

## How does urban morphology influence the walkability?

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**Abstract.** *It is known that the Modernism greatly influenced the way people use spaces, the car use was prioritized, changing the function of the street from a meeting space (human scale – Gehl, 2010) to a passage space (motor scale). It is in this context that this paper aims to present the aspects that interfere in the walkability with focus on different urban morphologies. For this purpose, the study was applied to three neighbourhoods of Lisbon (Portugal) with different morphological characteristics: Graça (organic mesh), Campo de Ourique (regular mesh) and Telheiras (contemporary mesh) and then for the analysis methodological were applied their respective axial maps – derived from the Space Syntax Theory (Hillier and Hanson, 1984). The findings show that, as some authors (Hillier and Hanson, 1984; Handy, 1996; Holanda, 2002; Medeiros, 2013) state, there are differences in performance between different urban forms. According to Jacobs (2000) and Gehl (2010), modern spaces or those that suffer the influence of modernism have morphological elements that repel people, which make the space almost desert, without life. Therefore, it is concluded that depending on the morphological characteristics present in the space there will be more or less life. In other words, the greater segregation between the morphological elements, lower the presence of people in public space.*

*Keywords: Urban Morphology, Urban Mobility, walkability, Space Syntax, Lisbon.*

### Introduction

Among the topics related to the performance of urban spaces, mobility has been one of the most widely debated. However, the discussion about this issue poses a paradox between non-motorized transport and the encouragement to individual transportation, which affects sustainability.

Based on this premises, this paper explores the ways in which different urban morphologies affect displacements on foot, by bicycle and by car (individual transportation) in three neighborhoods in the city of Lisbon (Portugal). In order to do that, axial maps, segment maps and visibility maps from the Theory of Social Logic of Space are used. In addition, countings

of pedestrians, bicycles and vehicles are carried out in the three neighborhood in order to validate the results.

### Urban Morphology

The act of walking is assumed to favor a coherent understanding and experience of the city, for reasons explained by different disciplinary fields. Walking around a city can be interpreted in terms of points of origin and destination, or the ability of places to become routes or points of arrival, as discussed by Hillier (2008). There seems to be an underlying logic in the process of organization of urban spaces that affects the choice of paths, which

expresses the preference of individuals for one or another.

Discussing the organization of spaces implies not only considering the urban structure as system of interdependences, but also understanding how the form of the city influences the act of walking. This component may play a greater role than it was once estimated, actively conditioning the flow of pedestrians.

Urban form is understood as a geometrical composition of the elements that make up a city (streets, buildings, blocks, facades, street furniture, vegetation, etc.) in terms of dimensions and proportions. In addition, it is important to explore the concept in light of the way the elements that integrate the urban space are arranged and relate to each other, either from a bi or tri-dimensional perspective. As relations matter and result in hierarchical variations, we intend to carry out a reading of the topological context.

In the literature, urban form has historically been categorized by their differences in layout. In his work "Wanderlust: a history of walking", Solnit (2001) poetically and accurately portrays the distinction between traditional urban form (cohesive) – or pre-modern (Holanda, 2013) – and contemporary (isolated) – post-modern (Holanda, 2013).

On the same topic, Medeiros (2013) emphasizes the two types of urban form mentioned by Kostof (1992); Kostof (2001) - the irregular/organic and the regular/grid/orthogonal/chess board – when comparing a sample of cities, both in Brazil and abroad. Nevertheless, when analyzing the articulation of the urban fabric and its impact on displacements, the author highlights that the main issue is not whether the city falls in one or other classification, but rather how the articulations take place in the city. Aspects of seaming, connection and relations between the various axes seem to be more relevant than the layout itself. Thus, the quilt pattern is considered the most negative scenario for urban mobility, even from the perspective of walking: the apparent planning expressed by the regularity of the layout comes undone due to the lack of global intention that prevents coherent levels of articulation amongst the parts.

For urban mobility, understanding the form entails understanding the geometrical and topological aspects simultaneously, focusing on relations. It is the understanding of the articulation of elements that make up a city – be it the street layout or the compacity of the buildings, the preferential means of transportation or the distances to overcome – which deserves the focus because this articulation seems to play a substantial role in an individual's process of displacement in space.

### Urban Life

Some scholars have presented premises for fostering urban life in the public spaces of a city:

Jacobs (2000): emphasizes the need of having diverse uses and adequate density of residences in each neighborhood;

Gehl (2010): believes that the ground floor must be accessible to pedestrians, and highlights the need for neighborhood streets to present a high number of doors per hectometer;

Alexander (2006): highlights the need to have spaces of higher complexity and believes that urban spaces should not be segregated, even the children's playgrounds, in order to incorporate the city to the child's play space.

Salingaros (2006): points out the need to there being several connections (pedestrian pathways) in a city and these connections should be linked to a great number and diversity of activities.

The basic premises of these authors, used as the theoretical foundation of this paper, are essentially (a) diversity of uses (mentioned by all four, but emphasized by Jacobs); (b) the complexity of the space's form from Alexander; and (c) the many connections to a large number and diversity of uses, highlighted by Salingaros as essential for life in public spaces.

In order to confirm the premises of these authors regarding life in urban spaces, we carried out a joint analysis of the syntactic aspects of the urban form and vehicles and pedestrian counting in three neighborhoods – Graça (organic grid), Campo de Ourique (regular grid) and Telheiras (contemporary grid) – in the city of Lisbon, with different morphologic and syntactic characteristics.

## Methodology

### Space Syntax Theory

In regard to the study of the built environment, the Theory of Social Logic of Space or Space Syntax (Hillier and Hanson, 1984; Hillier, 1996; Holanda, 2002; Medeiros, 2013) contributes substantially to the debate, when aligned with the strategies for reading the urban form derived from the systemic view (where parts of the city should be linked to create an integrated whole - Derridá, 1971; Foucault, 1971; Capra, 2003).

The main objective of Space Syntax is to investigate the relationship between the built environment – the building or the city, roughly referred to as architecture – and society – seen as a system of possibilities of encounters (Holanda, 2002).

The theory offers techniques for understanding and representing space, including the structure of the street network, providing materials that allow the researcher to investigate the city through its urban articulations.

According to Hillier (2001), by placing an object here or there within a spatial system, certain predictable consequences will affect the spatial configuration of the environment. These effects are quite independent of human desires or intent, but can be used by humans to achieve spatial and social effects.

Of the representation techniques recommended by Space Syntax for configurational studies, two are of particular interest for this research: visual fields (map of visibility) and lines (axial maps).

The linear representation is obtained by tracing the street network in the form of lines, based on the cartographic resources available, in order to reach the minimum number of lines that represent direct access throughout the urban fabric. After processing these lines, it is possible to generate a matrix of intersections, from which the representative values of its axial interrelationships are calculated by means of Depthmap<sup>®</sup> software.

This procedure results in the calculation of the total matrix of intersections of the system, which takes into account all the connections from all axes. We obtain a value called  $R_n$ , where  $R$  is the radius (how many axes we want to consider from another axis in the system) and  $n$  is the unlimited number of connections. The values obtained from the representation and quantification of urban space at the desired level are called value or potential of integration. These values can be represented numerically or by a chromatic scale or gradient, ranging from red (most integrated), to blue (more segregated).

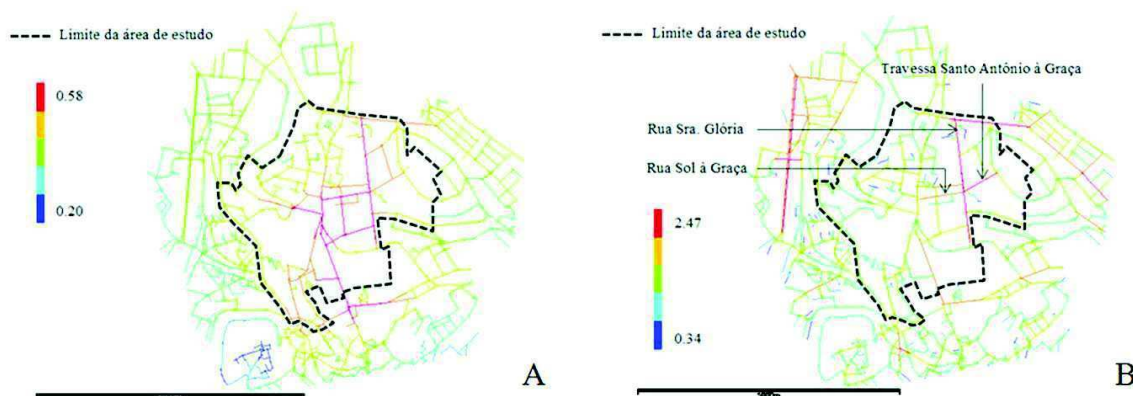
More integrated axes are those more permeable and accessible in urban areas, from which all the other axes are more easily accessible. They usually entail topologically shorter paths that can be reached from any axis of the system.

As the focus is the pedestrian, visibility maps are also used, because they show the presence of pedestrians in the space more clearly. Pedestrians are represented by dots which vary in color depending on their position, using the same color scale of axial and segment maps (from red to blue, with warm colors representing greater visual accessibility and cooler colors decreased visual accessibility).

### Counting

The counts were carried out based on the Gate Method (Grajewski, T. and Vaughan, L., 2001), which consists in drawing an imaginary line crossing the street space (taking into account sidewalks and cycle lanes if present) and set a time period of 2.5 minutes for counting moving people, bicycles or vehicles, at each gate (counting point). As the present paper deals with entire neighborhoods, a route was chosen for each one.

The counts were carried out in typical days (Monday through Thursday) of a typical month (October) in morning (between 7:30 and 9:30 am) and afternoon (between 5:00 and 7:00 pm) peak times. It is also important to highlight that the counts were performed following the direction of the route, in order to compensate possible quantitative mismatch of the gates,



**Figure 1.**  
Graça - (A) Axial map (integration Rn) and (B) Axial map (integration R3), both with immediate surroundings of 300m

since counts were carried out within a two hours interval.

### Measurement and analysis

The current limits of the city of Lisbon, with 84.6 km<sup>2</sup>, encompass a relatively stable urban structure, in the Portuguese province of Estremadura and the core of a metropolitan area (AML – Lisbon Metropolitan Area – Figure 1A) encompassing almost 2.8 million inhabitants and reaching a territory of 2,962.6 km<sup>2</sup>.

The neighborhoods were chosen because of the distinct aspects of their street grids, which in turn are a result of historical processes of consolidation of peculiar urban fabric. Graça is characterized by an irregular street layout, resulting from the diachronic appropriation of the terrain. Campo de Ourique is an example of a regular grid, similar to a chessboard. The neighborhood of Telheiras presents a grid derived from the premises of modern urbanism, using recurring contemporary solutions such as great voids, presence of main axes and secondary streets, road ring, cul de sacs, etc.

### Axial and Segments Maps

The neighborhood of Graça has a predominantly irregular layout, resulting from a specific process of adaptation to the site. The layout of streets very closely resembles the so called ‘Portuguese way of making cities’,

a peculiar way of creating urban settlements by adapting to the terrain. The area presents T shaped crossings and the blocks are irregular in both shape and size. These characteristics are reflected in the indicators, as shown in Figure 3A.

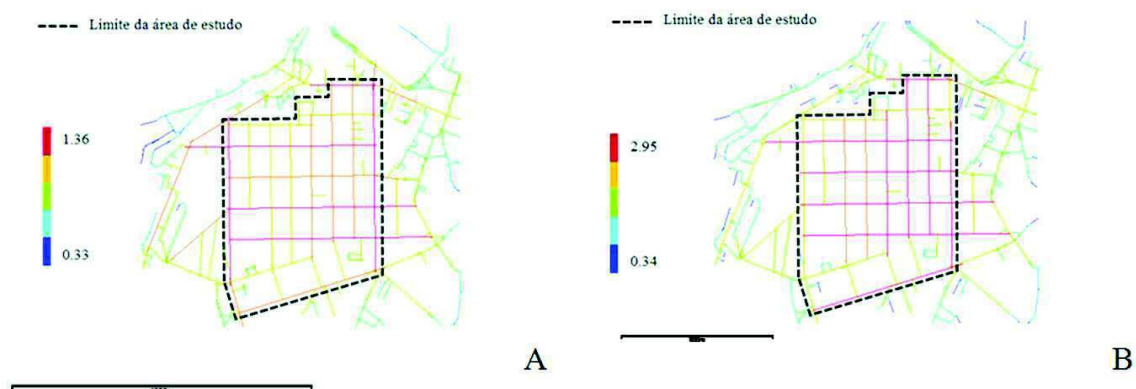
In terms of average global integration (Rn – 0,40) (Figure 3A and Table 1), Graça has the lowest average of the sample, due to its labyrinth like organization (Medeiros 2013). The rugged terrain and the steep slopes decrease the number of possible routes between any two given points.

As for the analysis of radius 3 (Figure 1B), it is possible to notice that the larger (and straighter) axes are those that show better integration results, and potentially correspond to local centralities. However, there is no diversity of land uses in these streets, which are predominantly residential.

The area of Campo de Ourique is characterized by an essentially regular layout, with predominantly X shaped crossings. Consequently, the blocks are also regular, with roughly the same size and proportions. The chess board urban grid favors a greater number of possible routes, in any two given points of the system, which result in higher syntactic indexes (Figure 2A).

In the analysis of the local aspects of Campo de Ourique (integration R3), it is possible to notice the underlying logic in the absence of a clear hierarchy is practically the same proportion of the global (Figure 2B), which does not happen in Graça, for example.





**Figure 2.**  
**Campo de Ourique - (A) Axial map (integration Rn) and (B) Axial map (integration R3), both with immediate surroundings.**

Campo de Ourique (Table 2A) presents the highest average global integration in the sample (0,74), presenting straight global axis that cross the neighborhood north to south and east to west. Considering the counts carried out, we can infer that the layout fosters motorized displacements instead of pedestrians.

The neighborhood of Telheiras has a very different layout, when compared to the other two, and it is a result of the contemporary experiments using a modern matrix. Its grid does not present a clearly defined pattern, since it sometimes resembles Campo de Ourique and in others it presents an apparently 'ordered' irregularity: there are both T and X shaped crossings, and the presence of excessively long blocks is frequent (with no regularity in terms of size and shape). Such features foster lower integration indexes, as illustrated in Figure 5 and Table 1.

It is possible to see that Telheiras (Table 1) presents an average global integration (0,48) slightly higher than Graça, since there are streets that cross the neighborhood east to west (Figure 3A) and which pass under the expressways. Therefore, there aren't any great disruptions, which makes this neighborhood more permeable/accessible.

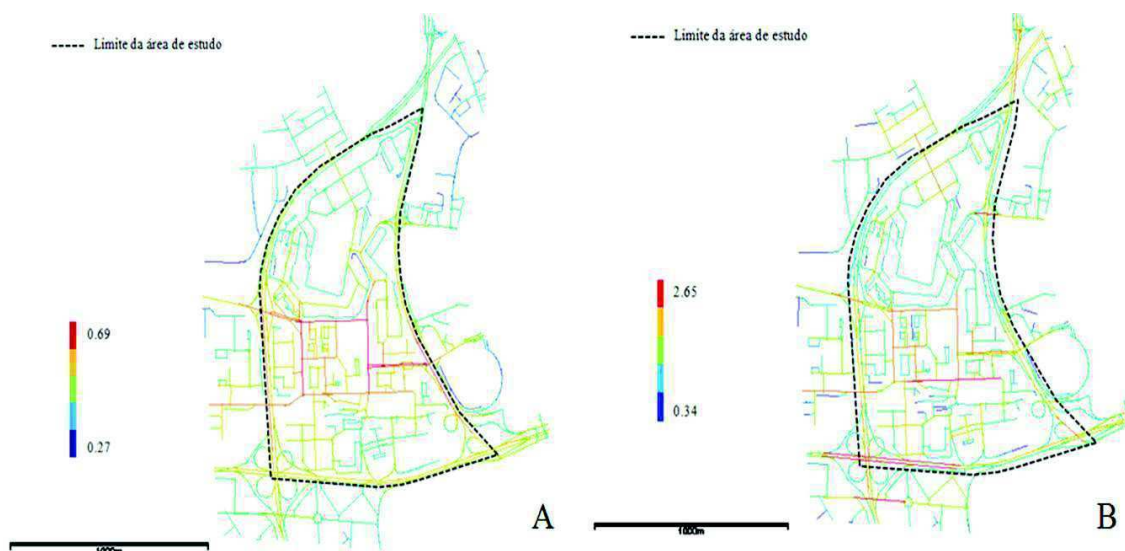
Locally, the analysis of radius 3 (Figure 3B) shows that the more integrated axis are the same as in analysis of global radius n, which is a very similar behaviour to what happens in Campo de Ourique. There seems to be greater synergy between the systems of these neighborhoods (when comparing global

and local performances) in relation to Graça (Figures 3A and 3B).

The segment map presents greater compatibility with the data of Transport. The axial map, however, is of crucial relevance because it encompasses the hierarchical characteristics of the system, therefore the simultaneous use of both strategies of analysis is paramount.

Making a comparative analysis between the syntactic results of the three neighborhoods, one can infer that, in general, the neighborhood of Graça is the one with best performance in the maps of 'isofoot' (the one which takes into account the obstacles at the foot level and not at the eye level – isovist). Although the area presents lower average integration values – despite a clearly defined hierarchy – there is a lower incidence of very broad spaces. The setting facilitates the reading of space by pedestrians (Hillier, et al., 1993), in addition to being considered good for urban living according to the precepts of Jacobs (2000), Gehl (2010), Alexander (2006) and Salingaros (2005).

In regard to the neighborhood of Campo de Ourique, it is important to highlight its position of superiority in terms of system integration due to the regularity of the grid. This means that, somehow, the grid is democratic in terms of homogeneity of relationships, being positive for motorized traffic. However, the high performance in here does not mean it is overall satisfactory, because from the perspective of the pedestrian, evidence indicates that grids



**Figure 3.**

**Telheiras - (A) Axial map (integration Rn) and (B) Axial map (integration R3), both with immediate surroundings.**

with a clear distinction in its street hierarchy are more easily understood. Both axial and segment maps, and the ‘isofoot’ are relevant for understanding patterns, once they provide strategies for identifying repetition, with proximity and distances between the areas analyzed.

Telheiras presents a context that would be less inviting for urban life, an observation which is aligned with the observations of Jacobs (2000), Gehl (2010), Alexander (2006), Salingeros (2005), etc. Its integration values, compared with the other two examples, are in an intermediate position just because it is connected with the neighborhood through strong east-west articulation axis. Moreover, even in the axial maps and in the isovists and ISOPE, the connection problem can be seen: the inner part of Telheiras is poorly connected, with the frequent presence of dead-end streets, isolated buildings and little diversity of uses. All these aspects discourage urban life, the experience of neighborhood, the possible encounters. These syntactic aspects are ratified by the countings carried out.

#### Visibility Maps

In terms of system visibility, we decided to analyze visual connectivity from the perspective of the feet (henceforth referred

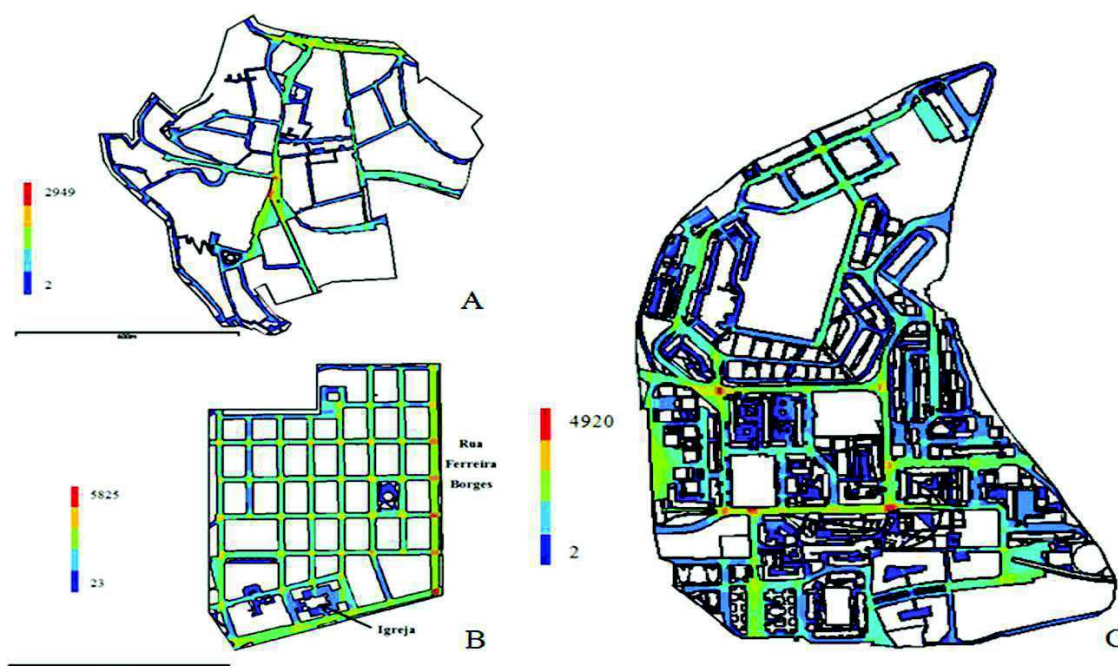
to as ‘isofoot’). In this analysis (Figure 4), it is possible to notice a different performance between the neighborhoods, due to their distinct form characteristics.

For the system of Graça (Figure 4A), it was verified that the greater connectivity of the system is along structural axes, that is, Rua da Graça, Largo da Graça and Rua Sapadores. It is important to highlight that, although Rua Senhora Glória presents a high value of integration (Figure 1A), its visual connectivity does not present meaningful values, maybe that is the reason why the street does not attract commerce and, consequently, movement.

The analysis of visibility at the level of the foot in Campo de Ourique (Figure 4B) shows a substantial alteration in behavior of the area around the church and the square, that go from warmer to cooler colors as a result of the presence of obstacles for the feet, such as gardens and fountains.

This change reverberates in the results of other sites in the neighborhood, with greater importance to the crossings at Rua Ferreira Borges – eastern limits of the neighborhood – in which its knots go from yellow to orange and in some cases to red, exhibiting greater visual global connectivity. These findings seem to be aligned to the reality of flow in the neighborhood, shown in the counts performed.

It is worth noticing that in the ‘isofoot’



**Figure 4**  
**Isofoot map (visual connectivity at the feet - 2) of Graça (A), Campo de Ourique (B) and Telheiras (C) with their immediate surroundings.**

analysis (Figure 4) the most connected points are those that correspond to the crossings, in the same manner that happens in Campo de Ourique. However, in Telheiras, X shaped crossings are rare and T shaped crossings are more common.

#### Counting

In regards to the counts carried out in the three neighborhoods under study, the results were analyzed separated by means of transportation – motorized (cars) and non-motorized (on foot or by bicycle) – in order to identify similarities and distinctions (Table 2).

When comparing the absolute data for the three neighborhoods, Telheiras stood out for presenting the highest flow values for all means of transportation. However, due to the discrepancies between the number of counting

points in each neighborhood – Telheiras presents almost seven times more gates than Graça, and almost twice as many gates as Campo de Ourique – we decided to carry out a proportional analysis. In order to do so, the number of people counted was divided by the number of gates in each neighborhood, and the results are presented in Table 2.

The findings indicate that the values for Telheiras are the lowest in almost all categories, except number of bicycles. Telheiras has thus the lowest movement flow (both for pedestrian and vehicles), which indicates less urbanity – in the words of Holanda (2002), due to few “eyes to the street”, as described by Gehl (2010).

It was also found that the neighborhood of Graça had the second highest volume of pedestrians, with an average of 158 people per hour, and with 145 vehicles per hour (on average, for each gate). Although Graça

**Table 1**  
**Syntactic Indexes.**

| Neighborhood     | Average Integration Rn | Average Integration R3 | Average Depth | Average Axial Connectivity | Visual connectivity - eye | Visual Connectivity - foot |
|------------------|------------------------|------------------------|---------------|----------------------------|---------------------------|----------------------------|
| Graça            | 0,40                   | 1,27                   | 7,81          | 2,78                       | 711,24                    | 669,48                     |
| Campo de Ourique | 0,74                   | 1,35                   | 4,20          | 2,81                       | 2785,24                   | 2186,91                    |
| Telheiras        | 0,48                   | 1,21                   | 6,38          | 2,63                       | 2012,64                   | 1036,65                    |

**Table 2**  
**Total and average flow per neighborhood.**

|   | Campo de Ourique | Graça  | Telheiras |
|---|------------------|--------|-----------|
| Pedestrian flow                                   | 4980             | 7110   | 17868     |
| Flow of Motorized Vehicles                        | 10152            | 6516   | 31092     |
| Flow of Non-Motorized Vehicles                    | 42               | 18     | 390       |
| Number of gates                                   | 45               | 26     | 303       |
| Average number of pedestrians per gate            | 191,54           | 158,00 | 58,97     |
| Average number of motorized vehicles per gate     | 390,46           | 144,80 | 102,61    |
| Average number of non-motorized vehicles per gate | 1,62             | 0,40   | 1,29      |

presents a well defined hierarchy in its grid, where the flow tends to be concentrated in certain streets, it still contains higher average movement of people and vehicles than a contemporary grid.

The neighborhood of Campo de Ourique, in turn, had the highest average flow of both pedestrian (192 ped./h) and motor vehicles (390 veh./h). This fact is possibly associated with a fairly flat topography and greater accessibility as explored by syntactic analysis of space.

Telheiras had the worst performance in relation to both, the movement of people (with an average of 59 per hour) and vehicles (with 103 per hour), always on average per gate. The measures suggest a possible non-aggregating characteristic of the area, the result of large empty spaces, as well as social characteristics of the population.

It is possible to observe, based on the countings, that the neighborhood of Graça is the only one to present a certain balance between the flow of pedestrians and motorized vehicles, demonstrating, in a way, that there is greater interaction between the different modes of transport. Campo de Ourique and Telheiras, on the other hand, have a similar behavior, since they exhibit nearly double the number of motor vehicles in comparison to pedestrians.

## Conclusion

The paper aimed at verifying how the form of the spaces interferes in the act of walking and in order to achieve that, complementary methodological strategies were used.

The results obtained from the three strategies

adopted (axial maps/segment maps, visibility maps and countings) show that the form is a determining factor for the act of walking, since the morphologic and syntactic aspects can grant more or less urban life to these spaces.

It was possible to verify that organic grids (as in the neighborhood of Graça) and regular grids (as in the neighborhood of Campo de Ourique) – considered by Alexander (2005) as complex – are the ones that foster more urban life in the urban space. In contrast, contemporary grids (as Telheiras) – considered by the author as non-complex (for the case of this research) – present less urban life, that is, there are fewer people walking around the space, as ratified in the countings.

It is important to highlight that the syntactic aspects are relevant, but must be analysed together with other strategies, since they present non-absolute and potential flow results. From this standpoint, the counting of pedestrians was the strategy that helped characterize the neighborhoods and place them within the context of urban life.

In face of the arguments presented above, we can infer that urban form is paramount for the presence of people in urban spaces, that is, the morphologic and syntactic characteristics of the city space play a relevant role in urban life. This restates the importance of Space Syntax in the study of walkability – which was analyzed in greater details in the Doctorate research of Barros (2014).

Therefore, the ingredients for a successful and pedestrian friendly space must encompass an urban form whose relations (Hillier and Hanson, 1984) incorporate the complexity inherent to space (Alexander, 2006), diversity



of land use (Jacobs, 2000), and an adequate number of doors for high level movement (Gehl, 2010), because they provide a greater level and diversity of connections between activities (Salingaros, 2005).

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