THE THRESHOLD OF RIO DE JANEIRO’S FAVELAS

The syntactical value of a spatial sign

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ABSTRACT

The main purpose of this paper is to contribute to the debate over the relation between Rio de Janeiro's favelas and formal city by questioning if, and to which extent, their lines of mutual connection mould the structure and accessibility of both the local and global networks. More specifically, the study applies space syntax segment angular analysis to shed new light on the role played within the city's network by the entrances of favelas. By examining and discussing the outcomes of previous syntactical, historical and ethnographical analysis of Rio de Janeiro, the paper finally argues that entrances work as thresholds, gates, that filter the movement and structurally define an inside-outside distinction between favelas and the planned city.

KEYWORDS

Network connections, threshold, favela/slum, space syntax, angular segment analysis.

1. INTRODUCTION

In July 2001, local activists of the Movimento Nacional de Favelas (National Movement of Favelas) installed gates and cameras at the main entrances of Rio de Janeiro's tenth biggest favela,4 Jacarezinho (Figure 1 and 6). They intended to protect the area against the abuses of police officers. The attempt, stopped by the police as irregular, was to create the first Condomínio-Favela, by provocatively adopting the security model of the city's wealthiest gated communities (Costa Vargas, 2006). In her book, Favela: Four Decades of Living on the Edge in Rio de Janeiro, Perlman (2010) observes that Rio's low-income, self-built settlements, when occupied by militias or drug smugglers, share a “distinguishing characteristic” (p.32) with the city's healthiest neighbourhoods: controlled entrances. That is, entrances work as filters regardless of the nature of their keepers.

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4 Favela is a figurative common term to name Brazilian slums. Brazilian press first adopted it, in the ’20s, to compare Rio’s land invasion by self-built wooden shacks to a local itching plant, i.e., favela (Abreu, 1994).
By randomly checking the news section or the literature over Rio’s favelas, it is evident that entrances constitute an acknowledged threshold between the outside and inside of favelas (or the formal city, depending on the point of view). The newspaper Folha de S.Paulo (1998) once reported that police blocked the entrances of a group of Rio’s favelas, Cantagalo-Pavão-Pavãozinho, until the local drug smugglers get “asphyxiated”. Thus, eloquently suggesting that the connection between every favela and the rest of the city pass throughout these spots.

Nevertheless, to the knowledge of the authors, there is virtually no literature that focuses on this critical spatial issue. This paper aims at filling this critical gap. The primary objective is to contribute to the debate over the relation between favelas and formal city by questioning if, and to which extent, their lines of mutual connection mould the structure and accessibility of both the local and global networks.

For consistently comparing the different scales and parts of the city of Rio de Janeiro and point out local structures that are not evident, the study uses Depthmap’s segment angular analysis. More specifically, the examination of the outcomes adopts choice (NACH) and integration (NAIn) as normalised measures. Rio de Janeiro's segment map, obtained by the simplification of the city's road centre-line (RCL) georeferenced map (IPP, 2018), is the base for the analysis. The outcomes of the analysis are examined in QGis, together with the spatial dataset of favelas areas (IPP, 2018).

![Figure 1. Maps of the settlements referenced in the text: Favela do Jacarezinho (top-left), Complexo Cantagalo-Pavão-Pavãozinho (bottom-left) and Complexo da Maré (right).](image-url)
The paper is structured in four sections. First, the problematisation section presents and relates the conclusions of two applications of segment angular analysis to Rio de Janeiro (Hillier et al., 2012; Krenz et al., 2015) with the historic urban studies of Abreu (1987; 1994) and the ethnology of Perlman (2010). Specifically, it focuses on the relation between the foreground and background and on the marginality of favelas within the city's network. Second, the dataset and methods section presents and discusses the data, criteria and methods adopted for simplifying the road centre-line map into a segment map and run the analysis. Furthermore, it illustrates the criteria for selecting a sample among the 1018 Rio's favelas, considering the critical lack of homogeneity in the mapping of their network. Third, the results section presents and discusses the values of favelas entrances within the issues highlighted in the problematisation section. Finally, the conclusions summarise the objectives, problems and outcomes of the study and suggest further research development.

2. PROBLEMATISATION

This section aims to discuss the outcomes of the previous applications of space syntax segment analysis to Rio de Janeiro (Hillier et al., 2012; Krenz et al., 2015). The purpose is to highlight their critical points concerning the object of this study, i.e., the connections between favelas and the global city's network. By this means, this section relates the hypothesis and conclusions of the analyses mentioned above with the arguments of two extensive urban studies of Rio de Janeiro, i.e., Abreu's history of the urban evolution (1987; 1994) and Perlman's forty-years-based ethnology on Rio's favelas (2010).

The main points we discuss here are the following: the historical and economic relation between the residential background and foreground and, by which means, this relation causes different levels of marginalisation between the favelas and the urban system as a whole.

To relate the configuration of a given spatial system with its broader social contest is one the main objectives of space syntax theory and method of analysis. The effort of Hillier et al. (2012), to normalise the measures of choice and integration, is part of such an effort. Indeed, the authors examine a sample of fifty cities of different size to detect the structures of movement (to-movement with integration, and through-movement with choice) within the chosen sample. What the authors mean to do by normalising the numerical values of movement is to define new instruments for comparing heterogeneous networks and predicting how, by varying the structure of movement, it is possible to mould different cities. Eventually, it is the consistency with the characteristic of the represented networks that allows the authors to validate the outcomes of their research. Precisely, what the findings of Hillier et al. (2012) notably reflect is the relation between the lines that led the economic growth (foreground) and the ones that structured the residential areas (background).

By comparing the measures of Rio de Janeiro with the other cities in the sample, the authors point out some fundamental points for the study we present. Indeed, they place Rio among the group of 'organic' cities, together with London, Tokyo and Istanbul. The authors point out that these cities differ from the others in the sample because they lack geometry, but just apparently. Indeed, the structure is “geometrically informed at the level of the line, not the area or the urban whole” (Hillier et al., 2012, p.187). Meanwhile, the relation between the background (mean NACH) and foreground (max NACH) of each city moulds some differences within the same group. London and Tokyo have a strong foreground network, created by a linear growth, where the background fills the interstitial areas. It is probably this same process of growth, led by the sequential addition of lines, that defines a strong connection between the local microeconomic structure and the residential areas.

On the contrary, the analyses of Istanbul and Rio present stronger local backgrounds, lacking global-to-local structures. The authors suggest a possible explanation for this kind of structure. That is the rapid residential growth led the construction of the city, by subordinating the economic logic of the foreground to the social logic of the background.

Krenz et al. (2015), some years later, reports the same hypothesis about the evolution of Rio de Janeiro's structure. This time the segment analysis runs on a new, more detailed map of Rio de Janeiro, which included the networks of the majority of favelas. The segment analysis run on this new representation of the city points out a higher maximum of NACH and, consequently, a more structured foreground network, when compared to Hilliers et al. (2012). The latter detects a broken-up structure. At 1.4 of NACH, it points out a “large-scale tree-like pattern” in the northern part of the city, without rings
appearing in the main area until 1.3 structure. Differently, Krenz et al. (2015) detect a complete ring structure at 1.3, connecting all the suburban areas with the broader whole. Nevertheless, their analysis confirms the relationship between the values of mean and maximum NACH, thus confirming that the movement in the global structure is distributed equally between background and foreground (Krenz et al., 2015).

Moreover, Krenz et al. (2015) argue that the global NACH analysis of Rio de Janeiro shows that favelas are not segregated. On the contrary, they are found close to the foreground. With a focus on the 100 largest favelas out of Rio's 1049, the authors report that 57% is in next or immediate proximity to a high choice value road (>1.4). A 34% is in a distance of at least 500 meters from a second range high value (>1.2), while 9% has no proximity to the foreground. These findings suggest the authors that favelas settle on ‘beneficial locations in terms of relation to the formal city rather than following the principle of unclaimed land’. Moreover, the local analysis of NACH detects a wide spread of potential local centres all over Rio's territory, including both favelas and formal areas.

Yet, while the formal areas present a continuous linear network, favelas are characterised by segregated central cores. This segregation is confirmed and becomes even more evident with the global and local NAIN analysis. That is, the local NACH and global and local NAIn detect the segregation of favelas while the global NACH shows their proximity to the foreground network. This apparent inconsistency set a critical point for the rejection of favelas as marginalised areas within the city's network. Nevertheless, it finds evidence and explanations in Abreu's history of Rio de Janeiro's evolution.

Indeed, if we weigh up the conclusions of the researches mentioned above with Abreu (1987), some crucial points emerge. First, the city planning policies intentionally defined a marginality, establishing a spatial dichotomy between the low-income and the wealthier residential areas. Second, the city residential background grew fast, but it follows the economic logic of the foreground.

According to Abreu (1987; 1994), the occupation of the suburban areas grew along railway lines since the beginning of the expansion of the city, in the second half of the 19th century. New settlements gathered around the train stations. Meanwhile, new roads were built by privates perpendicularly to the railway lines. This first phase already produced a socio-economic polarisation between the city centre and the suburbs. However, it is in the passage from slavery to a capitalist system of production, when Rio became the capital of the new Brazilian Republic, that the polarisation became structural. Low-income dwellers were removed from the city centre, according to the new modernist plans, and set themselves up in the suburbs or unclaimed areas on the steep slope hills surrounding the wealthiest areas.

The city kept growing along the “tentacular” (Abreu, 1987, p. 94) structure that surrounded the coastal mountains. Favelas moved together with industries on public or unclaimed lands, within an ‘anarchic’ industrial development in the north-east. In the '40s, during the construction of the first branch of Avenida Brasil (the expressway defining the most significant part of the 1.4 structure in the space syntax analyses mentioned above), from the port area up north, favelas invaded the surrounding areas. In some cases, new factories chose to settle in this same area to stay nearby both to the new expressway and to favelas (e.g., Jacarezinho), considered a reservoir of the workforce. The infrastructure kept developing along the northern city border, on the east-west direction, and on the flat northern area of the Baixada Fluminense, to guarantee a connection between the city and the farms in the rural areas that supply it. In the meanwhile, the use of reinforced concrete led to a fast high-rise development and upgrading interventions in the wealthiest southern regions. Real estates and public interventions attracted, as workforce, a growing number of immigrants, that settled their house nearby. This process led to the fast growth of favelas in the surrounding areas.

The extension of the railway system, the lack of a consistent plan of social housing and land use, made favela a structural, yet unacknowledged solution. Indeed, both the policies of eradication of favelas or planned resettlement mostly failed to attend the housing demand and gave rise, respectively, to new displaced settlement the former, and to grid-shaped favelas the latter, e.g., Complexo da Maré (Figure 1 and 6).

In the '90s, responding to the 1988 New Democratic Constitution of Brazil, Rio de Janeiro's master plan recognised favelas as parts of the city and established upgrading interventions. Nevertheless, Perlman
Figure 2. Train stations and foreground (NACH_n) of Rio de Janeiro, in relation with the topography (top) and favelas (bottom).

(2010) argues that even after this big plan of urbanisation, there is no doubt where the *asfalto* ends and the *morro* begins. Armed guards, by the entrances of favelas occupied by crime or militias, control and permit access to all those who are not recognised as residents. Properties nearby the entrances of favelas are depreciated because of constituting areas of drug-dealing or armed conflict, leading to social stigmatisation and conflict with the neighbours. Moreover, the least accessible areas within favelas are

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5 The common term *asfalto* (asphalt) reflects the planned formal city. *Asfalto* denotes infrastructure. In turn, *morro* (hill) reflects a topographic strategy in occupying the urban territory. This provides a strategic surveillance, in terms of visibility towards the surrounding environment, while occupying areas that were not filled due to their steep topography.
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even more segregated because they are utterly unlinked to public services and infrastructure. This inequality creates a further spatial, economic and social differentiation within the same favela. According to Perlman (2010, p. 150), favelas dwellers are not marginal but structurally included in a society that worked against their interest, so far.

To sum up, Rio de Janeiro grew organically along the lines of agricultural and industrial productive expansion (Figure 2). The broken-up structure detected by Hillier et al. (2012) finds evidence in the growing process. Both residential and industrial areas “leapt” (Abreu, 1987, p. 115) along the railway to gather around the train stations. Later, the formal real estate market developed a continuous local network (sometimes by forced eviction of low-income settlements), as founded by Krenz et al. (2015). In turn, as the outcomes of both global and local integration show, favelas were pushed to the least valued, nearby areas.

The characteristic of Rio de Janeiro's self-built settlements, of being segregated while close to the structure of movement is what motivates a further examination of their system of connection. Specifically, some evidence for focusing the study on the entrances is suggested by the comparison of favelas with the wealthy gated communities (Perlman, 2010) that are intentionally segregated, while staying near the system of movement.

3. DATASET AND METHODS

A crucial issue in applying space syntax theory and methodology is the setting up of a map that can consistently represent the spatial relations within the object of the analysis. In the process of defining the segment map of Rio de Janeiro's network for the proposed analysis, we follow three main steps. Each one relates to a specific problem: the simplification of a road centre-line (RCL) map to a segment map; the selection, from the network, of the segments corresponding to the entrances of each favela; the definition of a sample among favelas. The spatial datasets for all these steps are obtained from the online open database of the Municipality of Rio de Janeiro (data.rio), developed by its urban institute, the IPP (Instituto Pereira Passos).

It is important to report that, although the IPP is the same source of Krenz et al. (2015), we observe a difference between the number of favelas, i.e, 1018, in our database and the number, 1049, reported by Krenz et al. (2015). However, we do not observe any relevant effect produced by this incongruency.

As for the first step, to set up the segment map of Rio de Janeiro's network, we follow the methodology defined in Kolovou et al. (2017). In this process, we adopt slightly different criteria for the simplification of multiple lanes. Specifically, when the multiple lanes mould important discontinuities within the network, we try to preserve the representation of this discontinuities. This is the case when two local roads run along the two sides of a canal or an expressway with few interconnections. The simplification preserves the two local roads while, in the latter case, representing the expressway and its branches with a single line (Figure 3).

On the last stage, running the Douglas Peucker algorithm, we find the tolerance of 10 best preserving the relations within the network as a whole and, especially, within the favelas. Indeed, the tolerance of 15 might work in the simplification of the formal network but significantly modify favelas (Figure 3). Finally, the angular segment analysis was set on the 1024 Tulip Analysis, including choice, with metric radius (n, 800,1200, 2000, 3000, 5000, 8000, 10000) and segment length as the weighted measure.

Next, after the analysis, we import the result on QGis and collect the entrances of favelas within a new vector. The first attempt tries to partly automatise the selection by identifying the segment, within the network, that intersects the perimeter of favelas, as represented in the spatial dataset of IPP (2018). Unfortunately, this selection detects many tangential segments that, in the representation wrongly intersect favelas. Consequently, some entrances connected to these segments are ignored, as within the areas but not crossing their perimeter.

Therefore, we opted for manually select the entrances from a new vector representing the favelas network, obtained by cropping the map with the polygons of the settlements. This laborious operation collects the entrances by isolating those segments, along favelas borders, which connect directly with the outside network.
During this last process, we find deeper evidence of the lack of homogeneity in the representation of favelas. Some settlements, indeed, have not even one entrance. This, obviously, points out a crucial issue for the purpose of the study. Indeed, as it appears evident, by overlapping the map with the Google Satellite map, the inhomogeneity depends on a deficiency of the original RCL. Which, in turn, constitutes the most accurate representation of the city network, so far. However, we are still left with a significant number of favelas without this type of inconsistences and therefore be left with a significant number of valuable cases for this study.

By this means, we select among the spatial dataset of favelas the ones having at least one entrance, coherently with the purpose of the study. Then, we use this first selection to calculate the value of network density for each favela, by dividing the total length of the isolated networks by the value of their respective area (Berghauser Pont and Haupt, 2010). The minimum and maximum obtained are, respectively, 0.0001 and 0.09 m/m², with a mean of 0.02 and a median of 0.017. The comparison between these results and the value of the city's global network density (again, the total length of the city's network divided by the urbanised area, as in the spatial dataset of the city land use) suggests a possible solution. As we find the mean value of the city's network density to be equal to the median of this first selection, we checked the set of favelas above 0.017. The set appears to define a detailed representation of the favelas network. Finally, we opted to expand the selection to 0.016 to include some elements that have a similar grain but fall out of the set. Consequently, we obtained a sample of 406 favelas with a mean network density of 0.03.

To complete the setting-up, we cut off from the map those segments having a Node Count value under 20% of the mean as suggested by Hillier et al. (2012). This operation was, obviously, iterated for both favelas and city's global map, at all metric radii included in the analysis. These vectors constitute the base for examining and discussing the values of NACH and NAIn within the purpose of the study, as follows in the next section.

4. RESULTS

In the problematisation section of this paper, we reference the space syntax segment analysis of Krenz et al. (2015) for questioning a particularity of Rio de Janeiro concerning the relation between the favelas and formal network. To briefly summarise, Krenz et al. (2015) point out that favelas are mostly located near the global foreground network and locally define strong central cores. Nevertheless, they constitute
In a city shaped by discontinuous centres that occupy the flat areas around the coastal mountains and bodies of water, the global “broken up structure” (Hillier et al., 2012, p.185) suddenly comes out. Such structure curiously restricts the strongest foreground movement to a “large-scale tree-like pattern” (Hillier et al., 2012, p.185) running east-west on the northern half of the city (NACh > 1.4), while poorly integrating the south in a global ring shape (NACh > 1.3). It is important to remember that both sides present a stronger and more connected structure (Figure 2) if we run the segment analysis on a map including favelas, as already observed by Krenz et al. (2015). In turn, the analysis run on the formal network (Hillier et al., 2012) shows a weaker and more discontinuous foreground, especially on the southern half. This point already detects a global influence of favelas on the structure of the city as a whole.

Besides, it is possible to cross the outcomes of the referenced researches (see Abreu, 1987; Hillier et al., 2012; Krenz et al., 2015) for explaining the difference, mentioned above, between the two halves.

The detected bipartition of the global foreground structure corresponds to a historical dichotomy (Abreu, 1987): while the residential real estate has mostly shaped the southern part, the expansion of the north has been economically led by the growth of the industrial system.

Moving forward from the global to the local system analysis, we decide to look for a local radius that can detect the central cores of the city’s historical development. Rio’s favelas positioning within the global network motivates this choice (Figure 2). As favelas spread in a close spatial (and economic) interdependency with the formal areas, the hypothesis was that we could dig up new evidence for understanding their mutual connection at the scale of the historically leading poles. By comparing the max NACH and NAIN at different local radii (800, 1200, 2000, 3000, 5000, 8000, 10000), we find the radius of 5000 best fitting our purpose. Indeed, it is the largest radius that first detects the central cores of the city’s expansion, while still representing a reasonable walking distance (Figure 4).

What the NACH (radius of 5000) intriguingly points out, within all the areas, is that the local foreground branches off to favelas or passes them through (Figure 4 and 5). More precisely, among the selected sample of 406 favelas, the structure above the value of 1.4 reaches 28% of settlements (which represents 62% of the total area of the selected sample, and 40% of the area of favelas as a whole). Between the values of 1.3 and 1.4, we find another 28% (representing the 26% of the total area of the sample, and the 17% of the area of favelas as a whole). Next, between 1.2 and 1.3, the structure reaches 20% of the sample (equal to an 8% of the area of the sample, and to 4.5% of the area of Rio’s favelas). Finally, under 1.2 we find 23% of the sample (corresponding to 4% of the area of the sample and 2.5% of the area of favelas as a whole).

When we examine this latter group, we see that it has a relatively small mean area (equal to a tenth of the ones detected within the 1.4 structure, and to a fourth of the mean area of Rio’s favelas). What we can easily see within such a group is that it defines three different types of position: (1) favelas invading completely a block limited by the local foreground; (2) favelas that invade the linear interstices between the local foreground and a body of water or a mountainside, with entrances constituting a comb of blind alleys perpendicularly to the foreground; and finally (3), favelas at the edge of the local foreground on a poorly urbanised area.

To sum up, what we first detect by examining the max NACH of the entrances of each favela at a local radius of 5000, is that 28% of the favelas within the sample (again, 62% of the total area of the selected sample, and 40% of the area of favelas as a whole) intersects the significant local centre (>1.4). Besides, 58% is in close connection to it. What is more, within the group connected by entrances with a max NACH under 1.2, the local foreground is tangential to, at least, one side of their perimeter.

Moving forward, the same local analysis (radius of 5000) suggests a hierarchy among the entrances of every favela, as NACH measures the potential quantity of movement that passes through an element (Figure 6). Possibly, it detects, at the same time, the lines that led the invasion of every area, but we do not have enough evidence for arguing it. Nevertheless, this hypothesis represents possible further research.
Figure 4. Sample of selected favelas overlapped by the angular segment analysis of Rio de Janeiro at metric radius of 5000. The two maps depict, by the max NAln (top) and max NACH (bottom), the central urban cores at the chosen radius.
Figure 5. NACH representation at metric radius of 5000. Zoom on the central core of the Zona Sul, a wealthy residential area of Rio de Janeiro.
Following, we compare the outcomes of this analysis (radius of 5000) with the local one (radius of 800) presented by Krenz et al. (2015). The result is that the strong central cores of favelas that constitute an “archipelago of isolated islands”, segregated from the formal network at the radius of 800 (Krenz et al., 2015, p. 630), overlap the ending segments of the foreground structure as found at the radius of 5000. Here we find the connection between the central core of favelas (radius of 800) and the central cores of the city’s historical development (Figure 7).

Finally, what this representation might explain is why most favelas have a low degree of accessibility, both at global and local radii, while in close proximity to the global foreground structure. First, within the smaller favelas, entrances mostly correspond to dead alleys, thus defining poorly integrated areas. Second, favelas present a higher network density than the formal areas (as described in the dataset and methods section), but few lines along their border connect with the external network. This disproportion creates a bottleneck effect between the inside and outside. Such an effect is what structurally asphyxiates the movement from the inside-out and vice-versa.

Figure 6. Zoom on the NACH analysis at metric radius of 5000. It highlights the values of the entrances within the settlements represented in Figure 1, by the classic space syntax colour range.
Figure 7. Overlapping of max NACH representation of central local cores, at metric radius of 800 (in red), with NACH at 5000 (Greyscale) as represented in Figure 5.
5. CONCLUSIONS

The curious similarity between the systems of controlled entrances of Rio’s favelas and wealthy gated communities (Perlman, 2010) is what drives us to undertake this study. As Krenz et al. (2015) point out, Rio’s favelas are mostly located near the global foreground network and locally define strong central cores. Nevertheless, they constitute an “archipelago of isolated islands” (Krenz et al., 2015, p. 630), segregated from the formal network. The evidence of discontinuity of movement between the favelas and the outside city suggests us to focus on the entrances of favelas, their thresholds.

By examining the angular segment analysis of Rio de Janeiro’s network, including a meaningful sample of favelas, we can find some new pieces of evidence for understanding the connection between self-built settlements and planned city, at both global and local metric radii.

First, our analysis confirms the results of Krenz et al. (2015) concerning the foreground structure. By including favelas within the analysis, the foreground network acquires stronger importance in the city’s global movement. Then, by crossing previous analysis (Abreu, 1987; 1994; Hillier et al., 2012; Krenz et al., 2015) we suggest that the detected bipartition (north-south) of the global foreground structure corresponds to a historical dichotomy (Abreu, 1987). While the residential real estate has mostly shaped the southern part, the expansion of the north has been economically led by the growth of the industrial system.

Moving forward from the global to the local system analysis, we find the radius of 5000 the largest one that first detects the central cores of the city’s expansion, while still representing a reasonable walking distance. What the NACH (radius of 5000) points out, within all the areas, is that the local foreground branches off to the sample of selected favelas or passes through them. What is more, within the group connected by entrances with a max NACH under 1.2, the local foreground is tangential to, at least, one side of their perimeter.

The same local analysis (radius of 5000) suggests a hierarchy among the entrances of every favela, as NACH measures the potential quantity of movement that passes through an element. The consistency of this result, with a socially based differentiation among the entrances of favelas, defines an issue to further research.

Following, the comparison between the NACH at 5000 and at 800 points out that the strong central cores of favelas, at the radius of 800 (Krenz et al., 2015), overlap the ending segments of the foreground structure, as found at the radius of 5000. Here we find the connections between the central core of favelas (radius of 800) and the central cores of the city’s historical development (radius 5000).

To sum up, we propose that a reason for favelas having a low degree of accessibility, while in close proximity to the global foreground structure, could be found at their borders. As favelas present a higher density than the formal areas, but few lines along their border connect with the outside, the local network filters the movement. It structurally defines spatial thresholds between what is inside-out and vice-versa.

However, as favelas are complex systems, both spatially and socially, these findings need to be further examined and crossed with a wider range of factors, such as topography, as in Krenz et al. (2015), but also historical evolution, demography and legal framework, among others. Such an analysis constitutes the plan for further research.

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REFERENCES


