#96

CONFIGURATION, LOCATION, MOBILITY:

Effects on Spatial and Social Behaviour for Residents in Social Housing Complexes in Rio de Janeiro, Brazil

VINICIUS M. NETTO
Universidade Federal Fluminense, Rio de Janeiro State
vmnetto@id.uff.br

MIRELLA FURTADO
Universidade Federal Fluminense, Rio de Janeiro State
furtadomirella@hotmail.com

ABSTRACT

Space syntax theory seems based on the premise of movement as a general capacity of humans enacting their spaces. However, the capacity to move is not an ability equally distributed amongst social actors and; by the same token, mobility is not a homogeneous property affecting spatial behaviour. In this article, we problematize some of these factors brought about by contextual specificities not usually explored in syntactic theory and studies. In unequal urban societies, factors like income and location may be particularly felt, especially among the poorer. The article seeks to understand how mobility is conditioned by grid configuration, location and income – and how these combined factors might have effects on sociability. We developed an approach to capture the daily activities and spatial trajectories of 240 residents of affordable housing complexes in Rio de Janeiro, and a new measure of mobility relating extension and fragmentation in trajectories and number of activities performed. Our results provide evidence of a high dependence of mobility on income. Finally, we examine how different levels of mobility may affect the ability to perform in different spheres of sociability, involving levels of localism and diversity in social ties.

KEYWORDS

Space syntax, social housing, mobility, sociability

1. INTRODUCTION

Space syntax theory asserted a nearly unprecedented level of attention to movement as a condition of social organization and reproduction. Such extraordinary emphasis seems based on the premise of movement as a general capacity of humans enacting their spaces. However, the capacity to move may not be an ability equally distributed amongst social actors. A number of factors might interfere. In unequal urban societies, factors like income and location may be particularly felt, especially among the poorer. If that is the case, mobility cannot be considered a homogeneous property affecting spatial behaviour. In this article, we problematize the conditions of movement by shedding light on social and contextual specificities not usually explored in syntactic studies.

There is also a growing attention to daily activity and movement patterns in sociospatial theory. Beyond usual views of travel behaviour and occasional reassertions of Hägerstrand's (1970) time-geography, this attention stems specially from exploration of digital location data provided by mobile communication devices (e.g. Gonzales et al, 2008) and social media (Takhteyev et al,

CONFIGURATION, LOCATION, MOBILITY:
Effects on Spatial and Social Behaviour for Residents in Social Housing Complexes in Rio de Janeiro, Brazil

96.1

2011; Boettcher and Lee, 2012; Longley et al, 2015). Notwithstanding, there is a growing concern with new, dynamic forms of segregation engendered by different mobilities (Netto and Krafta, 2001; Netto et al, 2015; Wisskinsky et al, 2016), along with renewed emphases on segregation and exposure between socially different people within daily activity patterns (Schnell and Yoav, 2001, 2005; Wong and Shaw, 2011; Farber et al, 2015).

Our work draws upon such an intellectual environment. In this paper, we devise an approach to understand how mobility is conditioned by social and spatial factors such as income, residential location and grid configuration and what its implications to the resident's spatial behaviour are – and how they might affect people's sociability. We attempt to capture these factors analysing social characteristics, daily activities and spatial trajectories of residents of a number of affordable housing complexes in Rio de Janeiro, with different income levels. Part of the large-scale national housing programme 'Minha Casa Minha Vida' (MCMV), these complexes were for the most part recently built in expansion zones of the city, in North and West Rio – areas highly distant from the main employment centres, presenting serious mobility issues for their residents.

Through these data, we analyse the effects of location, configuration and income on mobility through a new indicator relating pedestrian and transport-based movement based on number of activities, extension and fragmentation in spatial trajectories, measured as a linear fractal dimension through Mandelbrot's (1983) method. This method allows us to assess the effects of mobility as a complex property, including access to job opportunities, consumption and services, and on observed social behaviour through correlations with the composition of personal social networks of residents. It also aims to offer an analysis of the composition of their networks of relationship and spheres of sociability (i.e. the situations of social contact) – along with the efforts involved in sustaining these networks, and the levels of localism of residents (i.e. the dependence of spatial, residential proximity in order to establish social relationships).

2. RESEARCH CONTEXT

The city of Rio de Janeiro has been subject to a mass production of housing complexes under the MCMV programme. The complexes are mainly located in areas of expansion, following a market logic that seeks cheaper and more distant from the central business district (CBD) lands for construction of the social housing complexes. The Northern zone is an already consolidated area of the city; its population consists of predominantly middle and lower classes. The Western zone is the most recent area of urban expansion – one of the few areas in the city with empty and comparatively cheap land, allowing opportunities for building massive social housing complexes (SHC). Both areas have serious problems of mobility and access to the rest of the city.

The location of SHCs in areas away from large centres of employment, study and leisure may have a negative effect on mobility, with severe implications for residents. Greater distances to commute everyday generate financial and temporal burden on actors, thus potentially limiting the number of activities that can be performed throughout the day.

For a better understanding of how location and income can affect the daily movements of these residents, we collected data on the routines of 240 residents through interviews performed in twelve SHCs located in North and West Rio. Importantly, this housing programme is composed of three distinct income levels, from low to middle-low income, the group 1 with incomes up until USD \$669,46, the second group up until \$1297,07 and group 3 up until \$2092,05[1]. In addition to the daily routines, we also collected information on the personal social networks of residents, gathering the location and circumstance of social contact with up to ten friends. These data offer us the possibility of assessing aspects of spatial behaviour, such as daily trajectories and mobility levels, and comparing them with social variables such as income and variables of sociability, in order to understand how they interact in urban life. Figure 1 shows location and syntactic analyses of Rio de Janeiro's grid generated on Depthmap.

1 Values converted from Brazilian Reals to United States Dollars, the quotation used was the first of the 2014 on 02/01.
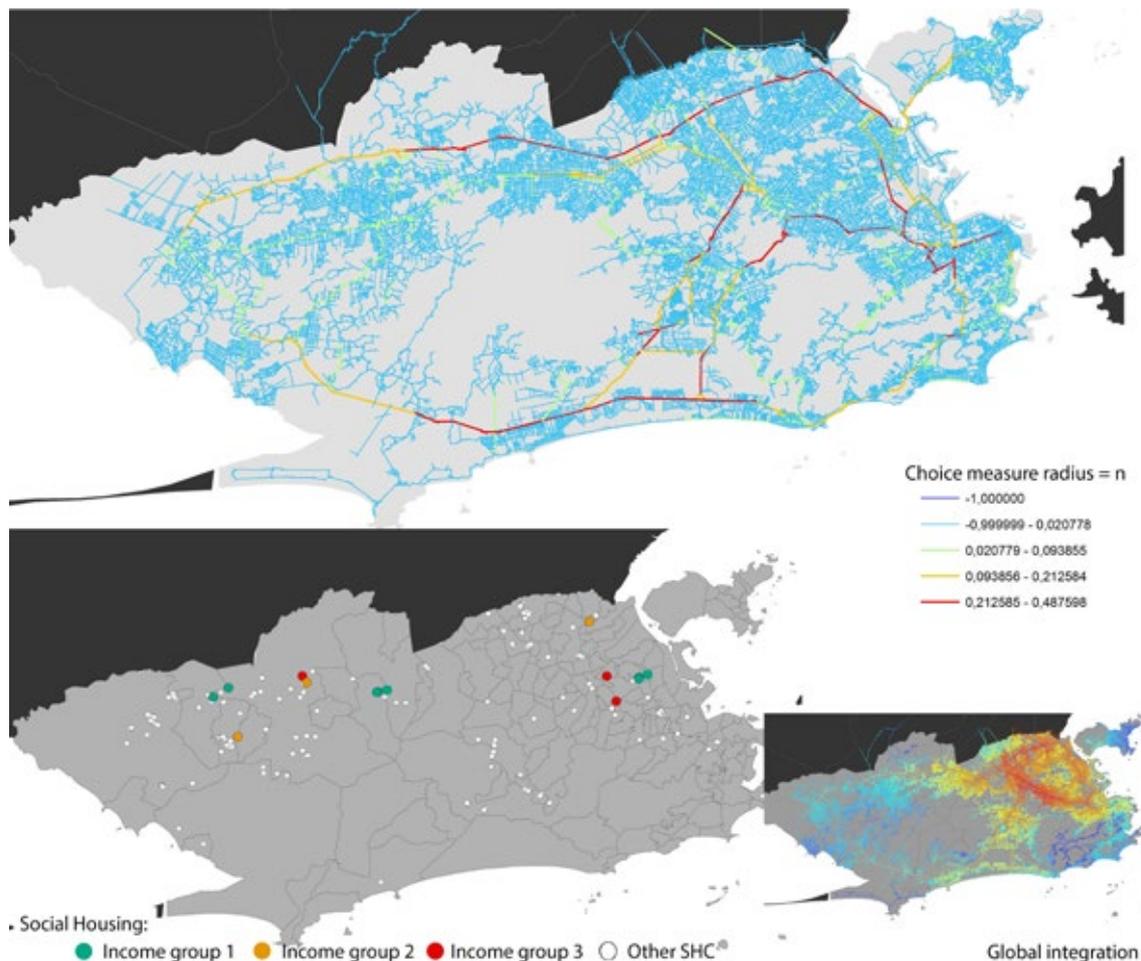
CONFIGURATION, LOCATION, MOBILITY:
Effects on Spatial and Social Behaviour for Residents in Social Housing Complexes in Rio de Janeiro, Brazil

96.2

Figure 1 - Syntactic analyses (global choice and integration) of Rio de Janeiro and localization of the complexes.

3. SPATIAL BEHAVIOUR

Through data collected in interviews, we were able to ascertain the impacts of the SHC' location on the spatial behaviour of its residents. We gathered information on income, places of work, leisure, medical services and consumption, and the location of ten friends of interviewees, as a way to look into the strong ties within their personal social networks (Granovetter, 1973). Our spatial behaviour analysis focuses on the complete trajectories of interviewees on the day before interviews, and approaches the city as a spatial network of streets plus places of activity. Activities analysed have well defined roles in people's routines (such as work and actions involved in leisure and daily consumption). Residents' trajectories may involve pedestrian movement, public transport or private vehicles, and were analysed the trajectories from twelve places of origin.

These trajectories are traces of people's actual presence in space. Mapping these paths could offer a good idea of how residents spatialise their everyday actions, and how residential location and patterns of mobility might shape their actions in the city. We consider the possibility that modes of transport used by the actors may have as much influence on mobility as the street network of that articulate the places of activity. Our initial hypothesis is that factors such as residential location and income may have roles in shaping the spatial behaviour and mobility of interviewees. Moreover, this analysis will allow us to evaluate the effect of the new residential location on the composition of residents' personal social networks. The representation of
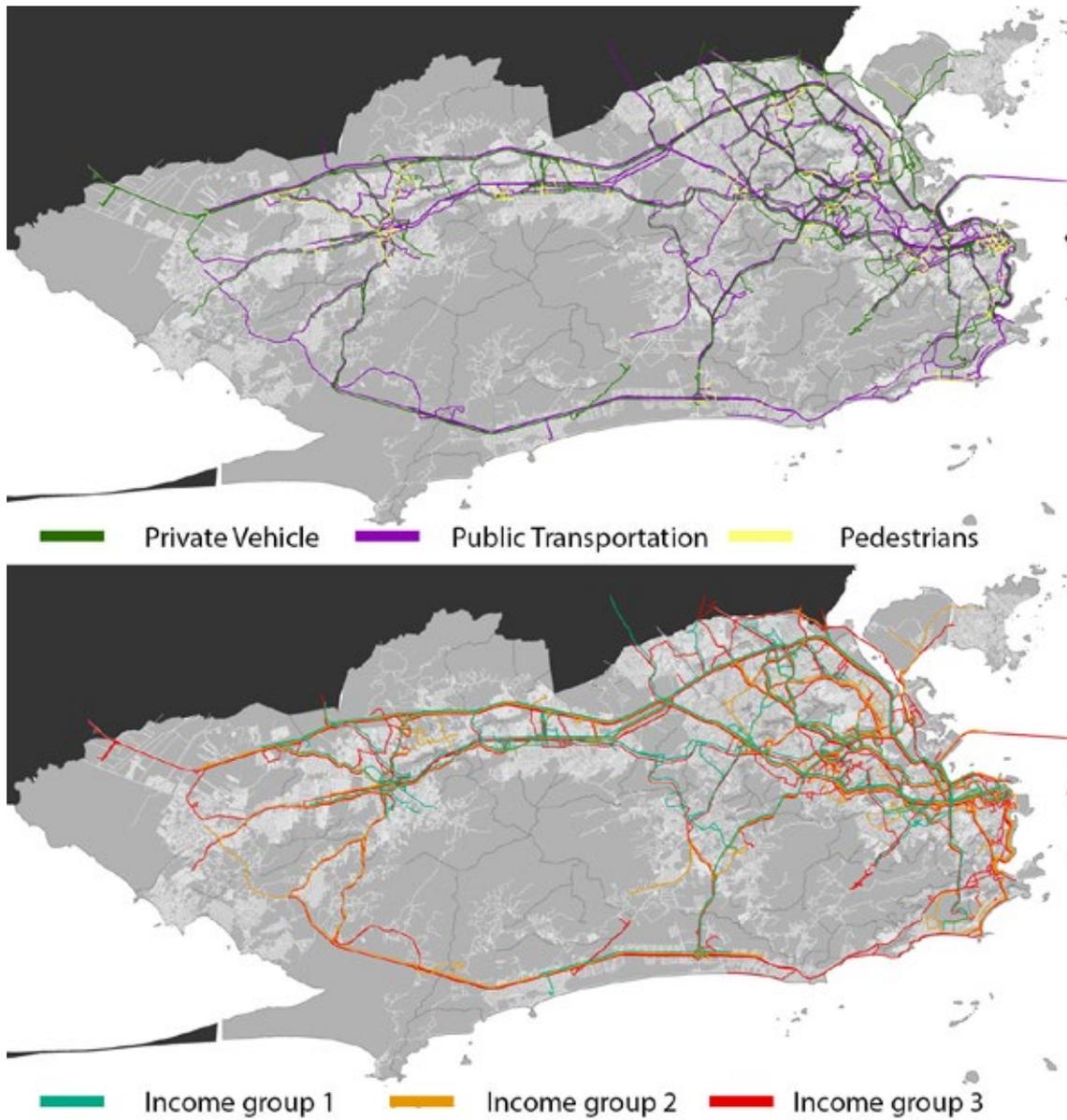
CONFIGURATION, LOCATION, MOBILITY:
Effects on Spatial and Social Behaviour for Residents in Social Housing Complexes in Rio de Janeiro, Brazil

96.3

Figure 2 - Spatial behaviour of SHC residents in Rio de Janeiro, according to transport modes and income groups.

CONFIGURATION, LOCATION, MOBILITY:
Effects on Spatial and Social Behaviour for Residents in Social Housing Complexes in Rio de Janeiro, Brazil
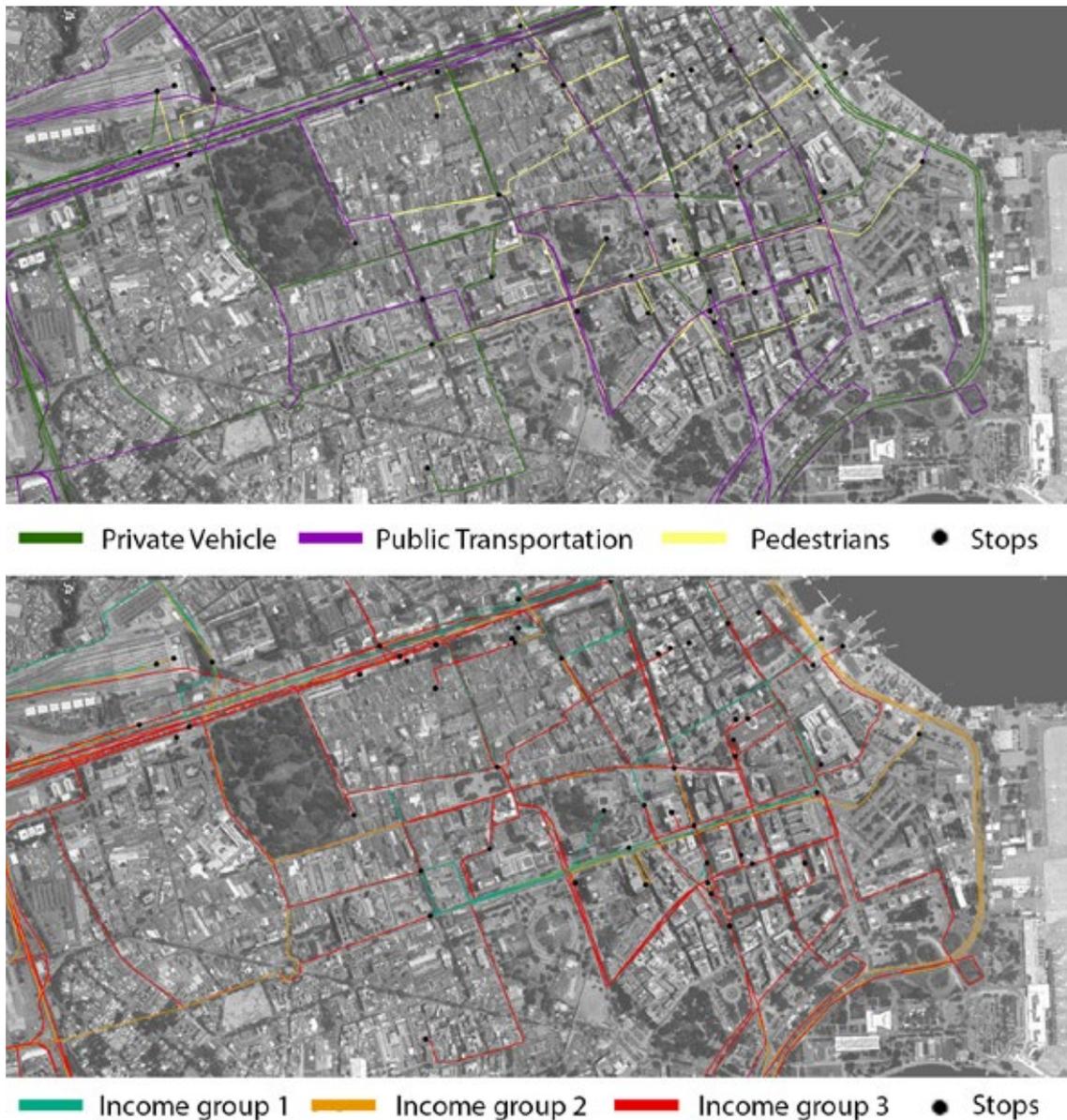
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Figure 3 - Spatial behaviour of SHC residents in Rio's CBD, according to transport modes and income groups.

trajectories allows the visualisation of potentially different spatial behaviours, and may offer hints into forms of mobility, along with the recognition of the role of residential location in the viability of residents' routines and spatial features of their social lives (figures 2 and 3).

Comparing trajectories on the spatial fabric of Rio de Janeiro with the integration and choice analyses (figure 1), we can observe that the trajectories of the lower income group (income 1) seem to concentrate on the main accessibility axes of Rio. One of the possible reasons for this behaviour is the mode of transportation. Lower income actors usually are more dependents

CONFIGURATION, LOCATION, MOBILITY:
Effects on Spatial and Social Behaviour for Residents in Social Housing Complexes in Rio de Janeiro, Brazil
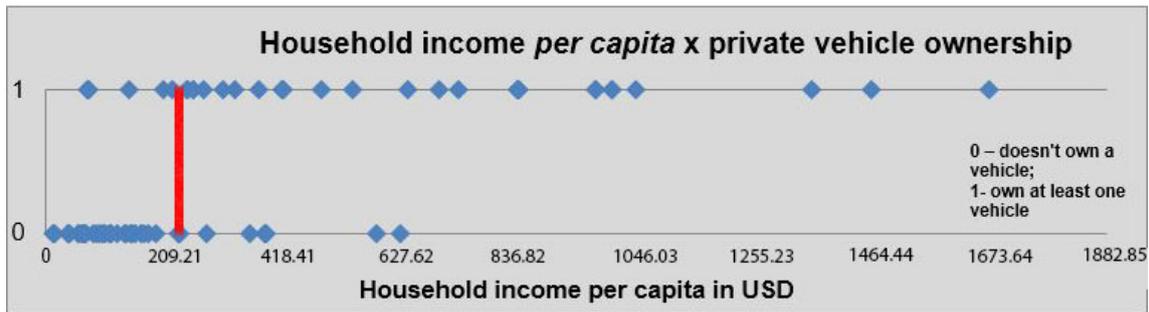
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Figure 4 - Income threshold for the ownership of private cars.

of the public transport. We estimated thresholds from which the ownership of private vehicle becomes more common. We found a threshold of $ 209.21 per capita, from which families are likely to own at least one private car (figure 4). For people who live in areas with low accessibility, a private vehicle can have substantial impact on individual mobilities.

As income increases, so does the ownership of private vehicles, which allows actors to use alternate routes and streets outside the main accessibility axes of the city. We will be able to verify how much this is the case later on, through the precise measurement of the fractal dimension of these different trajectories. In fact, a wide range of information can be acquired from mapping actual trajectories: the influence of the housing complexes' location on distances to work, services and friends, the levels of vehicle dependency, and the need for travels beyond the immediate residential neighbourhood to carry out activities and find services.

The analysis of median distances travelled by residents indicates that housing complexes localised in West Rio induce greater distances, offering unfavourable conditions of access to almost all analysed destinations, such as the CBD, work, retail activities, services (with exception to healthcare services) and friends. Table 1 shows that residents from the lowest income live in complexes more distant to the city's centre (the central business district-CBD), and reallocated themselves (to the housing complexes) from more distant neighbourhoods[2].

Income groups	Home - CBD	Home - previous Neighbourhood	Home - Work	Home - Retail	Home - Health care	Home - Leisure	Home - Friends	Work - CBD	Pedestrian trajectories	Public Transport trajectories	Private vehicle trajectories
1	31,8	**14,2**	**7,9**	**1,8**	**2,6**	**14,4**	**2,7**	**18.19**	1,8	22,1	16,0
2	**31,8**	7,0	11,9	2,3	4,6	6,7	5,5	16.83	1,8	29,1	9,0
3	**16,0**	5,7	13,8	2,2	6,2	8,2	6,4	7.14	1,6	26,3	26,5

Table 1 - Median distances (Km) travelled by different income groups.

Pedestrian trajectories are remarkable similar in extension for all income groups. Counterintuitively, higher income residents tend to deal with greater distances to commute. A great part of their daily routines tends to happen around these two places (home work) and along the trajectories between these places. Another condition involves the level of dispersion of work location for different income groups. We analysed distances from work locations to the city's CBD (namely the intercession point of the two most integrated streets, Presidente Vargas Avenue and Rio Branco Avenue). Absolute distances and maps of work density (figure 5) suggest different dispersion levels of work locations for different income groups. The CBD is an

2 Of the 290 interviews that were considered at this stage, 100 belong to income group 1, 61 to income group 2, and 118 to income group 3. Eleven interviewees declared that they would rather not inform their income.

CONFIGURATION, LOCATION, MOBILITY:
Effects on Spatial and Social Behaviour for Residents in Social Housing Complexes in Rio de Janeiro, Brazil

96.6

important location for higher income, and its importance decreases with income.

One of the possible explanations for this is that jobs requiring greater specialisation tend to be located in the city's major employment centres, while jobs with lesser degrees of specialisation may spread more easily and be found throughout the city. Another factor is that income can limit the ability to commute great distances, thus reducing the range of work search to locations closer to home. Higher income residents also deal with greater distances to retail, leisure activities and healthcare services. They are able to keep friends in more distant places from their new residential location.

If on the one hand journeys to work are shorter for lower income residents, on the other hand they are more removed from their previous residential locations, in Rio's many favelas (table 1). This suggests the potential for disruption in previously established social relationships
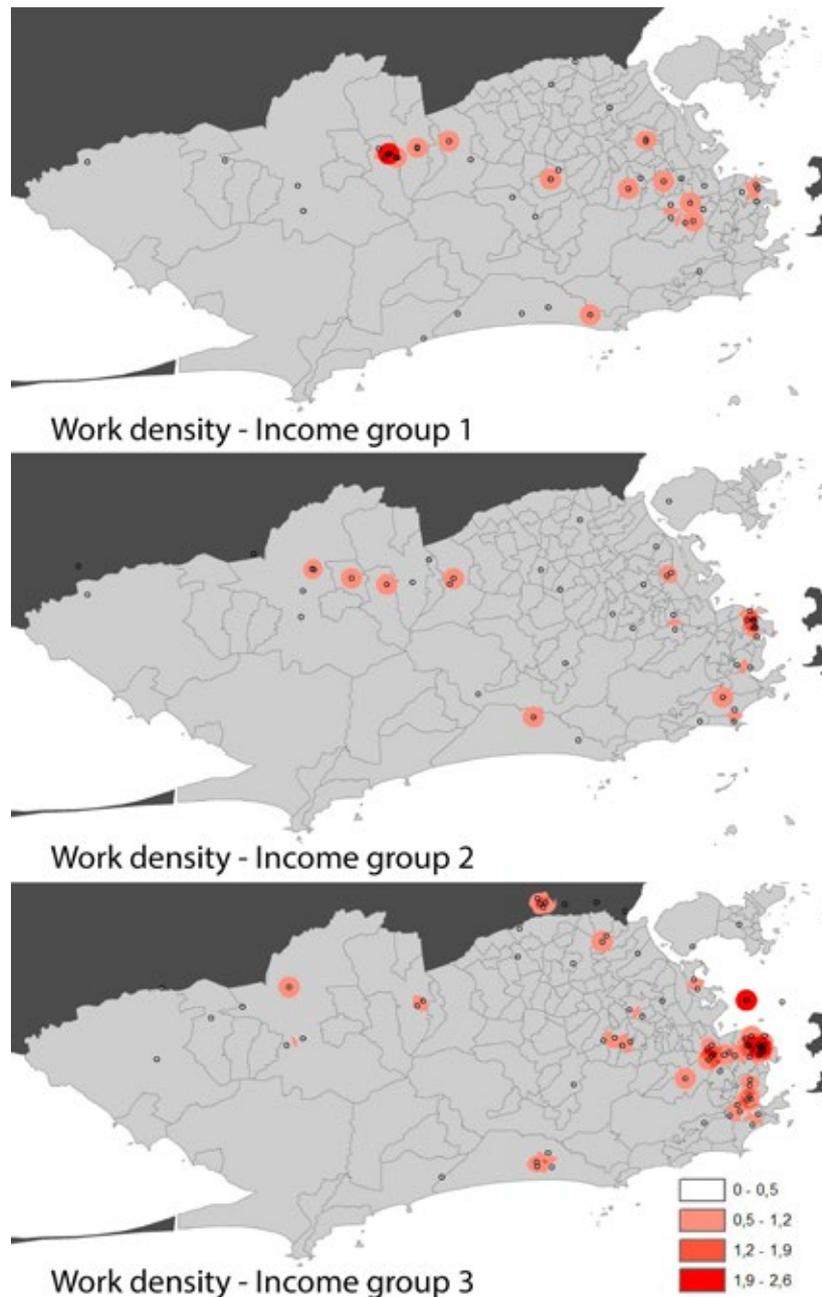

Figure 5 - Work density by income groups.

CONFIGURATION, LOCATION, MOBILITY:
Effects on Spatial and Social Behaviour for Residents in Social Housing Complexes in Rio de Janeiro, Brazil

96.7

dependent on residential proximity, as we shall see below. Low-income residents are also likely to use healthcare facilities closer to home, which suggests that higher income residents are able to choose farther facilities according to preferences and higher mobility. A higher income might offer more capacity to look for specific services. We shall confirm the possibility of differences in mobility levels in the next section.

4. RELATING INCOME AND MOBILITY

In order to ascertain the role of mobility in spatial behaviour and sociability, we must first turn to a definition of mobility. In fact, the concept of mobility extends over a very wide range of urban studies. Urry (2002) defines five types of interdependent mobilities able to form and re-form social relationships and networks:

- corporeal travel of people for work, leisure, family life, pleasure, migration and escape;

- physical movement of objects delivered to producers, consumers and retailers;

- imaginative travel elsewhere through images of places and peoples upon TV (1 billion worldwide);

- virtual travel often in real time on the internet so transcending geographical and social distance;

- communicative travel through person-to-person messages via letters, telephone, fax and mobile.

For the purpose of this work, we will deal with the first type of mobility defined by Urry, the corporeal travel of people. According to Urry, and with interesting alignments with space syntax theory (e.g. Hillier and Hanson, 1984; Hillier et al, 1993), what drives our travels, inside or outside the urban fabric, is the need for co-presence in space, vital for us to maintain a network of interpersonal social relationships. With a starting point in Urry's premises and in convergence with syntactic substantive emphases, we can define mobility as the capacity of an individual to generate trajectories that result in co-presence and activities in urban space.

Now studies that seek to establish relations between space and sociability (e.g. Putnam, 1993; Marques, 2015) have usually focused on territorial segregation as an obstacle to the development of larger, more diverse and less homophilic social networks. These works are mostly concentrated on residential location, then (non-statistically) correlated with number of spheres of sociability in one's personal social network. In turn, Linton Freeman's (1978) innovative view of segregation as 'restrictions on interaction' suggests that interpersonal contacts require more than a static territory. They involve daily interactions throughout the city fabric, and exposition to diverse situations where social relationships can be developed.

Furthermore, Freeman gives us an insight into how we can link space and social networks. Mobility can be seen as a factor that creates the possibility for co-presence in urban space and can contribute to reduce the socio-spatial segregation, helping people to overcome restrictions of interaction with those from different social background (Netto and Krafta, 2001; Netto et al, 2015).

$$N = r^{1-D}$$

Where N is the number of segments, r is the scale factor and D is the fractal dimension of trajectories.

We spatialised the trajectories collected in the interviews using a GIS (geographic information system) software. We suggest to use a measure of mobility composed of (i) extent, (ii) number of activities performed during the day, and (iii) fragmentation – the number of street segments used by the residents. The fragmentation of trajectories is analysed through its linear fractal dimension and the Mandelbrot method (1983).

CONFIGURATION, LOCATION, MOBILITY:
Effects on Spatial and Social Behaviour for Residents in Social Housing Complexes in Rio de Janeiro, Brazil

96.8

$$M = D^A$$

Where M is mobility, D is the fractal dimension, and A is the number of daily activities.

These trajectories are converted into pixels, with increasing detail according to the scale. We opted for a 0.7m pixel and a scaling factor of five times (r1e= 0.7, 3.5, 17.5, 87.5, 437.5, 2,187.5). As changes between scales follow a progressive proportion, we added a proportionality constant (K) to the equation: n = Kr 1-D interpreted through natural logarithm log n = log K + (1 - D) log r where n is the number of pixels in each resolution scale and r is the scaling factor. Combining the fractal dimension of trajectories and the number of daily activities as factors leads us to the following measure of mobility:

Through this measure, we could quantify the mobility of residents as a form of evaluation of how they perform their routines in city space. Figure 6 shows results for the extension of paths, number of activities, number of segments and the combined measure of personal mobility, according to the housing programme's income levels[3].
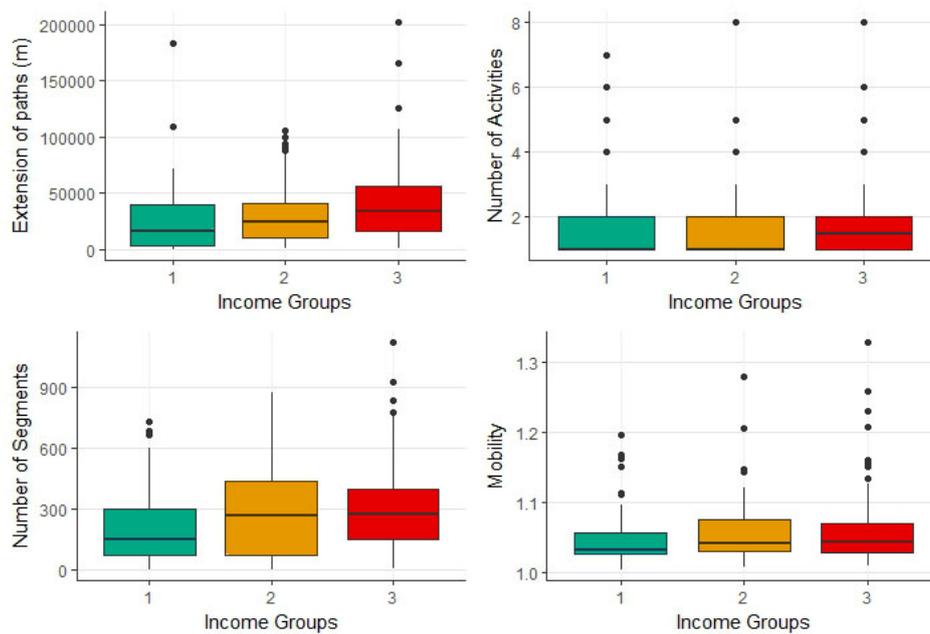

Figure 6 - Work density by income groups.

Results show that the lower income group has levels of extension, number of segments, number of activities and mobility lower than the other income groups. However, the variation between the two higher income groups for mobility is not large – due to similarities in the number of activities performed. One possible explanation for this is that both groups are above the income threshold that allows them to move around the city and join activities of consumption and leisure. Summing up, our analysis points to substantial differences in spatial reach for residents of different incomes group.

3 The box plot graph shows the dimension of data or their spread. The line inside the boxes is the average. The lower the height of the boxes, the more concentrated and similar are the observed intensities. The points above the boxes are discrepancies, i.e. observations very different from the others.

CONFIGURATION, LOCATION, MOBILITY:
Effects on Spatial and Social Behaviour for Residents in Social Housing Complexes in Rio de Janeiro, Brazil

96.9

- Mobility is likely to increase with income.

- The extension of pedestrian paths is very similar for the three income groups.

- The higher income group tends to work closer to the city's CBD. They also benefit the most from new location as far as proximity to the previous location is concerned.

- The lower the income, the greater is the distance from the residents' new location to their previous neighbourhoods. This item can have effects on residents' social network, as we shall assess from now on.

5. THE EFFECTS OF MOBILITY ON SOCIABILITY

We have seen that spatial behaviour has to do with the conditions of residents of affordable housing complexes to build and maintain their networks of personal relationships. These relationships form what has been defined since the 1950's as 'social networks' (see Wasserman, 1994; Lin, 2005). The composition of social networks is far from a trivial, inconsequent affair. There is an established understanding in the literature that the diversity of ties and number of nodes in personal networks are a key part of one's 'social capital'.

In turn, social capital can be defined as the aggregate of actual and potential resources linked to a durable network of relationships of mutual acquaintance or recognition (Bourdieu, 1986), and to (symbolic and material) resources accumulated and opportunities created through such relationships (Coleman, 1988). Networks and social capital are constructions that take effort and time. Basic characteristics of networks associated with social field of origin of actors may be explored through the concept of 'spheres of sociability'. In theory, the greater the number of relationships and the more diverse of their spheres are, the greater the potential for opportunities and mutual support between actors.
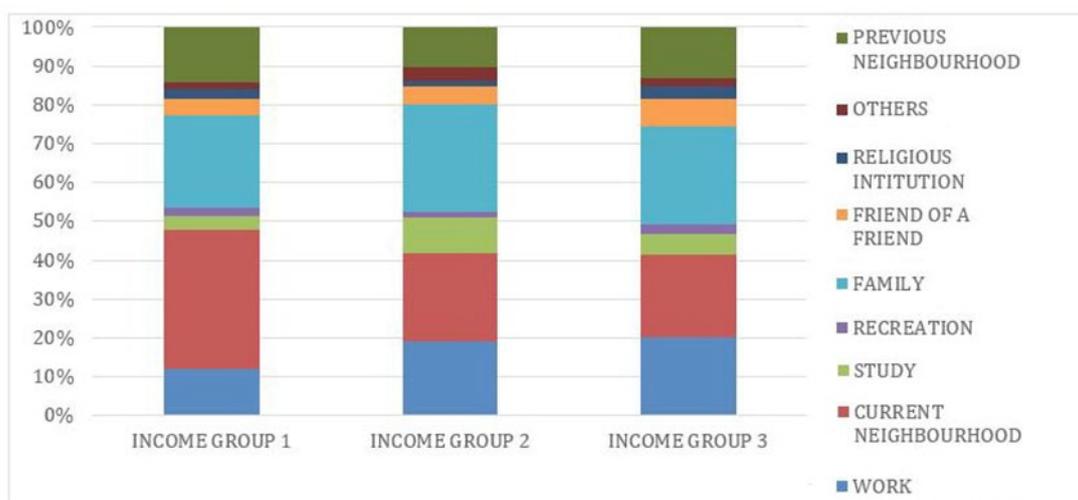

Figure 7 - Spheres of sociability of different income groups.

Research in Brazil has found strong links between residential location, segregation and the composition of personal relationships (Holanda, 2000; Marques, 2015; Netto et al, 2015). Lower-income actors rely more heavily on their neighbourhood to generate personal networks. The hypothesis that naturally arises is that moving to the housing complexes has an impact on personal social networks of residents. As a matter of fact, this would be expected for actors of any income profile – but in the case of smaller incomes, impacts could be stronger, due to lower mobility. Figure 7 brings our findings on the composition of sociability in different income groups.

As lower-income actors tend to have lower mobility, neighbourhood relations constitute a large part of their personal networks. For these reasons, a new location means that actors

CONFIGURATION, LOCATION, MOBILITY:
Effects on Spatial and Social Behaviour for Residents in Social Housing Complexes in Rio de Janeiro, Brazil

96.10

may suddenly see themselves partially deprived of their social networks, along with difficulties in maintaining older (and now more distant) friends. Friendships created through work and learning situations tend to increase with income. These two categories have more chances of reducing the homophily levels (similarity between actors), since they lead to an increase in diversity of the spheres of sociability and opportunities of contact with people from social fields and classes distinct from those of the resident.

The proportion of relationships on the neighbourhood gives us an insight into the spatial composition of these relationships; the relationships from the current neighbourhood have a greater presence in the friendships from the income group 1, and decreases as the income rises (figure 7). This fact might indicate a greater dependence of the neighbourhood for the individuals with lower incomes, or a higher level of localism in their networks. Our survey of activity and friendship distances (table 1) confirm theses tendencies, demonstrating that the residents with lower incomes maintain friendships and perform activities closer to home.

The analysis shows significant difference in the composition of the relationships of people from different income groups. Moving from distant neighbourhoods to the new complexes might have had an impact in these relationships, since as we have seen the neighbourhood has a great importance for the lower incomes.

A reasonable hypothesis is that there is a gradual decrease in the contact with friends from the previous neighbourhoods, induced by the new distance and mobility, which varies according to income. Higher income actors may experience less rupture of the spatial and temporal fabric that structures the social network of the residents. There would be a decrease in the number of members from the older neighbourhood, with impacts on opportunities for activities and daily support (capital reduction). However, in a new stage, we would have a progressive increase of new members by the proximity in the new neighbourhood, with possible increase of social capital. In fact, what our data points up to date is a renewal of the social network of the residents, with the growing presence of friends mainly within the housing complex. The new location is already felt in the social networks of residents living less than two years in their new homes.

Two concepts help us to make sense of patterns of relation between income, location, mobility and sociability:

 (a) Levels of localism: the location of members of personal networks and the places of activity of each resident can reveal the level of dependence of proximity to establish social relationships. We seek to understand possible impacts on residents and their efforts to keep their personal networks after moving to the new complexes.

(b) Diversity and homophily in personal networks: The sociability of the different income groups have great differences on its spheres of sociability that form their social network, these differences show their level of Localism (dependence on proximity in the space) and homophily. Through the interviews, we collected data that shows the dominant presence of the

$$S_i = \frac{-\sum_{j-l}^{k}(p_{ji})(ln\,P_{ji})}{(ln\,k)}$$

Where: Si = entropy index in friendship i, Pji = proportion occupied by spheres j in friendships i or proportion of units with spheres j, K = number of spheres, ln = natural logarithm

neighbourhood in the relationships of the residents, and inside the complexes for actors from the lower income group. This dominance of neighbourhood based relationships decreases as income increases, showing evidence of an impact of the income on the localism of the residents' relationships (figure 7).

CONFIGURATION, LOCATION, MOBILITY:
Effects on Spatial and Social Behaviour for Residents in Social Housing Complexes in Rio de Janeiro, Brazil

96.11

	Income	Fractal Dimension	Mobility	Social Diversity
Income	1	**0.21**	**0.18**	**0.56**
p-value	**1**	0.001	0.008	0.000
Fractal Dimension	**0.21**	1	0.56	0.23
p-value	**0.001**	1	0.000	0.000
Mobility	**0.18**	0.56	1	0.18
p-value	**0.008**	0.000	1	0.005
Social diversity	**0.56**	0.23	0.18	1
p-value	**0.000**	0.000	0.005	1

Table 2 - Spheres of sociability of different income groups.

In order to assess the level of diversity in personal networks, we used Shannon's information entropy (Shannon, 1948), considering nine spheres of sociability collected through interviews: work, leisure, current neighbourhood, learning activities, family, friends in common, religious institutions, former neighbourhood and 'others'.

We were able to verify correlations between the diversity of personal relationship, income, fractal dimension of trajectories and the mobility of each actor. The table below illustrates the correlation matrix (by Spearman's method) of these variables.

The correlation matrix shows positive correlations between income, diversity and the fractal dimension of paths, suggesting associations between the mobility and the diversification of social relationships.

6. CONCLUSIONS

Our approach is intended to assess relations between patterns of space, spatial behaviour and aspects of social life. We have seen that the mobility of the residents is closely related to income (figure 6). Restrictions in mobility found for residents in affordable housing complexes corroborates patterns observed by Holanda (2000), Marques (2015) and Netto et al (2015) regarding the effects of spatial segregation on the diversity of social ties in other Brazilian cities. We have also observed that the grid configuration has an impact on these individuals' mobility, tending to limit the trajectories of lower income actors to the city's axial lines with higher integration.

The lower mobility of actors from low-income groups might also have relations to their job opportunities. As we have seen, lower income groups tend to have their jobs closer to home, whereas higher income actors tend to have their jobs closer to the CBD. Possible interpretations of these behaviours may include higher levels of specialisation around jobs spatially concentrated in the CBD, along with higher mobility expanding possibilities in the search for jobs.

Higher income residents are also likely to have more benefits from residential location: their homes tend to be located closer to the CBD. Actors from higher income groups also reallocate themselves to complexes closer to their former neighbourhood, potentialising their contact with friends in that sphere of sociability and allowing them to preserve their original social networks, a key factor of social capital.

CONFIGURATION, LOCATION, MOBILITY:
Effects on Spatial and Social Behaviour for Residents in Social Housing Complexes in Rio de Janeiro, Brazil

96.12

In this sense, our analysis of spheres of sociability also shows significantly differences between income groups. Higher income group shows less dependence on proximity to form friendships and constitute their social network. Lower income actors have a greater proportion of relationships formed through the neighbourhood, demonstrating higher dependence on physical proximity – and localism. Unsurprisingly, levels of homophily also vary according to income and mobility. Residents with higher incomes and greater mobility tend to produce relationships at broader spatial scales, especially with actors who share their mobilities, increasing the chances of contact between their personal networks. Higher income residents are also likely to have more relationships related to study and work, which tends to reduce homophily levels.

Finally, we have found evidences of an overall decline in contacts with members of the social network in previous neighbourhood – along with evidences of addition of relationships within the new neighbourhood, adding whole new collections to personal networks, with potential effects still to be estimated.

CONFIGURATION, LOCATION, MOBILITY:
Effects on Spatial and Social Behaviour for Residents in Social Housing Complexes in Rio de Janeiro, Brazil

96.13

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CONFIGURATION, LOCATION, MOBILITY:
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96.14