Legible cities:

The role of visual clues and pathway configuration in legibility of cities.

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Abstract

To make a city more legible there should be continuity between salient elements of the city; between main integrators and visible fields of the landmarks, to form a coherent structure. Alternatively, these elements should overlap to emphasise each other to make the city more legible. The relationship of these two elements in the city structure depends on the degree of irregularity of the layout and the presence of the rules of Gestalt of "good configuration". Each urban morphology, according to its degree of irregularity and presence or absence of Gestalt rules can be categorised as organised, semi-organised and unorganised. The role of landmarks or visual clues according to the type of morphology differs from one type to another. To make a legible city, there should be a coincidence between the maps of main integrators to the landmark setting to emphasise the main structure of the city in regular settings (organised and semi-organised structures). In irregular layouts, there should be continuity between the pattern of visible fields of landmarks and the main integrators of the city to form a coherent whole. The hierarchy of the urban axes in global and local level- most integrated and least integrated axes- will be followed by the hierarchy of the visual clues in global and local levels, which defines the nature of systems of reference in the structure of the city. The aim of the study presented by this article is to show how the interaction of landmarks and pathway configuration influence the legibility of the city.

Introduction

Extensive literature reviews exist regarding the theoretical proposals for making an urban layout legible but non of the methods have suggested objective ways for evaluating legibility of urban layout. Some studies have focused on analysing the legibility of the interior of buildings to find out which elements are important in making those patterns readable and easy to navigate through. Siring and Choir (1990), Weisman (1981) and O'Neil (1991), Lynch (1960), Carr (1969) and Cullen (1961) have also analysed legibility of parts of urban layouts. Their analysis has been subjective and has led to certain guidelines. The present article proposes a methodology of evaluating legibility after the first stages of design. At the first stage of analysis, a comparative study was performed on three urban layouts with different rates of regularity of pathway configuration and pattern of spatial elements: the inner area of Sheffield Ring road (semi-regular), Saltaire village (regular) and Runcorn Newtown (irregular). It was assumed that the legibility of these urban forms would show differences.

The first step of the analysis was to determine which urban layout is the most legible form. The next stage was to figure out which parameters of that layout might have influences on making it more readable than the others. To determine the most legible form, a sample of residents in three urban layouts were selected; 30 in Saltaire, 40 in Runcorn and 80 in the inner area of Sheffield Ring Road. Drawing mental maps and verbal recall were chosen as two complementary devices to extract imageability of the users in the urban layouts. The residents were asked to draw whatever they remembered of the area of study. Completing this stage they were encouraged to enumerate the elements that they thought had any significance for them. Depicting all the urban axes and spatial elements that have appeared in mental maps of different respondents drew a ‘Group image’ of each urban layout. Their importance were emphasised and shown by their frequency in mental maps.

The criteria for choosing the respondents were as follows: the subjects were all English to avoid the impact of difference of culture on the results. They were also between 20 - 40 years old. It has been seen that between this ranges of age the ability of people in drawing maps reaches its optimum level. They were selected equally between men and women. They were all residents of the area or its close adjacency. There was no restriction on the occupation of the respondents, professional draftsmen were avoided. There was no limit on the time for drawing maps. On average, drawing each map took 15-20 minutes. Data gathered, the maps were evaluated to verify which urban layout would show the highest legibility.

The maps were scored according their complexity, completeness and accuracy. The attributes defining complexity of the maps were Cell Percentage[1] , Accumulative percentage and General Structure. Cell percentage refers to the amount of information represented in each map (between 0-100%). Accumulative percentage indicates the amount of details that were appeared in the maps (0-100%). These details complete the information of the map in an abstract way. General structure represents the general organisation of each map. The score of general structure varied from one to five. In general, the maps were categorised into two main groups: sequential and spatial[2] . Sequential maps were the simplest forms of the maps and were scored one. Spatial maps constituting scattered (scored as two), mosaic and linked (scored as three), pattern incomplete (scored as four) and pattern complete (scored as five). The attributes of accuracy of the maps were General Orientation and Number of

Accurately Placed landmarks[3] . General orientation of the maps was scored between one and three: One as having no orientation, two as intermediate and three as high orientation. The number of accurately placed landmarks was designated according to the correct order of the landmarks in the area and their correct position pathway configuration.

Evaluation of the maps of three urban layouts showed that the most complete and complex maps were drawn in Saltaire, followed by the inner area of Sheffield Ring Road and Runcorn Newtown. The percentage of appearance of the most complete and complex maps, in three urban layouts were as follows: 60% in the Saltaire case study, 51 % in the Sheffield case study and 20% in Runcorn case study. Comparison of the cell percentage of the maps of three urban layouts showed that with more than 99% level of confidence there is a significant difference between three urban layouts. The result of comparison can be shown as follows (Table 1):

CP Saltaire> CP Sheffield> CP Runcorn

The results of the comparison of the maps of accumulative percentage showed that with 99% of confidence there is a difference between the Saltaire and Sheffield case studies. Saltaire and Castlefield showed no difference. Comparing the general orientation of the maps has shown that among three urban layouts, Saltaire has shown the highest general orientation while the maps of the Runcorn case study indicate the lowest scores. Regarding this aspect, the difference of general orientation between Saltaire and Sheffield is significant. Sheffield shows difference from Runcorn Newtown, but the difference is not as significant as the one between the two later urban layouts. The results of evaluations concerning the number of accurately placed landmarks showed that between three urban layouts Sheffield and Saltaire did not present a significant difference. In Runcorn Newtown, the discontinuity of the pattern of pathway configuration made this evaluation hard to perform. In this case only the relative position of the landmarks were considered in the evaluation.

In general, regarding all the attributes of evaluation, Saltaire showed the most imageable urban form, while Runcorn represents the least legible form (Table 1).

Urban form	Cell Percentage	Accumulative Percentage	General Structure	General Orientation
SALTAIRE	7	1.13	3.1	2.93
SHEFFIELD	5.02	0.3	3.2	2.3
RUNCORN	3.08	0.63	1.7	2.4

Table 1: Comparison of sketch maps of three urban layouts.

The second stage of analysis was defining the physical and social characteristics that made the urban layout more legible compared to the two other urban forms. Analysis of pathway configuration, location of significant spatial elements and continuity of salient elements were among the physical characteristics that were studied. Verification of the impact of densities of movement through the urban spaces was a social aspect that was also studied.

1. Regularity of Pathway Configuration:

Regularity of pathway configuration, its variation and whether it influences the formation of the 'group image' of the urban layout was the premier attribute to study. Integration value and the mean depth of the urban axes in the layout were defined as the attributes that defined the complexity of pathway configuration. The association between the integration value of the urban axes that appeared in the 'group image' of the city and their frequency was researched. It has been seen that there is a correlation of .685 (highly significant at 0.01 level) in the Sheffield case study, .682 (highly significant at 0.01 level) in the Saltaire case study. In the Runcorn case study, the number of the axes that appeared in the maps was only eight. The association between integration value and frequency of recall exist as well. The most integrated axes appeared in the "group image" of the layout[4] . (Tables 2 and 3)

Axes	Integration Value	Degree of Importance in the Area (% compared to the most integrated axis)	Degree of Appearance in Mental Maps (%)
1-TheMoor	4.5472	85-90	86
2-Pinston Street	3.6195	65-70	84
3-Fargate	3.9834	70-75	87
4-High Street	4.0645	75-80	77
5-Church Street	3.5875	65-70	71
6-West Street	4.6073	85-90	66
7-Leopold Street	3.8976	70-75	58
8-ArundaleGate	4.3642	80-85	55
9-Hallam University	2.8351	50-55	49
10-Division	4.1064	75-80	67
11-Charter Row	3.2658	60-65	19
12-Furnival Gate	3.5204	65-70	20
13-Eyre Street	2.6610	45-50	34
14-Commercial St.	3.9485	70-75	24
15-Surrey Street	4.0575	75-80	31

Figure 2: The map of the high-integrated axes and the most frequent spatial elements, Sheffield.
(Source, Ph. D. thesis by the author)

In Figures 1-4, the comparison between the pattern of the axes in the "group image" of the city and the pattern of highly-integrated axes can be seen in the two urban layouts of Sheffield and Saltaire . Another physical characteristics refers to the distribution of the highly--integrated axes in the layout and whether this distribution has any effect on legibility of urban layout. According to Space Syntax studies, the correlation between integration local and integration global is called intelligibility of the layout (Hillier 1996).

Figure 1: Map showing degree of appearance of axes in mental maps, 1998-99 Sheffield

(Source Ph. D thesis by the author)

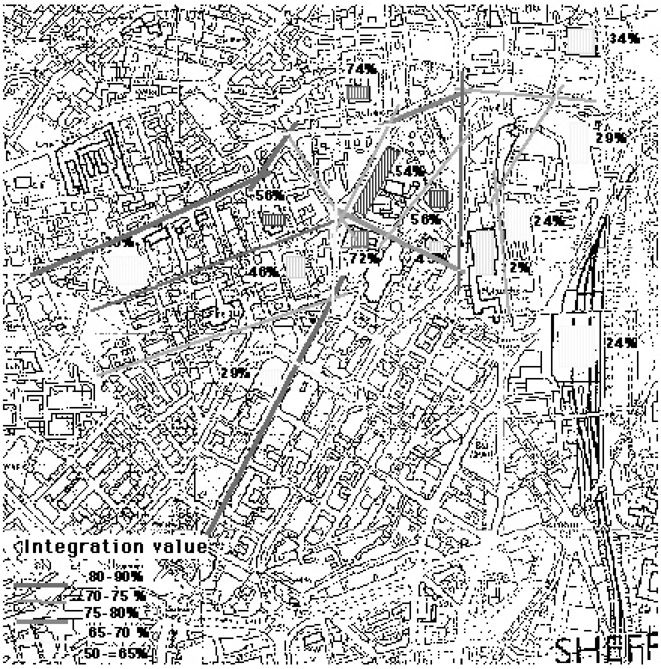

Figure 2: The map of the high-integrated axes and the most frequent spatial elements, Sheffield.

(Source, Ph. D. thesis by the author)

Axes	Appearance in sketch maps (%)	Integration 3	Degree of Importance (%) compared to the most integrated axis
Victoria Road	100	3.8324	77
Titus Street	56	4.5472	91
Caroline Street	56	4.9644	100
Saltaire Road	76	4.0420	81
Bradford Road	53	4.6141	92
George Street	43	3.9375	79
Albert Road	40	3.9485	79
Mary Street	23	3.5715	71
Exhibition Road	23	3.0309	61
Adda Street	23	3.1936	64
Helen Street	20	2.5450	51
Fanny Street	20	3.5715	71
Maddock Street	17	3.6859	74
Whitlam's Street	17	2.5450	51
Rhodes Street	13	2.8251	56
William H. Street	13	2.5450	51
Albert Terrace	13	3.4855	70

Table 3: Comparison of integration value and degree of appearance of the axes in Saltaire case study.

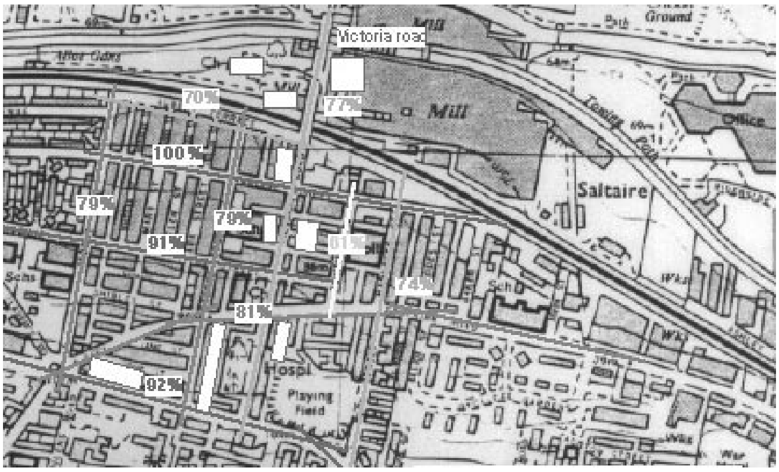

Figure 3: The pattern of the high-integrated axes in the Saltaire case study. (Source Ph. D. thesis by the author)

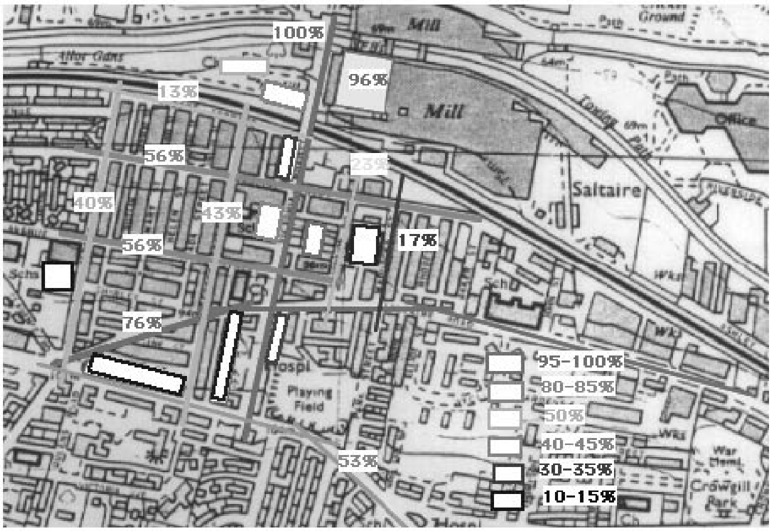

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Figure 4: Degree of appearance of the main axes and the main spatial elements, Saltaire case study. (Source Ph. D. thesis by the author)

As the urban form becomes more intelligible the correlation between local and global integration increases too. As Hillier indicates (1983) that this association increases, the people who are walking in the local areas are more aware of the general structure of the layout. This aspect has never been tested objectively before. In three urban layouts, the association between integration local and global is the highest in Saltaire and has the lowest value in Runcorn Newtown (Table 4). As Space Syntax studies indicate, intelligibility of the urban layout can be defined by another method calculating correlation between connectivity and integration n. Again the association between two sets of value is the highest in Saltaire compared to the two other urban forms. As can be seen, evaluation of the mental maps confirms the results of the above calculations; showing Saltaire the most intelligible and Runcorn the least intelligible urban layout.

Table 4: Correlations showing the intelligibility of three urban forms.

Intelligibility	**Runcorn**	**Sheffield**	**Saltaire**
Correlation Integration 3/ Integration n (R2)	0.1439	0.4535	0.5674
Correlation Connectivity/ Integration n	0.98	0.298	0.3177

2. Visibility of Spatial Elements:

Other physical characteristics regarding the urban layout are the location of spatial elements and their visibility through the urban layout. The cores of visibility are the zones that show high potential regarding visibility of important spatial elements. To verify whether the location of spatial elements has any impact on the recall of urban axes and the formation of 'group image' of the city the following procedure was followed: in three urban layouts, the significant spatial elements were selected. The criteria for selection were Appleyard's scales (Appleyard, 1969): form intensity scales, visibility scales and significance scales. Intercultural studies showed the generality of this criteria (Evans 1982, Gulick 1963, De Jong 1962). Using isovist method (Hillier 1996), the visible fields of significant spatial elements were drawn. The pattern of visible fields was superimposed on the axial map of the area (Figure 5). Integration of the final pattern was calculated to see where the cores of visibility exist and to evaluate the potential of urban axes regarding visibility of spatial elements through them. (Figure 6) In the Saltaire case study, the mean depth of the urban axes from the cores of visibility is reversibly associated with their frequency of recall in the maps. The correlation between the mean depth of the main axes from the cores of visibility and the degree of appearance of the main axes in mental map is -. 74** which is significant at 0.01 level (Table 5B). As depth of urban axis regarding the core of visibility decreases, the frequency of recall increases. (Table 5A)

Axes	Appearance in sketch maps (%)	Integration 3	Degree of Importance (%) compared to the most integrated axis
Victoria Road	100	3.8324	77
Titus Street	56	4.5472	91
Caroline Street	56	4.9644	100
Saltaire Road	76	4.0420	81
Bradford Road	53	4.6141	92
George Street	43	3.9375	79
Albert Road	40	3.9485	79
Mary Street	23	3.5715	71
Exhibition Road	23	3.0309	61
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Maddock Street	17	3.6859	74
Whitlam's Street	17	2.5450	51
Rhodes Street	13	2.8251	56
William H. Street	13	2.5450	51
Albert Terrace	13	3.4855	70

Table 5A: Comparison of degree of appearance of sketch maps and potential of axes from visibility point of view.

		Degree of appearance of axes (%)	Mean depth of the axes from the core of visibility
Degree of appearance of the main axes (%)	Pearson correlation	1.000	-.744**
	Sig. (2-tailed)		.000
	N	20	20

Table 5B: Correlation between the mean depth of the main axes from the cores of visibility in the area and the degree of appearance of the main axes.

In the Sheffield case study this association does not exist. The Information of the spatial elements is retrieved from memory. Not their direct visibility, but their importance as spatial elements retain in mind of users. The importance of the buildings affects frequency of appearance of axes in mental maps. (Table 6)

Figure 5: The superimposition of axial map and the visible fields of spatial elements, Saltaire case study.
(Source, Ph. D. thesis by the author)

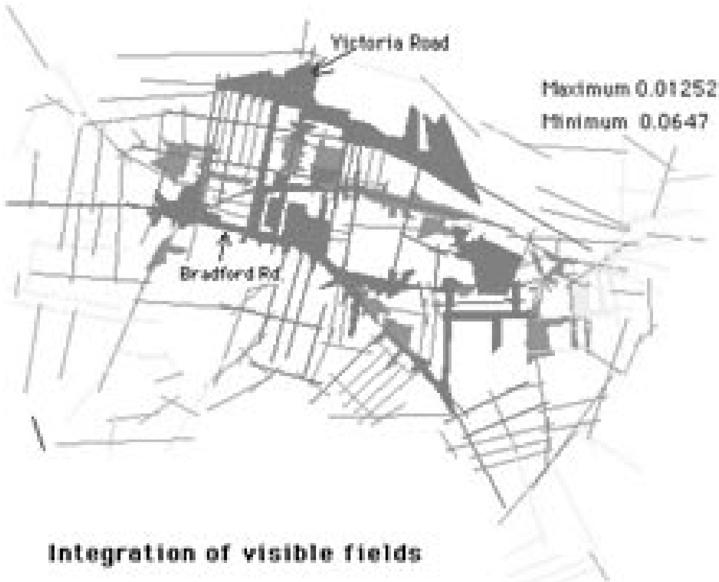

Figure 6: The calculation of integration of visible fields of spatial elements, Saltaire case study. (Source, Ph. D. thesis by the author)

Table 6: Degree of appearance of spatial elements in sketch maps of Sheffield ring road area.

Building	**Frequency of appearance (%)**
Cathedral	74
Downhaul	72
City hall	56
Crucible	56
Cole Brothers	46
Library	45
Lyceum	45
Markets	34
Ponds Forge	20
Hallam Shire University	32
Debenhams	29
Rail station	24
Bus station	24

There is also a relationship between the highly-integrated axes; the highly-integrated axes are interrelated and they end up to the two cores of high potential visibility of main spatial elements. These two zones are the Theatre and Peace Garden (Figure 7). In Runcorn, visibility of spatial elements does not play any role. The spatial elements are few and dispersed through the landscape.

3. Continuity of Salient Elements:

Another aspect that has impact on the recall of urban axes is continuity of salient elements[5]. Salient elements were defined as high-integrated axes, the axes with important spatial beside them and important nodes or clusters of landmarks that act as focal points in memory. Continuity of salient elements is described as follows:

- Successive order of high-integrated axes
- Successive order of high-integrated axes and the axes with significant spatial element beside them.
- Proximity of nodes and cluster of significant spatial elements

Figure 7: The integration of the visible fields of spatial elements in the Sheffield case study.
(Source, Ph. D. thesis by the author)

Verification of the possible impact of continuity of salient elements on the formation of 'image group' of the area was performed through searching similarity between the pattern of salient elements and “group image” of the city. In the Saltaire case study the high-integrated axes are continuous. In the Sheffield case study the high integrated axes and the axes with the most recalled spatial elements beside them make a continuous pattern. (Figures 8&9)

In Runcorn, the high-integrated axes and the axes with important spatial elements beside them are dispersed but these axes are among the ones that appear in mental maps (Figure 10). It was observed that, as continuity of salient elements decreases the pattern of “group image” of the area becomes more distorted and partial. This identifies that the continuity of salient elements might be associated with the legibility of the urban layout.

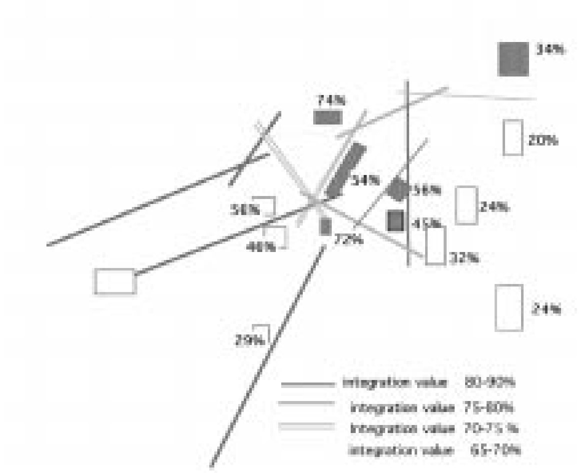

Figure 8: The diagram showing continuity of salient elements in the Sheffield case study. (Source, Ph. D. thesis by the author)

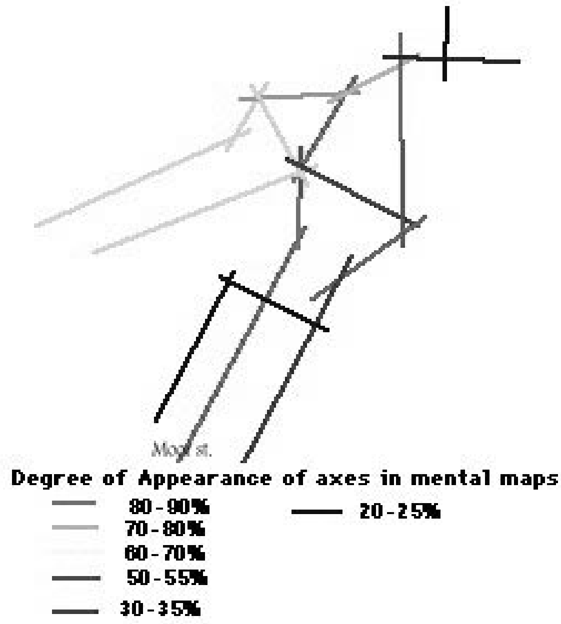

Figure 9: Degree of appearance of the axes in mental maps, Sheffield case study. (Source, Ph. D. thesis by the author)

4. The presence of Gestalt rules in some parts of the plan of the city:

In Saltaire the pathway configuration has a rectangular form. In verbal recall of the urban layout, 100% of the respondents pointed out the gridiron pattern of the layout. In the Runcorn case study, there is no order in the pathway configuration. But the loop-shape of two lines of movement follows a circular form. 80% of the respondents in the Runcorn case study mentioned the circular shape of parts of the lines of movement during verbal recall. In both studies, the simple form of the high-integrated axes appears to affect the configuration of the “group image” of the city.

5. Densities of Movement:

The presence and co-presence of people in urban spaces are two aspects that affect the memory in the formation of 'group image' of the area. In the Sheffield case study, the densities of movement were observed through twenty- three urban axes. The method of observation was as follows: 32 gates were selected and the number of persons passing through the gates during five minutes was counted. The counting was performed during two different days (non-holidays) in five different periods of time; 8-l0 am, 10-12 am. 12-2 pm, 2-4 pm. and 4-6 pm. The average of these counts, in each day, showed the flow of pedestrian movement on that axis during five minutes. Adding the two counts in two different days has shown the flow of pedestrian movement in ten minutes, which has been multiplied by six to get the average of the flow in an hour through each axis. The correlation between the flow of pedestrian movement through each axis and their frequency of recall in the maps were calculated. It was seen that a high correlation exists (R2 =0.642) (Table 7 and 8)

The association between the flow of pedestrian movement andthe frequency of recall of the axes indicates that high flow of pedestrian movement has a direct impact on the frequency of recall of urban axes, in some cases, irrespective of the location of shops or significant spatial elements. In three urban layouts, the main lines of movement have resided in the mind of users and have formed part of the "image group" of the layout.

Degree of appearance of the axes in mental maps in Runcorn case study

The map of salient elements in Runcorn case study

Degree of appearance of urban axes and spatial elements in Runcorn case study

Figure 10: Simplification of the maps of high-integrated and spatial elements and the map of the axes with high degree of appearance in mental maps in Runcorn case study.

(Source, Ph. D. thesis by the author)

6. How can the results contribute to the design procedure?

After the first stages of design, and using the results mentioned above, several applications could be deduced. The axial analysis of the map can be executed to figure out what is the pattern of high-integrated axes in the area (the urban axes that possess 60% of the maximum integration value might show the main structure of the area). The location of spatial elements can be shown in the same map or in an overlay.

Table 7: Flow of pedestrian movement and degree of appearance of axes in the Sheffield case study.

Axis	Flow of pedestrian movement p/hour	Degree of appearance of axes %	Axis	Flow of pedestrian movement p/hour	Degree of appearance of axes %
Moor	2566.2	86	Fitzwilliam	46.8	13
Pinston street	1872	84	Rockingham street	198	6
Fargate	4489.2	87	Rockingham T.	33.6	2
High stree t	2506.8	77	Carver lane	274.8	1
Church street	1323.6	71	Cambridge street	676.8	3
West street	628.2	66	Union street	700.2	4.8
Arundel gate	1149.6	55	Hallam university	627.6	44
Division street	898.2	67	Furnival gate	390	20
Wellington street	166.8	2.4	Eyre street	400.8	34
Charter row	279	19	Portobello street	105.6	2.4

Table 8: The correlation between the degree of appearance of axes most recalled in mental maps and flow of pedestrian movement through them.

No of axes	Degree of appearance	Correlation between degree of appearance and flow of pedestrian movement (R2)
11	over 50%	0.581
15	over 20%	0.898
20	various	0.642

The combination of the two layers would show the pattern of salient elements. Simple shapes of parts of the pathway configuration also can be highlighted to indicate the sections that might appear in the “group image” of the urban layout. The next step would be to check whether this pattern would have a high potential of appearance in the mind of the users. As evaluation of mental maps showed 'group image' becomes more complete and coherent as:

- Continuity of salient elements increases
- Regularity of pathway configuration increases
- Parts of pathway configuration appear to have simple and defined shapes (obeying “Gestalt” rules of good configuration)
- A kind of order appear among the significant spatial elements for example: successive order of spatial elements, accompanying the change of scale
- High densities of movement through certain urban axes exists, making the axes significant in the mind of users
- Relative simplicity of pathway configuration exists, which affects the memory in the formation of “group image” of the city.

Creating one or combination of these aspects would help to enhance the legibility of the system in general. Different ways of designer's interference to increase imageability of the layout can be categorised as follows:

6.1 Creating Continuity:

Continuity of salient elements can be increased by successive orders of high-integrated axes as well as successive orders of high-integrated axes with the axes that have significant spatial elements beside them. Visibility of the spatial elements from the point of intersection of the high-integrated axis and the axis that have the spatial element beside it would help to fortify the continuity of salient elements.

6.2 Creating Order:

Creating regularity can be performed by changing pathway configuration to achieve a more regular form and to decrease irregularity. Although creating an extreme regular layout should be prohibited to avoid monotony. A kind of order can be created in the layout by successive order of spatial elements in different scales. The change of scale of spatial elements can be harmonised with the change of scale of urban spaces making the readability of the layout more feasible.

6.3 Distribution of Zones of Activity:

Distribution of zones of activity and pathway configuration both affect the flow of pedestrian movement through the urban layout. The areas with high densities of movement stay in the mind of users. The areas of big social gathering or the routes that interconnect the major zones of activity stay in the mind because of the presence of the people as well as the activity itself. Reconsidering the land use policies would help to redefine the distribution of pedestrian movement in certain parts and can be changed by the designer in certain parts of the map.

6.4 Distribution of "Cores of Visibility":

One of the ways of making the urban layout more legible is to distribute the cores of visibility with regard to the distribution of high-integrated axes in the area. The high-integrated axes should end up at or pass by the main cores of visibility. The mean depth of urban axes from these cores is associated with their frequency of recall in mental maps.

6.5 Interrelationship of High-Integrated Axes:

As the evaluation of mental maps shows, the interrelationship of the high-integrated axes increases the legibility of' the layout. By changing the location of high-integrated axes to connect the centre to the surroundings the legibility of the layout can be enhanced. It was shown that as this connection is fortified the frequency of recall of the axes increase. The results agree with the study by Peponis (1989) that the spread of an urban core affect the flow of pedestrian movement.

6.6.Creating simple forms in some parts of the pathway configuration:

In some parts of the pathway configuration creating simple and geometric forms would create a pattern that might be better retained in the mind of users.

Notes

[1] - In a study by Walsh Cross and Reigner (1981) Cell Percentage and Accumulative Percentage are used to show the consensus of the users in representing the borders of their neighbourhoods.

[2] - In general structure the Appleyard's study (1969) in categorising maps was considered

[3] - Accurately placed landmarks was another attribute for evaluating the sketch maps proposed in a study by Rovine and Weisman (1995). For more details of scoring sketch maps refer to Shokouhi M. Unpublished Ph. D. Thesis, Sheffield University, March 2000.

[4] - The axial analysis of three urban layouts and the details of the degree of appearance of the axes can be seen in Shokouhi M. Unpublished Ph. D. Thesis, Sheffield University, March 2000.

[5] - In a study by Holahan and Sorenson (1995) the continuity of salient elements and their impacts on the recall of the maps in the users' minds were tested

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