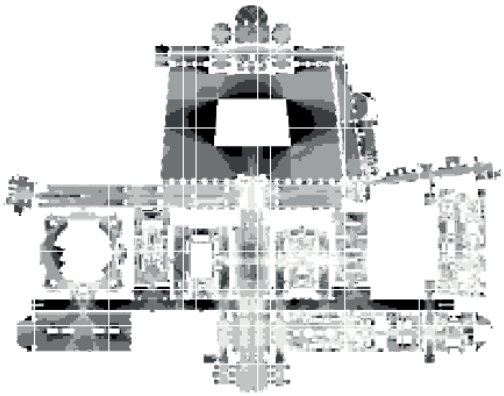
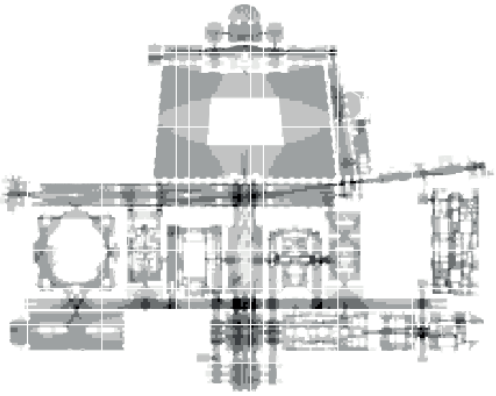
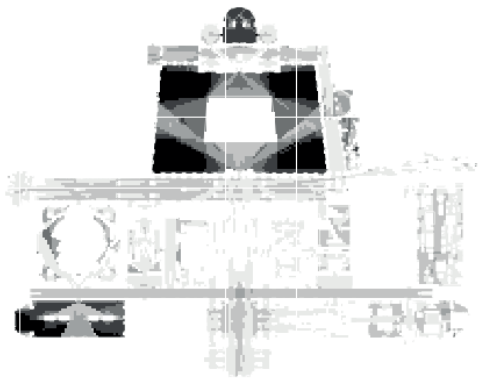
Terminology	Definition	Unit
Moving speed	Moving length / moving time	m/min
Visiting rate	The number of targets visited / the total number of targets	n/50
Viewing sign rate	The number of signs viewed / the total number of signs	n/n
Viewing exhibition rate	The number of exhibitions viewed / the total number of exhibitions	n/n
Viewing sign attention level	Viewing sign rate *the number of signs people stopped to view *the duration of pause	n/n*n*min
Viewing exhibition attention level	Viewing exhibition rate *the number of exhibitions people stopped to view *the duration of pause	n/n*n*min
Re-visiting rate	The number of targets re-visited / the total number of targets	n/50
Re-viewing sign rate	The number of signs re-viewed/ the number of signs	n/n
Re-viewing exhibition rate	The number of exhibitions re-viewed/ the total number of exhibitions	n/n

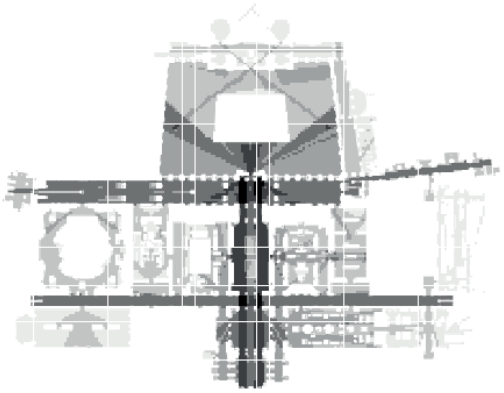
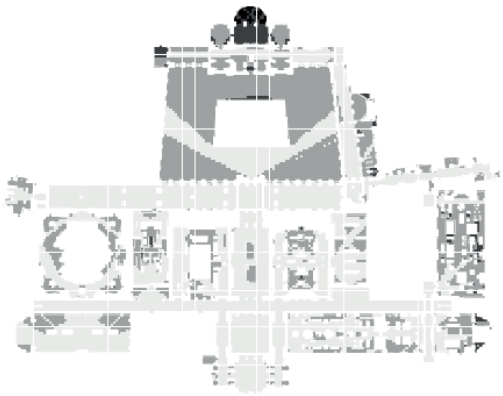
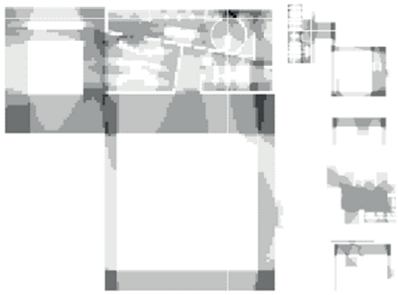
3. Analysis/Results

3.1. *Analysis of spatial conditions within the museums*

From the spatial analysis, it was found that most spatial conditions within SM-1 were superior because within LM-1 most spatial conditions were concentrated in the main hall. To be specific, in LM-1, the simple and large spatial layout created weak spatial conditions within LM-1. In SM-1, a small, complex layout was observed and thus, it could be said that much of this spatial layout had a strong character. This spatial relationship would provide a different spatial experience and allow people to gain knowledge in different ways.

Table 4. *Visibility Graph Analysis (VGA).*

			
Visual connectivity	302.49	Visual clustering coefficient	0.57
			
Visual control	1.0	Visual Controllability	0.17

			
Visual integration	3.98	Visual step depth	1.13
			
Visual connectivity	670.15	Visual clustering coefficient	0.74
			
Visual control	1.05	Visual Controllability	0.34
			
Visual integration	1.93	Visual step depth	0.98

** The more complex spatial layout becomes the higher spatial analysis in circulation and exhibition space are conducted.*

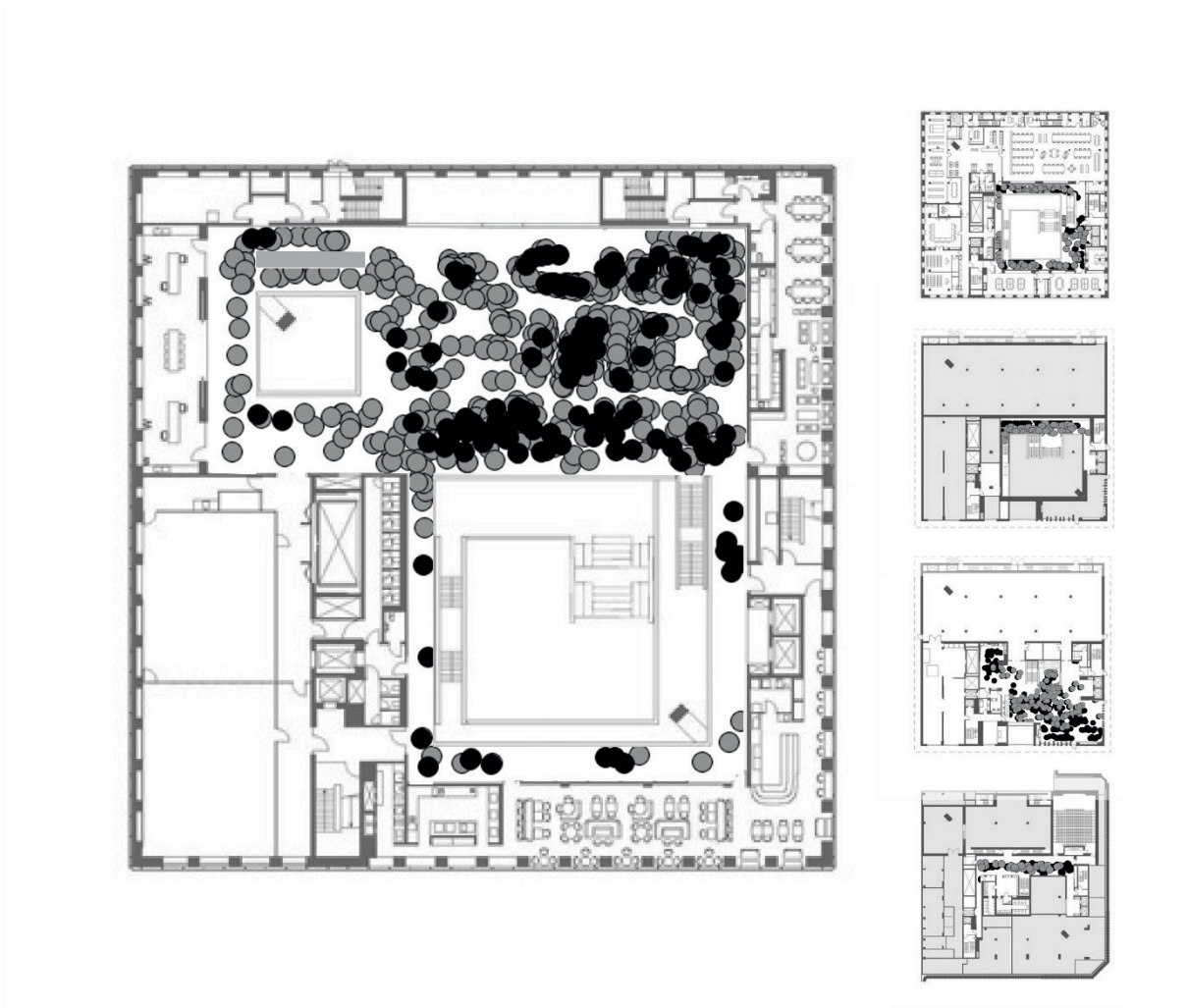
3.2. *Analysis of visitors' behaviour within the museums*

From the observation analysis, it was noted that spatial conditions within the museums strongly affected the visitors' behaviour, particularly with exploration and knowledge gathering. The routes visitors took to gather information and knowledge were different based on the size, function, and layout of the spaces in the museum. Also, spatial conditions impacted the way people behaved and thus their subsequent behaviour.

Moving and static snapshot in LM-1

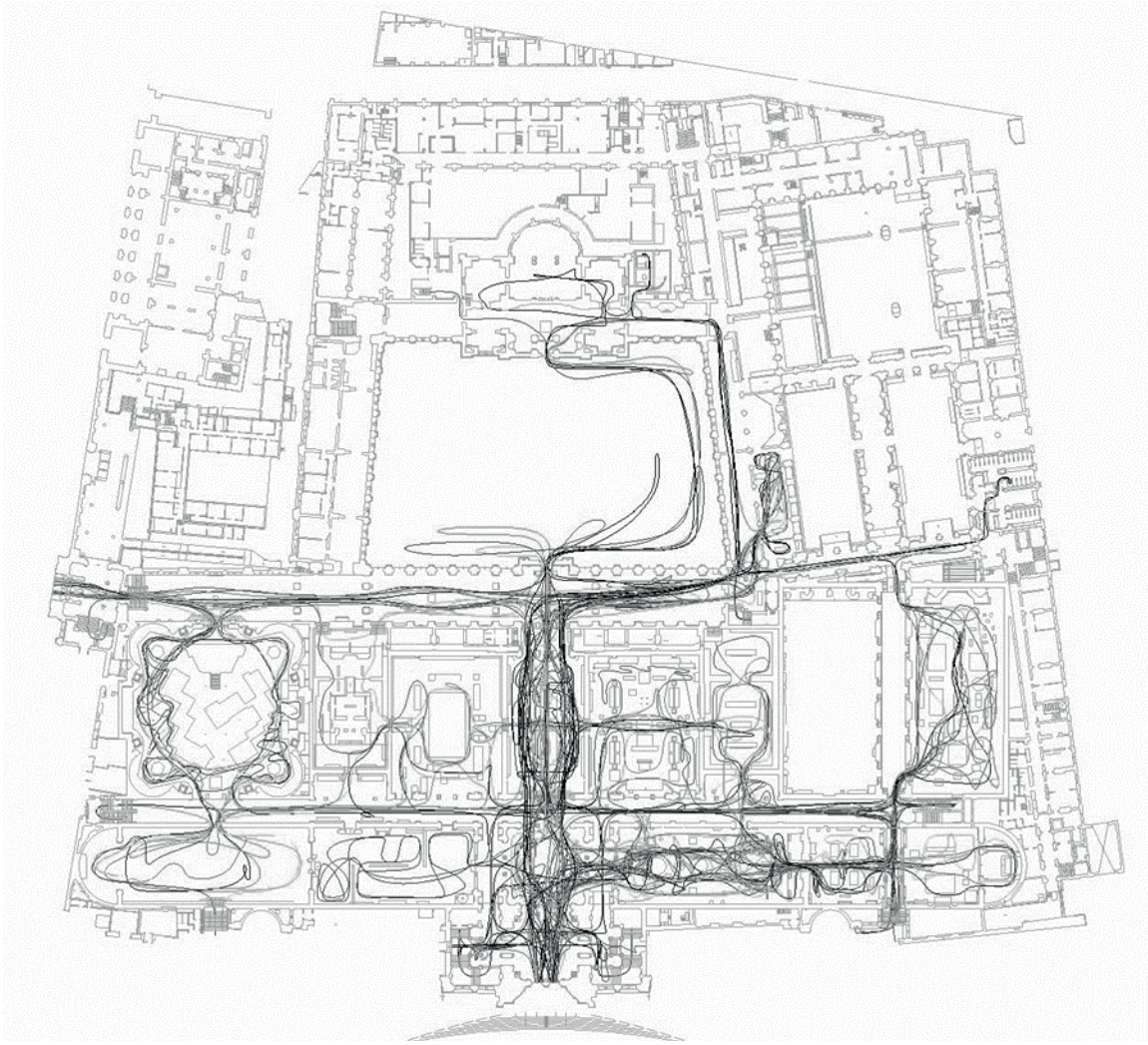
- The number of observed people was similar in circulation and exhibition spaces.
- In circulation spaces static people were concentrated in the halls and people usually moved around in the passages
- In exhibition spaces more people moved than were static. People were focused around exhibitions and more people were in the irregular layout exhibition spaces and show more diverse pattern than in regular layout exhibition spaces.

Moving and static snapshot in SM-1



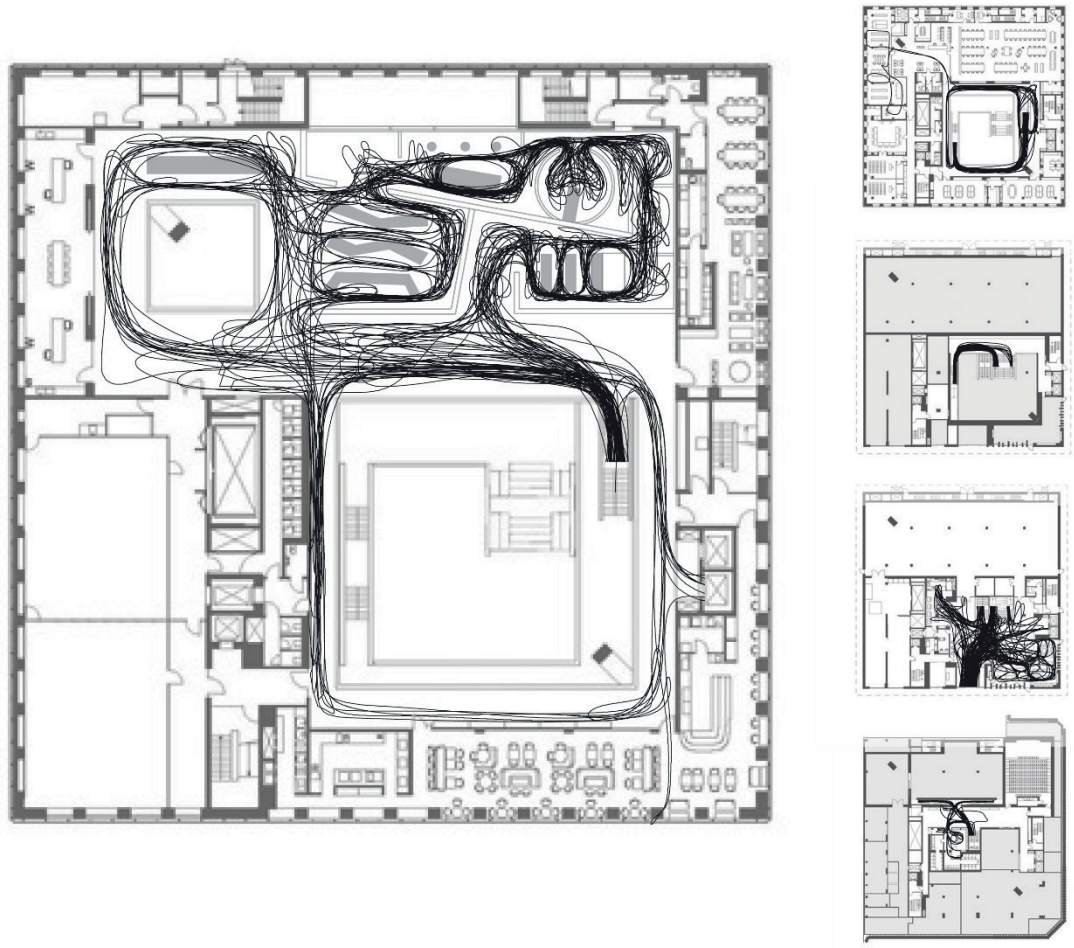
- There were more moving people during the snapshot count.
- In circulation spaces people were concentrated in the halls and the front part of the passages.
- In exhibition spaces people were focused around exhibitions and more people were in the irregular layout exhibition spaces than the regular layout exhibition spaces. In the irregular layout exhibition spaces there were more moving people than in the regular layout exhibition spaces.

Circulation pattern of visitors in LM-1



- The visitors' circulation was concentrated in the centre of the museum and the centre of the circulation spaces.
- The people were separated to two parts from the main circulation spaces. In the halls e were more complex pattern of movement.
- In exhibition spaces more people were concentrated in the spaces locate near the entrance. The irregular layout exhibition spaces had more complex movement than the regular layout exhibition spaces.

Circulation pattern of visitors in SM-1

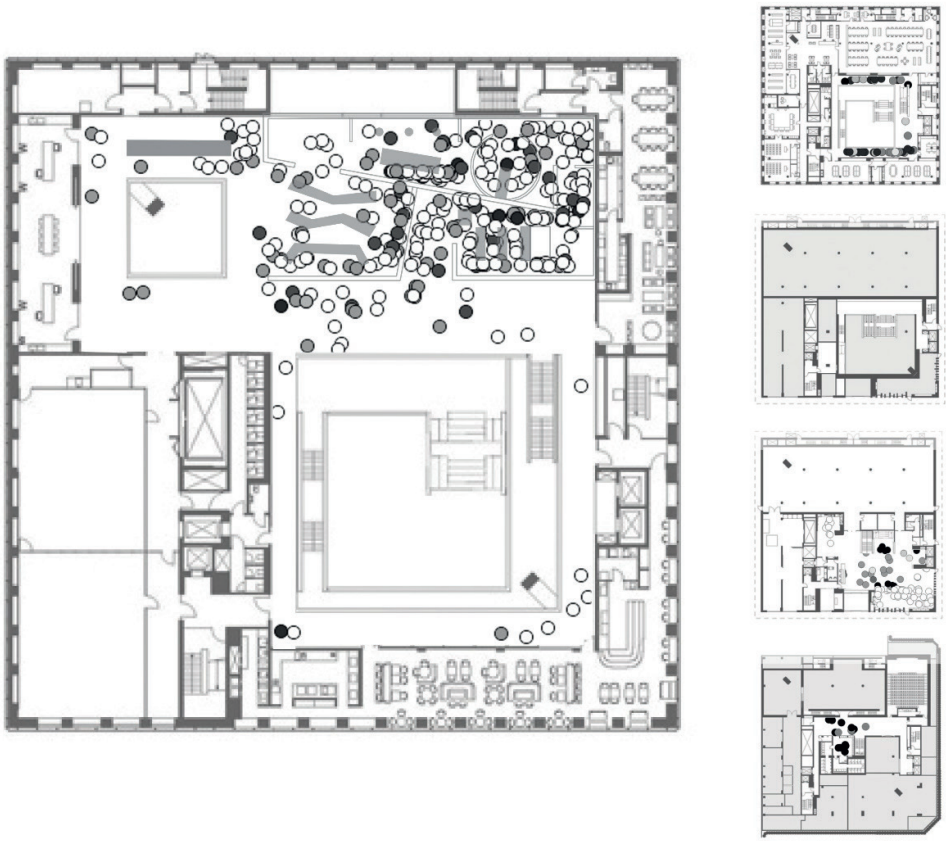


- People's movement was focused in main hall and it is separated in two ways in 2nd floor near gate to exhibition spaces.
- In the regular layout exhibition spaces, people showed similar, simple patterns of movement, while they showed complex patterns of movement in the irregular layout exhibition spaces

Quantity and duration of visitors' stops in LM-1

- People usually stopped within exhibition spaces.
- In circulation spaces, people stopped in front of the gates and in front of the halls that lead people to other spaces
- In exhibition spaces, people stopped more in the irregular layout exhibition spaces than in the regular layout exhibition spaces

Quantity and duration of visitors' stops in SM-1



- Stop duration was short despite the many number of stops.
- In the halls, people tended to stop for a relatively long duration since they had to check signs to find the way.
- In exhibition spaces, people sometimes stayed long, but it depended on the exhibition contents and the spatial layout.

3.3. *Analysis of spatial conditions and visitors' behaviour within the museums*

According to the visitor behaviour analysis, it is understood that the viewing behaviour in each museum's exhibition space is correlated with its spatial structure and physical characteristics. In other words, museum size, spatial functions such as circulation and exhibition, and spatial layouts were highly influential in determining the number of movements and static visitors, the visiting rate, the viewing sign rate and attention level, the viewing exhibition rate, and the attention level. Furthermore, it also affected visitors' re-visit rate, re-viewing sign and exhibition rate. *For more information, please refer the 'Discussion' due to the amount of paper.

Table 5. *The definition of Visitors' behaviour.*

Visitors' behaviour	circulation space	exhibition space
moving people	12.08	3.72
static people	12.97	3.16
moving speed	11.71	5.97
visiting rate	0.51	0.25
re-visiting rate	0.37	0.02
viewing sign rate	0.31	0.18
viewing sign attention level	0.61	0.11
viewing exhibition rate	0.14	0.09
viewing exhibition attention level	0.08	1.50
re-viewing sign rate	0.21	0.02
re-viewing exhibition rate	0.05	0.01

** The more complex spatial layout becomes the higher visitors' behaviour are conducted in circulation and exhibition spaces.*

	circulation space	exhibition space
moving people	14.30	17.42
static people	3.64	1.62
moving speed	53.03	13.79
visiting rate	0.51	0.51
re-visiting rate	0.42	0.04
viewing sign rate	0.43	0.46
viewing sign attention level	0.23	0.26
viewing exhibition rate	0.12	0.36
viewing exhibition attention level	0.33	2.54
re-viewing sign rate	0.33	0.04
re-viewing exhibition rate	0.10	0.02

** The more complex spatial layout becomes the higher visitors' behaviour are conducted in circulation and exhibition spaces.*

4. Correlations

4.1. *Linear-regression analysis*

From the linear regression analysis, it was found that the behaviour of visitors in terms of exploring and gaining information was clearly associated with individual spatial conditions within the two museums. Spatial impact and the relationship between spatial conditions and visitors' behaviour were superior in SM-1. However, there were differences in terms of spatial function and layout within both museums, related to their spatial size. More specifically, the spatial impact (B) visitors' behaviour was mostly concentrated in the exhibition spaces in LM-1. However, in SM-1, the spatial impact in the circulation spaces was more significant on visitors than in the exhibition spaces and the value of the spatial impact in both spaces are higher. Furthermore, the relationship between spaces and visitors (R^2) was also more significant in the circulation spaces than in exhibition spaces in both museums. The value of the relationship is higher in LM-1 but in the exhibition space, the value is higher in SM-1. *For more information, please refer the 'Discussion' due to the amount of paper.

Table 6. *B analysis*

[circulation space]

LM-1	moving people	static people	moving speed	visiting rate	re-visiting rate	viewing sign rate	viewing sign-attention level	viewing exhibition rate	viewing exhibition attention level	re-viewing sign rate	re-viewing exhibition rate
Average	0.178	0.079	0.055	0.088	0.111	0.167	0.302	0.252	0.075	0.343	0.314
PCS	The location affected the relationship between circulation space layout and visitors' behaviour.										
HCS											
Average: 0.178											
SM-1	moving people	static people	moving speed	visiting rate	re-visiting rate	viewing sign rate	viewing sign-attention level	viewing exhibition rate	viewing exhibition attention level	re-viewing sign rate	re-viewing exhibition rate
Averages	0.223	0.098	0.262	0.228	0.227	0.195	0.106	0.078	0.114	0.224	0.064
PCS	The location affected the relationship between circulation space layout and visitors' behaviour.										
HCS											
Average: 0. 165											

[exhibition space]

LM-1	moving people	static people	moving speed	visiting rate	re-visiting rate	viewing sign rate	viewing sign-attention level	viewing exhibition rate	viewing exhibition attention level	re-viewing sign rate	re-viewing exhibition rate
Average	7.665	18.345	18.554	0.507	0.090	0.326	0.263	0.056	2.325	0.170	0.020
PCS	The location affected the relationship between circulation space layout and visitors' behaviour.										
HCS											
Average: 4.393											
SM-1	moving people	static people	moving speed	visiting rate	re-visiting rate	viewing sign rate	viewing sign-attention level	viewing exhibition rate	viewing exhibition attention level	re-viewing sign rate	re-viewing exhibition rate
Average	15.649	3.172	33.594	0.419	0.089	0.540	0.830	0.410	4.244	0.080	0.066
PCS	The location affected the relationship between circulation space layout and visitors' behaviour.										
HCS											
Average: 5.372											

Table 7. *R^2 analysis*

[circulation space]

LM-1	moving people	static people	moving speed	visiting rate	re-visiting rate	viewing sign rate	viewing sign-attention level	viewing exhibition rate	viewing exhibition attention level	re-viewing sign rate	re-viewing exhibition rate
Average	0.127	0.154	0.187	0.127	0.083	0.126	0.238	0.026	0.020	0.161	0.056
IRES	The location affected the relationship between exhibition space layout and visitors' behaviour.										
RES											
Average: 0.119											
SM-1	moving people	static people	moving speed	visiting rate	viewing sign rate	viewing sign-attention level	viewing exhibition rate	viewing exhibition attention level	re-visiting rate	re-viewing sign rate	re-viewing exhibition rate
Average	0.145	0.154	0.220	0.138	0.098	0.111	0.142	0.128	0.087	0.059	0.132
IRES	The location affected the relationship between exhibition space layout and visitors' behaviour.										
RES											
Average: 0.129											

[exhibition space]

LM-1	moving people	static people	moving speed	visiting rate	re-visiting rate	viewing sign rate	viewing sign-attention level	viewing exhibition rate	viewing exhibition attention level	re-viewing sign rate	re-viewing exhibition rate
Average	0.127	0.154	0.187	0.127	0.083	0.126	0.238	0.026	0.020	0.161	0.056
IRES	The location affected the relationship between exhibition space layout and visitors' behaviour.										
RES											
Average: 0.119											
SM-1	moving people	static people	moving speed	visiting rate	viewing sign rate	viewing sign-attention level	viewing exhibition rate	viewing exhibition attention level	re-visiting rate	re-viewing sign rate	re-viewing exhibition rate
Average	0.145	0.154	0.220	0.138	0.098	0.111	0.142	0.128	0.087	0.059	0.132
IRES	The location affected the relationship between exhibition space layout and visitors' behaviour.										
RES											
Average: 0.129											

4.2. *Multi-regression analysis*

From the multi-regression analysis, it was found that the visitors' behaviour to explore and gain information was clearly associated with multiple spatial conditions within the two museums. To be specific, the association between spaces and visitors (B) was more considerable in circulation spaces than in exhibition spaces. Furthermore, the relationship between spaces and visitors (R^2) was more significant in circulation spaces. Moreover, the association and relationship between spatial conditions and visitors' behaviour were superior in SM-1, from multiple perspectives. *For more information, please refer the 'Discussion' due to the paper.

Table 8. *B analysis*

[circulation space]

LM-1	moving people	static people	moving speed	visiting rate	re-visiting rate	viewing sign rate	viewing sign-attention level	viewing exhibition rate	viewing exhibition attention level	re-viewing sign rate	re-viewing exhibition rate
Average	26.254	63.841	72.093	2.561	1.488	1.804	2.234	2.080	0.685	0.780	1.045
PCS HCS	The location and surrounding area affected the relationship between circulation space layout and visitors' behaviour.										
Average: 15.897											
SM-1	moving people	static people	moving speed	visiting rate	re-visiting rate	viewing sign rate	viewing sign-attention level	viewing exhibition rate	viewing exhibition attention level	re-viewing sign rate	re-viewing exhibition rate
Average	22.785	15.873	126.816	0.867	0.555	0.903	1.202	0.885	2.921	0.578	0.851
PCS HCS	The location and surrounding area affected the relationship between circulation space layout and visitors' behaviour.										
Average: 15.840											

[exhibition space]

LM-1	moving people	static people	moving speed	visiting rate	re-visiting rate	viewing sign rate	viewing sign-attention level	viewing exhibition rate	viewing exhibition attention level	re-viewing sign rate	re-viewing exhibition rate
Average	8.280	22.361	14.981	0.552	0.159	0.786	0.284	0.241	22.300	0.219	0.063
IRES RES	The location and surrounding area affected the relationship between exhibition space layout and visitors' behaviour.										
Average: 6.386											
SM-1	moving people	static people	moving speed	visiting rate	re-visiting rate	viewing sign rate	viewing sign-attention level	viewing exhibition rate	viewing exhibition attention level	re-viewing sign rate	re-viewing exhibition rate
Average	38.475	4.576	50.989	1.006	0.312	1.673	1.369	1.090	13.955	0.178	0.165
IRES RES	The location and surrounding area affected the relationship between exhibition space layout and visitors' behaviour.										
Average: 10.344											

Table 9. *R^2 analysis*

[circulation space]

LM-1	moving people	static people	moving speed	visiting rate	re-visiting rate	viewing sign rate	viewing sign-attention level	viewing exhibition rate	viewing exhibition attention level	re-viewing sign rate	re-viewing exhibition rate
visual connectivity visual clustering coefficient visual control visual controllability visual Integration visual step depth	0.926	0.793	0.830	0.885	0.958	0.942	0.997	0.910	0.931	0.969	0.945
*p≤0.05	**p≤0.01								Average:	0.917	
SM-1	moving people	static people	moving speed	visiting rate	re-visiting rate	viewing sign rate	viewing sign-attention level	viewing exhibition rate	viewing exhibition attention level	re-viewing sign rate	re-viewing exhibition rate
visual connectivity visual clustering coefficient visual control visual controllability visual Integration visual step depth	0.993	0.924	0.987	0.997	0.974	0.976	0.934	0.992	0.836	1.000**	1.000*
*p≤0.05 **p≤0.01									Average:	0.965	

[exhibition space]

LM-1	moving people	static people	moving speed	visiting rate	re-visiting rate	viewing sign rate	viewing sign-attention level	viewing exhibition rate	viewing exhibition attention level	re-viewing sign rate	re-viewing exhibition rate
visual connectivity visual clustering coefficient visual control visual controllability visual Integration visual step depth	0.617	0.598	0.553	0.617	0.489	0.644	0.917	0.306	0.630	0.642	0.526
*p≤0.05	**p≤0.01								Average:	0.594	
SM-1	moving people	static people	moving speed	visiting rate	re-visiting rate	viewing sign rate	viewing sign-attention level	viewing exhibition rate	viewing exhibition attention level	re-viewing sign rate	re-viewing exhibition rate
visual connectivity visual clustering coefficient visual control visual controllability visual Integration visual step depth	0.778	0.932	0.860	0.732	0.591	0.784	0.891	0.896	0.916	0.604	0.946
*p≤0.05 **p≤0.01									Average:	0.812	

5. Discussion

It can be seen that the behaviour of visitors to a museum vary depending on the spatial conditions of the museum. The scale of the museum greatly affects the flow of visitors and their spatial distribution. To better understand this, the spaces of large-sized and small-sized museum were analysed by using space syntax theory and associated observation methods. The space syntax analysis showed that in the larger museum, LM-1, the integration and step depth values appeared to be high. Such spatial analysis indicates that in the most integrated spaces and shallow spaces, the behaviour of visitors tends to be vibrant in a concentrated manner, for spatial cognition. That is, most behaviour of visitors in the museum appeared to be passive. In the smaller museum, SM-1, figures for most spatial conditions were even higher. This means that visitors' most behavioural patterns were more active and diverse.

Analysis of visitors' behaviour from observations showed that in LM-1, the number of static people and the viewing sign rate were high. Such visitor patterns appear due to the increased need to understand the museum's spatial structure when the museum is larger. This indicates that in LM-1, most visitor behaviours appear to be passive, an attempt to verify the spatial information. But most other types of visitor behaviour appeared higher in SM-1, for example, proactive visitor behaviour centred around experiencing the space.

Moreover, visitor behaviour varied in accordance with the spatial functions in each museum. The space syntax analysis for the larger museum, LM-1, showed that spatial conditions other than the figure of visual controllability and visual step depth appeared to be higher in the exhibition spaces than in the circulation spaces. This indicates that a wider variety of visitor behaviours appears in the circulation spaces. In the smaller museum too, the figures for most spatial conditions were higher in the circulation spaces than in the exhibition spaces. This means that in SM-1 the circulation spaces have a greater spatial effect on visitor behaviour. In addition, compared to the larger museum, most of the analysis figures for each space were higher in the smaller museum.

Analysis of visitor behaviour showed that as was the case in the spatial analysis of the larger museum, most behaviour (excluding a small number of exhibitions viewing behaviours) appeared to be active in the circulation space. Such results indicate that the cognition of spatial information in a circulation space of a larger museum precedes exhibition viewing behaviour. In an exhibition space where the distance from the main hall is greater than the distance to a circulation space from the main hall, the cognition of spatial information precedes in the circulation space. This indicates that the visitors themselves can moderate the effect from the spatial structure. But in the circulation and exhibition spaces of a smaller museum, behaviour is mostly focused on movement for viewing the exhibition and associated activities. In addition, visitor behaviour in the circulation and exhibition spaces appeared to be higher in SM-1 than in LM-1. This implies that there are other spatial factors in the spaces that affect visitors' movement in smaller museums.

Furthermore, it was verified that the visitors' behaviour varied according to the complexity of the given spaces in museums of different sizes. An analysis of the space syntax shows that in LM-1, most spatial conditions other than the visual clustering coefficient and the visual step depth were concentrated in halls with a simpler structure than in passages. Similar results were found for SM-1 too but such results were mostly higher in SM-1. This shows that although there are differences in the figures, regardless of the size of the museum, visitor behaviour in a circulation space is affected greatly by the spatial structure of the halls which have more simple forms.

An analysis of visitor behaviour shows that in LM-1, in the halls, information verification

behaviour for the cognition of the spatial structure had an even higher value. Among the visitor behaviours, information verification behaviour to perceive the spatial structure had an even higher value. In the passages, behaviours that preceded the viewing of the exhibits were active. Similar behaviours were found in SM-1 as in LM-1 in circulation spaces but the visitors' moving behaviour was more proactive when they were searching for their destination. In addition, the figures were even higher in SM-1. This shows that while there may be some difference in numerical figures due to the museum size, visitor behaviours in circulation spaces are affected more by the spatial structure specifically when there is a simpler form. Regarding exhibition spaces, in LM-1, a larger museum, most viewing behaviours were active in exhibition spaces with regular layouts. An analysis of the space syntax shows that in LM-1, all spatial conditions excluding visual clustering coefficient and visual step depth were concentrated in the regular exhibition spaces. In SM-1, a smaller museum, all spatial conditions excluding visual connectivity were concentrated in the regular exhibition spaces. SM-1 mostly had figures higher than LM-1. This indicates that while there may be numerical figure-based differences due to the size of the museum, visitor behaviour in an exhibition space is affected more by the spatial structure in exhibition spaces, specifically when there is a simpler form. Furthermore, as the expectation, such effect of the space varies according to the size of the museum. An analysis of the visitor behaviour shows that in LM-1, in the regular layout exhibition spaces, the behaviour of verifying information to proceed with viewing the exhibition showed a higher figure, while in irregular exhibition spaces, behaviours for viewing were more active. In SM-1 also, similar behaviours were observed as in LM-1, however the behaviours were varied and more proactive. Such results showed a mostly higher value in SM-1, even though the visitors' behaviour was spontaneously different; this related to its location along with the influence of the main and middle gates within the two museums.

These analysis results show the various interaction types between different space types in museums and visitor behaviour. This was calculated from individual and multiple correlations that explain the spatial impacts and interactive behavioural relationships within the studied museums. Most importantly, most of the spatial impacts and behavioural relationships were observed in the circulation spaces, more so than in the exhibition spaces in both large- and small-sized museums. It is to precede to the viewing exhibitions, which is the museum's defined spatial function for social education. However, such characteristics carry a different meaning depending on each museum. In the larger museum examined in this study, behaviours associated with spatial and information perception were mostly observed. In the circulation spaces of larger museums, static behaviour associated with checking information had a high correlation with spatial structure. In particular, multiple spatial conditions affected visitor behaviour in combination, and the larger scale of the museum affected visitor behaviour through spatial perception.

From the individual and multiple correlations, it was calculated that people's static behaviour had a strong connection with the spatial conditions of the circulation spaces. Their behaviours mostly had a connection with the information cognition behaviour related to individual spatial conditions, which they exercised to move around and view exhibitions due to the museum's large size. Most information check behaviours in large-sized museum that showed strong relationship between spaces and visitors' behaviour was similar to the most visitors' behaviour. Those relationships affect visitors' behaviour more considerably in simpler circulation spaces such as halls. In the exhibition spaces, the effects of space on behaviour was smaller than in the circulation spaces, but the behaviour of checking spatial information had a high correlation with most spatial structures. In particular, with regard to the complexity of the space, various

spatial impacts and associations between various spaces and behaviours were observed for the circulation spaces, while in the exhibition spaces, a spatial impact and association between various spaces and behaviours were observed in spaces with simple forms. This means that visitor behaviour seems to vary in the exhibition spaces as a result of spatial complexity as they try to find their route through the museum. As such, larger museums in this study can be said to have a classical space-behaviour network which describes a fixed and determined type of a museum.

In the smaller museum examined in this study, proactive behaviour was mostly observed. In circulation spaces, there was a high correlation between the spatial structure and active behaviours attempting to perceive that structure. In particular, individual and integrated spatial conditions affected visitor behaviour at the same time and to a higher degree than in larger museums. This might be due to the spatial complexity of the small-sized museum. It was calculated that most people's behaviour had a strong connection with the spatial conditions within the museum. Likewise, visitor behaviour was impacted more by circulation spaces and these behaviours mostly had a connection with the behaviour to view exhibitions. Most behaviours related to of actively viewing exhibitions on small-sized museum that showed strong relationship between spaces and visitors' behaviour was similarly observed in most visitors' behaviour. Furthermore, this was also spontaneously observed from the result of individual and especially multiple correlations. Those relationships affected visitors' behaviour more considerably in the simpler circulation spaces, such as halls. In exhibition spaces, compared to circulation spaces, the effects of space on behaviour were smaller overall but a common factor was found: proactive behaviours for viewing were highly affected and correlated with individual and multiple spatial conditions. In particular, regarding the complexity of a space, it was found that regardless of the function or complexity of each space, a new spatial usage pattern based on the willpower of the visitor appeared. This means that visitor behaviour seems to be contextual in the exhibition space according to their intentions on the different spatial usage with the curators' initiative in the small sized museum. As such, smaller museums in this study had a classic but also new space-behaviour network and can be said to have an interdependent and unpredictable relationship between the museum space and the visitor. Such a result creates a new space-behaviour network.

Of course, spatial characteristics alone cannot fully explain the diversity of people's movements. Ironically, visitor behaviour can be said to have resulted from the spatial structure. When people experience a museum, their initial movements could be affected by the complex museum layout (Choi, 1996). They might then gain information and knowledge in different ways depending on the spatial conditions. Experiences can also affect various patterns of individual behaviour and, in turn, different knowledge and intentions could then form (Koo, 2013). Distinct patterns of behaviour would emerge, resulting in new ways of spatial usage not initially planned or considered. In other words, the museums analysed in this study can be said to provide a rational spatial network that delivers social knowledge in a manner that is determinant and desired by the public, whilst suggesting an unpredictable spatial network that delivers social knowledge in a manner that is interdependent and desired by the individual.

6. Conclusion

Museums have been spaces open to the public since they first appeared in the 18th century. They deliver the society's knowledge by a providing a space wherein the public can interact with different exhibits. These museum spaces have had various functions and forms over the

years from the perspective of knowledge delivery. The characteristics of such spaces depend on the relationship between society and the public. For example, a closed social system creates a unilateral flow of knowledge delivery; in such a case, the space would be "regulatory" (Foucault, 1975). In a regulatory space, the acquisition of knowledge by the public will be uniform. In an open social system, knowledge delivery is done multilaterally (*Ibid*). The public and the space become interdependent. Acquisition of knowledge in a flexible space would appear in a more varied and autonomous form.

Of course, today's society cannot be defined as one specific form. Modern society has a wide array of social knowledge delivery systems. Museum spaces can create spatial systems with various functions and forms based these different facets of society. At times, museums might create a space based on the closed nature of society with strict rules, to provide information and knowledge in a uniform manner to museum visitors. Meanwhile, museum spaces based on an autonomous relationship with society would provide knowledge in a varied way and create an interdependent system with visitors.

The spatial characteristics of museums can be interpreted from a social perspective by looking at the formative relations with visitors. For example, in the larger museum used in this study, a more regulatory method was used to deliver knowledge to visitors. That is, in its circulation spaces, behaviours for the perception of the spatial system came first. In the exhibition spaces, activities to perceive the content of the exhibit took up the largest share. In both of these spaces, when the structure was more complex, various forms of behaviour appeared while in simpler spaces most behaviours were geared toward the acquisition of knowledge. If such a space-behaviour network is interpreted from a social perspective, the circulation spaces of LM-1 can provide rational knowledge and information, while the exhibition spaces deliver diverse knowledge naturally based on their spatial conditions, which is the classical function of a museum. As spaces become more complex, spatial conditions affect the way information is gained throughout the museum.

However, in the smaller museum, it was observed that depending on the ease of perceiving the space, communication between the visitor and the space occurred in different ways. For example, there were many cases where the knowledge was delivered to visitors in a more interdependent manner. In particular, regarding the function and complexity of the space, there was a proactive new pattern of using space generated by the willpower of the visitor regardless of the character of the space. If this space-behaviour network is interpreted from a social perspective, the exhibition spaces of SM-1 can create information that orients people to their destination in more natural and diverse ways. Consequently, the circulation spaces of SM-1 can also create diverse information and knowledge depending on the visitors' diverse use of the spaces. In this sense, as spaces become more complex, the processes of gaining information become more natural and rational. Though at the same time, information gathering is affected by the spatial conditions and personal intentions which arise during the process.

Therefore, it can be said that LM-1 has more regular and naturally determinant spaces while SM-1 has more integrated and probabilistic spaces that are interdependent with visitors from the perspective of information and knowledge cognition. The behaviour that is defined by the character of the space and according to the traits of each museum can sometimes have an interdependent relationship with space such that visitors can affect the space and vice versa. It could be said that both museums have the ability to be an open space for everyone's knowledge and education in their own way.

This study has sought to understand visitors' behaviour from the perspective of information recognition within two museums, encompassing various spatial conditions related to size,

spatial function, and layout. It is important to suggest the social meaning of museum spaces and their interdependence on visitors from the perspective of knowledge cognition. However, this study was limited as it only looked at museum spaces and information systems of different scales and layouts from a physical point of view. In the future, studies should evolve to enable identification with other types of spatial characteristics, contents, and visitors' information. Furthermore, the study was conducted from a global perspective by using visual graph analysis only. Further local and in-depth analyses should be considered to targ*et al.*l floors and spaces.

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