AN APPROACH TO EVALUATING EXHIBITION SPACES IN ART GALLERIES

Y.S. KIM and M. BRAWNE
School of Architecture and Building Engineering
University of Bath, Claverton Down
Bath, BA2 7AY
United Kingdom

ABSTRACT. There are certain building types in which movement of people is the most significant evaluation factor. Among these are art galleries and museums. Unlike other building types, which are often explained by investigating the relationship between people and objects, and between people and the built environment, art galleries and museums are a building type in which the social relationship between people hardly exists and people’s movement through space, that is, the functional relationship between people and space, is one of the most significant factors for their description. The typical museum experience is through direct, sequential, and visual contact with static objects on display as the visitor moves. Therefore, the movement pattern of the visitors must exert a significant influence on achieving the specific goal of a museum. There is a critical need for predicting the consequences of particular spatial configurations with respect to visitors’ movement. In this sense, it is the intention of this paper to find out the relationship between the spatial configuration of exhibition space and the visitors’ movement pattern.

1. Introduction

Museum professionals today tend to emphasise the importance of the quality of visitors’ experiences more than ever. In order to accomplish this goal, they have mainly concentrated on development of versatile programmes such as lectures, publications, video, explanatory labels and so on in order to provide visitors with a worthwhile experience. Apart from the various programmes, they have extensively dealt with the effectiveness of the arrangement of objects in already existing gallery spaces (Robinson 1928; Melton 1935, 1972; Bechtel 1967; Gardner 1986).

However, it is argued that this goal can be facilitated more fundamentally by manipulating the spatial organisation before all the decisions stated above are made. The typical museum experience is above all through direct and sequential contact with static objects as people move. In this sense, it is believed that the way in which objects are arranged in sequence, that is, how we see one after the other, does affect our understanding. Therefore how a visitor follows a route is an important factor of the layout. Accordingly, the first consideration should be to define the pattern of visitors’ movement through the manipulation of spatial configuration, hopefully in accordance with the arrangement of the objects. Furthermore, it could also be said that it is absurd to force the visitor’s viewing sequence by orientation signs, since moving through a space is not passive perception, but a dynamic process in which all the elements present around are compared both to each other and to others which are not present except in the memory of the visitor. Despite such an importance of the exhibition space, however, it is true that architects have been more concerned with the style of the building, interior decoration and an effective lighting system. When they consider the spatial organisation, they often borrow answers from various precedents in history, without explicit knowledge of the consequence of space with respect to the visitors’ experience. It is therefore a critical task for architects to offer useful information by providing an

empirical study of existing museum buildings, aimed at what the consequences of a particular spatial organisation with relation to the visitors' experience would be.

The main objective of this study is to find out how art galleries could effectively encourage visitors to arrive, understand, and to take away a worthwhile experience through the manipulation of the spatial organisation. It is widely believed that to achieve this worthwhile experience requires both time and proper sequence to look at art objects. In this respect, this study investigates the effect of spatial organisation of exhibition spaces on visitors so that a useful architectural statement can be made. It should be noted that this paper limits itself to the investigation of individual spaces. The investigation of overall exhibition space will be dealt with at the next stage. By being able to predict the effect of the spatial organisation on visitors' behaviour, museum professionals and architects can offer visitors a pleasant and enjoyable place as well as an effective educational institution. That is to say, the information to be offered as the result of the study should be crucial at an early stage of planning, when influential decisions are often made without explicit presupposition of the effect, and at later stage when the addition or redesign of the exhibition space is reconsidered.

2. Methodology

The trailing technique is employed in order to investigate visitors' behaviour in the exhibition space by using stopwatches, pencil and paper to record the time spent either in a gallery as a whole or looking at a painting. This technique has been prevalent among museum professionals and behavioural researchers to evaluate mainly the effectiveness of display (Robinson 1928; Melton 1972). Although there has been some criticism, such as reliability of the data obtained from it and lack of efficiency, this method is ideal for the present study, which does not need precise readings of short time like one or two seconds, usually spent before an object. This study deals with the relationship between space and visitors' behaviour (especially, their movement pattern), not the relationship between the display and visitors' behaviour (especially, the time spent before an object), which has been the main task of museum professionals. The data to be obtained from this observation were the time spent in each gallery and visitors' movement line in the individual gallery. While staying in a gallery, the observer drew visitors' movement lines in the space and, at the same time, recorded the time they spent in it. The observation was carried out between March 1990 and September 1990 in the Tate Gallery and the National Gallery which are both located in London.

The data obtained from the trailing technique is correlated to the physical variables (independent variables), which are the geometrical dimension and geometrical proportion of individual galleries, in order to find out how the gallery space affects visitors' behaviour.

3. Variables

By carrying out the preliminary observation in several museums and art galleries located in London, criteria to evaluate the visitors' behaviour and variables to assess the criteria were identified. Dependent variables are the criteria used to assess the effect of space on the visitors' behaviour. Independent variables are linked to exhibition space, which is supposed to influence the visitors' behaviour.

3.1. Dependent Variables

In order to assess the effect of spatial configuration on the visitors' behaviour, we have chosen
two factors, namely, the visitors' movement pattern and movement rate. It was found that there are two explicitly different movement patterns in a gallery, that is, a linear movement pattern and a circular movement pattern. As far as a long shape of gallery is concerned, the visitor tends to walk towards the other end of the gallery and hardly turn around to look at paintings on the other side of the wall. In this sense, this kind of movement pattern can be called linear movement towards the other end of the gallery. On the other hand, in a square-like gallery, the visitor tends to look at most of the paintings hung on both sides of the gallery. That is to say, the visitor turns around at the end of one side to look at paintings of the other side and then finally walks towards the exit. In this sense, this kind of movement pattern can be called circular movement. The visitors' movement pattern is the most significant factor in art galleries since it can be said that an art gallery's success depends on it in the sense that the objects on display are not isolated events but have some meaning which depends on an understanding of their relation to each other.

The movement rate means the time that visitors spend in a gallery rather than the speed which they move. Therefore, the movement rate represents both the time spent in walking around the gallery space and the time spent in appreciating the works of art. However, it is a characteristic of an art gallery or museum that there is no clear demarcation between moving and looking at the works of art, because in many cases, visitors look at the works of art as they keep moving around. In this sense, the rate at which visitors move around in a gallery is represented by the time that they spend in the gallery whether they look at the works of art or move around. Accordingly, it can be said that the movement rate is closely related to the visitors' movement pattern, and thus related to the spatial configuration.

The first variable, movement rate 1, is simply the time that visitors spend in a gallery from start to finish. As we pointed out earlier, it is assumed that the longer the movement rate 1 is, the more successful the gallery is, since one of the main intentions of art galleries is to attract more visitors and to hold them longer in a gallery. The second variable, movement rate 2, is the time that visitors spend actually looking at or appreciating paintings. The movement rate 1 might not be a significant criterion because it includes walking time as well as looking and appreciating time. In this respect, movement rate 2 is the time which subtracts the walking time from movement rate 1.

At this point, to calculate the walking time, the walking speed should be defined. From an experiment executed by the researcher and with the data obtained by observing the visitors, we established that the average walking speed in museums or art galleries is 1.2 m/sec. Therefore, we can formulate an equation:

walking time = walking distance / 1.2

Thus,

movement rate 2 = movement rate 1 - walking time

Here, it should be noted that walking distance is recorded by measuring the length of each visitor's movement line drawn on the plan during the observation.

3.2. INDEPENDENT VARIABLES

Having done the preliminary observation, some physical variables, which were significantly influential on museum visitors' behaviour in terms of their movement pattern and movement rate, were taken into account for actual observation. Those independent variables concerned geometrical proportion (ratio of length to width) and perimeter. It was generally noticed during the preliminary visits that the higher the length to width ratio was, the more people tended to
make a linear movement line. Although there are some exceptions in very small rooms, or long and narrow rooms, this variable is closely related to how people move around in a gallery room. Thus, it could be also related to the movement rate. The perimeter of a gallery room is important on the grounds that the visitors move along the walls on which objects or paintings are actually displayed. It is quite certain that if the perimeter is long, visitors spend more time to look at all the paintings. However, this is closely interrelated with the rule concerning the geometrical proportion. In addition to these two main variables, length and area have been taken into consideration on the same grounds as the perimeter. The length of a gallery room seems to have a considerable effect on the visitors' movement pattern and movement rate. It was seen that during the preliminary observation in a particular room, which has long length and high ratio, this variable plays a significant role in defining the movement pattern and the movement rate.

4. Samples of Case Studies

We chose two galleries as case study, namely, the Tate Gallery (TG) and the National Gallery (NG). They were further divided into five wings: the West-Wing (WWT) and the East-Wing (EWT) of TG, and the West-Wing (WWN), the East-Wing (EWN) and the North-Wing (NWN) of NG.

![Figure 1: The floor plan of the Tate Gallery, London](image-url)
As seen in plans, TG shows a symmetrical disposition of two separable exhibition spaces, which are WWT and EWT. The spatial configuration of the two wings is almost identical (see Fig. 1). NG can also clearly be divided into three exhibition spaces, that is, WWN, EWN and NGN (see Fig. 2). Those five exhibition spaces selected for the observation show quite different aspects in their spatial disposition. In particular, NWN is different from the rest in the sense that the galleries in NWN are almost identical in terms of their shape and size and encourage the visitors to move through one gallery after another, whereas the other wings have alternative routes diverging from a major traffic line. The other wings also display some differences. The two wings of TG have a long, straight traffic line on which main galleries are located, and from the major traffic line there are some minor galleries. On the other hand, WWN and EWN differ from the wings of TG in the sense that there is no one single major traffic line which is straight like in TG.

Figure 2. The floor plan of the National Gallery, London

5. Individual Gallery Spaces

5.1. Attributes of the Physical Variables in Both Galleries

Table 1 shows the average values of every physical variable of the five wings to be analyzed. Those physical variables presented in a table give an overall view of the five exhibition spaces as well as the differences and similarities between them. Here, it is important to make a comparison between the five wings. It can be seen at a glance that the number of paintings in a gallery shows considerable difference, in particular between WWT and EWT. In spite of the similar spatial configuration of the two wings, WWT has 25.8 paintings or sculptures in a gallery, while there are only 10.6 in EWT. This could be because the average size of the paintings of EWT is bigger. Such difference in the number of paintings naturally results in another considerable difference in Pr/Pa (perimeter/the number of paintings). That is to say, a painting occupies 6.25 m of the
As for the geometrical ratio, the average is 1.67 which is derived from 9.1 m x 5.1 m. WWT and NWN show a little higher ratio, that is, 2.06 and 1.80 respectively. While the geometrical ratio does not show a significant difference, the area of each wing shows a considerable difference between the wings. In general, the galleries of TG are larger than the ones of NG. The average area of WWT is more than double that of the NWN. At this point, what is interesting is that although the average area of NWN shows the smallest figure, the geometrical ratio (1.80) is comparatively high. Except for the NWN, therefore, it can be noticed that the higher the geometrical ratio is, the larger the gallery space is.

As far as the average number of paintings of a gallery is concerned, EWT stands apart from the rest, that is, the number of paintings displayed there is far smaller in comparison with other wings, because of the large paintings and big sculptures there. As far as the relationship between the geometrical ratio and the area is concerned, NWN is exceptional in the sense that despite the fact that the geometrical ratio is quite high, the average area of the galleries is the smallest among these wings. Other wings have common physical characteristics.

**TABLE 1. The physical variables of the five wings**

<table>
<thead>
<tr>
<th>Variables</th>
<th>WWT</th>
<th>EWT</th>
<th>WNN</th>
<th>EBN</th>
<th>NWN</th>
<th>MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Gal.</td>
<td>16</td>
<td>14</td>
<td>10</td>
<td>11</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>No. of PaG</td>
<td>25.8</td>
<td>10.6</td>
<td>16.8</td>
<td>20.4</td>
<td>18.7</td>
<td>18.5</td>
</tr>
<tr>
<td>Width (m)</td>
<td>9.8</td>
<td>10.4</td>
<td>8.8</td>
<td>9.3</td>
<td>7.0</td>
<td>9.1</td>
</tr>
<tr>
<td>Length (m)</td>
<td>19.7</td>
<td>17.2</td>
<td>11.7</td>
<td>14.2</td>
<td>12.8</td>
<td>15.1</td>
</tr>
<tr>
<td>Ratio (L/W)</td>
<td>2.06</td>
<td>1.64</td>
<td>1.34</td>
<td>1.49</td>
<td>1.38</td>
<td>1.67</td>
</tr>
<tr>
<td>Area (m²)</td>
<td>106.2</td>
<td>177.9</td>
<td>106.2</td>
<td>149.1</td>
<td>89.4</td>
<td>143.8</td>
</tr>
<tr>
<td>Perimeter (m)</td>
<td>58.9</td>
<td>55.1</td>
<td>41.0</td>
<td>46.9</td>
<td>39.6</td>
<td>48.3</td>
</tr>
<tr>
<td>Po/Pm (m)</td>
<td>2.75</td>
<td>6.29</td>
<td>3.01</td>
<td>3.55</td>
<td>2.30</td>
<td>3.58</td>
</tr>
</tbody>
</table>

5.2. INDIVIDUAL GALLERY SPACE AND VISITOR'S BEHAVIOUR

5.2.1. WWT. In WWT, there are 16 gallery rooms, of which eight are off the main circulation line. Eleven were observed and analyzed. Among the observed gallery rooms, room 7, 11 and 12 are situated off the major traffic line. In the correlation analysis between the independent and dependent variables (Table 2), it can be seen that there is a significant correlation between the geometrical ratio and the movement rate 1, and between the geometrical ratio and the movement rate 2. Although it is not so strong, the length and the movement rates also show reasonably good correlation. On the other hand, the movement line and the other physical variables do not show any significant correlation. Again the time spent in front of a painting does not make a good correlation with other independent variables. In other words, apart from the geometrical ratio and the length, other independent variables, namely the area, perimeter and Po/Pm, do not appear to play a role in influencing the visitors' behaviour in this wing.

At this point, it can be seen that room 9 and room 12 have an exceptional character. In spite of the fact that room 9 is the largest (385 m²) and has high geometrical ratio (3.18), the movement line shows 80% of the circular movement, which is supposed to be characteristic of gallery
rooms of low geometrical ratio. It can be speculated that because this room is at an angle of 90° to
the main circulation line rather than parallel to it, visitors are encouraged to go further inside.
Once they get inside, they tend to return to the beginning point of the room and then proceed in
spite of the fact that there is another exit on the other side which leads to the main corridor of the
gallery. This indicates that sense of orientation is an important factor in defining the visitor's
movement pattern. The big door of the exit is always kept closed, which plays a role in
preventing people from using it. By naturally enforcing circular movement on the visitors,
therefore, the paintings hung on both sides are effectively shown. The character of this room may
suggest therefore that the way in which a space is placed in the overall configuration is very
important in terms of the visitor's movement pattern. Room 12 measures 6 x 17 metres so that the
geometrical ratio is considerably high in comparison with other galleries in this wing.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Ratio</th>
<th>Length (m)</th>
<th>Area (m²)</th>
<th>Peri. (m)</th>
<th>Per/(m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move.</td>
<td>0.785</td>
<td>0.629</td>
<td>0.400</td>
<td>0.508</td>
<td>0.060</td>
</tr>
<tr>
<td>Room 1</td>
<td>(0.787)</td>
<td>(0.786)</td>
<td>(0.786)</td>
<td>(0.786)</td>
<td>(0.407)</td>
</tr>
<tr>
<td>Move.</td>
<td>0.753</td>
<td>0.554</td>
<td>0.316</td>
<td>0.427</td>
<td>0.094</td>
</tr>
<tr>
<td>Room 2</td>
<td>(0.730)</td>
<td>(0.729)</td>
<td>(0.729)</td>
<td>(0.729)</td>
<td>(0.406)</td>
</tr>
<tr>
<td>Linear</td>
<td>-0.148</td>
<td>0.195</td>
<td>0.362</td>
<td>0.294</td>
<td>0.216</td>
</tr>
<tr>
<td>Move.</td>
<td>(0.886)</td>
<td>(0.886)</td>
<td>(0.886)</td>
<td>(0.592)</td>
<td>(0.177)</td>
</tr>
<tr>
<td>Rate 1</td>
<td>0.190</td>
<td>-0.245</td>
<td>-0.450</td>
<td>-0.371</td>
<td>0.292</td>
</tr>
<tr>
<td>/Painting</td>
<td>(0.022)</td>
<td>(0.018)</td>
<td>(0.018)</td>
<td>(0.018)</td>
<td>(0.401)</td>
</tr>
</tbody>
</table>

(*) correlation coefficient after eliminating room 7, 9 and 12

Despite the high ratio, in which visitors are expected to make a linear movement, this gallery
shows a relatively high proportion of circular movement line, i.e. 55%. The rather narrow gallery
space of 6 metres enables visitors to look at both sides of the room almost simultaneously without
any great effort. That is to say, the paintings hung on both sides are easily accessible from any
point of the room, which tends to encourage visitors to make a circular movement. In addition,
even if there is an opening leading to the main corridor of the building, most visitors tend to turn
back toward the major traffic line.

Room 7 has 95% of circular movement line and the greatest movement rate in spite of the high
geometrical ratio (3.00). Because this space is located off the major traffic line and there is no
opening on the other side, it can be presumed that people in this room are more serious visitors so
that they spend more time to appreciate the works of art. In fact, this room seems the only space
in which the serious or motivated visitor can look at the paintings without being interrupted by
people who just pass through.

At this point, if we look at the correlation again after eliminating three galleries, namely
room 7, 9 and 12, it can be seen that the correlations among the variables are significantly
improved (Table 2). The best correlation occurs between the geometrical ratio and the movement
line. In addition, what is more interesting is that the correlation between the length and the linear
movement line has improved considerably. These facts indicate that in general, the spatial
configuration of a gallery space significantly affects the visitors' behaviour, in particular their
movement pattern. The more detailed results from the analysis of the West-Wing indicate that (i)
the higher the geometrical ratio is, the less the visitors make circular movement in a gallery room, 
(ii) the higher the geometrical ratio is, the more time the visitors spend in a gallery room, and (iii) 
the length of a gallery space also plays a significant role in defining the visitors' movement. In 
fact, this variable is obviously related to the geometrical ratio. Here, it should be indicated that 
perfect positive correlation (1.00) is shown between the geometrical ratio and the rest of physical 
variables. That is to say, the higher the geometrical ratio is, the larger the gallery space is. 
Therefore, the second and third results seem to be obvious.

5.2.2. EWT. This wing has 14 gallery rooms, and the observation was carried out in nine of 
these. This wing is quite similar to WWT in terms of the allocation and distribution of gallery 
rooms. The visitors' movement pattern and their movement rate in EWT, however, shows 
considerable difference. First of all, the average time spent in a gallery room is 77.9 seconds, 
whereas WWT shows 171.2 seconds, which is more than twice. Another variable, T/P (movement rate 1/perimeter: sec/m), also shows the difference: 2.75 sec/m in WWT and 1.36 
sec/m in this part. In fact, in room 28, in which paintings by one painter, Mark Rothko, are 
displayed, the spend time is 31.9 seconds, which is far less than average. Furthermore, the 
visitors' movement pattern in this wing indicates 78.33% of linear movement, whereas it is 
35.91% in WWT.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Ratio</th>
<th>Length (m)</th>
<th>Area (m²)</th>
<th>Peri. (m)</th>
<th>T/P (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move-</td>
<td>0.276</td>
<td>0.415</td>
<td>0.482</td>
<td>0.462</td>
<td>-0.436</td>
</tr>
<tr>
<td>Rate 1</td>
<td>(0.382)</td>
<td>(0.379)</td>
<td>(0.613)</td>
<td>(0.610)</td>
<td>(-0.436)</td>
</tr>
<tr>
<td>Move-</td>
<td>0.273</td>
<td>0.395</td>
<td>0.430</td>
<td>0.434</td>
<td>-0.440</td>
</tr>
<tr>
<td>Rate 2</td>
<td>(0.388)</td>
<td>(0.533)</td>
<td>(0.578)</td>
<td>(0.564)</td>
<td>(-0.449)</td>
</tr>
<tr>
<td>Linear</td>
<td>-0.083</td>
<td>0.132</td>
<td>0.319</td>
<td>0.245</td>
<td>0.195</td>
</tr>
<tr>
<td>Move-</td>
<td>(-0.730)</td>
<td>(-0.430)</td>
<td>(-0.062)</td>
<td>(-0.303)</td>
<td>(0.323)</td>
</tr>
<tr>
<td>Rate 1</td>
<td>0.117</td>
<td>0.088</td>
<td>0.045</td>
<td>0.064</td>
<td>0.322</td>
</tr>
<tr>
<td>Painting</td>
<td>(0.499)</td>
<td>(0.479)</td>
<td>(0.349)</td>
<td>(0.412)</td>
<td>(0.359)</td>
</tr>
</tbody>
</table>

(1) correlation coefficient after eliminating room 24

As for the correlation between variables (Table 3), we can hardly see any significance. The 
highest correlation occurs between the area and the movement rate 1, and between the length and 
the movement rate 1. The correlation between the physical variables and the movement line is 
insignificant. It can be argued that these results are determined by the special character of the 
paintings displayed in these galleries. As stated before, most of these are modern or post-modern 
paintings, which are generally extremely abstract or unfamiliar and the general public do not seem 
to enjoy them, let alone fully understand them. Or they are very easy to understand, and thus only 
need a very brief appreciation. Therefore, visitors tend to pass through this gallery space looking 
briefly at the objects rather than stopping to contemplate the paintings. In this sense, visitors tend 
to pass through making mostly linear movement lines regardless of the geometrical ratio. This 
tendency results in relatively better correlation between the physical variables and the movement 
rate. In other words, the visitors' spending time is directly related to the area, perimeter and 
length of the gallery rooms.
At this point, let us look at some rooms more closely. Room 28 displays seven huge paintings which were painted by Mark Rothko and all look quite similar in terms of colour and pattern. It was therefore observed that most visitors looked at a painting by the entrance and then did not go inside to look at the others because of their similarity. Rooms 29 and 30 also display abstract paintings and sometimes sculptures. Because of the allocation of the openings, like in room 9 in WWT, however, some visitors tended to make a circular, though relatively fast, movement in spite of the fact that the works of art were abstract or less well-known. In contrast, although room 26 has a very similar character in terms of the properties of object size and geometrical ratio, the movement pattern shows 100% linear lines.

As a result, it can be seen that the properties of the objects on display play a significant role in defining the visitors' movement pattern and movement rate. However, although the properties of the paintings on display influence people, the physical settings such as openings, size and length still play a considerable part in defining the visitors' behaviour in this part of the gallery. In particular, rooms 29 and 30 show that the visitor's movement pattern and movement rate can be greatly influenced by manipulating the location of openings in connection with other variables such as geometrical ratio and length in a gallery space.

5.2.3. WNW. Table 4 shows that the best correlation occurs between the movement rate 2 and Pe/Pa (Perimeter/No. of Paintings) (-0.888) and between the movement rate 1 and Pe/Pa (-0.861), which are negative. Again, Pe/Pa makes a significant correlation with the linear movement line (0.707) and the time spent before a painting, that is, R/Pa (0.830). In addition, significant negative correlations are shown between the MR1/Pe (Movement Rate 1/Perimeter) and other physical variables, such as the length, the area and the perimeter (r = -0.668, -0.662 and -0.675 respectively). This implies that the larger a gallery space is, the less time visitors spend before a painting.

As for the physical variables, there is a good correlation between the perimeter and the movement rate 1 (0.672), and between the area and the movement rate 1 (0.654). On the other hand, the correlations between the geometrical ratio and other dependent variables are almost insignificant.

At this point, it can be noticed that in spite of the lack of difference of the geometrical ratio for both galleries, rooms 6 and 10 show a remarkably low percentage of the linear movement line. This fact has resulted from having only one opening, that is, being located off the major traffic line, whereas other galleries have two or three. Therefore, once the visitors get into the room, their returning route is supposed to be the other side of the room. In addition, the fact that visitors in a gallery or museum hardly ever repeat the same route also seems to encourage a circular movement.

In this respect, if we consider another correlation after eliminating those two galleries, it can be seen that the overall correlation has been considerably improved. In particular, the correlation between the geometrical ratio and the linear movement line becomes quite significant (0.822).

Meanwhile, the correlations between the Po/Pa and other dependent variables are still highly significant. All in all, some important behavioural aspects can be drawn from Table 4. In general, the larger the gallery space is, the less time the visitor spends before a painting. The higher the geometrical ratio is, the more linear movement line is made in the gallery. Finally, the larger the space a painting occupies on the gallery wall, the less time the visitor spends in the gallery. In addition, it can also be seen from Table 4 that the relatively low ratio (1.38) of the gallery spaces results in the high percentage of circular movement line (70.7%).

Therefore, it can be said that the geometrical ratio and the movement line are closely related to each other. The variable MR1/Pe (Movement Rate 1/Perimeter: sec/m), indicates that the visitors spend more time in this part: 3.16 sec/m, whereas they spend only 2.75 sec/m in WWT and 1.36 sec/m in EWT.
TABLE 4. Correlation coefficient between variables (WWW)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Ratio</th>
<th>Length (m)</th>
<th>Area (m²)</th>
<th>Peri. (m)</th>
<th>Pe/Pa (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move-</td>
<td>-0.308</td>
<td>0.551</td>
<td>0.654</td>
<td>0.672</td>
<td>-0.861</td>
</tr>
<tr>
<td>Rate 1</td>
<td>(-0.616)</td>
<td>(0.484)</td>
<td>(0.675)</td>
<td>(0.678)</td>
<td>(-0.823)</td>
</tr>
<tr>
<td>Move-</td>
<td>-0.327</td>
<td>0.498</td>
<td>0.606</td>
<td>0.618</td>
<td>-0.888</td>
</tr>
<tr>
<td>Rate 2</td>
<td>(-0.683)</td>
<td>(0.429)</td>
<td>(0.644)</td>
<td>(0.654)</td>
<td>(-0.944)</td>
</tr>
<tr>
<td>Linear</td>
<td>0.246</td>
<td>0.273</td>
<td>0.228</td>
<td>0.219</td>
<td>0.707</td>
</tr>
<tr>
<td>Move.</td>
<td>(0.822)</td>
<td>(0.677)</td>
<td>(0.489)</td>
<td>(0.505)</td>
<td>(0.506)</td>
</tr>
<tr>
<td>Rate 1</td>
<td>-0.200</td>
<td>-0.686</td>
<td>-0.662</td>
<td>-0.675</td>
<td>0.810</td>
</tr>
<tr>
<td>/Painting</td>
<td>(-0.062)</td>
<td>(-0.661)</td>
<td>(-0.688)</td>
<td>(-0.683)</td>
<td>(0.764)</td>
</tr>
</tbody>
</table>

(1) correlation coefficient after eliminating room 6 and 10

5.2.4. WWW. Table 5 shows correlations between the variables. The most significant correlation occurs between MR1/Pa and all other independent variables, which show a negative correlation except with Pe/Pa (0.758). This implies that the larger the gallery space is, the higher the geometrical ratio is, the less time the visitor spends before a painting.

There are also significant correlations between Pe/Pa and other dependent variables which are negative except with MR1/Pa. Like in WWW, the greater the space a painting occupies on the gallery wall, the less time the visitor spends in the gallery. However, what is different from WWW is that the correlation between Pe/Pa and MR1/Pa is negative. At this point, it can be said that this good negative correlation is more convincing than the positive one of WWW. The reason is that the ratio does not have any correlation with other physical variables in WWW, whereas in this wing it shows a highly significant correlation.

As for the movement rate and the movement pattern, and other independent variables, there is no significant correlation at this stage. Room 38 has an exceptional character. In spite of the relatively low ratio (1.25), it shows 55% of linear movement line, and thus the time spent in a gallery is very short. The relatively high percentage of linear movement line of room 38 is probably caused by the way the paintings were arranged on the walls. By hanging well-known paintings on one side only, the balance between the walls has been lost to the extent that people do not readily approach the other side of the room even though the geometrical ratio is low. In fact, most gallery rooms observed in this study showed great consideration in balancing both sides in terms of the paintings' size and quality. Therefore, if the balance was seriously broken, the effect on people's behaviour was enormous. At this point, if we eliminate room 38, it can be seen that the correlations between the variables are considerably improved. In particular, the correlation between the geometrical ratio and the linear movement line shows great significance (0.821). In addition, the correlation between the geometrical ratio and the movement rate, and between physical variables and the movement rate have improved remarkably.

The low ratio of the gallery spaces in this wing results in high percentage of circular movement line (71.7%) and thus much spending of time. This aspect is well illustrated in room 34, which is the largest gallery space. This room shows far less time spent than others in terms of MR1/P (1.89 sec/m). As a result, some behavioural characteristics can be summarised.
TABLE 3. Correlation coefficient between variables (JWN)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Ratio</th>
<th>Length (m)</th>
<th>Area (m²)</th>
<th>Peri. (m)</th>
<th>P/Pa (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move-0.625</td>
<td>0.580</td>
<td>0.578</td>
<td>0.555</td>
<td>-0.649</td>
<td></td>
</tr>
<tr>
<td>Rate 1 (0.853)</td>
<td>(0.793)</td>
<td>(0.782)</td>
<td>(0.765)</td>
<td>(-0.888)</td>
<td></td>
</tr>
<tr>
<td>Move-0.431</td>
<td>0.374</td>
<td>0.373</td>
<td>0.346</td>
<td>-0.593</td>
<td></td>
</tr>
<tr>
<td>Rate 2 (0.590)</td>
<td>(0.498)</td>
<td>(0.484)</td>
<td>(0.460)</td>
<td>(-0.826)</td>
<td></td>
</tr>
<tr>
<td>Linear</td>
<td>0.561</td>
<td>0.592</td>
<td>0.483</td>
<td>0.483</td>
<td>-0.694</td>
</tr>
<tr>
<td>Move-0.821</td>
<td>(0.754)</td>
<td>(0.713)</td>
<td>(0.701)</td>
<td>(-0.930)</td>
<td></td>
</tr>
<tr>
<td>Rate 1</td>
<td>-0.817</td>
<td>-0.781</td>
<td>-0.765</td>
<td>-0.767</td>
<td>0.758</td>
</tr>
<tr>
<td>Painting (-0.920)</td>
<td>1.085</td>
<td>(-0.861)</td>
<td>(-0.854)</td>
<td>(0.888)</td>
<td></td>
</tr>
</tbody>
</table>

(1) correlation coefficient after eliminating room 38

The higher the geometrical ratio is, the more time visitors spend in the gallery. This obviously results from the fact that the higher the ratio is, the larger the gallery space is. The higher the geometrical ratio is, the less time visitors spend on each painting. This is also related to the fact that the higher the ratio is, the larger the gallery space is. Therefore, it is natural that other physical variables are closely correlated to the time spent for a painting. There is a good negative correlation between P/Pa, and the movement rate and the linear movement line.

5.2.5. JWN. At a glance, it is obvious that there cannot be any significant correlation between the variables because of the resemblance of the spaces. However, the movement lines of the visitors indicate 86.1% of circular movement. If room 25, which has an exceptional character, is removed, most visitors tend to make circular movement (93.7%). As a matter of fact, room 25 is a transition space from which visitors have a choice as to whether to go to room 24 or room 19. This seems to encourage visitors to make a linear movement line. The figure of MR1/P is the highest among the cases (3.89 sec/m), even though the geometrical ratio is relatively high compared to the remaining parts of the gallery. In these respects, the characteristics of this wing are the high percentage of the circular movement line and thus the long time spent in a gallery.

5.3. CONCLUSIONS

Five exhibition spaces (wings) have so far been analyzed in terms of the spatial characteristics of the individual gallery space. It has been noted that museum visitors’ behaviour is significantly influenced by the physical dimension and geometrical shape of a gallery space and the location of openings in the space.

Openings in a gallery
First of all, it was noticed that the location of the opening(s) in a space plays a great role in defining the visitors’ movement pattern and thus their movement rate. When the opening is situated on one side of the gallery space, like in the North-Wing of the National Gallery, the visitors are naturally forced to make a circular movement line along the wall to finish the space. Therefore, visitors tend to spend more time in this kind of space than in other gallery spaces. When the openings are situated on both sides of the gallery space, like in the Tate Gallery and the
rest of the National Gallery, the higher the geometrical ratio is, the more visitors make a linear movement line.

Spatial Configuration
The higher the geometrical ratio is, the less time the visitors spend, provided that the physical dimensions are identical. In this sense, geometrical ratio, movement rate and movement pattern are closely interrelated. As for the movement rate, when the visitors make a circular movement, it is natural that they spend more time per metre measured on the perimeter of the gallery. One of the interesting facts was that the gallery spaces with high geometrical ratio tend to be also large spaces, in particular in the West-Wing of the Tate Gallery and the East-Wing of the National Gallery.

It can be said that the geometrical ratio is closely related to the size of the space, that is, the proportion of a space is generally likely be constant in an integrated part of an art gallery building, though there are differences between art galleries.

Character of paintings
It was seen that in the East-Wing of TG, the perimeter per painting shows 6.29 m, whereas the overall average is 3.58 m. This implies that either the paintings in this wing are generally larger than the ones in other wings or they are hung at much less density. Furthermore, the time spent per painting is 1.36 sec., which is much less than in other wings (the overall average is 2.86 sec.). In fact, more recent paintings are characterised by larger size and abstract aspects. Apart from the large size of the paintings and lower density of hanging, there is another reason why the time spent in front of a painting was less. This seems to lie in the fact that paintings in this wing were less well-known or more difficult to understand for the general public, or that the visitors are very quick to understand, and thus need a very brief appreciation. Therefore, the variables fail to make good correlations.

6. Discussion

Although recent museums show a considerable similarity in their spatial organisation with traditional museums, which were mainly built during 19th century, it is suggested that architects and museum professionals could benefit from a more systematic investigation of how spatial organisation affects the visitors' behaviour. Such an investigation could be useful in view of the growing concern about the quality of the visitors' experiences. This paper represents an attempt from the architectural point of view to find out the way in which museum people and architects can enhance the quality of the visitors' experiences.

As a result, it can now be said that there is a significant relationship between spatial organisation and the movement pattern and rate of the visitors. Throughout the analysis, it was noticed that other factors also played a role in defining the visitors' behaviour. The character of the paintings such as colour, size and the subject-matter certainly influenced the visitors' behaviour. However, the spatial structure of the exhibition space is the first and most important factor in defining the visitors' movement pattern and movement rate. In this sense, even if the character of the paintings is likely to discourage the visitors from spending enough time to look at them and from moving along the intended route, as we have seen in the East-Wing of the Tate Gallery, it may be possible to encourage them to do so naturally by manipulating the spatial structure.
References


