# FORM AND URBAN CHANGE. An urban morphometric study of five gentrified neighbourhoods in London.

## Abstract

Research in Urban Morphology has long been exploring the form of cities and their changes over time, especially by establishing links with the parallel dynamics of these cities' social, economic and political environments. The capacity of an adaptable and resilient urban form to provide a fertile environment for economic prosperity and social cohesion is at the forefront of discussion. Gentrification has emerged in the past few decades as an important topic of research in urban sociology, geography and economy, addressing the social impact of some forms of urban evolution. To some extent, these studies emphasise the form of the environment in which gentrification takes place. However, a systematic and quantitative method for a detailed characterization of this type of urban form is still far from being achieved. With this paper, we make a first step towards the establishment of an approach based on "urban morphometrics". To this end, we measure and compare key morphological features of five London neighbourhoods that have undergone a process of piecemeal gentrification. Findings suggest that these five case studies display similar and recognisable morphological patterns in terms of their built form, geographical location of main and local roads and physical relationships between street fronts and street types. These initial results, while not implying any causal or universal relationship between morphological and social dynamics, nevertheless contribute to; a) highlight the benefits of a rigorous quantitative approach towards interpreting urban form beyond the disciplinary boundaries of Urban Morphology and b) define the statistical recurrence of a few, specific morphological features amongst the five cases of gentrified areas in London.

Keywords: urban morphology, urban morphometrics, quantitative analysis, gentrification

## 1. Introduction

#### 1.1. Urban Morphology and the need for a systematic approach of urban analysis

Amongst the disciplines relating to the built environment, Urban Morphology is that which has peculiarly placed change at its core since the very foundation of the modern discipline in the early 1960s (Muratori, 1960; Conzen, 1960). In so doing, urban morphologists have always focused on the *ordinary* components of urban form, for example the streets, street networks, blocks, plots and buildings, i.e. the "urban fabric", rather than the city as a whole. In all respects, it is the interest on this *scale* which distinguishes the tradition of Urban Morphology from others which, by focusing on the allocation of functions or "regional analysis" (Wilson, 2000), networks (Boccaletti et al., 2006), size/performance or "allometry" (Bettencourt et al., 2007) or large urbanization processes (Strano et al., 2013), have predominantly observed cities at a much larger scale.

The manner in which changes in the urban form intersect changes in the social and economic nature of cities, and establish complex relationships of cause and effect with them, is a topic of increasing interest in the normative disciplines of the built environment such as urban planning and design. This topic is about the association between fine-grained adaptive/resilient spatial structures and prosperity, safety and social cohesion through evolution in time (U.N.HABITAT, 2013). There is little doubt that adaptability and resilience are spatial preconditions for the continued evolution of urban systems (Holling and Goldberg, 1971). However, their downsides are not always clear. These must be thoroughly addressed if we are to align economic growth with social equity. As a consequence, a rigorous approach towards analysing urban form from an *evolutionary* perspective is now, more than ever, relevant in interpreting its future trajectories (Batty, 2009).

However, more than a half-century since the seminal studies of the pioneers of Urban Morphology, a review of the relevant literature reveals that there is still no established agreement on a method for the analysis of urban form. In fact, notwithstanding the remarkable achievements, the precise nature of several key-notions of the discipline's theory appear surprisingly elusive (Whitehand et al., 2014). This may explain the evident lack of a quantitatively rigorous, comprehensive and systematic framework for the analysis of urban form (Dibble, 2016). Consequently, the debate on gentrification, as well as other socio-cultural phenomena occurring in cities, suffers from a lack of quantitative evidence. This knowledge gap prevents social scientists from generating reliable associations between urban form and the phenomena of social relevance, at the neighbourhood scale. Gentrification is merely a case in point.

In this paper, we assess the urban form of five areas in London which have undertaken processes of change in their physical form and social composition. This study of their urban form is firstly a contribution towards advancing a systematic and quantitative method of analysis, or "urban morphometrics". Secondly, we aim at highlighting that "traditional", fine-grained urban fabrics are responsive to dynamics of social change (in this case, piecemeal gentrification). Finally, we explore whether the centrality of the streets correlates with structural, physical aspects of the areas observed.

# 1.2. Research in gentrification

From its first coinage, the term "gentrification" has been associated with social displacement and physical renewal/upgrade, as two sides of the same coin. Ruth Glass, in the early 1960s, observed that "one by one, many of the working class quarters have been invaded by the middle class – upper and lower (...). Once this process of 'gentrification' starts in a district it goes on rapidly until all or most of the working class occupiers are displaced and the whole social character of the district is changed" (Glass, 1964: xvii). Since then, many have extended the meaning of "gentrification" to include, for example, vacant land infill and the regeneration of former industrial sites. According to Pacione (2001) gentrification is a socio-spatial phenomenon that entails interlinked changes in the values of inner city areas, the upgrade of housing stock and services and the profile of their residents and visitors.

Supply-side "structural" theories identify capital investments of the late 1950s to early 1960s as the prime stimulus of gentrification, and in particular, the cause of the

differential between the real value of property and the land value of inner city areas (Smith, 1987). This differential can be attributed to a protracted lack of investment in inner city infrastructure following middle to high class suburbanisation. When the value of inner city stock subsequently became low enough to attract investment from developers or public agencies to later re-sell at a profit, the way was paved by middle-income classes to return to centres in search of more engaging ways of life. This is, to Smith, a violent process of appropriation of value by the middle classes. *Demand-side "agency" theories* (Ley, 1994), on the other hand, attribute gentrification to the rise of the economic capacity and cultural profile of the middle classes who, following the transition from an industry-based economy to a service industry and the subsequent dissatisfaction with contemporary urbanism, have engaged in a search for space with social meaning (Atkinson and Bridge, 2004; Lees et al., 2010).

Society, cultural values, policies and economies have since changed, and with them, our relationship to location. As a phenomenon, gentrification is now ubiquitous, fairly distinct from the original forms of upgrade of historic stock and by no means a disappearing phenomenon (Lees, 2000). Today's gentrifiers, next to the typical pioneers, might tie themselves less permanently to their place of choice than in the past, giving gentrified areas a different character than the original one achieved through progressive upgrade of stock. A different form of gentrification today happens at the hand of large developers as well as small and medium ones (Davidson and Lees, 2005). This form of gentrification comes with extensive and fast new developments where opportunity for upgrade can be created through policy.

Viewing gentrification as a temporal phenomenon, Duany (2001) and Smith (2002) have identified "waves" in the process of gentrification, the first of which took place from the beginning of the 1950s and saw migration into run-down areas of cultural, artist-based groups. A second, more defined wave took place in the 1970s and 80s. This was linked to a process of economic restructuring which involved the migration of higher groups into the same areas, encouraged by an overall improvement in quality carried out by the first wave of pioneers. Finally, a third, more generalised phase took place in the 1990s and saw both the legal and financial sector moving in, yet again, in search of quality in both housing and services and therefore, a secure return from capital investment. Each of these phases reflects a degree of transformation in the profiles of the new inhabitants, attributable to their economic capacities and the rising cost of land and property values. In fact, this phasing represents a pattern that includes both small-scale local intervention and, at a later stage, larger and faster developments by agents of significant size (both private and public). Although capital investment is inextricably associated with urban change in all of its forms, the scale and time-frame of its utilisation may change considerably. Literature here distinguishes gentrification "by capital" from gentrification "by collective action" (Warde, 1991: 224). According to Butler and his work on the London neighbourhood of Barnsbury, the "collective action" form of gentrification is closely associated with the first, and in part, the second waves of the process, while "by capital" is likely more associated with the third (Butler, 2003).

In short, we can now extend the notion of gentrification to urban fringes, small towns and villages because gentrification is no longer a phenomenon of economic centres only. Such more recent forms of large-scale, capital-led "super-gentrification" are typical of a globalized, highly mobile post-industrial economy (Hamnett and Whitelegg, 2007). This scenario of profound social change has emerged from a wealth of studies carried out in the last decade. It challenges the foundational axiom of gentrification studies, namely that the increase of real estate values leads to *direct* displacement of the original working class residents rather than their gradual uplift or just their "replacement without displacement" (Hamnett, 2003; Freeman, 2005). Freeman and colleagues offer a synthesis of this occurrence and provide substantial evidence from England and Wales (Freeman et al., 2015). Their conclusions are that; a) the debate about gentrification and displacement in the UK has been so far largely devoid of a reliable basis of evidence and b) the results from their study on gentrifying neighbourhoods in England and Wales in the period 1991-2009 are "for the most part inconsistent with the notion that gentrification leads to widespread direct displacement" (Freeman et al., 2015: 14).

# 1.3. Urban form in gentrification research

The kind of gentrification that occurs in a certain urban area can be related to the form of the urban areas involved. Applications of Urban Morphology can help reveal how urban form has embedded, transferred and transformed the social interests of those who have, and are, inhabiting cities (Zukin, 1987: 144). It would be ingenuous to assume that there exists a template representative of gentrified urban areas. However, gentrification in urban form may occur in ways that show recurrent patterns. Several studies have illustrated how the first areas to become gentrified have shared a number of physical characteristics: the availability of substandard but structurally sound housing, "with potential", clustered to allow a contagious effect to occur; rare amenities such as views, proximity to, or good transport links with, a central business district; the presence of local commercial activities attractive to gentrifiers (Pacione, 2001). Here, housing is either gentrified in traditional, upgraded housing types or in converted institutional or industrial structures. Meanwhile the retail is generally gentrified in either a piecemeal fashion, or through large-scale interventions such as 'festival marketplaces' (Ellin, 1999).

Butler and his colleagues' recent studies, cited above, suggest that some early examples of gentrification might have experienced further waves of gentrification at the hand of private, small scale investment, while still maintaining their original, structural urban character. These are categorised as physical features shared beyond the individual units, possibly across the whole area; well-defined boundaries screening neighbouring, less affluent areas; well-linked central spaces used as destinations with social character and use; an ordered, pleasant and prosperous atmosphere, offering an overall sense of safety and a family-oriented feel where children can experience a degree of informally supervised independence. Streets are generally described as lined by terraced houses, not necessarily of any particular architectural merit, or by cottages and mews, and at times by Victorian houses. These subsequently gentrified environments are often described as being: dense and vibrant, with a good range of services accessible by foot; well-connected to the centre; not the centre themselves; conferring a sense of calm and order. Importantly, the requirement for safety was linked to an open, inter-connected urban form. Many regenerated areas have been adopted by subsequent generations of gentrifiers, still looking for a rich, vibrant and characterful urban life.

Gentrification increasingly colonises peripheral parts of our cities by large-scale, coordinated developments built on vacant land, or by massive clearings. This "capital investment" type of gentrification sells a lifestyle (Hackworth, 2001) and identifies new-build corporate developments in marginal locations as significant expressions of post-recession gentrification. Davidson and Lees, (2005: 1170) cite London's Riverside, with its vacated industrial and commercial sites and derelict docks, as an example of gentrification, now targeting previously unliveable areas of the city for transformation into aspirational residential and leisure quarters. They identify a first, conservative regeneration policy being larger in scale (the Docklands) than the following, New-Labour one, which is linked to existing, traditional retail and commercial cores along the river. While these new super-gentrifiers often appear to pursue a compact and dense urban environment, structurally similar to the traditional mixed neighbourhood model, they may also embrace different physical forms, for example high-end tower-blocks and gated communities in large scale developments (Shaw, 2002).

The grain of a place is not only linked to image and attractiveness, but also to the scale, speed and feasibility of economic regeneration. Furthermore, the urban grain also appears to be linked to socio-cultural investment in an area. To this point, Beauregard (1990) describes the many variations gentrification has taken in Philadelphia categorised by, amongst other factors, the initial physical character and location relative to the city centre. In some cases, gentrification has taken place in the historic Victorian row-houses on mixed-use land, at the hand of small capital. In other cases, small-scale commercial/industrial buildings have been converted into work units for artists, which have slowly stimulated an upgrade in the area (again, small personal investment). In others, large warehouses and industrial buildings have been demolished and replaced by luxury apartment buildings were converted into luxury compounds, next to the renovation of large Victorian terraces, again by larger-size developers.

# 2. Scope and limits of this paper

Several theories have been developed to explain the process of gentrification. Some have, to a degree, considered the physical properties of gentrified areas. However, in all these works the analysis of the physical environment has been illustrative and descriptive, at best. In gentrification research, the focus is predominantly on the way urban form reflects lifestyles, values and aspirations of the dominant gentrifiers, as opposed to the original residents or as a vehicle of structural drivers such as capital investment, accessibility and positional values. Both cases of this long-standing "agency vs. structure", or "consumption vs. production" controversy in the explanation of gentrification (Slater, 2011), remain confined to the background of the gentrification process. Little effort is invested towards creating a rigorous method to analyse the physical results of the gentrification process.

Both the temporal and physical dimensions of gentrification, along with the scale of investments and agents, may be associated with cyclical waves of change over time of

the urban fabric, as explored in the core-tradition of Urban Morphology. Concepts like the "burgage cycle" and the "fringe belt" offer a solid evidence of the various ways in which urban spatial and social change have always occurred in cities, which may be associated with earlier and indeed recurrent historical forms of "gentrification" (Whitehand, 1972; Whitehand, 1988; McQuillan, 1990; Gordon, 1990). The physical structure of places also influences what kind of gentrification takes place in an area, what type of social capital is invested and what may be the implications on preexisting and future communities. In the ordinary urban fabric, more 'traditional' urban forms are expected to possess a diversity of smaller-scale properties (having been built and adapted over time). This, in turn, attracts multiform economic opportunities, diverse social groups and creative clusters (Ye and van Nes, 2014; Marcus, 2008; Wood and Dovey, 2015).

Finally, the distinction between "internalist" and "externalist" studies, where the former interpret urban form as a relatively independent system while the latter consider it a function of external forces, is well known within the urban morphology field (Gauthier and Gilliland, 2006). However, urban form is rarely scrutinised in gentrification studies as a specific subject, either in an internalist or externalist perspective, or in a quantitative way and never in one that is systematic or comprehensive.

In this paper we explore the urban form of gentrified areas to understand; a) whether "traditional" common traits are quantitatively recognizable in their morphological structure across the case studies and b) whether correlations among the spatial elements of the case studies emerge, in particular between street centrality and any of the other variables. The hypothesis we want to test—within the limits of this research—is that traditional, fine-grained urban forms are more capable than others of responding to small-scale, largely self-organised dynamics of socio-cultural nature, in this case, gentrification by "collective action". A second hypothesis is that street centrality is correlated to the structural aspects of urban form and as such, qualifies as a primary evolutionary force in cities.

It should be noted, however, that the number and size of the cases investigated, and the confinement within this study to only cases of gentrified neighborhoods representing a single type of gentrification, that by "collective action", places constraints on the capacity of this study to infer reliable generalizations, an essential passage in case study research (Yin, 2013). Nevertheless, we claim that exploring the recurrent spatial patterns, which emerge across all, or most of the five gentrified cases under consideration, could usefully contribute to reinforce, or weaken, the hypothesis above. Importantly, this paper proposes a rigorous way of measuring urban form at the scale of the urban fabric that is systematic and quantitative, and that allows a discussion of the relationship between a social phenomenon—such as gentrification—and its spatial environment, over a new ground of evidence.

## 3. Case Study analysis of five London neighbourhoods

# 3.1. Case studies

We analyse the urban form of five out of the eight areas previously investigated by Tim Butler and colleagues (Butler, 2003; Butler and Lees, 2006; Butler and Robson, 2001; Butler and Robson, 2003), where the focus is placed on the recent evolution of the socio-cultural character of those areas. Drawing from Warde's distinction between gentrification "by collective action" as opposed to that "by capital", recalled above, Butler argues that *"the history of gentrification in London over the past nearly forty years has been largely one of upgrading of mainly 19th century property by individuals or small-scale developers"* (Butler, 2003: 2148); that includes the five selected areas of Telegraph Hill, Battersea, Brixton, Barnsbury and Dalston; the remaining three cases are all Docklands sub-areas of a specialist kind, whose "regeneration" is recognized to be of a "by capital" type. Given the scope of our paper, which focuses on gentrification as a particular manifestation of small-scale, evolutionary urban change in the ordinary urban fabric of cities, we <u>adopt</u> the aforementioned five areas, all ordinary and all gentrified by "collective action", as our case studies.

Of these five areas, four (Telegraph Hill, Battersea, Brixton and Barnsbury) present a clear geographical definition (Butler and Robson, 2001: 2151, 2152, 2155) (Butler, 2003: 2475). Of these four, the authors identify the geographical boundaries according to somewhat loose criteria, referring to spatial features such as homogeneous streets and housing types, and also – critically – to the perception of the inhabitants of their own territory and identity as emerging through a wealth of direct interviews. Those boundaries have been maintained in our present study (with the only exception of Barnsbury which we have slightly expanded to reach the western "natural" boundaries ourselves without the benefit of interviews, solely on the basis of our interpretation of the urban form as emerging from maps as well as direct, *in-situ* survey. The final geographical definition of our five case studies is visible in Fig. 1.

#### FIG 1 ABOUT HERE

Figure 1. Identification of the five case studies in the 15km x 15km street network map of central London.

An accurate study from an historical and sociological perspective is offered in Butler and Robson (2001) for Telegraph Hill, Battersea and Brixton, and equally in Butler (2003) for Barnsbury. The same is not available for Dalston. Those pieces of sociological research also offer, for the same areas, a description of some physical features that the authors deem worth noting. Such descriptions are very typical of the way urban form is seen in the context of gentrification research, where form plays an ancillary role in supporting an understanding of, for example, the values and culture introduced by a particular type of middle class that flocked into the place, or the mechanisms of place identity shown by some resident groups. In this paper, we refer the reader to these studies for further insight into the social nature of the selected areas, of which we offer a succinct synopsis in the Supplementary Materials (Paragraph 1).

## 3.2. Variables and definitions

The urban fabric of the five selected areas is analysed by means of eight variables, one of which measures the street network while the remaining seven measure features of the urban fabric (Tab. 1, Fig. 2).

Measures of the *street network* have recently been the subject of a wealth of studies, mainly regarding the physics of complex networks, as part of a growing interest in spatial networks (Barthelemy, 2011) in the age of urbanization. Among the various methods of measuring a *street network*, centrality has taken a predominant role since the seminal studies in Space Syntax (Hillier and Hanson, 1984) and more recently in urban design (Porta et al., 2010). In this research, we measure and map *betweenness* of the centrality of London streets by means of a Multiple Centrality Assessment approach (Porta et al., 2006). For brevity we will refer to this index as *centrality* in the rest of the paper. *Centrality* captures a relevant character of a place, that of 'remaining closely between' all other places in the entire system (see Paragraph 2 of the Supplementary Materials for details). Research shows that *centrality* can be linked to key dynamics in cities, such as population and employment density (Wang et al., 2011), presence of retail and services (Porta et al., 2009; Produit et al., 2010), location of historical paths that shape the evolution of cities (Strano et al., 2012), street quality and popularity in terms of footfall (Remali et al., 2015).

Measures of the urban fabric have been selected following an urban morphological rationale. According to Caniggia and Maffei (2001, c.1979), the process of urban evolution proceeds through piecemeal change and densification of the land along both sides of the street. This is a plot-by-plot, rather than block-by-block process, that emanates from the most central to the least central streets, ultimately resulting in the generation of blocks. In accordance with this process, we adopt the street edge as our unit of analysis, and we define it as the sum total of all the plots on one block which face the same street (i.e., having their main entrance on it). It is worth noting that this definition is similar, but not identical, to Caniggia and Maffei's "fascia di pertinenza", i.e. "pertinent strip" (Caniggia and Maffei, 2001, c.1979: 125). In fact we refer the street edge to the block instead of the "route", making it an unambiguous, computational unit suitable for systematic quantitative analysis. For each street edge we measure: its total area (M1); the area covered by all the buildings within it (M2); the total *floor-area* of these same buildings (M3); the typical width of the street defining the street edge (M4); the *percentage* of area which is covered by buildings (M5), the average *height* of all the buildings lying in it (M7); and finally the percentage of street front which has buildings lying within eight meters from the pavement line (M8).

Code	Name	Definition	Unit	Range	Formula
M1	Street Edge	The area of the street edge	m <sup>2</sup>		
M2	Coverage	The total area of the buildings' footprints	m <sup>2</sup>		$M2 = \sum_{i=1}^{n} B_i$
M3	Density	Total amount of gross floor area over the street edge area	m <sup>2</sup> /m <sup>2</sup>		$M3 = \frac{M_2 \times M_7}{M_1}$

M4	Street Width	The prevalent street width between the two sidewalk lines	m		
M5	Coverage Ratio	% of land covered by buildings on the street edge area	m <sup>2</sup> /m <sup>2</sup>	0 - 100	$M5 = \frac{M_2}{M_1} \times 100$
M6	Centrality	<i>Centrality</i> of the street that defines the street edge			(*)
M7	Front Height	Average height of all buildings in a street edge	No. of floors		$M7 = \frac{1}{n} \sum_{i=1}^{n} H_i$
M8	Built Front Ratio	% of the street edge front abutted by buildings	m/m	0 - 100	$M8 = \frac{BF}{F} \times 100$

Table 1. Indices of the urban fabric. In M2: let  $B_i$  = the footprint area of building *i*. In M7: let n = number of buildings in the Street Edge;  $H_i$  = height (in number of floors) of building *i*. In M8: let BF = length of street front which has buildings lying within eight meters from the pavement line; F = length of the Street Edge front. (\*) The formula of *centrality* (M6) is presented in Paragraph 2. of the Supplementary Materials.

#### **FIG 2 ABOUT HERE**

Figure 2. Illustrational sketches of the indices of urban fabric from M1 to M8.

#### 3.3. Statistical analysis

Each of the five selected areas is described through the totality of its street edges. This technique allows us to obtain a large amount of data, for each neighbourhood, a necessary condition for applying the Central Limit Theorem (CLT). This statistical approach allows us to assess the convergence of a sum of *n* independent and identically distributed random variables, with mean  $\mu$  and finite variance  $\sigma^2$ , to a normal distribution N ( $n\mu$ ,  $n\sigma^2$ ). The CLT is a precondition for obtaining consistency in statistical analysis.

Our work in this section takes into account well-known statistical tests, such as Analysis of Variance (ANOVA) and Linear Regression (LR), to understand the emergence of common patterns across the five areas under scrutiny, and to estimate the emerging relationships between the variables. Moreover, we explore the existence of statistical correlations through the computation of the Pearson Product Moment correlation coefficient (PC), which identifies correlations based on the covariance of a set of random variables. An introduction to the mathematics behind the cited methods can be found in classical books of Mathematical Statistics and estimation theory such as Roussas (1997), Fisz (1963) and Devroye (Devroye, 1987).

### 4. Results

#### 4.1. Visual analysis of the street network

We present in Fig. 3 five extracts – one for each case study – of the Multiple Centrality Analysis performed on the 15x15km graph of London's *street network*. The maps represent the Kernel Density Estimation (KDE) of *centrality* with cell edge c=10mts and bandwidth h=100mts. An explanation of the KDE method is provided in the Supplementary Materials (Paragraph 3.).

#### FIG 3 ABOUT HERE

Figure 3. Kernel density of *centrality* (M6) for the five case studies.

Visual inspection of the extracts highlights one common pattern: highly central streets ("urban mains" tending to red) do not traverse the study areas, but rather tend to define their boundaries. For example, we notice that the streets with the highest centrality values in Barnsbury are located at its West (Caledonian Road), East (Upper St.) and South (Pentonville Road) edges. Central streets of a second grade ("local mains", tending to yellow) tend to bisect the study areas, splitting them in two. This double-scaled system of urban and local mains frames a background of less central streets ("locals", tending to blue). Since *centrality* generates the *potential* for intense urban activities, we observe a pattern whereby gentrified neighbourhoods tend to be calm, safe and mainly residential in their cores, or "sanctuary areas" (Appleyard et al., 1981; Mehaffy et al., 2010), connected to vibrant and busy roads at their edges by a system of intermediate, locally central streets.

### 4.2. Analysis of the urban fabric

## 4.2.1. Analysis of Variance (ANOVA)

Do the urban forms of the five study areas exhibit similarities in terms of spatial features, as measured through the eight selected variables? If so, which individual features are the most similar, and to what extent? And, most importantly, to what extent is the apparent similarity between two average values in two different areas statistically significant? To explore this, we firstly perform a boxplot analysis of the distribution of all eight indices of form across each case study. We then undertake the Analysis of Variance (ANOVA) to ascertain whether the mean values of each variable are statistically equivalent across the case studies. In the Supplementary Materials (Paragraph 4.), we present the summary statistics and ANOVA outputs for each of the variables considered, while the synthesis of the analysis is presented in Fig. 4 and in the following paragraph.

#### **FIG 4 ABOUT HERE**

Figure 4. Distributions of the eight variables across the five case studies.

The descriptive analysis based on the boxplots (Fig. 4) shows that all the neighbourhoods exhibit a rather similar mean value (i.e. average) of front height (M7) at around 2.5 stories. Similarly, the built front ratio (M8) takes mean values between 60 and 80%, with Battersea reaching up to 90% and Telegraph Hill dropping to 40%. These values are typical of the perimeter block urban type, with or without front gardens between the building and the street. We also note that the median values (the middlemost value in an ordered sequence of numbers) for all cases, except Telegraph Hill, are significantly higher than the means. This demonstrates the relevant presence of outliers at the bottom threshold of the values (i.e., street fronts completely unbuilt or built up at very low intervals). The urban type synonymous with gentrified neighbourhoods, therefore, more closely resembles the perimeter-block pattern rather than the 'towers in the park' or the set-back type. Other prevailing characterisations of the built form of these five cases are: a street edge area of roughly 4-5,000 sq. m, 1-2,000 of which – equal to about the 30-50% – is covered by buildings at a density of  $1m^2$  of floor area per m<sup>2</sup> of street edge area, which equals to roughly 100 units per hectare, served by streets of 8m of width.

The hypothesis test of statistical relevance for the mean values of *centrality* (M6) fails. This might be due to the fact that the numerical value of centrality does not have any practical meaning; it measures, in fact, a degree of connectivity rather than a dimension in space. Although *centrality* does not pass the hypothesis test, it might be useful to explain its behaviours in relation to the other variables through a correlation and a regression analysis. We will explore this in the next sections.

# 4.2.2. Analysis of correlation

In several instances, significant linear correlations between pairs of variables have been detected in one or two of the selected study areas (Tab. 2). However, only in one instance does such a correlation emerge in all cases: there is a strong, positive correlation between *density* (M3) and *coverage ratio* (M5). This outcome excludes the presence of "tower block" developments, where typically density increases by vertical rather than horizontal extension, i.e. driven by building height only, without a comparable increase of building coverage. If this urban type were to be significantly present in any of our case studies, we would have found that denser street edges would not have been accompanied by larger coverage ratios, which is in fact what we observe. In short, this finding confirms that all, or most of the neighbourhoods selected share the same type of urban form, i.e. a traditional, low/medium rise perimeter block type.

It is then worth noting that *centrality* (M6) does not appear to correlate significantly with any other variable (with the only exceptions of *street width* in Brixton and Telegraph Hill). The lack of correlation, in this case, reinforces the role of street centrality as an independent driver of urban form.

#### **TAB 2 ABOUT HERE**

Table 2. Cases of significant correlations between variables across the five neighbourhoods.

## 4.2.3. Regression analysis

In Tab. 3 we present the linear regression analysis for the eight variables, calculated on the unified dataset of all case studies. We note that the contribution of the *coverage* ratio (M5) to explain the *Density* (M3) is indeed very high ( $R^2$ =0.84), corroborating the findings of the correlation analysis.

Secondly, the linear model that considers *centrality* (M6) as a dependent variable yields the weakest result ( $R^2$ =0.35). However, *street width* (M4), *built front ratio* (M8) and *coverage* (M2) together nearly perfectly describe the centrality. We notice that *street width* (M4) exhibits a similar behaviour, as it is best explained by *front height* (M7). These results seem to suggest a link between certain features of city form and the properties of streets.

We thusly report in Tab. 4 the linear regression for the overall *street centrality* (M6) index for each neighbourhood, taken separately. Firstly, we notice that the models generally explain *centrality* well, and this is particularly noticeable for Barnsbury, Brixton and Telegraph Hill. Moreover, we observe that the main contribution to the explanation of *centrality* comes almost invariably from the *street width* (M4). This tells us that, in the five areas under scrutiny, the streets that are physically larger tend to be more central, i.e. positioned precisely on the shortest paths connecting all other streets in the city to each other.

#### **TAB 3 ABOUT HERE**

Table 3. Linear regression analysis for the eight indices calculated on data from all five neighbourhoods.

#### TAB 4 ABOUT HERE

Table 4. Linear regressions of *centrality (M6)* for the five gentrified areas taken separately.

# 4.3. Results: a narrative of the typical urban form undergoing gentrification by collective action

The centrality of streets seems to be most significantly explained by the width of the streets and the building density. Densely built up urban main streets are typical features of a traditional urban model, as opposed to post-war modern urbanism. By visually analysing the geographic distribution of *centrality*, gentrified areas are found to sit *between* urban main streets, which constitute their boundaries. However, lower grade "local mains" often traverse the area, Barnsbury (Liverpool Road) and Telegraph Hill (Pepys Road) being clear examples. These traversing local mains rarely attract consistent retail commerce, with the exception of local businesses (cafes, newsagents, groceries), which tend to be present at the intersections with the highly central streets.

The urban mains at the edge of the gentrified areas provide links to public transport, retail and other important non-residential uses at the urban scale which are at walking distance (400-500mts) from anywhere in the area. Local mains serve the inner residential clusters with local services and accessible routes positioned frequently (200-250mts).

The prevailing urban type in all five cases is consistently characterised by low/medium rise, traditional perimeter blocks. This dominant model, characterised by street edges of 4-5,000 sq. m, seems to coexist within significantly different situations, where much smaller or larger street edges may present values between 1,000 sq. m and 6-7,000 sq. m, providing a significant diversity of scale, fit for a wide variety of needs and challenges.

Remarkably though, building density 'grows' together along with the buildings' overall footprint or, in other words, areas developed relatively 'sparsely' and those developed relatively 'intensively' nevertheless show buildings of roughly similar heights. In this model, the area of development is occupied at a fairly high rate, with buildings covering 30 to 50% of the neighbourhood; this figure is even more significant if we consider that street edges typically include local "pocket" parks and vacant plots.

The typical density is around 1 sq. m of gross floor area per sq. m of street edge, implying roughly 100 units per hectare. This value lies in the highest section of medium density housing and corresponds to building types such as row houses, garden apartments or low town houses (Newman, 1972: 57). Streets are never too large, between 7-9m, with 2-3 storey high buildings sitting close to the street line for about 60-80% of the overall street front.

The somewhat divergent behaviour of the urban form Telegraph Hill must be noted. However, after a closer inspection, this case does not present a different urban structure altogether, but rather variations on the same traditional perimeter block structure illustrated above. Firstly, we notice blocks of a larger size, which give room to larger specialist functions within them, such as the Transport for London Bus depot on New Cross Road, or the Telegraph Hill Park. Secondly, and even more importantly, the short edges of these large blocks abutting streets (Sherwin Road and Arbuthnot Road) are dominated by blank walls rather than developed fronts. In an evolutionary perspective, this unusual feature is probably evident due to the very low centrality of these streets, which has not exerted enough "environmental pressure" to further develop the deep backyards of fronting plots. Such blank street edges appear to be the expression of a process of densification that has not yet reached its peak, although this could certainly be the case should the value of the increase in the future.

# 5. Conclusions

In this paper, we have studied the urban form of five ordinary areas in London that have experienced a process of bottom-up gentrification, or gentrification "by collective action", at various stages after WWII. To describe rigorously their urban form, we introduced a systematic and quantitative, though not yet comprehensive, method of urban morphological analysis. We identified the "street edge" (i.e., the amalgamation of the areas of the urban plots facing the same street) as the unit of analysis. We also define<u>d</u> eight variables that are "structural" and that can be measured remotely using commonly available geographic repositories such as Google Street View or Ordnance Survey Maps. Finally, we undertook a multivariate statistical analysis of the five cases, therefore alluding to the development of a next step in Urban Morphology analysis that we call "urban morphometrics" (Dibble et al., in print; Carneiro et al., 2010).

Results suggest that the five gentrified neighbourhoods are well-defined areas with major roads on the edges and with calm, internal streets at their cores. This network provides a strong connection to main amenities and transport systems on the main streets, as well as safe and pleasant urban environments, with some local businesses, providing for a more family-oriented lifestyle at the interior. These characters seem to be in accordance with Butler's observations regarding gentrified environments being places closely connected to central spaces, but without being centres in themselves (Butler, 2003). Instead they exhibit the characteristics of a "sanctuary area", i.e. a reasonably self-contained, but inter-connected predominantly residential area that offers opportunities for lively urban experiences within walking distance (Mehaffy et al., 2010). Furthermore, the five gentrified neighbourhoods consistently exhibit a low/medium rise housing typology at a density of around 100 units per hectare, with a high rate of built-up block perimeters, confirming the "traditional" physical setting portrayed in Ruth Glass' original definition of gentrification (Glass, 1964).

This portrait of a typical gentrified neighbourhood should sound familiar in the context of studies on gentrification, and especially gentrification by "collective action". This seems consistent with the typical, uplifted London neighbourhoods which have gradually become incorporated in the past few decades. It also confirms the two characters of "good" urban districts as advocated by Jacobs and Appleyard, who talked of mostly residential "sanctuary" areas, i.e. "well-managed environment(s) relatively devoid of nuisance, overcrowding, noise, danger, air pollution, dirt, trash, and other unwelcome intrusions", sitting within easy reach from places where people "can break from traditional molds, extend their experience, meet new people, learn other viewpoints (and) have fun" (Jacobs and Appleyard, 1987: 116). The importance of these structural features, of what is effectively a traditional urban form, for the sustainability of a city into the future, has been highlighted retrospectively in the last twenty years of the post-modern "counter-revolution" in urban design (Marshall, 2005; Porta et al., 2014).

These findings appear to support the research hypothesis: features of "*traditional*", fine-grained, perimeter block-based urban form are clearly detected over the five gentrified areas observed. Moreover, patterns emerge that link the centrality of streets to street width and building density, as well as to their sheer geography (bordering urban mains that define inner "sanctuary areas" of lower centrality). However, the limits of this study (highlighted in section 2) suggest that more comprehensive studies may be undertaken before any wider generalisations can be made in regards to such a hypothesis.

Finally, the analysis applied in this study contributes to the establishment of a systematic, quantifiable and comprehensive method for the analysis of urban form, named "urban morphometrics", which could greatly enhance the understanding of complex social dynamics in cities.

## 6. References

- Appleyard D, Gerson MS and Lintell M. (1981) *Livable streets, protected neighborhoods*: University of California Press.
- Atkinson R and Bridge G. (2004) *Gentrification in a global context,* London and New York: Routledge.
- Barthelemy M. (2011) Spatial Networks. Physics Reports 499(1-3): 1-101.
- Batty M. (2009) Darwin at 200 and the evolution of planning. *Environment and Planning B: Planning and Design* 36(6): 954-955.
- Beauregard RA. (1990) Trajectories of neighborhood change: the case of gentrification. *Environment and planning A* 22(7): 855-874.
- Bettencourt LM, Lobo J, Helbing D, et al. (2007) Growth, innovation, scaling, and the pace of life in cities. *Proceedings of the National Academy of Sciences* 104(17): 7301-7306.
- Boccaletti S, Latora V, Moreno Y, et al. (2006) Complex networks: Structure and dynamics. *Physics Reports* 424(Issues 4–5): 175–308.
- Butler T. (2003) Living in the bubble: gentrification and its' others' in North London. *Urban Studies* 40(12): 2469-2486.
- Butler T and Lees L. (2006) Super- gentrification in Barnsbury, London: globalization and gentrifying global elites at the neighbourhood level. *Transactions of the Institute of British Geographers* 31(4): 467-487.
- Butler T and Robson G. (2001) Social capital, gentrification and neighbourhood change in London: a comparison of three south London neighbourhoods. *Urban Studies* 38(12): 2145-2162.
- Butler T and Robson G. (2003) London calling: the middle classes and the re-making of inner London, Oxford and New York: Berg Publishers.
- Caniggia G and Maffei GL. (2001, c.1979) Architectural Composition and Building Typology: Interpreting Basic Building, Florence: Alinea.
- Carneiro C, Morello E, Voegtle T, et al. (2010) Digital urban morphometrics: automatic extraction and assessment of morphological properties of buildings. *Transactions in GIS* 14(4): 497-531.
- Conzen MRG. (1960) *Alnwick, Northumberland: a study in town-plan analysis,* London: Orge Philip and Son.
- Davidson M and Lees L. (2005) New-build 'gentrification' and London's riverside renaissance. *Environment and planning A* 37(7): 1165-1190.
- Devroye L. (1987) *A course in density estimation*, Cambridge, MA: Birkhauser Boston Inc.

- Dibble J. (2016) Urban Morphometrics: Towards a Science of Urbanism. *Department* of Architecure. Glasgow: University of Strathclyde.
- Dibble J, Prelorendjos A, Romice O, et al. (in print) Urban Morphometrics: Towards a Science of Urban Evolution. *ISUF International Seminar of Urban Form*. Rome, IT, 14.
- Duany A. (2001) Three cheers for gentrification. *American Enterprise Washington* 12(3): 36-39.
- Ellin N. (1999) Postmodern urbanism, New York: Princeton Architectural Press.
- Fisz M and Bartoszynski R. (1963) *Probability theory and mathematical statistics*, New York: John Wiley and Sons.
- Freeman L. (2005) Displacement or succession? Residential mobility in gentrifying neighborhoods. Urban Affairs Review 40(4): 463-491.
- Freeman L, Cassola A and Cai T. (2015) Displacement and gentrification in England and Wales: A quasi-experimental approach. *Urban Studies*: 1-18.
- Gauthier P and Gilliland J. (2006) Mapping urban morphology: a classification scheme for interpreting contributions to the study of urban form. *Urban Morphology* 10(1): 41.
- Glass R. (1964) Introduction to London: Aspects of Change Centre for Urban Studies. London [reprinted in Glass R, 1989 Cliches of Urban Doom (Blackwell, Oxford) pp 132^ 158].
- Gordon G. (1990) The morphological development of Scottish cities from Georgian to modern times. In: Slater TR (ed) *The built form of western cities: essays for MRG Conzen on the occasion of his eightieth birthday.* Leicester University Press, 210-232.
- Hackworth J. (2001) Inner-city real estate investment, gentrification, and economic recession in New York City. *Environment and planning A* 33(5): 863-880.
- Hamnett C. (2003) Gentrification and the middle-class remaking of inner London, 1961-2001. Urban Studies 40(12): 2401-2426.
- Hamnett C and Whitelegg D. (2007) Loft conversion and gentrification in London: from industrial to postindustrial land use. *Environment and planning A* 39(1): 106.
- Hillier B and Hanson J. (1984) *The social logic of space*, Cambridge, UK: Cambridge university press.
- Holling CS and Goldberg MA. (1971) Ecology and planning. *Journal of the american Institute of Planners* 37(4): 221-230.
- Jacobs A and Appleyard D. (1987) Toward an urban design manifesto. *Journal of the American Planning Association* 53(1): 112-120.

- Lees L. (2000) A reappraisal of gentrification: towards a 'geography of gentrification'. *Progress in human geography* 24(3): 389-408.
- Lees L, Slater T and Wyly EK. (2010) *The gentrification reader*, London and New York: Routledge.
- Ley D. (1994) Gentrification and the politics of the new middle class. *Environment* and Planning D 12: 53-53.
- Marcus L. (2008) Spatial Capital and how to measure it. In: Haas T (ed) *New Urbanism and Beyond: Designing Cities for the Future*. New York: Rizzoli International, 135-139.
- Marshall S. (2005) *Streets and Patterns: The Structure of Urban Geometry*, London: Spon Press.
- McQuillan A. (1990) Preservation planning in post-colonial cities. In: Slater TR (ed) The built form of western cities: essays for MRG Conzen on the occasion of his eightieth birthday.: Leicester University Press, 394-414.
- Mehaffy M, Porta S, Rofè Y, et al. (2010) Urban nuclei and the geometry of streets: The 'emergent neighborhoods' model. *Urban Design International* 15(1): 22-46.
- Muratori S. (1960) *Studi per una operante storia urbana di Venezia*, Roma: Istituto Poligrafico dello Stato.
- Newman O. (1972) *Defensible space: Crime prevention through urban design,* New York: Macmillan.
- Pacione M. (2001) *Urban geography: A global perspective*, London and New York: Routledge.
- Porta S, Crucitti P and Latora V. (2006) The network analysis of urban streets: a primal approach. *Environment and Planning B: Planning and Design* 33(5): 705-725.
- Porta S, Latora V and Strano E. (2010) Networks in urban design. Six years of research in multiple centrality assessment. In: Estrada E, Fox M, Higham DJ, et al. (eds) *Network Science: Complexity in Nature and Technology*. London: Springer, 107-129.
- Porta S, Latora V, Wang F, et al. (2009) Street centrality and densities of retail and services in Bologna, Italy. *Environment and Planning B: Planning and Design* 36(3): 450-465.
- Porta S, Romice O, Maxwell JA, et al. (2014) Alterations in scale: Patterns of change in main street networks across time and space. *Urban Studies* 51(16): 3383-3400.

- Produit T, Lachance-Bernard N, Strano E, et al. (2010) A network based kernel density estimator applied to Barcelona economic activities. *Computational Science and Its Applications–ICCSA 2010*. Springer, 32-45.
- Remali A, Porta S, Romice O, et al. (2015) Street quality, life and centrality in Tripoli. In: Vaughan L (ed) *Suburban Urbanities: Suburbs and the Life of the High Street*. London: UCL Press.
- Roussas GG. (1997) *A course in mathematical statistics*, San Diego, CA: Academic Press.
- Smith A. (2002) Mixed-income housing developments: Promise and reality. Fellowship Program for Emerging Leaders in Community and Economic Development. Cambridge, MA: Joint Center for Housing Studies of Harvard University and Neighborhood Reinvestment Corporation
- Smith N. (1987) Gentrification and the rent gap. *Annals of the Association of American geographers* 77(3): 462-465.
- Strano E, Nicosia V, Latora V, et al. (2012) Elementary processes governing the evolution of road networks. *Scientific Reports* 2.
- Strano E, Viana M, da Fontoura Costa L, et al. (2013) Urban street networks, a comparative analysis of ten European cities. *Environment and Planning B: Planning and Design* 40(6): 1071-1086.
- U.N.HABITAT. (2013) Streets as Public Spaces and Drivers of Urban Prosperity. Nariobi: UN Habitat.
- Wang F, Antipova A and Porta S. (2011) Street centrality and land use intensity in Baton Rouge, Louisiana. *Journal of Transport Geography* 19(2): 285-293.
- Warde A. (1991) Gentrification as consumption: issues of class and gender. Environment and Planning D: Society and Space 9(2): 223-232.
- Whitehand JWR. (1972) Building cycles and the spatial pattern of urban growth. *Transactions of the Institute of British Geographers* July(56): 39-55.
- Whitehand JWR. (1988) Urban fringe belts: development of an idea. *Planning perspectives* 3(1): 47-58.
- Whitehand JWR, Gu K, Conzen MP, et al. (2014) The Typological Process and the Morphological Period: A Cross-Cultural Assessment. *Environment and Planning B: Planning and Design* 41(3): 512-533.
- Wilson GA. (2000) Complex Spatial Systems: The Modelling Foundations of Urban and Regional Analysis, Englewood Cliffs, NJ: Prentice-Hall.
- Wood S and Dovey K. (2015) Creative Multiplicities: Urban Morphologies of Creative Clustering. *Journal of Urban Design* 20(1): 52-74.

- Ye Y and van Nes A. (2014) Quantitative tools in urban morphology: combining space syntax, spacematrix, and mixed-use index in a GIS framework. *Urban Morphology* 18(2): 97-118.
- Yin RK. (2013) Case study research: Design and methods, Thousand Oaks, CA, London and New Dehli: Sage.
- Zukin S. (1987) Gentrification: culture and capital in the urban core. *Annual Review* of Sociology: 129-147.