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EMERGENT CONFIGURATIONAL EFFECTS OF DIFFERENTIATED GROWTH PATTERNS AT OPORTO'S URBAN FRINGE

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Abstract

In this paper we report the results of an on-going research on the issue of contemporary suburban form, having as study territory the metropolitan region of Portugal's second largest city, Oporto. We have modelled the urban grids of five representative suburban areas of this metropolitan region, on four analysis periods along the last fifty years, using a diversified methodological approach, combining cartographic redrawing (Pinho and Oliveira 2009) with space syntax and with some of the analytical tools proposed by Stephen Marshal (2005) in "Street and Patterns". This research package is intended to supply several 'analysis apparatus', whose outputs, although distinct, could produce complementary and synergic data about different aspects and scales of urban form.

Our results show evidence of different suburban growth patterns, characterized by different spatial distributions and by different morphological mixes of urban expansions in each period. To these different growth patterns correspond also different global configurational outcomes, namely clear intelligibility inequalities between the study areas. We show that these different configurational outcomes are explainable by, and statistically correlated with, the previously observed spatial distributions and the differentiated morphological compositions of urban growth, as described by some of Marshall's classification and quantification techniques. Thus, we demonstrate the existence of a strong relation mediating the local morphological properties of urban growth's components - which are, for the most part, non-programmed individual interventions - and the emergent global spatial effects that they produce as they construct the grids along time. These results offer some clues to how we could plan contemporary suburban areas from the bottom-up, i.e., creating morphological regulations at the very local level, in order to achieve desired global patterns. Building on these clues, we conclude proposing some recommendations for spatial planning policies, aimed at the enhancement of the structural spatial properties of these new urban territories.

1. INTRODUCTION

In Portugal, as elsewhere in the world, extensive metropolitan urbanization has produced new patterns of urban development, with physical and spatial characteristics that are utterly different from those of the traditional city. Around the compact urban core, now almost a relic of what a city used to be, the new urban-region extends far into the surrounding environment, assuming the peculiar forms of an 'urbanized landscape' or of a 'landscaped city' - a mingling of urban spaces and built forms with natural and rural spaces, accompanied by a gradual disappearance of the traditional dichotomy between these two worlds (Friedmann and Miller 1965; Levy 1999; Sieverts 2003; Bosdorf and Zembri 2004).

These profound transformations were by no means followed by a clear understanding of the morphological characteristics and growth dynamics of those new urban territories. Instead, the awkward morphology of contemporary suburban areas gave rise to a tide of theoretic criticism and repudiation, which sees such transformations as the signs of a distressing and apparently unstoppable dismemberment of the city. This negative theoretical stance, often more driven by aesthetical mistrust than by objective observation, has led to a general paucity of knowledge on the effective morphological nature of contemporary suburban areas (Sieverts 2003; Brueggman 2006; Marshall 2006; Vaughan, Griffiths et al. 2009). Thus, urban planning practice, when confronted with the extended city, is left without a reliable morphological model for action, oscillating between the appealing image of the traditional city and an intractable urban reality that is totally at odds with it.

As early as 1965, Friedman and Miller were able to anticipate that the city-region, at that time a recent urban manifestation, "will elude easy perception by the eye and will be difficult to rationalize in terms of a Euclidean geometry. It will be a large complex pattern which, unlike the traditional city, *will no longer be directly accessible to the senses*" (op. Cit., p. 319, our emphasis). Although 47 years have passed since these authors claimed that "the challenge to search for [new models of the peripheral city] confronts the planning profession with mounting urgency" (op. Cit. p.319), these models are yet to be found. The same claims can still be found in recent works that dwell on the same problem (Southworth and Owens 1993; Levy 1999; Scheer 2001; Stanilov 2004; Vaughan, Griffiths et al. 2009).

Morphologically, therefore, we could talk about a city we know, the city of traditional urban form, and another one that is strange to us, although much larger, the city of extensive urbanization, sprawling fast around the other. But because we don't recognize this new city as something clearly 'urban', we tend to characterize it always by opposition to the city we know: 'the city with good form' versus 'the city without form', so to speak (Figure 1).

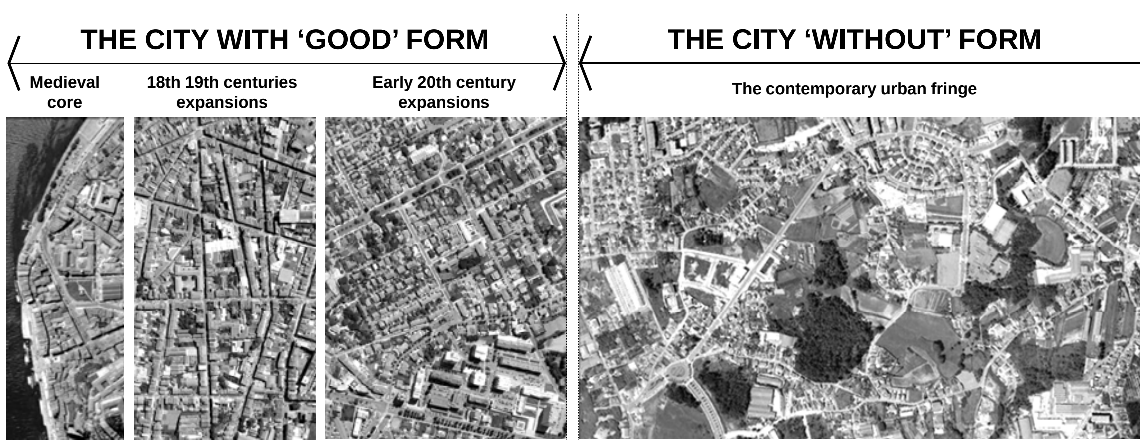

Figure 1 – The city with 'good' form and the city 'without' form.

Several reasons have been pointed to explain this epistemological deadlock; for instance, the relative young age of these urban environments, the analytical problems raised by their huge territorial scale or their fast transformation rates (Stanilov 2004). We propose, however, that what really has hindered the morphological description and conceptualization of contemporary suburban form is the fact that the problem has been mainly addressed through a visual, rather than structural, perspective. By this, we mean that the knowledge that we need to overcome the deadlock is not about the superficial looks of the extended city, but rather about the way its spatial form is structurally composed. We believe that the main flaws of contemporary suburban form exist at that deep, non-visible, space-structural level. Therefore, we should not expect to understand contemporary suburban form clearly, before we understand the nature of its spatial structure. Nor should we expect zoning regulations alone to be sufficient to promote morphological coherence or spatial legibility in places where there is no clear previous urban matrix. And much less should we expect the private sector alone to be able to ensure this, in the absence of some kind of structural guidelines (Figure 2).

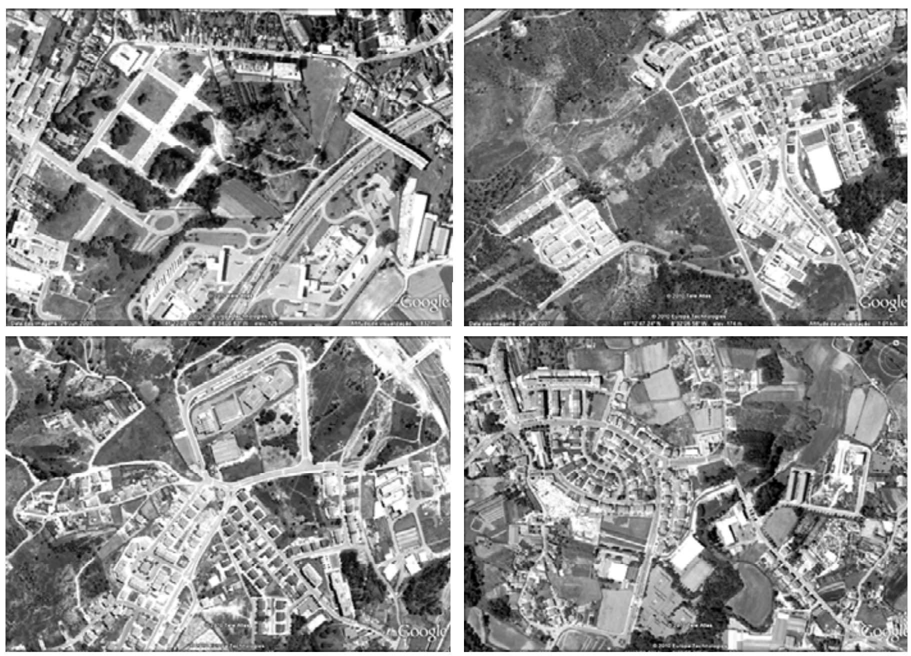

Figure 2 – Private initiative allotments in Oporto's urban fringe. Note the haphazard and incoherent character of the several interventions.

Contemporary suburban areas have been said to be 'chaotic', 'without structure', 'fragmented' and 'illegible'. Most certainly, these are suitable adjectives to qualify some of the general physical and spatial characteristics of these territories. But they don't help much when one needs to think what to do about them. If these new urban areas are chaotic and structurally flawed, we need to know what kind of structure is missing, where and why; if they are fragmented and illegible, we need to be able to quantify the real impacts of such patterns on urban functioning. And, above all, we need to understand objectively these emerging spatial structures and their growth dynamics, in order to find new ways of planning the extended city, knowing what we want to transform and what we want to keep of it.

2. METHODOLOGY

Bearing in mind these ideas, we conducted a diachronic study of the urban grids of five representative suburban areas of Oporto metropolitan region, along the last fifty years. Our main objective was to observe suburban growth, looking for the morphogenetic processes behind the apparent morphological disorder and structural randomness of these territories. We also sought to identify the specific morphological characteristics that made these urban areas so different from the traditional city and, apparently, so difficult to grasp.

We wanted to observe those processes at the micro-scale but also to keep track of transversal phenomena, in order to observe local and global trends. So we chose five study areas from Oporto's urban fringe and carried out a comparative study of them. They are the five civil parishes[1] with the highest urban grow rates in the last fifty years, from the five municipalities that surround the city of Oporto. Of course, parishes' areas are rather different as are they administrative limits, so we standardized them by defining a circular area (28.3 Km2) with a 3 kilometre radius around each one. From now on, we will refer to these five areas[2] as A, B, C, D and E, as shown in Figure 3.

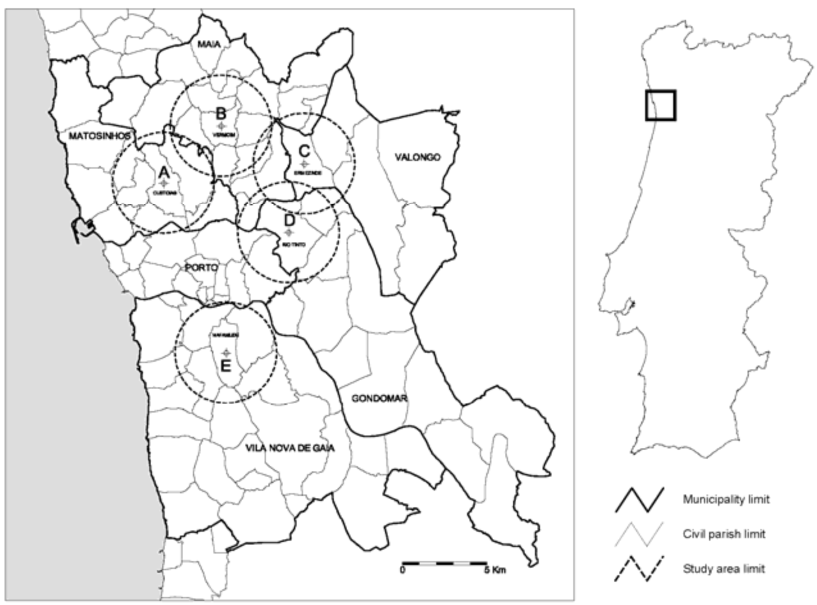

Figure 3 – Study areas location on Oporto's metropolitan region.

Diachronic representations of urban form are extensively used for the observation of dynamic morphological processes. They allow comparison between different periods of urban development, turning clear the transformations between one period and the other. There are several methods to do this, from the simple observation and comparison of old maps to the more sophisticated use of GIS technologies to digitally superimpose cartographies from different periods. We used one of this methods, cartographic redrawing (Pinho and Oliveira 2009), in order to recreate the street networks of the five study areas at four different periods, spanning the last fifty years of urban growth.

[1] The Portuguese system of territorial administration is divided, at the local level, in two tiers: the municipal level, and the civil parish level.

[2] The Portuguese names of the parishes are Custoias, Vermoim, Ermesinde, Rio Tinto and Mafamude, respectively.

Our research methodology was based on the concomitant use of three different analysis techniques: the aforementioned cartographic redrawing (Pinho and Oliveira 2009), space syntax (Hillier and Hanson 1984; Hillier 1996) and street pattern analysis (Marshall 2005). The idea behind this diversified research package was to explore suburban form through different 'analysis apparatus', whose outputs, although different, could provide complementary and synergic results (Figure 4).

Cartographic redrawing was used for the rigorous recreation of each case study's urban grid at each analysis period. These periods correspond to the publication dates of the cartographies used for that purpose, these dates being respectively 1950, 1975, 1995 and 2005. Hereafter, we will refer to these periods as 1P, 2P, 3P and 4P. The first three periods were described by digitalized paper maps[3] (scale 1:25 000), and the last by the current vectorial cartographies of each concerned municipality. The cartographic redrawing technique is, in itself, rather simple. It starts by the superimposition and georeferentiation, on a GIS platform, of a current vectorial map over a preceding raster map. Because the vectorial map is fully editable, it is possible to create a new version of it, subtracting all the elements that are not represented on the preceding map. By repeating this process with increasingly older maps, one is able to produce several 'snapshots' of the evolution of city's form. Moreover, current vectorial maps are a lot more precise than the old ones, making reasonable the assumption that, whenever differences are found between structures represented in both maps, one can trust and keep the current vectorial representation. Thus, it is not only possible to recreate several digital representations of the past planimetric form of the city, but also representations that are actually much more accurate than the existing ones.

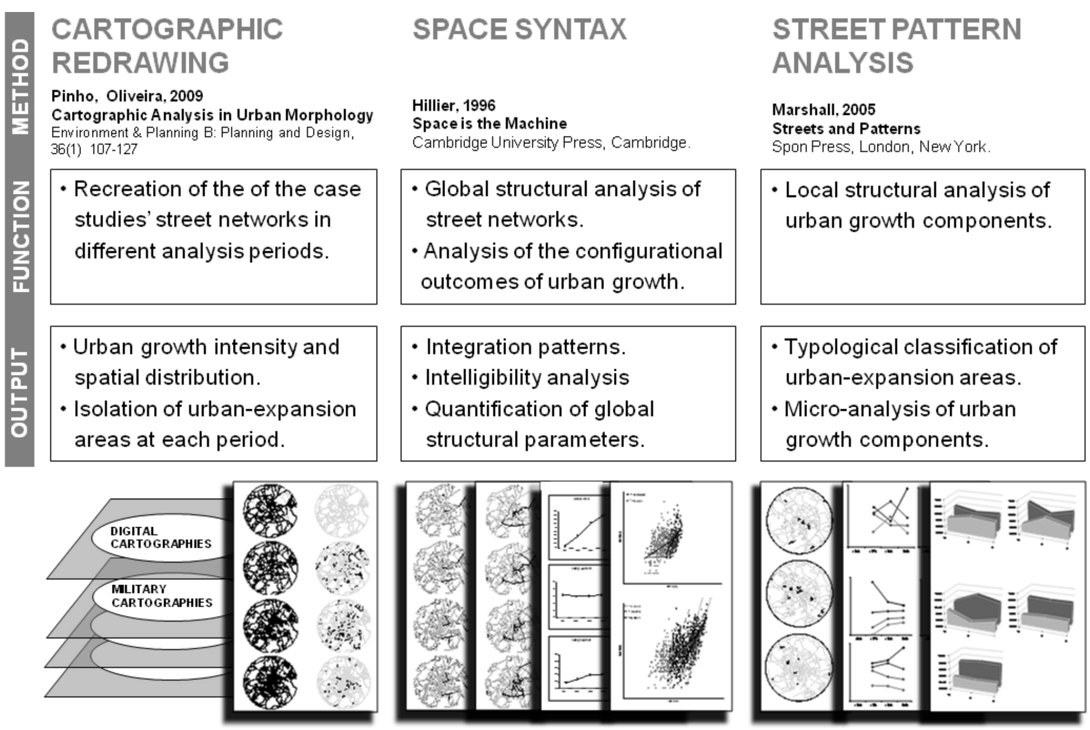

Figure 4 – The research framework; each analysis technique was used for different research purposes with potentially complementary outputs.

[3] Extracts from the Portuguese Military Map (edited by the Portuguese Army's Geographical Institute, IGEOE), covering the entire Portuguese territory.

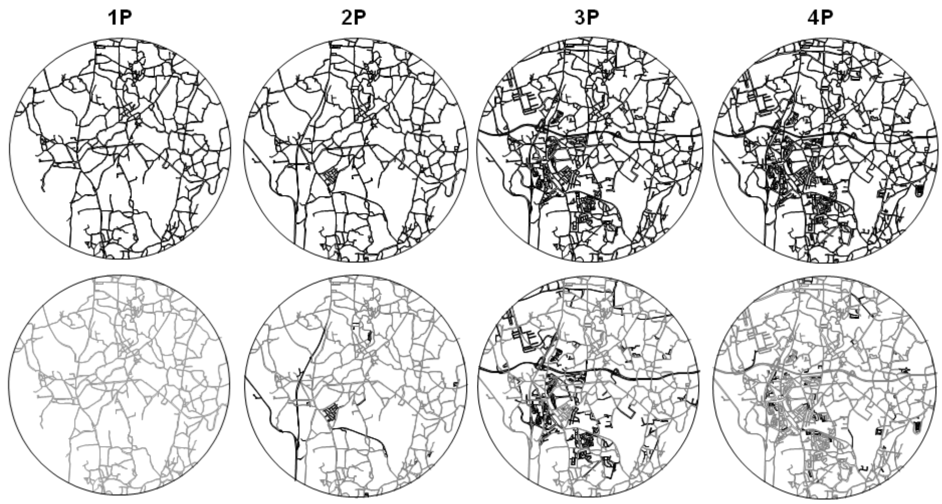

Figure 5 – Example of the cartographic redrawing produced for each case study (here, case study B). Above, the grid in each period; below, the respective urban-expansion areas.

Besides allowing for the recreation of each case study's urban grid, this method also presents an additional feature, particularly important in this research. It allows for the rigorous isolation of urban-expansion areas, i.e. the set of all built elements (streets and other open spaces, in this case) that were produced between one period and the subsequent. We have determined the intensity and the spatial distribution of urban growth by comparing these graphical sets between case studies and analysis periods. The cross-checking of that data with aerial photographs makes it possible to separate it down to the several individual interventions of each period, a procedure necessary to the subsequent study of their distinct morphological characteristics through street pattern analysis.

Space syntax was used to explore the spatial structure of the grids recreated by the previous technique. We have made a broad syntactic research of each study area in each analysis period, using several kinds of analytical procedures, including integration pattern analysis, intelligibility analysis and the quantification of several syntactic measures. The evolution along time of the results of these analytical procedures, show the configurational impacts of the urban growth patterns identified by cartographic redrawing. These are global impacts, measured as variations on the global structure of the studied grids, whose effects we can estimate at the light of space syntax theory. However, urban growth is not a global spatial phenomenon (happening everywhere and at the same time), but a rather local and discrete one, composed by many individual interventions (the ones isolated before) occurring at some moment in time. As such, the configurational outcomes of urban growth are also emergent effects, arising from local transformations of the grids occurring in a discrete manner.

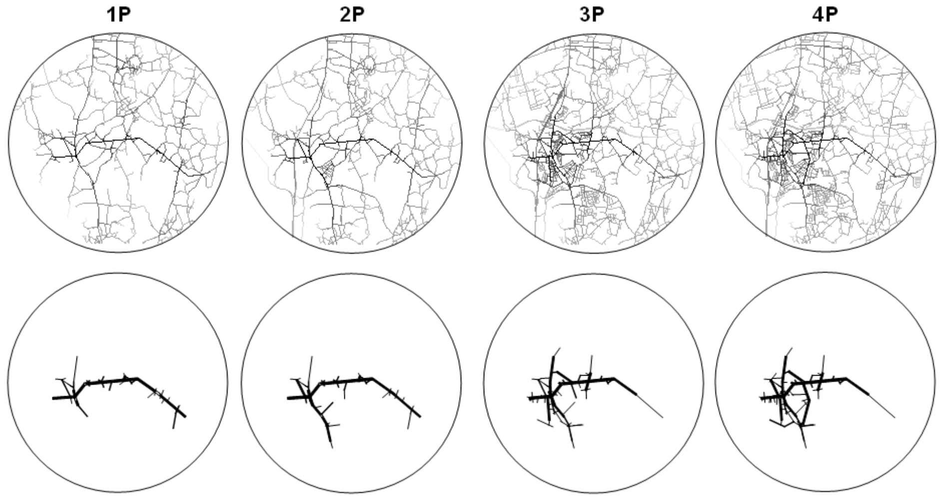

Figure 8 – Example of the graphic representation of integration patterns. Here, the evolution of global integration on case study C. Above, the general pattern. Below, a set of the most globally integrated spaces, or integration cores (here, the 10% most integrated spaces).

The last analysis technique was used to explore the morphology of urban growth at the micro level. We used some of the several analytical tools proposed by Stephen Marshall (2005) in his book "Streets & Patterns", to classify and quantify the individual interventions made to the grids in each period. These analytical tools adopt a topological approach to grid typology, producing results that are consistent with those of space syntax. For simplicity, we have called these techniques 'street pattern analysis' (based on the title of the book and on its more recurrent concepts)[4].

Stephen Marshall's book is mainly concerned with two fundamental questions: how to classify street pattern types in a consistent and systematic way and how to distinguish quantitatively their particular morphological characteristics. Altogether, the book introduces a vast analytical framework that goes far beyond the use that we give it here. But the general purposes for following some of its methods were the same: to classify the individual interventions identified by cartographic redrawing and to quantify some of their morphological characteristics.

As mentioned before, the cross-checking of the graphic set of urban-expansion areas of each period with current aerial photographs made possible the further individualization of that set. Because suburban development happens much more by the addition of new structures than by the erasure of old ones, one can easily discriminate each intervention by comparing their visual characteristics (as type and colour of roofing, pavements, etc). Given the formal diversity of each individual intervention, their classification would have to be simple, yet sufficiently comprehensive. In his book, Marshall dwells on the problem of morphological classification of urban lay-outs, reaching an integrated taxonomy of street patterns based on their topological configurations. We have looked at two basic topological properties mentioned therein: the internal configuration of each individual intervention and the external configurational relationships it establishes with the surrounding grid. Internally, expansions were classified as linear or cellular and externally, as connective or tributary, making a total of four possible combinations (Figure 9).

[4] We should stress, however, that this is just a personal choice and that nowhere in the book the author refers to his methods using that expression.

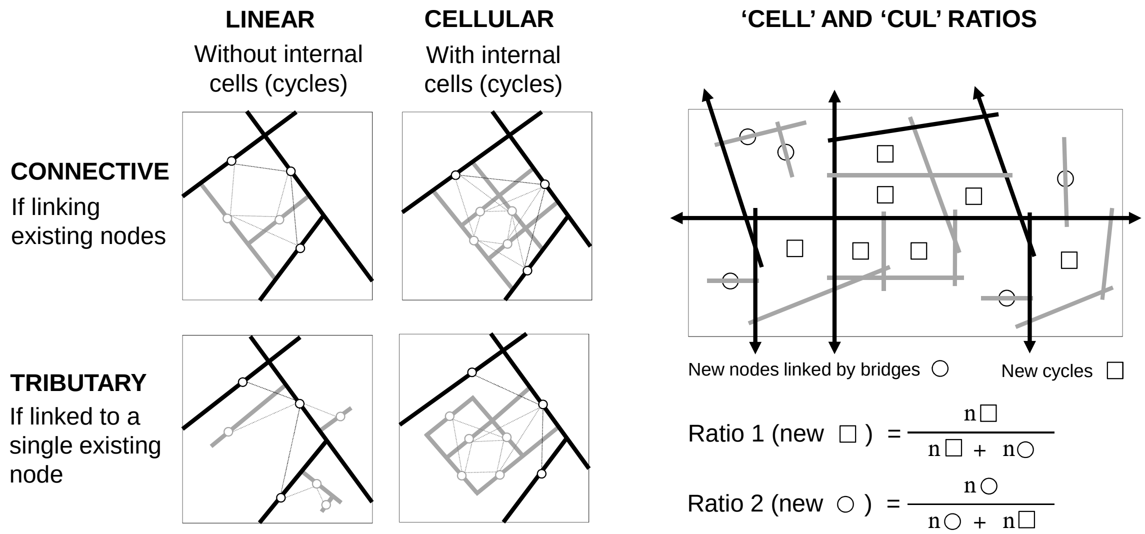

Figure 9 – The morpho-typological classification system of the individual grid interventions (left). The 'cell' and 'cul' ratios defined by (Marshall 2005), with some adaptations (right).

Linear expansions don't contain cycles, that is, they are simple nodes or sequences of nodes. Cellular expansions contain internal cycles. Connective expansions link existing nodes, thus creating new cycles. Tributary expansions link themselves to just one existing node, without creation of new external cycles. For each analysis period, we classified as such each identified individual intervention and made an accounting of their relative quantities.

The internal characteristics of each intervention (linear or cellular) are rather easy to establish. Externally, however, most interventions are not so purely connective or tributary, although this criterion was shown to be effective if used with some degree of freedom[5]. To cope with this possible bias we used another method proposed by Marshall in his book. This author defines two simple morphological parameters for measuring street pattern configurations. Given the number of internal 'cells' (graph cycles) and 'culs-de-sac' (nodes of the graph linked by cut-edges, or bridges[6]) in a planar graph representation of a street network, it is possible to establish a 'cell ratio' and a 'cul ratio', as proportions of the total number of 'cells' and 'culs-de-sac'. In a pure tributary lay-out (a tree, without cycles) the cul ratio will be one and the cell ratio will be zero. Conversely, in a pure cellular grid the cull ratio will be zero and the cell ratio will be one. More generally, in real life mixed situations, the values will vary, the sum of both also being one (Marshall 2005). We used the same basic principle, though with slight modifications (Figure 9). In the first place, axial graphs are non-planar, which makes the counting of cycles a non-trivial task. However, the axial map can also be seen as a planar representation of that non-planar graph (if we interpret lines as nodes and their intersections as links). Therefore, rings made by sequences of intersected lines codify cycles in the graph. In fact, this is the basis for the concept of axial ringiness, introduced in by Hillier and Hanson (1984) in "The social logic of space". Thus, counting cycles in the axial representation becomes a rather simple (even if boring) task. We counted (on the axial maps) only the new cycles in each period[7] (i.e., cycles created by the grid's

[5] For instance, some cellular interventions have an extremely tributary character (and as such were classified), showing many cycles isolated from the surrounding network, even though they are externally connected with two existing nodes and not just one. In the same way, although creating new links in the network, some connective interventions can come with some tributary appendices.

[6] In graph theory, a cut-edge (or bridge) is an edge which, if suppressed, divides the graph in two connected components.

[7] Not counting previous cycles, e.g. if a connective intervention divides a former single cycle into three cycles, the count of the new cycles will be two.

expansions), discarding trivial cycles of length three, for these are almost always created by the simple intersection of lines in open space and not because there is anything built in the middle. In second place, we were not interested in quantifying the morphological composition of each individual intervention, but rather the composition of each growth period. The idea was to obtain global values for the overall growth pattern in each analysis period, representative of how much of it was 'connective' and how much was 'tributary'. These values would serve as morphological indicators *per se* and also as benchmark values to control the typological quantification explained before. Thus, for the set of all urban-expansion areas in each analysis period, we counted the total number of new cycles and new nodes linked by cut-edges. With these values, we calculated the two ratios mentioned before, only now reflecting the morphological composition of each period's total urban growth.

We used the three analysis techniques (cartographic redrawing, space syntax and street pattern analysis) in a sequential and systematic way, on the five case studies. The data produced was then analyzed comparatively. In the next section of the paper, we will review the results of each technique and explore their potential complementary outputs.

3. RESULTS

The three analysis techniques adopted, for each case study at each analysis period, produced a huge amount of data, which was reported in an exhaustive manner elsewhere (Serra 2008). Also, previous results of this research have already been published once (Serra and Pinho 2011). Therefore, in order to avoid repetitions and for the sake of pertinence, we will present here our previous results and some new data in a more selective and critical manner.

Our general finding was the evidence of clearly differentiated patterns of morphological change between the study areas. These differences were not expected, at least not in a so marked way, because all case studies are located within a 10 Km radius from the centre of Oporto and are locally considered as similar nearby suburbs. However, the results of the several analysis techniques showed a clear differentiation of the case studies in two groups, with distinct morphological characteristics and evolution patterns. As we shall see, not only are the results of each technique consistent, but they also reinforce each other, showing that, in spite of their seemingly uniform disarray, we should not look at these territories as devoid of morphological differentiation.

The street networks of the first period of analysis (1P), as represented by the redrawn maps, show a relative low street density and a prevalent pattern of sinuous and narrow roads, with large non-public spatial islands, characteristic of rural road networks. These are the original spatial matrices over which urban growth will occur. With the exception of case studies D and E[8], which already show at 1P some small grid condensations of urban characteristics (much smaller and more regular spatial islands with greater road density), all the other case studies show that general pattern (Figure 10).

[8] These case studies are the nearest to the central city, and thus had an earlier urban development.

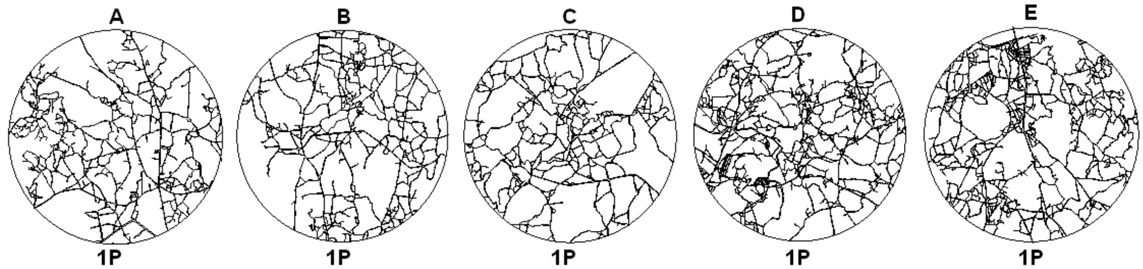

Figure 10 – The street networks at 1P

We have measured urban growth intensity by comparing the number of axial lines describing the redrawn street networks of each period, which is proportional to road density. Starting from different density levels (with density decreasing with increasing distance from the central city), all case studies show the same growth rate, with a maximum intensity phase[9] between 2P and 3P. Most of the transformations that the grids have undergone happen during this period (Figure 11).

An urban growth compacity index (measuring its concentration) was constructed by counting the individualized grid interventions of each period contained within a circle with half the radius of the study area[10], centred therein. This number was then expressed as a proportion of the total number of grid interventions in each period. For values above 50%, urban growth was considered concentrated; for values below that threshold, dispersed. The results show a clear differentiation in the spatial distribution of grid expansions. This is not constant along time. There are periods of concentration and others of dispersion in the same study area. However, during the period when urban growth is more intense (2P/3P), case studies A, B and C show a clearly concentrated pattern, while case studies D and E, a strongly dispersed one (Figure 11).

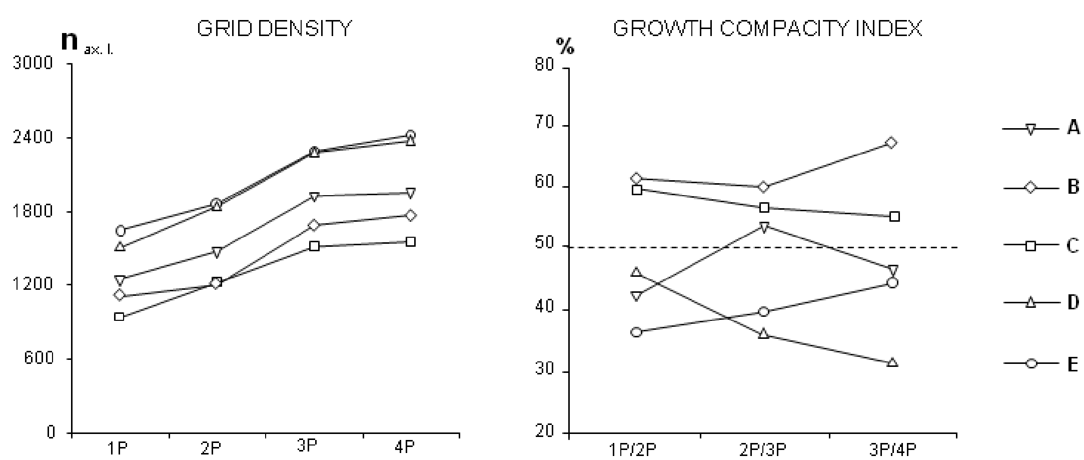

Figure 11 – Evolution of grid density and growth compacity index.

[9] Corresponding to the urbanistic boom which Portuguese cities suffered between the 70' and the 90'.
[10] Radius = 1,5 Km; area = 7,1 Km2

Looking at the final period's grids, it is possible to discern some of the effects of such differentiation in growth patterns (Figure 13). Case studies B and C (and, to a certain degree, also A), evolved from dominantly rural grids to grids characterized by a dense, central urban core, and a sparse and still rural surrounding area. In these cases, distinction between urban and rural components is rather clear. However, case studies D and E evolve into a kind of hybrid grid, with no clear distinction between rural and urban components (Figure 12).

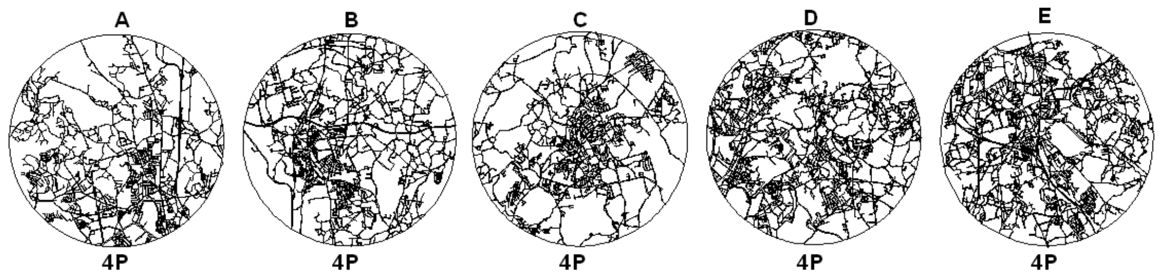

Figure 12 – The street networks at 4P.

The space syntax results, in addition to providing new findings, showed that these differences between case studies were also present at the configurational level. At 1P, the initial rural grids showed integration patterns characterized by general segregation (low integration values), meaning low movement permeability and low general accessibility (Figure 13). Moreover, there are few integration inequalities, i.e. hierarchical differentiations between grid spaces. Except for case study E, which shows a centre with some structure at this phase, the other initial grids are dominated by a just a few integrated long lines, corresponding to more linearised road structures (which are, for the most part, segments of old radial roads linking northern and southern towns to Oporto).

In practical terms, this implies that movement would tend to be evenly dispersed in the network, becoming rarefied. The topology of the rural grid do not favours any particular route structure, apart from a few more integrated spaces with distinct morphological characteristics (more linear). This seems to be exactly the contrary to what happens in urban street networks. There, a complex structure of more integrated routes, usually radiating from the urban centre and carrying most of movement flows (thus, attracting movement dependent functions) form a kind of super-grid, allowing easy access from the periphery towards the centre of the system and vice-versa. In the interstices of this core network, lie more quiet and less integrated spaces, yet with easy access to it (Hillier and Vaughan 2007). Our results show that the initial rural grids lack this kind of structural organization, which is the hallmark of functional urban environments. Therefore, that particular kind of structure will have to be constructed over time by urban growth, whether in a planned or unplanned way.

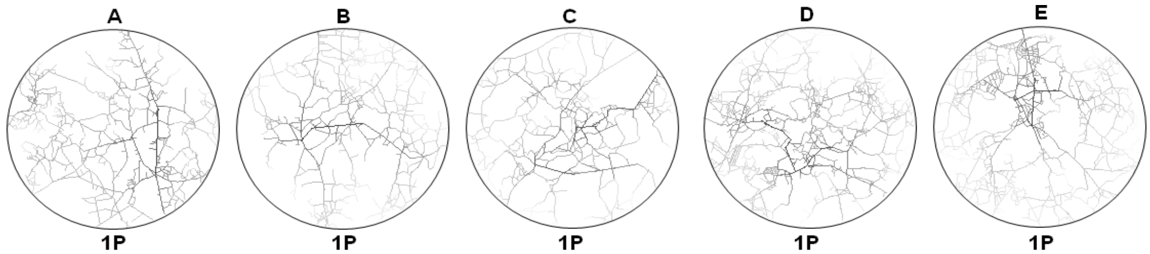

Figure 13 – The global integration patterns at 1P.

Looking at the final global integrations patterns (Figure 14), we can see case that the case studies in which concentrated growth was dominant (B, C and to a lesser extent also A), produced cohesive urban zones with complex integration cores and clear spatial hierarchies. While in the cases were dispersed growth prevailed (D and E) we observed the stagnation, or even the dilution, of previous spatial hierarchies and a loss of structural differentiation between grid spaces. In spite of the intense grid transformations, and even if mean integration values kept increasing along time in all cases, in case studies D and E the dispersed growth pattern was not able to alter significantly the undifferentiated spatial character of the initial rural grids.

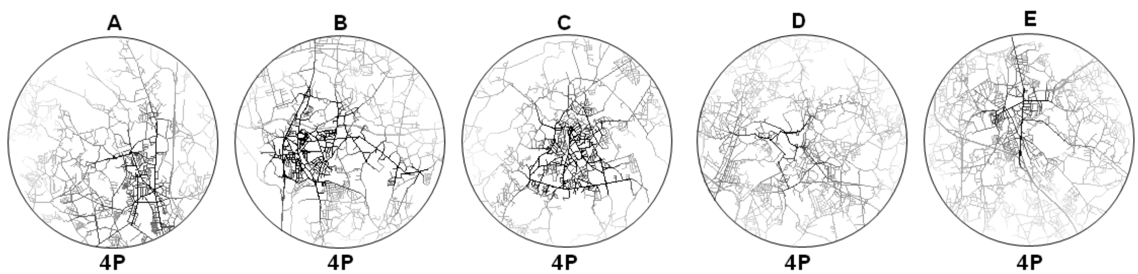

Figure 14 – The global integration patterns at 4P.

The numerical quantification, in each period, of nine syntactic variables[11] describing different global structural properties, showed other interesting patterns of morphological evolution. These have been described extensively elsewhere (Serra and Pinho 2011), so here we will just stick to the most relevant results. The syntactical property known as intelligibility, as proved to be a reliable indicator of a spatial system's navigability by humans. Moreover, this property is central in the space syntax theory of the city, under the concept of generic function, being claimed as an explanation for the morphological regularities that have been identified in cities all over the globe in the more varied cultural contexts (Hillier 1996; Hillier 2001). As such, it is also of the utmost importance to this work, because suburban contemporary areas have been qualified not only as 'labyrinthine', but also as 'non urban' (at least when compared to the traditional city).

The evolution of the intelligibility values of the case studies showed an unexpected, yet very relevant result. The evolution of these values for each case study is expressed in the charts of Figure 16. A profound difference regarding the evolution of the systems' syntactic intelligibility is noticeable, as case studies A, B, and C present increasing intelligibility values, while case studies D and E, show a sharp decrease during the

[11] Number of axial lines, mean axial length, mean global and local integration, mean connectivity, grid axiality, axial ringiness, scale synergy and intelligibility.

period of most intense growth. The initial values are all low and close to each other, adding low intelligibility to the rural grid characteristics identified before. However, in case studies A, B and C, urban development manages to invert this situation and to raise the values considerably. Rather, in case studies D and E, in spite of an initial increase and the continuous and intense growth, the values end up at the initial level.

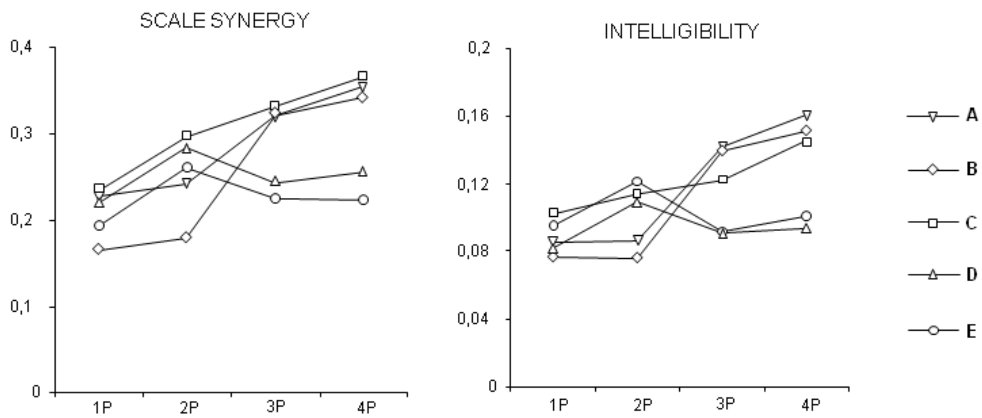

Figure 16 – The evolution of scale synergy and global intelligibility values.

Such a differentiated behaviour means that there are qualitative differences in the morphological construction processes of the studied grids. If suburban contemporary areas are marked by their labyrinthine character, these results show that some of the case studies were losing that character and becoming more intelligible along time, while others were getting worse. Likewise, some had a true urban development process, increasing the intelligibility of the previous rural grid; while the others have grown into something different, perhaps less urban, with an intelligibility level similar to that of the rural grid, even if much more denser and developed.

It is important to stress that these results refer to the global structure of the street networks emerging from urban growth, which is fundamentally a local process. Therefore, the results are also describing emergent global effects, arising from discrete individual interventions acting at the local scale through time. In other words, the morphological causes for these effects must be sought at a lower level, that of the micro-components of urban growth.

And, in fact, what seems to be producing these intelligibility differences are the typologies that, in each period, contribute to grid construction. Figure 17 shows the results of the quantification of these typologies, compared with the evolution of the intelligibility and synergy values for each case study. Again, the division of the study areas in two groups is rather evident. In the first group (A, B and C), connective expansions are always prevalent over the tributary ones. However, in the second group (D and E) during the period of most intense growth, the tributary types overcome connective ones. One can say that the first group has a permanent connective grid construction, while in the second group grid construction becomes predominantly tributary during the period when most of the grid is produced. This seems to have a clear relation with the evolution of the system's intelligibility. As we can see from the charts in the middle and lower rows Figure 17, it is exactly during the period of most intense growth, when tributary forms overcome connective ones (case studies D and E), that the values of intelligibility and scale synergy plunge. In other words, there seems to be a direct correspondence between the prevalence of tributary forms and intelligibility decrease.

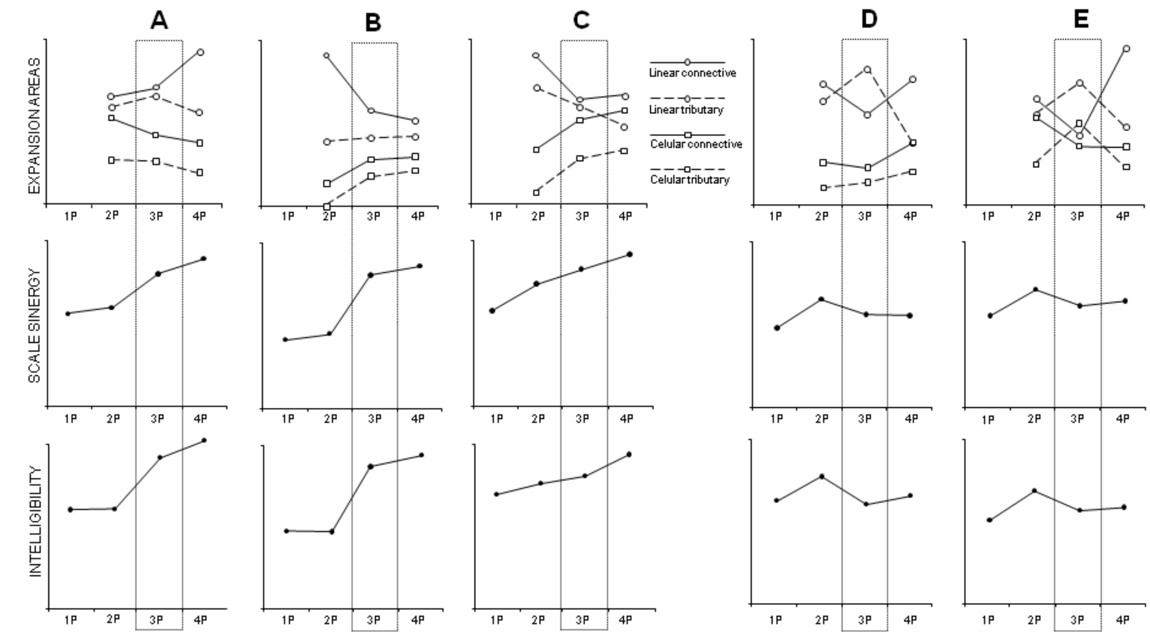

Figure 17 – The relation between grid morphological types and intelligibility.

The quantification of the two ratios explained before, measuring the relative proportions of new cycles and new cut-edges in each period, is consentaneous with the previous results. In case studies A, B and C the creation of new cycles is clearly prevalent over the creation of new cut-edges, while in case studies D and E, the relation between the two ratios is more balanced. Moreover, in these cases, during the period of most intense growth, the creation of new cut-edges surpasses the creation of new cycles. In addition to confirming the typological quantification data, these results show us that the case studies of the first group were getting more cyclic (or more grid-like) along time, while the second group was getting acyclic (or more tree-like), specially at 2P/3P (Figure 18).

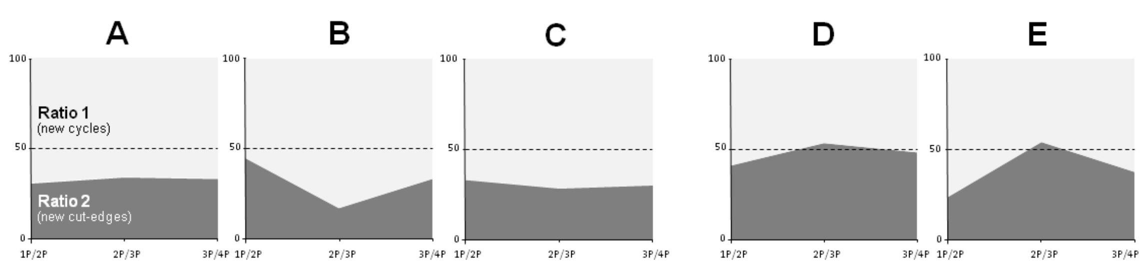

Figure 18 – Quantification of new cycles and new cut-nodes ratios.

The values of these two ratios have provided further evidence of this strong relation between grid typo-morphologies and syntactic intelligibility. They are clearly correlated with the variation of intelligibility values (global intelligibility and scale synergy), that is, the value of each period subtracted by the value of the previous period. In Figure 19, we show the correlation with Ratio 1, that is, the ratio of new-cycle creation, showing that the more cyclic a grid gets the more intelligible it becomes. Of course, because both ratios are complementary, the correlation with Ratio 2 would be the same, only negative.

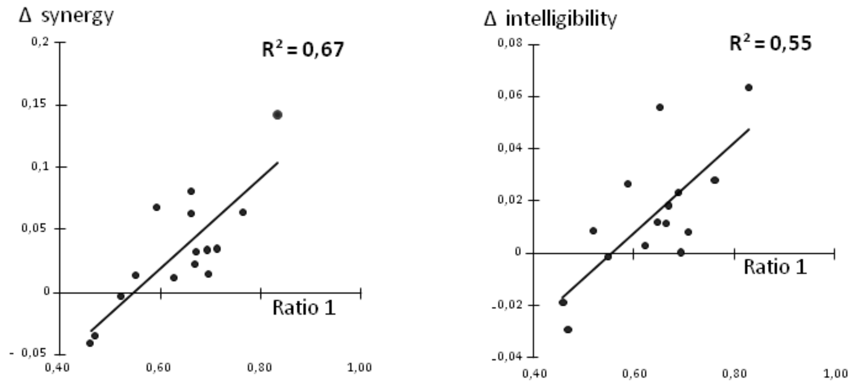

Figure 19 – Correlation between Ratio 1 and intelligibility variation values.

Throughout this last section we have seen how the adopted methodology was able to produce a different morphological picture of suburban development, one that is not based on its odd superficial characteristics but rather on its deep structural organization. These results seem important, because they clarify the relationship between the local processes that constructed these grids along time, which are (for the most part) non-programmed individual interventions, and the emergent global effects that they produce, which have an impact on the global functioning of the areas as a whole.

4. CONCLUSIONS

Contemporary suburban areas present an analytic challenge to urban morphology. Seen through the lenses of classical morphological theories they seem a perversion of 'good city form', hopelessly disjointed and nonsensical. These characteristics produced a critical bias that has conducted to a general paucity of knowledge on what concerns their objective morphological characteristics, and to excessive generalizations of their potential flaws. We need to invert this state of affairs, exploring new analytical techniques and methodologies, capable of coping with the formal complexity of today's suburban areas. This work has provided a step in that direction.

Our findings provided evidence of different suburban growth patterns with different configurational outcomes, namely clear intelligibility inequalities between the study areas. Although they can be felt on the several studied environments, these morphological differences exist at a deep and structural level of urban spatial form and their formal identification is inaccessible to traditional analysis techniques. Nonetheless, they ought to be taken into account when deciding how to intervene there. Thus, a general output of this research, is the recognition of space syntax as a highly relevant tool for the study of contemporary suburban morphology, producing results capable of informing in a more reasoned way the planning practice in these areas.

Albeit determinant to the functioning of the studied areas, for the reasons mentioned before, these configurational differences refer to their global spatial structure. Obviously, these global structures did not come into being all at once, but were instead constructed over time by urban growth. As such, they are also emergent structures produced by many local interventions (promoted by private initiative, for the most part), following their own local logics.

Cities are problems of organized complexity, as Jane Jacobs (1961) first stated in a such enlightened way. They are complex systems by nature, made of many parts in dynamic interaction, leading to the emergence of structures that are not properties of those individual parts. This is particularly so in regarding to the development of urban form, as we have seen. But looking at today's suburban areas, the question that arises is: how can we handle, if not in a 'haussmanian' manner (today not very popular), such uncontrolled and apparently unpredictable processes?

Complexity science has shown that it is sometimes possible to generate ordered patterns emergently or, in other words, to produce order that is not planned[12]. In recent years, this has been brought to the urban theoretical field with very promising results. As Michael Batty (2007) puts it, "the challenge is to dig below the surface and detect the processes that generate what we see" (Op. Cit. p.4). Stephen Marshall (2005; 2009) has been occupied in translating this into the urban practical agenda, exploring how we could use the understanding of emergence and self-organization to assist the generation of urban spatial layouts, that is, how could we use local rules (instead of imposing a pre-defined macro structure) in order to achieve desired global patterns. In this work, we have tried to contribute to that endeavour, demonstrating the existence of a strong relation mediating the local morphological properties of the micro-components of urban growth, and the global structure of the street systems, produced by them over time.

We have seen how areas where urban growth was predominantly dispersed and non-connective evolved into hybrid grids with low intelligibility values. We have also seen that concentrated and connective growth led to urban and intelligible grids. If we take syntactic intelligibility as an urban quality per se, as space syntax's theoretical *acquis* does, it becomes clear that our results point some clues to how we could plan suburban areas from the bottom-up, i.e. creating regulations at the very local level that would have positive impacts at the global level. In fact, both concentration and pattern prescription are parameters not difficult to introduce in public policies. The former, moreover, is already currently pursued in many situations. The latter not so much, because the debate on the qualitative properties of urban patterns has been producing, until recently, few operational conclusions. However, as Marshall (2005) argues and we have tried to show, this is not necessarily so. Our results point to the possibility of establishing basic morphological prescriptions for patterns of urban grids that, if generally followed, would lead to the emergence of intelligible urban systems. The patterns that we are talking about are defined at the lowest level of their morphology, that of their inner and outer topological relations. This avoids the difficulties in implementation that morphological prescriptions suffer, unless they are compulsorily implemented under a general master-plan. To promote a predominantly connective grid construction, shunning the tributary type, would not be difficult, both through planning instruments, and through the collaboration with agents of urban change. Therefore, as a technical output of this research, we would recommend that public policies should add to their concerns on urban dispersion, those on urban connectivity at the micro-scale.

Gone are the days when planning practice intended to control each variable of an urban system and to capture the solution on a blueprint. The excessive positivism of such stance was quickly recognized, and planning theory became more interested in the planning process itself, with the indirect effect of relegating urban form to a secondary role, as an uncontrollable (or even irrelevant) variable of the urban phenomenon. This then changed again, when the debate on urban sustainability gave a new impulse to the study of city form. Perhaps now we should start thinking that, after all, the blueprint could be put aside once and for all; for 'good city form' would emerge by itself, if only we could understand clearly, and thus promote, the processes that give rise to it.

[12] In fact, nature has been showing this since ever.

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