Spatial configurations and user preferences: Built environments in urban India

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Abstract- In an urban area, users use spaces on the basis of preferences and importances given. User preferences are usually common for a society due to common socio-cultural background. The paper attempts to understand the differences in user preferences of residents of two select localities in a developing city of Nagpur in India by studying the relationship between their spatial cognition and spatial configuration. Spatial configuration is quantified by axial line modeling based on space syntax theory. Local integration (R3), global integration (Rn) and connectivity are considered as parameters of spatial configuration. Interpretive parameters are synergy and intelligibility. The correlation study between parameters of cognition such as frequency of recognition, frequency of use and syntactic parameters is done. It has highlighted the differences in user preferences due to different spatial configurations.

Index Terms- Spatial Configuration, Spatial Cognition, User Preferences, Cognitive Constructs, Space Syntax

I. INTRODUCTION

India is in a rapid phase of urbanisation. Up till now, the urbanisation process was mainly affecting megacities, but now small and medium size cities are also developing. These medium size cities mostly have traditional organic pattern of spatial configurations which has evolved over time. The new patterns of spatial configurations are based on modern city planning principles evolved after industrial development in Europe and North America. These are adopted in Indian cities not giving much consideration to culture specific user preferences. In an urban area, users use spaces on the basis of preferences and importances given; which can be termed as cognitive constructs. These are usually common for a society due to common socio-cultural background. The user preferences in Indian context are quite different due to socio-economic, demographic and cultural differences. Traditionally evolved configurations are usually in congruence with user preferences as these preferences acted as a regulator of their progression. But there is a significant mismatch between the configurations of the contemporary built environments and the user preferences. The mismatch between the user preferences and the spatial configurations has led to rise of conflicting situations in developing cities as shown in figure 1. The present study does not want to discredit or discount the valuable contribution of modern city planning principles in building good cities in post independence India, but the paper puts forth a view that it may be useful to move ahead with the understanding of the user preferences specific to Indian context. There is a need for Indian built environment studies contributing to such positive theories. The paper deals with developing a methodological framework to understand the culture specific user preferences and the role of configurations in deciding preferences. The user preferences about using the environment can be learnt through the study of man-environment relationship. Spatial cognition is a mending mechanism between man and environment (Rapoport, 1977 pp 108). The understanding of cognitive constructs can help to comprehend user preferences.

Fig 1: Conflicting Urban situation
Source: Author

The paper attempts to understand the differences in user preferences of residents of two select localities in a developing city of Nagpur in India. The two localities differ in their configurations. One locality is a part of old organically evolved part of the city and other locality is a planned development in post independence period. Thus they differ in terms of their configurations. The study has helped to understand the culture specific user preferences and effect of configuration in deciding preferences.

II. METHODOLOGY

Spatial configuration is defined as a relation affected by the simultaneous co-presence of at least a third element and possibly all other elements in a complex. (Hillier, 1996, pp 71) Thus, configuration is a set of relations between spaces that exist at a particular point in time. Configuration may facilitate or restrict the possibility for visual and physical linkages. While using the built environments, human beings try to structure those linkages to make it manageable. This process of deciding about behaviour

on the basis of defining what is done, where and when, how here differs from there, in a built environment is called 'spatial cognition' (Rapoport, 977 pp113). The spatial configuration is not directly responsible for the behaviour. But the subjective structuring of that configuration in terms of spatial cognition is responsible for the behaviour. The relationship between spatial cognition and configuration is two way. Spatial configuration is responsible for shaping cognition and over a period of time, cognitive constructs shape spatial configuration.

Spatial cognition has two views. One is related to anthropological view and other is psychological (Rapoport, 1977 pp 108). Psychological view is about the correctness of schemata developed which depends on environmental knowledge. It varies individually due to age, sex, experience, exposure and spatial aptitude. But the anthropological view deals with the process of imposing order on the existing built environment by the society. The cognitive constructs develop by attaching importance and meaning to the built environment. Psychological view and anthropological view are related to each other.

To quantify and understand spatial configuration, there can be various methods of analysis of built environment to understand its configuration. Most of them depend on visual and physical aspects, metric distances and geometrical aspects of configuration. However such methods apparently lack in perceiving the 'spatial configuration- social behavior relationship' (Mohareb Nabil, 2009). Analysis till date suggests that far reaching practical implications on human response are not because of visual appearance but because of spatial configuration. The quality of individual space is not important; but the quality of relationship between spaces is important if we are discussing spatial configuration and user behaviour. Therefore, system of spaces needs to be considered with its topology rather than geometry of spaces.

Space syntax is used as a method to understand the topological relationships rather than metric distances between a space and all other spaces. The notion of syntax, derived from linguistics, refers to the relationships between different spaces or interactions between space and society (Jiang Bin, & Claramunt Christophe, 2002). Depth is defined as the minimum distance in terms of number of steps between two nodes. It is an important parameter of representing topological inter-relationships in a system of spaces. The quantification of relationships or configurations in terms of numerical parameters is based on the notion of topological distance or depth. The types of syntactic analysis include Visual-field analysis, Node analysis and Axial-line analysis.

Axial line modeling is chosen for the intended analysis. In axial-line analysis, the space is represented by straight lines called as axial-lines. In brief, the space to be examined is modeled by 'the fewest and the longest straight lines covering all convex spaces' (Hillier & Hanson, 1984, p. 91-92). The important syntactic parameters of spatial configuration are connectivity, integration (global and local), and the interpretive parameters are synergy and intelligibility. They are identified as parameters of spatial configuration. Intelligibility is defined as the correlation between connectivity and global integration and it is an indicator of how clear an urban system is for its users. Synergy is an indicator of 'part to whole relationship' in a system. 'UCL Depthmap' software is used for syntactic analysis. Figures 4, 5, 6 and 7 show axial maps generated by UCL Depthmap using 'graduated colour symbology' based on the integration values. Such graphic technique helps in visualization and comparison of spatial configuration of different systems. Generally, an accepted rule is to represent high global or local integration with warm colours such as red, orange and to display low integration values using cool colors, such as blue or green.

User preferences can be understood by externalizing cognitive map of users. Cognitive map is not a tangible entity and very difficult to externalize and comprehend. Spatial behaviour is an overt expression of spatial cognition (Markandey, 1997). Hence spatial behaviour in terms of pattern of use of spaces can help to understand cognitive constructs.

Sketch map method is often used by researchers. Sketch map assumes that a person understood the abstract representative notion of a map, its relation to the real world and translating spatial information from large to small scales. Through pilot survey, it was observed that the cartographic understanding of the respondents is very poor. Hence, a method of questionnaire based survey, recognition tests and behavior maps is used.

(i) A questionnaire was prepared and used to collect data about cognition and socio demographic character of the respondents, the data about the use of facilities, activity nodes within the locality and outside the locality.
(ii) A recognition test based on photographic information is worked out. For such a test, important landmarks located on axial lines with highest and second highest values of local/global integration are identified. The photographs of these landmarks were clicked at eye level in almost the same viewing angle as they are mostly seen while moving on the road. The photographs at these identified locations were then printed on photo-paper and respondents were asked to recollect, recognize and mention the locations of the photographed landmarks. Such a task is done for local level landmarks, nodes and paths and also for global level landmarks, nodes and paths.
(iii) Post recognition questions dealt with assessing the reasons for recognition.

(iv) For behaviour map, a photocopied map of the locality with North, all road network, important landmarks, and open spaces; is given to respondents. They are asked to mark their own residence, important roads and the facilities, activity nodes they use routinely on the given map. Figure 2 shows one of the behaviour maps by a respondent.

Figure 2: Behaviour Map of a Respondent

Source: Author

To understand the user preferences through the study of the relationship of spatial configuration and spatial cognition, the parameters of cognition are identified with the help of the scrutiny of the collected data. In anthropological aspect, the parameters of cognition were identified as frequency of use of local and global activity nodes and paths. The parameters of cognition in terms of psychological aspect were identified as frequencies of recognition of local and global landmarks. In the study, 'Local' activity nodes or landmarks refer to those which are within the delineated boundary of the localities studied and those which are outside delineated boundaries are referred as 'global'.

The parameters of configuration are already identified. Correlation analysis between parameters of configuration and cognition is carried out.

The study is carried out in the city of Nagpur which can be considered as a fair representative of developing cities in India because it is located at the centre of India and is a cosmopolitan city without any specific cultural, climatic, topographical peculiarity.

This study is conducted for two localities in Nagpur: Trimurti Nagar and Mahal. Mahal is an old locality that is selected as a representative of traditional, organically evolved old area and Trimurti Nagar is a new planned locality which is selected as a representative of post independence orthogonal planning.

III. FINDINGS

First part of the questionnaire was about socio-economic characteristics of the respondents of the select localities. The multiple bar diagram (figure 3) presents the comparative socio-economic characteristics of the respondents.

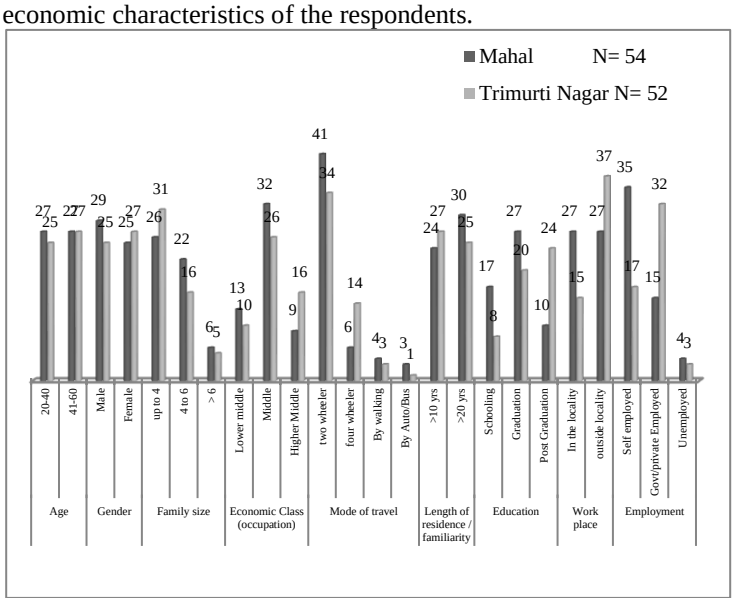

Figure 3: Socio-Demographic Information of the Sampled Respondent Residents

As mentioned already, for understanding the relationship between spatial configuration and cognition, it is important that the two groups should be homogeneous with respect to certain socio-economic-demographic characteristics. Hence by using Chi-Square test for homogeneity, one can test whether the two localities can be considered homogeneous with respect to the different socio-economic parameters. It was found that the composition of the sampled respondents from both the localities is homogeneous with respect to age, gender, family size, economic class, length of residence and mode of travel. However, there is a significant difference in the sampled respondents of the two localities with respect to education, employment and work-place location. To understand the role of configuration in development of these two aspects of cognition, co-relationships between syntactic parameters and parameters of spatial cognition are studied. For studying such relationship, correlation coefficients between syntactic parameters such as R**3**, Rn, Connectivity and frequency of use, frequency of recognition are calculated. Correlation matrix of these coefficients is shown in Table 1 and table 2. To test the significance of the observed correlation coefficients, 't – Test' is carried out. The correlation coefficients highlighted are found to be significant.

Table 1 Correlation Matrix: Syntactic Parameters and Frequency of use

New planned locality : Use of roads/ paths within the locality				
	R3	Rn	Connectivity	Frequency Of Use
R3	1			
Rn	0.82	1		
Connectivity	0.7	0.41	1	
Frequency of use	0.51	**0.54**	0.3	1
Old: Use of roads/ paths within the locality				
	R3	Rn	Connectivity	Frequency Of Use
R3	1			
Rn	0.77	1		
Connectivity	0.82	0.7	1	
Frequency of use	0.5	0.37	0.62	1
New planned locality: Use of activity nodes within the locality				
	R3	Rn	Connectivity	Frequency Of Use
R3	1			
Rn	0.72	1		
Connectivity	0.46	0.74	1	
Frequency of use	0.31	0.70	0.46	1
Old : Use of activity nodes within the locality				
	R3	Rn	Connectivity	Frequency Of Use
R3	1			
Rn	0.69	1		
Connectivity	0.82	0.66	1	
Frequency of use	0.58	0.013	0.27	1
New planned locality : Use of activity nodes outside the locality				
	R3	Rn	Connectivity	Frequency Of Use
R3	1			
Rn	-0.49	1		
Connectivity	0.87	0.083	1	
Frequency of use	0.0017	0.25	-0.13	1
Old : Use of activity nodes outside the locality				
	R3	Rn	Connectivity	Frequency of Use
R3	1			
Rn	0.13	1		
Connectivity	0.84	0.22	1	
Frequency of use	0.35	0.13	0.53	1

Table 2 Correlation Matrix: Syntactic Parameters and Frequency of Recognition

New planned locality: Recognition of local landmarks/ paths				
	R3	Rn	Connectivity	Frequency of recognition
R3	1			
Rn	-0.18	1		
Connectivity	0.86	-0.29	1	
Frequency of recognition	0.14	0.05	0.03	1
Old: Recognition of Local landmarks/ paths				
	R3	Rn	Connectivity	Frequency of recognition
R3	1			
Rn	0.65	1		
Connectivity	0.89	0.41	1	
Frequency of recognition	-0.27	-0.14	-0.27	1
New planned locality: Recognition of Global landmarks/ paths				
	R3	Rn	Connectivity	Frequency of recognition
R3	1			
Rn	0.47	1		
Connectivity	0.93	0.5	1	
Frequency of recognition	0.03	-0.12	-0.008	1
Old: Recognition of global landmarks/ paths				
	R3	Rn	Connectivity	Frequency of recognition
R3	1			
Rn	0.019	1		
Connectivity	0.89	0.66	1	
Frequency of recognition	-0.04	0.32	-0.08	1

In the new planned locality, frequency of use of paths within the locality is positively correlated with R**3** and Rn but it is not correlated with connectivity. Thus, if the local Integration and global integration of a road are high then more is the frequency of use of the road in new planned locality. In old area, frequency

of use of paths within the locality is positively correlated with R**3** and connectivity, but there is no significant correlation between Rn and frequency of use.

This shows that residents of the old locality use locally integrated roads and subsequently local facilities more than the residents of new planned locality. This is because of the configurational peculiarity where people tend to move on local network before getting connected to global network. For use of activity nodes outside the locality, none of the configurational parameters have any significant relationship in case of new planned locality.

In case of old locality, the preferences about use of global activity nodes have significant correlation with connectivity. New planned locality residents have more education and mostly employed in public/private sector. The workplace locations are outside the locality. The residents of new planned locality have better commutability and they tend use facilities located on global network.

As seen from table 2, in new planned locality there is a significant correlation between Rn and frequency of recognition of global landmarks. However, it is observed through correlation study between frequency of recognition and syntactic parameters, that the role played by configuration in recognition or cognition in terms of psychological aspect is not significant.

IV. Discussion

The differences in use of global and local facilities by residents of old and new planned localities are due to configurational differences. The axial map of old locality showing global integration is shown in figure 4. The axial map of new planned locality indicating global integration is shown in figure 5. In case of old locality, there are many but small axes. The axes in new planned locality are longer and fewer. Though the average values of local and global integration are almost same, in case of old locality, there is significant variation in maximum and minimum values. Also the average values of connectivity are almost similar but in case of old locality, there are few axes with very high connectivity. As far as synergy and intelligibility are concerned, there is not much difference but still old locality is more synergistic and less intelligible as compared to new planned locality. Due to these syntactic peculiarities, the natural movement pattern in old locality is more restricted within the locality. It encourages the use of local facilities more and subsequently the social interaction and cohesion, making the locality much more humane.

In case of new planned locality, the syntactic configuration is such that the natural movement pattern encourages movement on longer paths with higher global integration, leading to more use of global facilities than local. That is further boosted by better commutability in case of new planned locality residents. Due to nature of employment and location of workplace, the commutability of the respondents from new planned locality is higher. Thus commutability has emerged as confounding

Figure 4: Global Integration map (Rn) of Mahal - smaller but many axes

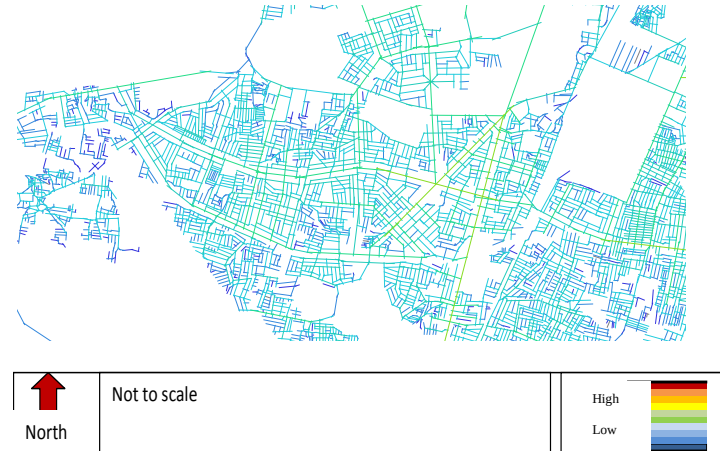

Figure 5: Global Integration(Rn) map of Trimurti nagar- longer and fewer axes

variable. It is not actually studied but it has emerged out of study which affect the relationship between the dependant and independent variable.

The variations in maximum and minimum values of local integration in case of old locality helps in making residential streets physically segregated from the total system. Axial map indicating local integration of streets in old locality is shown in figure 6. This restricts the vehicular movement within streets encouraging their use as active social space. Similarly the axial map indicating local integration of streets in new planned locality is shown in figure 7. In case of new planned locality, mostly due to grid iron pattern, such variation in minimum and maximum values of integration does not exist.(fig 7) Many internal residential streets are equally physically integrated thus restricting their use as social spaces for playing or other activities such as celebration of festivals. More of physical integration of a space in a system restricts its role in social integration.

Figure 6: Local integration map of Mahal

Figure 7: Local integration map of Trimurti nagar

Not to Scale
North

In new planned locality, there are higher numbers of spaces with higher values of global integration. This is responsible for making the locality more intelligible. But many of its axes are having less local integration. Thus making the locality less synergistic compared to old locality. In case of old locality, though it is less intelligible, it is more synergistic and spaces within system are not directly connected to global system but they have a hierarchy and spaces at local level gradually get connected to spaces at global level. This also helps in use of local facilities as you are confronted with local facilities before you get connected with global system.

It is observed through correlation study between frequency of recognition and syntactic parameters, that there is hardly role played by configuration parameters in recognition or cognition in terms of psychological aspect. Also there is any role of architectural characteristics of individual built-forms in cognizing the built environment for its use.

V. CONCLUSION

It can be concluded that due to socio-demographic and economic peculiarity of the situation, the user preferences in India can be considered to be different. User cognize and then use built environments according to topological relationships. Physical and visual linkages through configuration play an important role in deciding the user preferences about the movement and use of facilities in built environment. These preferences are governed by various factors other than configuration at global level, but at local level, the preferences are significantly affected by configuration. Configuration affects the accessibility but the way accessibility is envisioned by the users, depend upon the common cognitive constructs due to socio-economic peculiarities of the Indian society. Hence instead of following westernized planning principles, it is important to understand the culture specific user preferences in Indian context for dealing emerging built environments in Urban India.

APPENDIX

Following table gives the algorithm for calculations of syntactic measures.

Syntactic measure name/parameter	Description	Parameters	Remarks
Mean depth	Total Depth, TD(n), is the total of the shortest distances from node n to the other nodes in the systems, Mean Depth: Mean Depth for a node n is the average depth from node n to all the other nodes.	Mean Depth $MD = L/(N-1)$ where, L = Total Depth (in terms of no. of steps) and N = total number of spaces in a system.	Very much a research number.
Relative Asymmetry	Relations of depth necessarily involves notion of asymmetry RA generalizes this by comparing	Relative Asymmetry $RA = 2(MD-1)/(K-2)$ MD: mean depth, K: number of space in a system	Lower value lesser depth more of integration
Real Relative Asymmetry (RRA)	RA values can be used to compare various spaces of approximately same size. But if one has to compare across systems which differ significantly in size, there is a need to take one more transformation to eliminate the effect of size.	Real Relative Asymmetry (RRA) = RA/X where X = [6.644K. Log lo(K + 2) - 5.17K + 2] / (K ~- 3 K + 2)	RA values are then adjusted between theoretical and empirical limits to allow direct comparisons across patterns regardless of their size.

			known as the Real Relative Asymmetry (RRA).
Integration	Integration: Integration of a node is by definition expressed by a value that indicates the degree to which a node is integrated or segregated from a system as a whole (global integration), or from a partial system consisting of nodes a few steps away (local integration)	Integration $= 1/RRA$	Low values indicate integration and high values indicate segregation
Connectivity:	It denotes the number of immediate neighbourhoods of an axial line.	It measures the number of lines that directly intersect given axial line.	

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