### SPATIAL CONFIGURATION, SPATIAL BEHAVIOUR AND SPATIAL COGNITION: SYNTACTIC AND PERCEPTUAL ANALYSIS OF THE MARKET STATION AREA IN PORTO ALEGRE

Maria Cristina Dias Lay, Antônio Reis, Virginia Dreux, Débora Becker, and Vitor Ambrosini  

*Federal University of Rio Grande do Sul*

The paper investigates the role of spatial configuration in shaping users’ spatial behavior and spatial cognition in the central area of Porto Alegre and the effects of Market Metro Station on the legibility and imageability of the area. In order to measure these environmental qualities, accessibility, user perception of urban security, morphologic characteristics, pedestrian movement, intensity and location of activities are investigated. Data were collected by complementary techniques, such as physical measurements, interviews, cognitive maps, observations of behavior, questionnaires, information about passengers gathered from the Metro Central Office, information about crime collected from the City Council Urban Security Sector and configurational analysis. The results of integration analysis about the influence of intensity of pedestrian movement on urban security are not similar to the many studies carried out elsewhere.

### Introduction

This research focuses on social and spatial factors cross-examined with regard to their effects on environmental performance and spatial cognition of urban open spaces, which in many major Brazilian cities, present lack of security related to crime. This problem deserves special attention in this investigation, as authors (e.g. Tiesdell, 1998; Canin, 2001) emphasize the importance of fear of crime on affecting the use of urban spaces, limiting user mobility. A whole set of variables has been related to the lack of urban security, including those of social-economic, political and physico-spatial nature. Various studies have concentrated on the analysis of the relationship between the morphological and configurational characteristics of urban space and the occurrence of criminal events (Hillier & Shu, 1999; Poyner, 1983; Newman, 1972).

From a social point of view, according to Peponis and Wineman (2002), built space can be defined as a field of structured co-presence, coawareness, and encounter. It follows that built space is to be understood as a relational pattern, a pattern of distinctions, separations, interfaces and connections. One of the theorems chosen by Peponis and Wineman (2002) to illustrate ways in which built space works socially deals with linear spaces, such as streets in urban areas and the paths of movement along those spaces, and argue that high accessibility implies a higher probability that a space will be used for movement. The measures of accessibility (defined by the concept of integration) proposed by Hillier and Hanson (1984) are functions of the number of direction changes made, the number of boundaries crossed, or the number of spaces traversed.

Accessibility, which means access to a certain space with its implications for potential movement, presence of people and use of spaces, is one of the configurational characteristics which has been identified as directly related to the occurrence of crimes, mainly by studies involving syntactic analysis (Hillier & Shu, 1999; Shu, 1999; Jones & Fanek, 1997). The degree of accessibility and consequently potential of movement and presence of people in the urban space would affect the choice of path to be followed by pedestrians, since people would be attracted by spaces with people and would tend to avoid deserted spaces (Gehl, 1987).

The methods of syntactic analysis developed by Hillier derive from considerations of behavioral significance, with their application directed at the quantitative description of space apart from the users of that space. That is, once one has established these measures, they constitute a rich source of data for exploring and understanding behavior in space. Space syntax has contributed sophisticated ways for dealing with urban layouts as differentiated patterns of large-scale connections. This complements the emphasis on local attributes (such as the dimensional profile of street sections, the characterization of boundaries, or the attributes and qualities of individual open spaces) that is typical in many studies of urban space use (Whyte, 1980). Since Jane Jacobs (1961), the circulation of people and appropriation of public space has been mentioned as a crucial element to the urban vitality and that the number of encounters diminishes the possibility of crimes, the constant presence of users being important in urban spaces. Among the aspects mentioned by Voordt & Wegen (1983) in the “Delft Checklist” to be adopted in analysis of space vulnerability and in design recommendations to increase urban security, is the existence of co-presence, that is, movement and presence of people.

Accordingly, a number of assumptions have been put forward in the literature, such as: a constant pattern of movement, characterizing spaces with the presence of people, would increase the security of users of urban spaces (Hillier, 1988); spaces with greater potential of movement would imply spaces less frequented by criminals and, hence, would be more secure spaces (Hillier & Shu, 1999; Voordt & Wegen, 1983); places where the lines of vision are interrupted would have less potential for movement and would tend to favour the occurrence of crime. Hillier (1988) argues that, independent of density of a certain area, if the configuration makes the natural movement of pedestrians more difficult, there will not be a sufficient number of people to generate the perception of a well appropriated and used space. Hence,
various studies involving the analysis of the levels of accessibility of urban spaces indicate that places with greater integration levels and consequently greater potential of movement of pedestrian and vehicles, tend to present a smaller number of criminal occurrences than places with greater levels of segregation and, consequently, smaller potential of movement of pedestrian and vehicles. However, in recent studies carried out in the southern region of Brazil (Basso, 2002; Reis et al., 2003), relationships between levels of integration and occurrence of crimes were not found.

The literature on human cognition suggests that configurational aspects of built environment have significant consequences. Lynch (1960) says that legibility may play a decisive role in acquiring a sense of spatial control in spatial experience. Moreover, he argues that in the process of wayfinding, the strategic link is the environmental image: a generalized mental picture of the exterior physical world, which benefits from architectural legibility as experienced by an individual, further emphasizing affective qualities of spatial form that is central to the emotional and physical well-being of the inhabitant population, personally as well as socially. Hillier (1996) has argued that spatial configuration may face constraints on spatial experience since it appears to encourage or impede aspects of human activity through spatial cognition and subsequent behavior. Golledge and Stimson (1997) have also emphasized that the path or network structure used in everyday spatial behavior becomes critical feature of the image of a spatial environment. Others suggest that spatial layout of the built environment influences the accuracy of cognitive representations of real-world spatial information (e.g. Appleyard, 1969; O’Neill, 1991). Hart and Moore (1971) define spatial cognition as the knowing of cognitive representation of the structure, entities, and relations of space, that is, the internalized reflection and reconstruction of space in thought. Similarly Downs and Stea (1973) note that the process of cognitive mapping is a means of structuring, interpreting and coping with a complex sets of information that exist in different environments. Although they are generally incomplete, with varying forms of representation of elements, cognitive maps are useful instrument for recovering information about the way we represent the environment, the regularity or irregularity of frameworks such as street systems, and the most salient positive and negative elements which further denote user attitudes towards that environment.

Despite the unveiled potential implied in each methodological approach, the existing gap in the field of knowledge of the relationship between global configurational aspects and their cognitive representation, and the role of spatial configuration within it must be pointed out. According to Kim (2003), this gap can be described in two ways: firstly, the neglect of perception-cognition studies within research based on syntactic descriptions of spatial configuration, and secondly, the neglect of analytic descriptions of spatial configuration in research into cognitive representations. Indeed, relatively few studies have incorporated global configurational aspects and their cognitive dimensions within a single framework in investigating the relationships between man and built environment, more specifically those involving the analysis of relationships between the configurational characteristics of accessibility, the occurrence of crimes, legibility and environmental image (e.g. Basso, 2002; Reis et al., 2003). In this context, this paper investigates the relationships between spatial configuration, spatial behavior and spatial cognition at an empirical level related to two subjects: the role of spatial configuration in shaping users’ spatial behavior and spatial cognition of the ancient core in the central area of Porto Alegre; and the effects of recently constructed Market Metro Station on the legibility and imageability of the area. In order to measure these environmental qualities, accessibility, user perception of urban security, morphologic characteristics, pedestrian movement, intensity and location of activities are further investigated. The assumption is that the construction of the metro station in an area formed by important historic and administrative buildings, as well as by a dense and popular commercial sector might have influenced user environmental image previously held, as well as the level of co-presence. A further purpose of this research is to examine the assumption currently held in the literature about configurational analysis of spatial layouts according to syntactic variables that there is correlation between the spatial features of layout and crime distribution patterns.

METHODS

The investigation was carried out in Porto Alegre, the capital city of the Estate of Rio Grande do Sul, Brazil, with 1.3 inhabitants and a population of 3 million in its metropolitan area. The research analysis was composed of two parts: the study area and the detailed study. For the study area, the ancient core of the city of Porto Alegre was selected (figure 1). The detailed study includes the analysis of the Market Metro Station located in the ancient core and the overall performance of the area in terms of legibility, imageability and security as influenced by the increase in pedestrian movement after the metro station was built, with 50,000 passengers/day. This public open space, formed by some of the ancient buildings in Porto Alegre, is one of the most prominent elements in the genesis and consistency of the city core, so as to be acknowledged as the real center, the very heart of the town that causes the gathering of the commercial activities along the surrounding streets.
The study area hosts prominent political and administrative activities and the most frequented public uses and events, where diversity is eminent: users represent the blend of Brazilian multicultural population, in terms of income groups, ethnic and life-cycle composition. It is limited by streets with intensive pedestrian and vehicular movement, surrounded by bus terminus (12 - Figure 2) where connections within the city and between the city and its metropolitan region occur. The Market Station (4 - Figure 2) is located next to the Public Market (11, Figure 2), an important landmark in the area. It is comprised of a subsurface Control Building (4 - Figure 2) and surface level platforms (2 - Figure 2), connected by an underground passage. Access to the station is attained through four series of steps: two of them are located at the pedestrian pathway next to the Market (13 and 14 - Figure 2) and the other two are located in the Station Plaza (5 and 6 Figure 2, Figures 3 and 4).
The methodological procedures adopted in the investigation represent a pluralistic approach to the field. In order to analyze spatial configuration (accessibility), spatial cognition (legibility, imageability, user perception of urban security) and spatial behavior (pedestrian movement, identification, intensity and location of activities), data were collected by complementary techniques. These consisted of physical measurements, 46 interviews with cognitive maps, observations of behavior (total of 14 behavioral maps), and 90 questionnaires, besides information about passengers gathered from the Metro Central Office, and information about crime collected from the Human Rights Municipal Office and the City Council Urban Security Sector. Respondents were selected among people living in the city centre (n=30), workers in the study area (n=30) and city centre users (n=30). In addition to the information gathered from Security Sectors, areas known as places of occurrence of different types of crimes and areas perceived as being insecure were indicated by the respondents on plans of the layout included in the questionnaires. Quantitative data were analyzed through non-parametric statistics and qualitative data were analyzed by meaning and frequency. Configurational analysis was made by the identification of global integration (Rn) using Spatialist.

RESULTS

The results focus upon the analysis of configurational characteristics in the study area, present the analysis of the users’ cognitive and behavioral maps, examine the relationships among the three, and investigate the role of users’ perceptions of legibility, imageability, accessibility and security in the above relationships.

Legibility and imageability were measured through questionnaires and cognitive maps. According to 87.5% of respondents, legibility and wayfinding in the city center and in the study area are adequate, in the sense that the area can be easily understood, and orientation is effortless as a consequence of the great number of outstanding physical elements. The main elements identified in the cognitive maps are related to their historical value and use, including the busiest commercial streets, several historic buildings, public buildings, bus terminal, open air informal market and public squares, contributing to the high imageability in the area.

<table>
<thead>
<tr>
<th>ELEMENTS</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Building</td>
<td>31</td>
</tr>
<tr>
<td>Rua dos Andradas (street)</td>
<td>26</td>
</tr>
<tr>
<td>Av. Borges de Medeiros (street)</td>
<td>17</td>
</tr>
<tr>
<td>City Council</td>
<td>16</td>
</tr>
<tr>
<td>Bus Terminus</td>
<td>15</td>
</tr>
<tr>
<td>Informal market</td>
<td>13</td>
</tr>
<tr>
<td>Praça XV (square)</td>
<td>12</td>
</tr>
<tr>
<td>Av. Mauá (street)</td>
<td>11</td>
</tr>
<tr>
<td>Av. Salgado Filho (street)</td>
<td>11</td>
</tr>
<tr>
<td>Praça da Alfândega (square)</td>
<td>10</td>
</tr>
<tr>
<td>Rua Voluntários da Patria (street)</td>
<td>10</td>
</tr>
<tr>
<td>Market Station</td>
<td><strong>8</strong></td>
</tr>
<tr>
<td>Chalet Praça XV</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 1 – Most mentioned elements

The importance of these elements was revealed according to the total number of references included in the cognitive maps (Table 1). Apart from the streets, the most mentioned built elements are located next to the Market Station: the Market, City Council and Bus Terminus.

According to Table 1, imageability of Market Station is considerably low when compared to the most mentioned landmarks in the area. Its visual perception seems to have been discouraged by the lack of aesthetic attributes and the reduced visibility of the building (4-Figures 3 and 4). Moreover, the square roofing the Control Building is mainly used as passage. Nonetheless, 97.8% of respondents who do not use the metro know where the station is located.

When asked to list the most positive attributes of the city center, historic buildings were first mentioned, followed by diversity of good services and interesting places, mentioned by some as if the area had a “singular identity”. The most negative attributes were related to lack of maintenance and lack of security of public open spaces (35.6%) mainly due to the presence of homeless and informal vendors, and the absence of maintenance of buildings (9%). However, results indicate that despite the negative aspects, the city center affords an overall positive visual appearance, with effective legibility and high imageability. Nonetheless, except for the Market and the City Council, most of the positive attributes mentioned are located outside the study area, while the most negative ones are located within the study area. The study area is perceived as the most disagreeable sector of the city center.

Accessibility to the study area and within the study area was measured through configurational analysis of the axial map. As it can be observed in the axial map (Figure 5), the presence of wide open spaces in the axial map is not represented by a single specific element, but emerges from
a complex of lines converging at that space. The distribution of the integration values coming out from the configurational analysis of the axial map provided results consistent with Cutini’s study (2003) on the morphology of open spaces: the lines converging at the square are mostly result included in the integration core. The study corroborates Cutini’s comment that axial analysis cannot account for the presence of squares, nor support any interpretation of their position and their morphology as related to their specific urban role. However, axial lines show that streets leading to the station are among the ones with higher integration values, which indicate that the station is located in an accessible area (Figure 5; Table 2).

Spatial Behavior was analyzed by means of observations and questionnaires to investigate pedestrian movement in the study area, identify the more used and less used places/spaces, type and intensity of activities, relations between physical characteristics and intensity of use, the easy of access to the metro station. Comparing the information obtained by the analysis of syntatic properties with spatial behavior, the presence of the wide open spaces surrounding the Market and the Station is not represented by a single specific element, as early mentioned, but emerges from a complex of lines converging at that space. The urban space does not appear because it is assimilated to urban streets and the wide open spaces is lost. Consequently, when looking exclusively at the axial maps, it is almost impossible to apprehend how intense pedestrian movement is, how bustling the area is in terms of diversity of activities and users, as well as to identify and understand why certain places within the same wide space tend to be more intensively used or avoided. For these kind of data gathering, observations of behavior revealed to be paramount, as axial analysis appears not to support further interpretations related to the specific urban role.

![Axial Map of city centre](image)

Figure 5: Axial Map of city centre

Global integration values indicate that five out of ten more integrated lines in the city center are located within the study area and in streets adjacent to the station, while the two out of ten most segregated lines are the two sectors of the quay side, isolated from the study area through the surface railroad.

<table>
<thead>
<tr>
<th>More integrated axial lines</th>
<th>More segregated axial lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rua dos Andradas (sector 1)*</td>
<td>Quay (sector 1)</td>
</tr>
<tr>
<td>R. Marechal Floriano*</td>
<td>Quay (sector 2)*</td>
</tr>
<tr>
<td>Av. B. de Medeiros (sector 1)</td>
<td>R. Com. Alvaro Aspim</td>
</tr>
<tr>
<td>Rua Gal. Vitorino</td>
<td>R. Garibaldi</td>
</tr>
<tr>
<td>R. Senhor dos Passos</td>
<td>Rodovia (sector 1)</td>
</tr>
<tr>
<td>Av. Salgado Filho</td>
<td>Av. Eduardo Paiva (sector 1)</td>
</tr>
<tr>
<td>R. Jerônimo Coelho</td>
<td>Cais do Porto (sector 3)*</td>
</tr>
<tr>
<td>R. Gal. Câmara*</td>
<td>Av. Eduardo Paiva (sector 2)</td>
</tr>
<tr>
<td>Rua dos Andradas (sector 2)*</td>
<td>Rodovia (sector 1)</td>
</tr>
<tr>
<td>Av. B. de Medeiros (sector 2)*</td>
<td>Rodovia (sector 2)</td>
</tr>
</tbody>
</table>

Note: (*) represent line inside the study area. Global integration values (Rn) were obtained with Spatialist.

![Example of behavior map](image)

Figure 6: Example of behavior map

Note: 2-Market Station-plataforma; 3 – Av. Mauá; 4 - Market Station - underground control; 5 and 6 – access to Station; 7 – Gas Central; 9 – Palácio do Comércio; 10 – Av. Júlio de Castilhos; 11 – Public Market; 12 – Bus Terminus; 13 and 14 – access to Station

Potential of pedestrian movement in the more integrated axial lines coincide with intensity of pedestrian movement observed. However, even higher intensity of pedestrian movement and activities were identified in axial lines with much lower integration value, as in the case of the existing line between the Market and the Station. In this specific situation, movement is increased.
due to the location of the four entrances to the underground, which are accessed by at least 50,000 passengers/day. Between the two accesses to the Station located at the sidewalk next to the Market (Figure 6), there is a bus stop, summed to the great number of people crossing the Market Building, which has entrances at all facades that allow to cross the building as a covered walkway from all directions. Therefore the morphological characteristics of the building, such as layout and visual/functional connections, also play an important role. Not mention that the Bus Terminus, where people from the metropolitan area arrive and depart everyday is adjacent to the Market building. Out of 88.8% of respondents that use the Station, 48.8% connect with buses in the area.

According to the information gathered through questionnaires, access to the Station is positively evaluated by 85% of respondents. The reasons given were the absence of physical barriers, adequacy of connection to other means of public transport, and its location near the Market and other amenities in the city center. Respondents who were dissatisfied complained about the lack of universal access, poor signage, the lack of covering and inadequate width of staircase.

**Urban security** was measured by comparing the information obtained by the analysis of syntactic properties with the indication made by respondents of places where crime has already occurred, places considered as the most insecure, and respondents’ attitudes concerning security measured through questionnaires, added to the information obtained from the Police Department. It was verified that the streets and places identified as the most vulnerable to crime in the selected sample area are constituted, fundamentally, by the highly integrated axial lines. Therefore, the area perceived as being the most insecure by respondents present syntactic properties which display a high level of potential of movement and co-presence, further confirmed through behavioral observations. In addition, lack of maintenance of public spaces and buildings influenced user perception of security. The map summarizing spatialization of crime in the city center indicates that occurrence of crime in the study area is among the higher (Figure 7).

While 74.7% (151 out of 202) of crimes reported by respondents occurred in the study area, nine out of ten places identified among the higher occurrence of crime in the city center, are located within the study area. Moreover, five out of ten more integrated lines in the city center are located within the study area and in streets adjacent to the station. Contrarily to the literature, the axial lines with higher integration values coincide with higher occurrence of crime, as indicated in Figures 5 and 7. Table 2 indicates that the two sectors at the Quay side are listed among the more segregated lines, which might be interpreted as a consequence of the presence of the Station performing as physical barrier, limiting pedestrian movement. Nonetheless, occurrence of crime was not identified nearby. On the other hand, integration value in Av. Mauá is low, ranking near the ten most segregated lines listed in Table 2, and occurrence of crime is high. In this specific sector, lack of visual connection between buildings and the street at ground floor level, as well as the predominant type of use at ground level (private garages and office buildings with a single entrance) with entrances controlled by porters or electronic devices, limited public access and poor social vigilance due to restrict co-presence of people in the streets is predominant. Yet, it must be emphasized that the morphological characteristics and type of activities in the buildings limiting the lines highly integrated and with occurrence of crime are visually and functionally connected with the public space and co-presence of people in streets is intense.

User perception of security in the city center tends to be negatively evaluated by 75.5% of respondents. The correlation found between user satisfaction with urban security in city center and length/frequency of visits to the city center (Spearman, correl. coef. = 0.211, sig = 0.046) indicates that the user perception of lack of security increases according to lenght of experiencing it. This correlation might be explained by the fact that 72.2% of respondents were victims of crime or had testified occurrence of crime in the city center. The results obtained so far indicate that there are variables other than the ones currently mentioned in the...
literature implicated with relationships between spatial configuration, spatial behavior, spatial cognition and urban security.

**CONCLUSIONS**

Results show that, although the level of co-presence increased significantly after the Market Metro Station was built, the assumption that the construction of the metro station in an area formed by important historic and administrative buildings, as well as by a dense and popular commercial sector might have influenced user environmental image previously held, was not confirmed. Despite the significant number of commuters, imageability of Market Station is considerably low when compared to the most mentioned landmarks in the area. Findings suggest that the reduced visibility of the subsurface building and lack of aesthetic attributes might have adversely affected visual perception, indicating that these attributes are fundamental for a strong image and that use alone is not sufficient to produce a strong image.

The results of integration analysis about the influence of intensity of pedestrian movement on urban security are not similar to the many studies carried out elsewhere. The assumption put forward in the literature that urban spaces with low integration value would present low pedestrian movement and possibility of crimes might increase, while places with high integration values would present higher pedestrian movement and possibility of crime might decrease, was not confirmed. The available figures do not allow for relationships to be established between the urban spatial characteristics related to accessibility, the occurrence of crimes, spatial behavior and user perception of security of urban open spaces. The results further support Reis et al. (2003) for the argument that a relationship might exist between the facility for a offender to escape and high levels of integration, or high accessibility, which generates greater facility for entrance and escape of a certain place, making easy for a criminal to escape because of the many existing routes. More studies on security in urban spaces need to be carried out to see whether this result is replicated and to provide more in-depth analysis.

Finally, this research illustrates how the syntactic description of spatial configuration and the theoretical positions of spatial cognition can be combined in an integrated approach in investigating human spatial experience. The incorporation of spatial configuration implies a specific conception in understanding the role of spatial configuration in environmental cognition and behavior. An important consequence of this conception is that understanding human spatial experience must be carried on in a continuous conversation with both objectivity of configuration and subjectivity of cognition or it will lose its proper object of inquiry.

**REFERENCES**


