Plot-Based Urbanism and Urban Morphometrics:

Measuring the Evolution of Blocks, Street Fronts and Plots in Cities

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Abstract

Generative urban design has been always conceived as a creation-centered process, i.e. a process mainly concerned with the creation phase of a spatial transformation. We argue that, though the way we create a space is important, how that space evolves in time is ways more important when it comes to providing livable places gifted by identity and sense of attachment.

We are presenting in this paper this idea and its major consequences for urban design under the title of “Plot-Based Urbanism”. We will argue that however, in order for a place to be adaptable in time, the right structure must be provided “by design” from the outset. We conceive urban design as the activity aimed at designing that structure. The force that shapes (has always shaped) the adaptability in time of livable urban places is the restless activity of ordinary people doing their own ordinary business, a kind of participation to the common good, which has hardly been acknowledged as such, that we term “informal participation”.

Investigating what spatial components belong to the spatial structure and how they relate to each other is of crucial importance for urban design and that is the scope of our research. In this paper a methodology to represent and measure form-related properties of streets, blocks, plots and buildings in cities is presented. Several dozens of urban blocks of different historic formation in Milan (IT) and Glasgow (UK) are surveyed and analyzed. Effort is posed to identify those spatial properties that are shared by clusters of cases in history and therefore constitute the set of spatial relationships that determine the morphological identity of places. To do so, we investigate the analogy that links the evolution of urban form as a cultural construct to that of living organisms, offering conceptual framework of reference for the further investigation of “the DNA of places”.

Key words: Urban Morphology; Plot-Based Urbanism; Morphometrics; Informal Participation; Evolution.

1. Introduction

What makes a place distinct from any other? The quality of a place that is acknowledged by the people at the level of the collective memory, that quality that is achieved mainly by social learning and goes therefore deep into what Caniggia and Maffei called "spontaneous consciousness" (2001) to constitute a living substrate of our daily cognitive efforts and generates what repetitively is mentioned as "place identity" or "sense of place": what is it and, even more important, how can we generate it?

In a recent personal discussion, we have been lucky enough to come to this point with Christopher Alexander. We agreed that whatever this quality is, it is not anything that can be created by means of a solitary approach of the artist-creator, but instead must be generated in some way that involves gradual adaptation in time and therefore the end user and its life-long experience and changing needs. At that point, I came out with the idea that *"we do not want to generate a place which is beautiful and human now. We want to generate a place such that it will be beautiful and human in 3 centuries!"*. Chris stayed in silence for a bit – but just a bit – then raised his eyes and said: *"No! I can make it in 5 years!"*. The day after his wife Maggie accompanied us to visit the West Dean Visitors Centre, less than half an hour drive from the place where they live (Fig.1). That is a small building that Chris erected in the magnificent countryside of Sussex as part of a complex of old farmhouses turned into the venue of the West Dean College (see: http://www.livingneighborhoods.org/ht-0/westdean.htm), and there I faced the reality of what he so adamantly stated: when pacing the building across, and the entrance gate and the front garden with the 4 apple trees right in front of the main door, and the splendid back garden with the small stone bridge over the stream, we had the chance to touch concretely with our hands what does it mean to have gotten it "just right". That quality was there, it was undoubtably and tangibly there. He really did it in five years (and even less).

– Figure 1 about here –

In the subsequent days we reflected intensively on this experience. Was I wrong then? Is it that "timeless" quality we search for, the identity of a place, anything that we all can create in one shot if we just are good enough to "get it just right"? Or is it true that, on the other side, only time and restless adaptation can lead a place to achieve and express that underlining complexity that makes it (and keeps it) deeply human? Not surprisingly, we eventually came to the conclusion that this is not an either/or problem. In short, we concluded that both those ideas, which seem so far away and even opposite one another, do apply together. They both rely on the same foundations, that place identity is something that only a life-driven process can generate. The difference is about the kind of process. Chris' life-long practical and intellectual experience has brought him to devise a whole series of tools and structures, including the Pattern Language, which he believes are conducive to making this ability practical. Still it would not in any case be the ability of the person, an exceptional creative gift, it would be an ability of the process. In his latest reflection, Chris states very clearly that in order for this to happen, we need essential changes in the organizational, political and financial systems that rule the production of houses in our civilization. He clearly sees an opposition in principle of a World System A and a World System B, (Alexander, in print). These two systems cannot co-exist, we should therefore operate for an essential subversion of the current mechanisms that drive the reproduction of the built environment if we want any chance to "get it just right" in the future to arise. The problem of a life for Christopher Alexander, the inherent inability of his vision, despite its evident capacity to create livable places, to become mainstream in housing production of our times, is now fully accounted for in this "battle" between system A and system B. This extraordinary ability to generate human and adaptable places "in five years" that Alexander claims, relies entirely on very specific conditions of the process that are – this is the point – fairly unusual. These conditions are only secondarily financial; they are mainly cultural and political. For example, it is fundamental that the building gets constructed through the actual manual work of architects, technicians and the end-users, such that pre-fabricated materials are banned out of the picture and, mostly important, the distance that separates those taking decisions from those affected by the same decisions is tightened (if not overcome altogether); moreover, it is also fundamental that decisions are taken in the right sequence, which means that planners must delegate a great deal of their decision-making back into the hands of the end users. One side-effect of all that is that we should learn how to build houses without drawing them in advance, which of course undermines completely the system of control and certification currently in use. In short, World System A requires and entirely different configuration of powers, organizations and attitudes, which ends up in what Alexander himself terms *"a social revolution"* (Alexander, 1985). When those conditions are ensured, and the right process can take place like at West Dean, the results are remarkably and consistently "just right", and you can get them in five years. But what if they aren't? Can we possibly find a way to get it "just right" lowering the level of challenge that we would cast upon the conventional planning system?

Our answer is yes, under certain conditions. The first condition is that we do not see this problem as a matter of compromising with Alexander's framework, i.e. to do something Alexander-ish, a sort of friendly or reformist version of his social revolution. No, we must understand that Christopher Alexander is evidently right: if we want to get it in five years that is the only way to go, and there is are possible shortcuts. Consequently, the second condition is that we are fully aware that the only process that can bring life into the built environment beside Alexander's is the historical process of adaptation that starts after the design and even the construction phases, and spans over generations; that means: we can make it, but not in five years. Indeed, it is going to take decades, possibly centuries. The third condition is that the design phase establishes in the place the right spatial structure, i.e. the structure that, rather than inhibiting it, allows and enables the process of adaptation to take over and keep going. Understanding what this structure is in practice, which spatial materials belong to it and which don't, is of utmost importance if we want to have a hope to make it and get it "just right". We call the process of design that aims at establishing the right structure in a place, so that this place is enabled to adapt and change over generations, Plot-Based Urbanism (PBU). We argue that PBU is basic planning, i.e. a version of the planning discipline that keeps only what is essential to promote and enable the occurrence of self-organized processes of adaptation in time. In short, we argue that if you want spatial systems to self-organize in time you need to plan them first, but to plan them right. After decades of hyper-planning, we find that the current anti-planning climax is not less ideological than what it counters; we see in urban history the evidence of this, when we acknowledge the countless examples of perfectly human, adaptable urban fabrics that started as planned structures and then evolved in magnificent places that we still regard today as exemplary achievements of human civilization.

In this paper we explore the idea of PBU adopting an evidence-based approach. We look at the form of urban fabric in history and how it has evolved into something entirely different in the course of the XXth century. In so doing, we focus on capturing the essential structure of cases that have proved the capacity to change and adapt over time, as opposed to those that haven't. We then make a step further on, and try to measure that structure, in order to find out what are its spatial components, how they relate to each other, and how much each of them contributes to the overall structure. But before that, we must introduce the analogy that leads us along the way. In this analogy, the structure we are focusing on acts for the visible constitution of places pretty much as the genetic structure of living organisms ("genome") acts for shaping their distinct visible ("phenotypic") features. That sheds light onto what we are attempting to do: mapping the DNA of places.

2. The analogy of biological evolution in the built environment

The conception of evolutionary living organisms as a metaphor of artifacts in the built environment has a long history in design theory. Comprehensive treatises of this topic have been recently offered by Steadman (2008), Marshall (2008) and Mehaffy (in print). Recent approaches to this long-standing connection have explored different and in some cases opposite directions. Followers of these different efforts can be grouped according to what part of the generative process they focus on (whether within or after the creation/construction phase) and what emphasis they place on the problem of producing human spaces (design) as opposed to just analyzing existing places (analysis). We name these groups: generative artists, scientists of complexity, pattern seekers and urban morphologists.

Generative artists. Focus on: design phase and production. The concept of spaces having their specific DNA has been investigated by architects in search for as a basis for creative morphogenesis (Frazer, 1995; Eisenman, 2005; Soddu and Colabella, 2005; Schumacher, 2010). With all the emphasis that these efforts have placed on terms like fluidity, variation, sequentiality, process and dynamism, they all boil down to the production of static final objects that are supposed to remain quite fix and stable after construction. The genetic metaphor is therefore entirely consumed within the process of creation with the highest disregard to what would happen to the object after that and throughout the interaction with the end users until the end of the its life-cycle. In this sense, the metaphor has been here exploited as tool to boost and direct human creativity, where the human in question is mainly and only the designer/creator. Therefore we find here in essence the ultimate version of the interpretation of architecture as a branch of the visual arts, and of the architect as the artist-philosopher, which historically sits at the heart of the modernist approach, a link that is explicitly re-called by some of the most genuine protagonists in this area (Soddu, 2005). Finally, it is important to notice that while very often evocated, the sciences of complexity are not utilized in these works in any form other than in the use of several buzz-words like chaos, non-linearity and the like. Rather than a scientifically informed approach to the subject, we see in this attitude a very clear link with post-structuralist philosophies, where the analogous and even stronger habit to stretch the semantic field of the scientific language well beyond the limits accepted in the source-disciplines has already been vigorously questioned both in itself (Sokal and Bricmont, 1999) and for its impact on late-modernist design theories (Salingaros, 2004).

Scientists of complexity. Focus on: post-design phase and analysis. The sciences of complexity have been otherwise explored in works that explicitly assume knowledge in areas such as the physics of fractals or complex networks for delivering classic interdisciplinary research (Batty and Longley, 1994; Hillier, 1999; Bettencourt et al, 2007; Porta et al, 2010). Though these are sometimes referred to as works in “urban morphology”, in that they deal with the physical form of cities, they cannot be confused with the proper area of urban morphology we refer to with this term. Complexity in the built environment is here investigated with the same instruments used for other classes of self-organized non-spatial phenomena such as social or scientific systems; however, biological evolution is not part of the picture in that references to biological sciences is maintained secondary or just metaphoric. Finally, research in this area is focused on the understanding of the behavior of real systems, while the problem of the generation of new systems is interpreted as a pure problem of modeling growth as an evolution of the original structure. These works are now flanked by a growing interest on spatial network within the community of physics (Boccaletti et al, 2006; Bartehelemy, 2010).

Pattern seekers. Focus on: post-design phase and production. Several scholars have since the early Sixties attempted to investigate the nature of adaptation in buildings and urban spaces as conducive to more human spaces (Habraken, 2000; Brand, 1994; Akbar, 1988; Neis, 2011;Salingaros, 2005). The science of complexity is here assumed at a deeper level, far from a transposition of theories, methods, and language from the source-disciplines. Christopher Alexander is regarded as a particularly influential case in this area. Rather than starting from actual knowledge available in the physics of complexity or the biology of evolution, to then acting trans-disciplinarily, he started from the interrogation of design itself, its fundamental nature and social meaning, to develop an entirely original scientific approach and a wealth of autonomous achievements that encompasses language, theory, tools and practical realizations. For this reason his work, rather than only borrowing from other areas of knowledge, has in fact contributed to them in various manners and forms. For example, Mehaffy (2010) documents some 8 million Google hits referring to applications of the pattern language and pattern concepts to software, including the technology behind the iPhone, the Mac, many computer games, and the Wiki, and the same can be said or the sciences of education (Goodyear, 2010). The depth of the research in this area, which often is brought to the conceptual level, and the focus on common structures of general significance, makes these efforts revolving around a search for patterns that are relatively stable in time and space, and yet capable of generating the most various range of specific visible manifestations. In Alexander, it is exactly this that characterizes life-generating processes in nature: transformations appear in sequence where each step preserves and expands the previous structure in a chain of "structure-preserving transformations" (Alexander, 2003). It is this attitude that makes research in this area close to the analogy with evolution in life, though this link is not always explicitly discussed.

Urban morphologists. Focus on: design phase and analysis. Urban morphology is an area of urban studies that, in its current form, emerged between the 40s and the 60s of the XXth century from the work of two scholars who have never apparently been aware of one another's research, and can be defined as prominent as different: the German-born and then British urban geographer M.R.Conzen (1960), and the Italian architect and historian Saverio Muratori (1960). The history of this area of studies and its various strands has been effectively delineated in a series of papers appeared in "Urban Morphology", the journal of the International Seminars of Urban Form (Cataldi, 1997; Whitehand, 2001; Marzot, 2002; Hofmeister, 2004). Studies in this area share a focus on the ordinary city fabric as opposed to the extraordinary monuments, a deep interest in the mechanisms of transformation and change in time, an attempt to establish the link between the form of urban fabrics and the underlining socio-economic processes, and especially an evidence-based attitude to the analysis through extensive mapping of real cases. However, the original dichotomy of its disciplinary constituency, split between geography and architecture, remains to inform a twofold identity: on one side we find studies in urban geography that aim at establishing a taxonomy of observed phenomena, on the other we find studies in urban architecture that aim at finding lessons in history for the design of new spaces. Though very far from the artistic simplifications that architects-designers like Aldo Rossi and Giorgio Grassi have drawn from his work in the 70s and 80s, Muratori himself, like Caniggia and Maffei (2001), and many others later on, have long sought a direct link between historical configurations and the problem of design.

In our research, we borrow from these studies in urban morphology the scale, the emphasis on the ordinary urban fabric and its changes in time, the use of maps to extract the evidence from real cases, the search for common structures under the seeming endless diversity of visible forms, and the objective of finding a link between the understanding of existing patterns and the production of new interventions in the city. However, differently from them, we put a special effort in the quantitative measurement of spatial relationship with the explicit aim to finding out the underlining structure in the form of recurrent statistical patterns. In the search for this structure, we follow the analogy with evolution in living organisms to frame our action.

3. The evolution of the urban fabric: structuring the analogy

We see that the way spatial components combine in the XXth century generates spatial structures that are profoundly different from ever before. We see therefore that the XX^{th} urban fabric should be regarded as an entirely different “species” of city. Let’s take this analogy seriously for a while and get deeper into it. In living organisms, genes are a region of the genomic sequence (DNA), corresponding to a unit of inheritance. For example, a region of the reader’s DNA that we call a gene determines the colour of her/his eyes. More specifically, that particular gene that confers her/him that particular colour to her/his eyes is called an “allele”, so that an allele is one particular variant of that gene which determines the visible “phenotypic” manifestation of a feature or “trait”. In living organisms, individuals of the same species share the same DNA, i.e. the same combination of genes, but of course those genes are present in each individual in the form of one of its specific variants. In short, individuals of the same species share the combination of genes, but they do not share the same alleles, which accounts for the endless variations of individuals in the same species while ensuring to individuals in each species one shared “structure”. The mechanism through which the DNA gets replicated in next generation’s individuals is the sexual reproduction; those individuals belong, by definitions, to the same species, because a species is defined as a group of individual organisms capable of interbreeding. Errors in the replication of the DNA, or “mutations”, happen occasionally and spontaneously for various causes in the reproduction of individual organisms; a new species arises when individuals originally belonging to the same species undergo mutations such that they can’t interbreed; this process, called “speciation”, normally occurs when the individuals, for various reasons, get separated in space, or more precisely get to interact with different ecological niches, and therefore their evolution proceeds in reciprocal “isolation”.

Evolution as a scientific theory is currently comprehensively accepted by biologists to study life. Moreover, evolution has been used as a metaphor in other areas of knowledge such as in social and cultural studies and linguistics. In a recent study the terms “natural selection” searched on scholarly works of all times in all subject areas identified by the ISI Web of Knowledge has hit over 14,000 papers in over 140 different subject areas (Pagel, 2009); the author concludes saying that *“the theory of evolution by natural selection [...] now faces the challenge of finding order in the evolution of complex systems, including human society”* (idem, p.808). A cross-disciplinary application of the theory of evolution in life sciences that is of special relevance for our study has been proposed by Richard Dawkins to interpret evolving systems in human culture (Dawkins, 2006). *“Cultural transmission* – Dawkins argues – *is analogous to genetic transmission in that, although basically conservative, it can give rise to a form of evolution”* (idem, p.189). Though not limited to humans, cultural evolution in humans spans over an unparalleled range of expressions: *“Language is only one example out of many. Fashions in dress and diet, ceremonies and customs, art and architecture, engineering and technology…”* (idem, p. 190). Like genetic traits in living organisms propagate by replication of genes, culture in humans propagates by replication of its unit of coded information, the “meme”. Moreover, if genes in living organisms replicate through sexual transmission, memes in cultural systems do that essentially by imitation, for example in occasions like seminars, conferences or through the media. The meme is defined as *“an entity that is capable to be transmitted from one brain to another” (idem, p.196)*, but a meme should not be conceived as just a concept: the author opens to a notion of this entity that has roots in the physiochemical structures of the human brain. Quoting works from brain scientist Juan Delius, Dawkins states: *“if memes in brains are analogous to genes they must be self-replicating brain structures, actual patterns of neuronal wiring-up that reconstitute themselves in one brain after another”* (idem, p. 323). Memes, in short, are found to be long-term information stored in our brain in the form of *“changes at the level of the inter-neuronal transmission sites, the synapses”* (Delius, 1991, p. 82), and in some instances even with new additional synapses and neuronal ramifications; in this sense, Delius offers a quite simple and precise definition of memes as *“synaptic patterns that code cultural traits”* (Delius, 1991, p. 83). Finally, the analogy between memes and parasites is proposed and extended to cover not only the malignant case of viruses, but also the benignant case of symbionts. In other words, cultural memes would replicate themselves in brains in configurations of various kinds, including those of mutually reinforcing cooperating cultural constructs that in such association take a selective advantage over other competing ones.

– Figure 2 about here –

It is important to emphasize how the notion of culture that is embraced in Dawkins and Delius is close to that of “spontaneous consciousness” in the construction of the urban fabric as discussed in Caniggia and Maffei (2001). We are speaking in fact of codes of information that are transmitted only by practices of social learning: for example, practices of imitation, conditioning, imprinting, observation, and of course, especially in humans, language-mediated instruction (in written, oral, visual and audio communication), or in short everything one does not achieve by genetic inheritance or individual learning. The relevance of Dawkins’ memetics to interpret the trends in contemporary architecture has been already noted (Salingaros, 2006). In this paper we look at the evolution of urban form as informed by a particular class of memes, one of spatial nature that we term *“spemes”* (table 1). Spemes should be considered relationships in space between spatial variables. For example, the speme Block Density can be calculated as the number of residential units divided by the area of the block, where these both are spatial variables. One particular variant of the speme Block Density is a block density of, say, 25 un/ha, which should be regarded as the phenotypic manifestation of the speme allele that drives the habit to build, under those conditions, at that density. The urban fabric of a city is largely the manifestation of habits to respond to certain historical, technological and locational circumstances with a complex of co-extant spemes in mutual relationship. Like living individuals of the same species are the phenotypic manifestation of a complex of genes or genome, and local cultures that of complexes of memes or memomes, in a similar manner a particular individual type of urban fabric can be regarded as the manifestation of a complex of spemes or “spemome”. For example, a typical modernist tower-block development is structured by spemes like medium-high density + low-to-zero built front ratio + low entrance ratio etc, whose combination in space represents the spemome of that type of fabric.

		Living organisms		Culture (in general)		Culture (the urban form)	
		Element	**Example**	**Element**	**Example**	**Element**	**Example**
Basic unit of information		nucleotide subunits	Adenine Guanine	learnt item	how to mix clay with sand	spatial variable	dwelling units (num) area of the block (ha)
Unit of information	generic	gene	monkey gene	meme	way of making pots way of building arches	speme	Density *(D)*
	specific	allele	variant of monkey gene	meme allele	making casseroles making lancet arches	speme allele	*D* = 25 un/ha
Complete code of information		DNA	DNA of a monkey	local culture	etrurian culture	Local Urban Code (LUC)	LUC of a sprawled street front
Complete individual		living organism	a monkey	cultural construct	custom ritual	street front	street front
Associational process		chemical	chemical	consonance	farming products and food	spatial	co-location
Intergenerational transmission		sexual reproduction	allogamy	imitation	through discussion	imitation	through discussion
Selectors		environmental	climate	cultural	appeal of the idea of God	economic locational technological	proximity to central street

Table 1. Constitutive elements of the theory of evolution in living organisms (left), in culture in general (middle: our interpretation of Dawkins, 2006) and in urban form as a special case of culture (right, our proposal).

One of the main problems in this analogy is to understand what is, in the urban form, the element that corresponds to the individual organism. This problem is well known in structuralist research. Our work seeks relationships that are recurrent through a diversity of cases. It is this recurrence that makes one disposition in one case structural, i.e. belonging to a structure. In its inaugural lecture at the Collège de France in 1960, Claude Lévi-Strauss pointed out that: *"No one science can today consider the structures in its field as being reduced to a whatever disposition of any of its parts. One disposition is structured only when obeys two conditions: it must be a system ruled by an inner cohesion; and that cohesion, not accessible by the observation of one isolated case, is revealed in the study of its transformations, thanks to which we find properties that are similar in seemingly different systems"* (Levy-Strauss, 1965). The problem of the identifying the right unit of analysis is therefore vital. You manage a number of properties that are visible and measurable, then you look at their reciprocal relationship, and you can't do all this but by limiting your observation to a certain boundary. For example, you may observe the rituals of food preparation in a family, and then compare how they work across different families. But you may do the same comparing tribes, or single individuals. Not only what you observe changes according to the nature of the unit that you are observing (for example, food preparation can be a major ritual for the families but virtually non existent in individuals alone) but also the same elements may be recurrent across certain units and sporadic across others (for example, preparing food by putting women and children at work may be recurrent in families and very rare in collective rituals, where that role may be taken over by men's). In the biology of evolution, traits that are recurrent in individual organisms (for example: monkeys) could not be observed in comparing their single parts (for example: monkeys' arms or arterial system). In short, the choice of the unit of analysis should be dependent on the traits that you suppose to be recurrent and the kind of modifications in time that you want to investigate. In our case, cities are artefacts of extreme complexity whose visible manifestations are of endless diversity. One fundamental problem, when we search for common spatial rules or structures, is deciding what is the right scale of observation. We see for example that the form of a city as a whole is heavily determined by factors such as the topography of the terrain or the layout of regional routes. For example harbour cities may typically retain a curved shape in plan, those on top of a hill may well be radio-centric and roughly circular, and those on a watershed are typically linear. However, if we see all these cases at the lower scale, for example that of the neighbourhood, we will recognize that they all share several spatial features: they are made of streets and blocks, their blocks are predominantly filled with buildings, buildings may mostly face the streets etc, and that happens regularly in all previous examples. However, we need to identify a unit that not only exhibits common rules, but rules that are typical and consistent across. A neighbourhood, to this respect, is typically heterogeneous in that it is evidently made of many different types of fabric (for example, high rise and low rise, high and low density, etc).

There has been a vigorous move in the urban design culture in the past 20 years towards the reconsideration of the "traditional city" as a source of inspiration after decades of modernism. Much of this move has been around the re-discovery of the urban block along with a new emphasis on density and multi-functionality, altogether heading to the re-appreciation of the XIXth century city and a renovated culture of "place-making" (a very successful meme in all respects). However, differently from planners and urban designers alike, urban morphologists, who hold an established disciplinary focus on the evolution of the urban fabric, have warned against the ingenuous use of the block as a unit of design (Samuels, Panerai, Castex, & Depaule, 2004). Blocks are made of plots, plots are occupied by buildings, buildings may interface with streets in many different ways, and all this is strictly interrelated with the centrality of streets themselves. Reducing all that to a problem of designing blocks, if the inner structure is not comprehended and implemented, is just conducive to fake cities made of "pseudo-blocks", the "Disneyland effect". Fact is, cities in history have never evolved block by block. Evidence from urban morphology and street network research (Mehaffy et al, 2010) shows that cities grow following a pattern of densities referred to the centrality of streets. This means that, simply put, street fronts are built up on both sides of central streets and keep on growing, step by step, on the sides of successive streets as they emerge. Blocks, this is the point, are the resultant formation of a dynamic construction whose homogeneous and typical unit of development is the street front. The signs of this historical process, which could be either self-organized or planned, are clearly visible in the positioning and geometry of plot boundaries today, to the point that just looking at them as they currently are it is possible to reconstruct that process of formation altogether (Caniggia and Maffei, 2001). Blocks alone therefore do not represent the complexity of the urban fabric unless the inner structure at the level of street front is fully acknowledged in the analysis. Typically, for example, blocks show fronts of different consistency and type, the only exceptions being at the top edge of the density scale, when all the block is filled up to highest density along all its fronts.

In light of this discussion, we study the manifestation of spemes in both blocks as a combination of different street fronts. It is important though to make it clear that, with just a few exceptions limited to the case of Glasgow, street fronts studied in this research have been collected from blocks that also have been studied, i.e. data on blocks and street front refer to the same physical artefacts. One question of research is therefore to what extent this block/street front unit of analysis shows the capacity to capture the process of "bifurcation" in city evolution that our generation is witnessing for the first time, and that is illustrated in the next section.

4. Plot-Based Urbanism: basic planning for self-organization

4.1. SPRAWL AND TOWERS-IN-THE-PARK: THE YEAR 1950 AND THE FIRST BIFURCATION IN THE EVOLUTION OF THE URBAN FORM

More than 10 years ago, influential documents like Towards an Urban Renaissance (The Urban Task Force, 1999) and The Urban Design Compendium (English Partnership and Housing Corporation, 2000) inaugurated a new page in urban planning by summarizing in form of guidelines a wealth of literature from the late Eighties which included works by Peter Newman and Jeff Kenworthy in Australia (Newman & Kenworthy, 1999), Peter Calthorpe (Calthorpe & Fulton, 2001) and Andres Duany (Krieger & Lennerz, 1991) in the USA, Ian Bentley (McGlynn, Smith, Alcock, Murrain, & Bentley, 1985), Mike Jenks (Jenks & Burgess, 2000) and Hidebrand Frey (Frey, 1999) in the UK, and many others.

To be true, this new wave of urbanism, which took the names of New Urbanism in the USA and Place Making in the UK, proceeded on the shoulders of giants like Jane Jacobs (Jacobs, 1961), Christopher Alexander (Alexander, 1965), Gordon Cullen (Cullen, 1965), Kevin Lynch (Lynch, 1960), Oscar Newman (Newman, 1973), Donald Appleyard and Allan Jacobs (Appleyard, 1982) (Jacobs and Appleyard, 1987). These were protagonists of the first sharp criticism to the many facets of conventional urbanism in the early Sixties, still shrunk between endless sprawl and senseless towers-in-the-park. Such two models of conventional urbanism stemmed directly from the theories of those masters of thought, like Ebenezer Howard (Howard, 1902) and Le Corbusier (Corbusier, 1923), who shaped the new discipline of urban planning and design at the very dawn of the XXth century.

However, contemporary challenges are such – in terms of scale, type and urgency – that a much deeper shift is needed in urban disciplines just to start dealing with them. Some of us have recently argued that what we still miss is the serious consideration of the factor of time in urbanism, or, in other words, a deeper "time-conscious" approach (Thwaites, Porta, Romice, & Greaves, 2008). Inevitably, that means focusing on change as the essential dynamic of evolution in the built environment, which in turn leads to re-addressing concepts like control, self-organization and community participation. After time and change have been finally firmly placed at the centre stage, the whole discipline of urban planning and design, its conceptual equipment as well as its operational toolbox, reveals its weaknesses under a new light and calls for the construction of a different scenario.

It is a long story indeed. A story dense of intellectual challenges and adventurous human trajectories that sometimes resulted in sharp conflicts with each other. It was also a story of major failures. The whole culture of Place Making can be reduced to a long and difficult recovery from two models, the Garden City and the Radiant City, and the countless Levittowns and Pruitt-Igoes that derived from them. Those two models have permeated our urban culture and shaped both our industrial cities and our discipline since their very origins. After so much time and so many realizations, after the environmental challenges posed by global warming and the immense social challenges posed by global urbanization, the shortcomings of such two models are in front of our eyes: they are simply not sustainable anymore. The way to overcome these models is not easy. One may think that obstacles are very hard to overcome because they are enrooted in complex financial or political problems, but that is not the case. The problem is mainly cultural. And the first thing we can do to move our civilization forward towards better places is to acknowledge that there has been a deep cultural problem, it has mattered a lot, it is still here and it is not going to be removed without effort. Let's spend a few words on this cultural problem, keeping in mind the interpretation that we illustrated above, after Dawkins and Delius, of the structure of places as the traits of codes of information of a cultural kind, or memes.

Look around the new "urban jewels"; give a glance to glamorous architectural journals; listen to what is taught in the best schools of architecture. Generations after generations, we architects still perpetuate the gospel of conventional urbanism in a surreal childish game, where the higher the failure, the greater the honour. Our idea of designing cities is that you should do the job pretty much as if you were designing a building, but just a bit larger. Urban Design is still based on the scaling up of our architectural visions. Architects are very young professional figures: in the past they were master builders, serving the community by doing the right thing as it had always been done before, which resulted in adopting, preserving and respecting the overall structure of spaces. Even when a different professional figure emerged in the Renaissance and got established in the XVIIIth century, that of the architect scientist, builder and historian who responded to the new needs associated with major specialist buildings, those prominent constructions were conceived as part of the broader urban fabric with which maintained and reinforced the spatial links. Then, architecture was entirely reconfigured, in a different and even opposite way. We should pay a lot of attention to this passage. This passage, at the beginning of the XXth century, is crucial, because architecture changed its status from being a practical art and an experimental science, in the age of the master-builders as much as in Palladio's age, to being just a branch of the visual arts in the age of the avant-guards or, as Habraken calls it, the age of "Palladio's children" (Habraken, 2005). It is at this point that the dimension of the extraordinary prevailed on the ordinary, which has always been by far the largest portion of our cities, without even the slightest awareness of that, and architects started doing a different job. But the problem is that, in John Habraken's words, *"the demands of the everyday environment are vastly different from what is required to create the extraordinary. Nevertheless, the profession's self image, publications and ways of working still cling to its roots in monumental architecture"* (Habraken, 2005, p. IX).

The attitude to deal with the ordinary environments of our cities as if they where extraordinary exceptions as a side-effect of the original link of both professions with the emerging world of avant-gardes and visual arts is the cultural trap that our civilization owe to architects and urbanists (Wolfe, 1981; Silber, 2007; Jacobs, 1961; Ellin, 1999). This trap has substantially contributed, since the dawn of the XXth century in theory and after WWII on the ground, to subvert the very fundamental "permanent" structures that have been driving the creation and development of our cities throughout time and space, i.e. across history and geography. The practical consequences of this process, the emergence of what we believe is the very first "bifurcation" in the history of urban evolution, have been anticipated in theory and then detected in practice in "real time", for example by Ernst May, the planner in-chief of the city of Frankfurt (figure 3): these consequences are first and foremost the dissolution of the traditional block into a much larger in scale and inherently distinct urban element that has then evolved into two different and alternative configurations: the low-density low-rise "garden-city" suburb and the medium-to high-density and high-rise "tower-in-the-park" (Hall, 1996). These new urban formations have no parallel whatsoever in urban history. They are characterized mainly by the cancellation of the "perimeter block" (i.e. the block entirely built up along the street fronts) substituted by free standing high rise buildings or set back low rise cottages, the consequent cancellation of the services and shops aligned with street, substituted by specialized commercial centres, a significant increase in the sheer size of the block and a general drop in the building density.

– Figure 3 about here –

In parallel, the observation and study of ordinary spaces, i.e. measuring and understanding the form of everyday urban fabrics, developed as a separate discipline, "urban morphology", that is still today a specialism to a great extent detached from the mainstream of practice (Samuels, 1990). Rediscovering the essential properties, the permanent structures of places, to be able again to design the contemporary ordinary city: that is at the heart of the challenge. This approach is evidence-based and challenges our mother-discipline of architecture to the heart, questioning its very foundations. Apparently, it is a leap into an entirely different scientific domain and begins to delineate the foundations of a different discipline.

4.2. THE OXYMORON IN PRACTICE: PLANNING, ANTI-PLANNING AND DIFFERENT FORMS OF PARTICIPATION

One major characteristic of the different discipline is a focus on self-organization in the formation of urban space. This focus means conceiving the city as the stratification of billions of projects and plans, some large and some small, some collective and some individual, in endless mutual interaction in time. It means seeing what has been negated for too long: that self-organization has nothing to do with chaos, it is in fact a higher level of order. And that most if not all the most lively and successful parts of our cities are in fact those less planned, which means – by definition – more complex. And that the secret of all good cities has always been one specific feature, with which a city can be good or bad depending on many other factors, but it is alive and kicking, and without which a city can just be bad, because it is dead: adaptability. Adaptability, or the structural disposition of spaces to change by welcoming changing needs in time: that is key.

But if we bring the idea of self-organization from the domains of nature and society, where it has been firstly investigated, to the specific field of urbanism, we find one particular and very profound feature that, if missed, will render our approach too general and eventually blind: self-organization in cities has never been alternative to planning. Quite on the contrary, self-organization in cities has always been the effect of planning: *"building the city today could mean the wish to find again, perhaps with different forms, the qualities of proximity, mixture and the unexpected, i.e. a public space accessible to all, a variety of mixed activities, a built-up area that keeps adapting and transforming itself in unplanned neighbourhoods"* (Samuels, Panerai, Castex, & Depaule, 2004, p.159). Unplanned neighbourhoods are the result of adaptations and transformations of formerly planned structures. All major historical centres that we love today and that to our eyes epitomize organic and possibly "spontaneous" growth are in fact the result of transformation layered in time over structures that had largely been subdivided according to a plan since their very first origin, transformations that – in turn – had often been constituted by the addition and overlapping of single planned developments. It is in fact that kind of planning practice, heavily based on the work of surveyors acting under the commission of land holders (Slater, 1988) (Conzen, 1988), that made it possible for those transformations to occur and keep happening that reshaped a planned fabric into a rich, diverse and seemingly "natural" built environment.

This is to say that we should escape the flat juxtaposition of planning and self-organization that has so heavily braked our capacity of innovation in even the most progressive theories of urbanism in last decades. No one has ever built a significant piece of city in history only by "spontaneously" adding buildings after buildings without previously parcelling land, setting space for streets and establishing common rules and rights. Admittedly, it was a very fundamental, basic level of planning, but nevertheless it was about setting limits and shaping norms which normally were exactly the right limits and norms, and nothing more than that. So the point, if we are to govern again the realization of human and lively ordinary spaces in our cities, is not necessarily to explore hypothesis of no-planning or radically alternative anti-planning systems: the point is to learn what planning is best fit to set the right spatial structure for future change and adaptation. That is even more true in our times, when we need to achieve by virtue of a conscious and organized effort what once was shared and even unconscious knowledge, i.e. our “spontaneous consciousness” (Caniggia & Maffei, 2001).

One of the forms that the (fundamentally) anti-planning agenda has increasingly taken in recent times to reaffirm the lost link between communities and their environments is that of “participative planning”, meaning the many forms of inclusion of inhabitants or stakeholders in general in a consensus-building decisional process (Innes & Booher, 1999). Strengths of this approach are unquestionable, including especially the formation of social and political capitals and the relevance for decision making of information related with inhabitants’ life-world, which indeed is key and would otherwise be lost. However, weaknesses of these “collaborative” approaches have been many times outlined as well, both at theoretical and practical level.

What we need to emphasize in the context of this paper is one aspect that is very seldom, if ever, cited: the participative agenda, with all its emphasis on subjects (social actors) that have interests at stake at the moment of creating or regenerating the place, is even more focused than conventional approaches on the design phase, and very rarely takes into account the impacts that designed structures cast on future change. Urban settings do serve generations after generations of human beings in centuries; on the other hand, human needs and values change with people, which means in years and even months. So if the spatial structure is rigid and does not welcome change, it will not accommodate the needs and values of newcomers and therefore will shortly end up in a profoundly anti-human, unsustainable and anti-democratic spatial system, no matter the level of participation that had been originally insufflated into its creation.

That is not to say that processes of participation like “charrettes” are useless: quite on the contrary, such formal participation is needed to deal with some scales of urban change and some kinds of problems. For example, with some simplification we can associate formal participation to the dimension of the extraordinary: we evidently cannot rely on expensive (in financial and political terms) participative machines to deal with the everyday business of controlling change in everyone’s domain. The best feature of formal participation is its capacity to channel information from inhabitants’ life-world into the decisional arena and that is particularly needed whenever that arena is set at some higher level well off the ground of the ordinary inter-personal, inter-organizational or “grass-root” gaming. Moreover, experience suggests that formal participation works better where the capitals of public attention, financial resources and political commitment are concentrated on a few relevant decisional processes, as all of those capitals are increasingly insufficient and hard to be regenerated after expenditure. That is the way formal participation should enter a new and balanced planning system.

However, our argument here is to say that we also need to reactivate the circulation of information between inhabitants and powers through informal processes of participation based not as much on large formal gatherings and structured processes of inclusion as on the daily and direct control of inhabitants over the ordinary modification of their own individual and collective space, at different scales. And for the reasons discussed above, these very traditional processes of informal participation through ordinary change need to be enabled under conditions (including spatial conditions) that must be carefully identified, organized and planned. If such informal processes are not equally embedded in a renovated planning system, the link between planning and the space of the ordinary is destined to fail and so the actual content of democracy in planning to be significantly lowered. What is the nature of informal participation then? Jamel Akbar (Akbar, 1988) helps us in defining this essential problem by focusing on the many forms of control, i.e. who is legitimate to change what in the built environment of the everyday (figure 4).

– Figure 4 about here –

Jamel Akbar's model, that builds on lessons from John Habraken (Habraken, 2000), powerfully enlightens the deep nature of processes of change in the space of the ordinary and tells a lot about how we can encourage informal participation in them by orienting the planning process towards one or the other of the various "forms of submission" and by managing the size of "parties" involved, which in turn is relevant in understanding what we should borrow from traditional cities in a contemporary version of Plot-Based Urbanism. It is important to understand in fact that the space of self-organization so typically supported by pre-modern urban fabrics will never come back on its own under present day's conditions, which in fact typically inhibit it or, in other words, "kill it in the cradle". If we want self-organization to start up and take on in cities, we must plan them in a specific manner with that objective in mind.

And here we see the programme of the different discipline: we must explore the spatial, social, financial and political structures that will enable and feed once again processes of self-organization and informal participation in contemporary cities.

4.3. PLOT-BASED URBANISM: A DEFINITION

Plot-Based Urbanism (PBU) is the set of spatial structures conducive to urban spaces that are adaptable over time. These structures are spatial in nature, which means that they are not necessarily related with any particular kind of planning process: on the contrary, every process that embeds these principles is conducive to adaptable spaces.

PBU owes its denomination to the acknowledgment of the fundamental importance of the plot in the spatial structure of ordinary urban fabrics. How the plot is shaped, its size and geometry, its relationship with the street and the street hierarchy, how it forms up street fronts and eventually urban blocks, how all this informs human activities and urban functions, and finally how the plot finds a correspondence with property, usage and control, all that is fundamentally the matter of PBU. However, PBU doesn't mean that everything that is made of plots is fine. PBU is a specific kind of spatial structure made of a certain kind of plots, juxtaposed and mixed in a certain way, establishing a certain kind of relationship with the streets they front, etc. Eventually, issues of density and compactness are inherently part of the question.

Ultimately, Plot-Based Urbanism is place making made time-conscious (Thwaites et al, 2008).

Research on 20 small Scottish towns has shown the evolution of urban blocks through transitions from traditional to modern and from modern to post-modern (Hart, Hooi, Romice, & Porta, 2010). In the first transition, for many well documented reasons (the car being the most consequential), blocks expanded in size, decreased in functional complexity, lost front definition and became fairly homogeneous in structure, a pattern that is certainly not limited to Scotland but in fact is very general across at least the western world (Samuels, Panerai, Castex, & Depaule, 2004). The consequences of this change have been immense: block size impacted on access and movement, uniformity of functions and zoning, while lack of front definition largely affected the character of places. Moreover, the overall drop in density had been of sufficient magnitude to change forever the destiny of our cities. These structural changes had severe social repercussions: the separation of users and uses as well as the death of the street as a place for public life. In the second transition (modern to post-modern which has then led to the now widely practice of "place-making"), a lot changed to address the consequences of this block expansion on the form and performance of the city; nevertheless the size of blocks themselves remains fairly unchanged. The street is correctly perceived as the generator of life, and street layouts are amended, designed and implemented to encourage activity to take place. Architecture is scaled down to the people but, crucially, the block is still perceived as the design unit of the urban realm, like for example in the IBA experience in Berlin 1987 (Kleihues, 1987).

At the heart of Plot-Based Urbanism is the understanding that streets and street fronts require diversity and adaptability to support urban life; in design terms this implies, very simply, smaller units. The modernist/place-making block is still unitary in its overall conception and execution because it is conceived as the unit. The traditional city block was smaller and made of aggregations of smaller units, the plots. Plots have a direct relation to the street, with a profound impact on diversity and character, but also to the number of entrances to the block, with impact on activity within the block. Moreover, plots are independent, with impact on the diversity of the block, and guarantee that such diversity reflects the streets on which the block sits, impacting on its responsiveness to city life.

Research in urban morphology suggests that components of the structure of the block, as a combination of street fronts, are: PLOT, STREET, CENTRALITY, STREET FRONT, BLOCK.

PLOT. A PLOT is a fenced portion of land that is entirely accessible from the public space. Though PLOT and property may coincide, and very often do, what defines a PLOT is accessibility, not property. A result of this definition is that large properties may be split into small PLOT without necessarily subdividing the property of the land. In all such cases, PLOT are to be interpreted as the ultimate units of development.

STREET. A STREET is a mostly open space that is publicly accessed and establishes a functional, visual and spatial link with private domains, i.e. PLOT, by which it is defined. Cities exist and evolve across centuries, through endless changes of different magnitude happening at different pace. STREETS tend to be the most permanent elements of all, imposing conditions to the fabric that sits on them. STREETS are highly loaded with character and changing in type, meaning and value whilst penetrating the city. When allowed, they establish a functional and formal relationship with such fabric in terms of fundamental factors like density, land-use, size and geometry and accessibility of PLOTS. Such relationships are mainly the product of the evolution of the fabric in time, being selected according to local conditions including environmental, cultural, technical and financial. The key-factor that constitutes the link between STREETS and PLOTS is CENTRALITY.

CENTRALITY. CENTRALITY is here intended as a particular character attached to streets by their geometry (i.e. length) and topology (i.e. the way they are connected to each other). Work conducted in UDSU (Porta, Crucitti, & Latora, 2006) (Porta et al, 2011) as well as elsewhere (Hillier & Hanson, 1984) (Hillier, 1996) has led to mapping and modelling street CENTRALITY in a reliable and scientifically grounded way. Subsequent work is studying the formal relationships between streets and frontages to understand patterns of change of the latter in relation to change in the former. Studies in this line of research are beginning raising evidence on these key-relationship and, though there is a long way to go before these factors are sufficiently understood in detail, research is nonetheless firmly settled in its discipline, i.e. urban morphology, and therefore likely to develop relatively quickly.

STREET FRONT. STREET FRONTS are the formation of PLOTS facing a STREET. They are the key components of urban BLOCKS, yet their relation to STREETS is, in history, more direct and important. If a STREET FRONT can adapt to a STREET's character over time it makes it more versatile; if on the other hand it is linked to a whole BLOCK, its capacity to change and adapt is restricted, its lifespan shortened, with implications on character and quality of life. STREET FRONTS are made of PLOTS; and yet again, PLOTS have followed in time markets and density adapting in size to the nature of the STREET, which eventually is heavily influenced by its CENTRALITY .

BLOCK. An urban BLOCK is a mainly built-up urban area defined on its borders by STREETS, whose components are STREET FRONTS. We intend the urban BLOCK as a complex rather than a uniform element. Its character may vary a lot on each STREET FRONT depending on the type of STREETS it faces upon. An ordinary urban BLOCK exhibits four STREET FRONTS, because it normally sits on four STREETS. Because STREETS generally possess different "importance" (main, local, secondary...) depending on their CENTRALITY, the STREET FRONTS constituting an urban BLOCK reflect such diversity. This is due, again, by the evolutionary character of the ordinary urban fabric: its formation is led by STREETS developing in time from the most to the less central, a process which is accompanied by the subdivision of adjacent land in PLOTS and therefore the constructions of STREET FRONTS. Urban BLOCKS are the result of this stepped process, not its constituent unit: they are formed by the completion of this cycle of formation when it reaches the point where four STREETS close up in a loop and their STREET FRONTS get consequently developed. Planning strategies, especially those related with coding, should acknowledge this peculiar process by assuming that the unit of analysis and coding is the BLOCK only as a historical combination of STREET FRONTS.

5. Urban morphometrics: measuring the traits of urban form

Opening this paper, we have proposed the problem of place identity as a problem of life-generative design. Following a personal discussion with Christopher Alexander, we have questioned how life-bringing structures can be generated under a reformist, rather than revolutionary, approach to social change, ending up with the conclusion that this is possible, but only by embracing the temporal dimension of the long-term, i.e. many generations. We have then acknowledged that this implies the notion of evolution and the analogy with biology, and offered our interpretation of how this analogy has been variously treated by scholars in the disciplines of design at different scales. We have then positioned ourselves in the area of urban morphology and clarified the way we would use the analogy with evolution biology when speaking of evolution in the form of the urban fabric: for us, the urban form is a phenotypic trait determined by spatial codes of information of a cultural nature that we term "spemes". The coherent set of spemes that informs a certain recurrent unit of urban fabric is termed "spemome", and we have identified this unit to be the urban block as a combination of street fronts. We have proposed the hypothesis that the modern urban form after the year 1950 is a fundamentally different type of urban fabric than ever before, i.e. the first "bifurcation" in the relatively short history of urban fabric's evolution. We have finally proposed Plot-Based Urbanism for the recovery from this bifurcation as a different disciplinary framework for urbanists, that is grounded on the recognition of the set (spemome) of structural recurrent dispositions (spemes) of the urban fabric in the passage across this bifurcation, i.e. from pre-1950 to post-1950 urban form.

In this section, we present our first work along this line of research. First of all, we undertake this endeavour by means of a morphometric approach. We therefore observe the evolution of urban form, select the visible traits that we think have evolutionary significance, quantify those traits and their change in time, and try to verify statistically the hypothesis that a bifurcation has happened at some point close to the year 1950 leading to the emergence of at least one different species of urban form. Because the replication of the speme is produced, as any other cultural code, by imitation, we define two individual units of urban form as belonging to different species when their spemes cannot be imitated one into the other's set of codes, i.e. when we do not find recurrent traits in individuals of one species that are successfully replicated in individuals of the other.

5.1. MILAN (IT) AND GLASGOW (UK): THE DATASET

This research has engaged for 5 years students and staff of the course of Urban Design at the Polytechnic of Milan, from 2007 to 2009, and the University of Strathclyde, from 2009 to 2011. As part of their assignments, students have been led to analyse in the two cities of Milan (IT) and Glasgow (UK) some 41 blocks + 177 street fronts and 28 blocks + 116 street fronts respectively, using the same set of graphic elements, i.e. the same legend. This legend was developed from the start by the authors after a careful evaluation of the two seminal works of the founders of modern urban morphology, "Alnwick, Northumberland, a study in town-plan analysis" by M.R.G. Conzen (1960), and "Studi per una operante storia urbana di Venezia" by Saverio Muratori (1960). We especially analyzed the graphic methodology used by these two prominent scholars in mapping the urban fabric as related with their wider approach to the study of urban form, developing an understanding of similarities and differences among them. Our aim was to make a synthesis that: 1. Retained of Conzen the focus on the three elements of Town Plan, Building Form and Land Use as well as the quantitative description of those elements; 2. Retained of Muratori the penetration into the scale of the inner distribution of spaces within the building leading to the concept of "building type", and the overarching attitude towards making the work of analysis orientated to design. We see in figure 5 how these two authors used to map the urban form. In Conzen (figure 5a) we see a wide spectrum of information that covers the building type (determined according to the historical origin of the building and the kind of plot occupation), the plot (identified by property boundary), and the land use. In Muratori (figure 5b) we see the particular technique that is now recognized as the "signature" of the "Italian school" of urban morphology, i.e. the "rilievo murario" or "walls' representation". The technique was based on the personal expertise of Muratori's staff in understanding the age of the walls at sight, on the basis of their technical consistency and material. That allowed the realization of notorious sets of elegant drawings representing entire portions of urban fabrics of extreme complexity such as those of Venice. The detailed representation of internal partitions, however, would have been of no use in our research, and would rather have made it impossible the clear distinction of building types as defined in this research.

– Figure 5 about here –

Our research has been finally grounded on the plan representation of urban form exemplified in figure 6 as per the legends shown in figure 7. We codify two standard layouts, named Plan 1 and Plan 2, used in combination to represent each urban block. In this representation, Plan 1 reports the plan of the ground floor of the buildings and the open space of the block, the land-use at the ground floor (in colour on top of the buildings' footprint), the kind of open space surface, the entrances to the housing units with the number of housing units served in total, and the type of interface between buildings and street (including the active fronts, i.e. the fronts with non residential activities at the ground floor). In Plan 2 we represent the typical upper floor with an indication of the building type (in colour on top of the building footprint) and the accesses at the ground floor divided by type of access. Plot boundaries are represented in both Plans. Our definition of plot however differs from that of Conzen, which basically equals that of property. We define a plot as the unit of space that can be reached from an entrance placed on a public place until we face an impassable barrier (i.e. a fence, a wall). Our definition is, therefore, based on accessibility, not on property, though often the two overlaps.

– Figure 6 about here –

The main information on Plan 2, as stated above, is the recognition of the building type. Keeping our work as far as possible from the wealth of definitions of "building type" that have punctuated the recent history of urban architecture, we tried to stay stuck to the original lesson of Muratori and his closer "lineage' of scholars, with particular reference to the work of Caniggia and Maffei (2001). The taxonomy of building typology in this research is based only and entirely on three factors: 1. The single or multi family tenure condition of the building; 2. The number of housing units served by one stair case at the typical upper floor; 3. The level of aggregation (or isolation) of the building with respect to the adjacent buildings. This taxonomy is reported in Figure 7b and exemplified in the two cases shown in Figure 8.

– Figure 7 about here –

– Figure 8 about here –

Our students, grouped in pairs, were assigned two blocks per group. Blocks were pre-selected by the authors and assigned to groups. The overarching criterion adopted for the selection of the blocks was to pick up from the current city cases that were representative of typical models of urban fabrics across three levels: 1. Fronts are selected by staff in representation of a range of combined different options based on density, land-use and building type. This organizational framework, that we termed Local Transect, with reference to the Transect planning tool elaborated by Andres Duany and the Smart Code system (CATS, 2003), is structured as follows:

- **01_HIGH DENSITY**
  - 01.A. Mixed Use
    - 01.A.a. Aggregated
    - 01.A.b. Isolated
  - 01.B. Mostly Residential
    - 01.B.a. Aggregated
    - 01.B.b. Isolated
- **02_MEDIUM DENSITY**
  - 02.A. Mixed Use
    - 02.A.a. Aggregated
    - 02.A.b. Isolated
  - 02.B. Mostly Residential
    - 02.B.a. Aggregated
    - 02.B.b. Isolated
- **03_LOW DENSITY**
  - 03.A. Mixed Use
    - 03.A.a. Aggregated
    - 03.A.b. Isolated
  - 03.B. Mostly Residential
    - 03.B.a. Aggregated
    - 03.B.b. Isolated

One specific block would be then a Low Density / Mostly Residential / Isolated case (03.B.b), for example a typical “sprawled” suburban development. It is important to notice that by no means the age of the block played any part into this selection. As noted, the selection was based uniquely on factors of form (density and aggregation) and land use (mixite’). Once assigned the blocks, students’ proceeded in steps. First, they achieved the Ordnance Survey maps of the blocks (and their immediate surroundings), and developed a first round of graphic elaboration. Second, they looked at web resources such as Google Earth, Google Street View, Bing Maps, About My Place or Open Street Map, to update and enrich their maps. Third they went out and run a personal field campaign to finalize the work on the blocks. Finally, they prepared the final layout of Plan 1 and 2. The entire process is doable in a couple of weeks for every pair of students (and of blocks) including the production of the final layout.

Trait	Name	Num	Description
1	Area of the block	m^2	Total area of the block measured on the border with the street right of way
2	Permeable area (%)	m^2	Total area of permeable terrain in the block
3	Building height in num. of storeys (mean)	n	Average height of all buildings in the block. The average height is weighted on the coverage area of each building
4	Built front ratio	m/m	Extension fo the block perimeter that presents buildings within the band obtained by offsetting the perimeter 8m Inside, on the total block perimeter length
5	Building floor area	m^2	Total amount of the floor area of the buildings in the block. It equals, in each building, the coverage area multiplied by the number of storeys
6	Compactness	m^2/m^2	The percentage of the area of the block on the area of the circumscribed circle having centre in the block centroid
7	Covered area ratio	m^2/m^2	The ratio of the area covered by all buildings in the block on the area of the block
8	Building density	n/ha	Number of housing units on the area of the block (in hectares)

Table 2a. Blocks: final list of variables

Trait		Num	Name
1	Street front length	m	Linear extension of the street front
2	Built front ratio	m/m	Linea extension of the street front that presents buildings within the band obtained by offsetting the perimeter 8m Inside, on the total extension of the street front
3	Active street front ratio	m/m	Linea extension of the street front that presents non-residential activities at the ground floor, on the total extension of the street front
4	Plot edge on street (mean)	m	Average extension of the plot front on street
5	Plot edge on street (st dev)	m	Standard deviation of the extension of the plot front on street calculated over all the plots in the street front
6	Accesses from street (pedestrian ratio)	n/m	The number of pedestrian accesses from street on the total extension of the street front. One access leading to many units counts as 1.
7	Accesses in plot (ratio)	n/n	The number of pedestrian accesses located in the inner space of the plot on the total number of accesses from the street.
8	Street section (width)	m	Width of the street
9	Street centrality	C^B	The betweenness centrality of the street
10	Distance from city centre	m	Distance from the centre of the city
11	Building density	n/m	Number of housing units on the total extension of the street front

Table 2b. Street fronts: final list of variables

The representation adopted in Plan 1 and Plan 2 allowed our students to gather, directly from the graphics, a wealth of measures referred to a set of variables. The calculation of the variables, in effect the fifth and final step of the students' work, proved to be the most difficult, for the number of different interpretations that are always possible in teams with no previous training or experience in this field. At the end, it has always been a work of trial and error with a number of successive revisions and refinements over another fortnight of work. Students calculated a set of 49 variables, some independent and some as functions of the formers (in that case, automatically calculated by pre-constituted spreadsheets). These variables were grouped into two non-overlapping sub-sets: variables of the block (28 variables) and of the street front (21 variables). Blocks and street fronts, therefore, have not been conceived as alternative, but rather as complementary descriptions of the same case. The 49 variables measured by the students on Plan 1 and 2 have been successively subjected to a process of revision and selection by the authors in order to reduce their redundancy. This has been done on the basis of a correlation analysis and a Principal Component analysis, so that we eliminated the most of the pairs of variables on top of the correlation ranking and kept most of the high contributors to the PCA principal axis. At the end of this process, we finally reached a dataset 8 variables for the blocks and 11 variables for the street fronts (table 2).

5.2. RESULTS

Our analysis of the dataset was undertaken in two successive steps. First we run a Principal Component Analysis (PCA) to reduce the number of dimensions of the data, given by the number of variables used (i.e. 8 for the blocks and 11 for the street fronts) in a more manageable set of 3 Principal components. This turned out to explain respectively the 77% and the 45% of the variance of the original dataset (figure 9b and e): the difference in the explanatory capacity between blocks and street fronts is in itself a finding of our research, indicating that variables used to capture the urban form of street fronts behave in a more variegated way from case to case, i.e. the form of street fronts is more specific of each front. Blocks, in short, exhibit a more homogeneous form when quantified on average over the whole block than in terms of their street form components. Moreover, we look at the contribution of variables to the 3 principal components, identifying those variables that are, alone, most representative of the behaviour of the whole set of variables across all cases. We observe that the top half variables in ranking are:

For **Blocks (Bv.)**:

- 1. AREA OF THE BLOCK
- 5. BUILDING FLOOR AREA
- 8. BUILDING DENSITY
- 7. COVERED AREA RATIO

For **Street Fronts (Fv.)**:

- 6. ACCESSES FROM STREET (PEDESTRIAN RATIO)
- 7. ACCESSES IN PLOT (RATIO)
- 10. DISTANCE FROM CITY CENTRE
- 3. ACTIVE STREET FRONT RATIO
- 1. STREET FRONT LENGTH

That tells us two things. On one hand, variables of "size" (BV.1 AREA OF THE BLOCK and BV.5 BUILDING FLOOR AREA; FV.1 STREET FRONT LENGTH) are all included in the top half. On the other hand, density (BV.8 BUILDING DENSITY), coverage (BV.7 COVERED AREA RATIO), accesses (FV.6 ACCESSES FROM STREET (PEDESTRIAN RATIO) and FV.7 ACCESSES IN PLOT (RATIO)) and active fronts (FV.3 ACTIVE STREET FRONT RATIO), all key variables in the description of the "bifurcation" illustrated above, are equally included in the top half.

– Figure 9 about here –

Second, we performed a correlation analysis separately for blocks and street fronts in three ways: on one side, we looked at the correlation between variable and the age of urbanization; on the other side, we studied the percentage of cases clusterized by Ward-linkage method according to class of age (before and after the year 1950); finally, we analysed the correlation between variables in all possible pairs. The relevant results are presented below:

In figure 9c and f all cases are placed in the 3D space of the PCA components and then coloured according their age of urbanization. We see here a clear structure emerging as dots are not randomly placed but rather concentrate in certain areas of the space according to their colour. This means that the urban form of the cases as captured by the variables used in this study projected over the three PCA components is clearly correlated with their age. This result is confirmed in figure 10 (top) where this correlation is found to be significant for blocks (a) and fronts (b), especially in terms of average values (Bρ=0.89 and Fρ=0.98), with the correlation of fronts being remarkably higher and almost equalling 1.

– Figure 10 about here –

As for the correlation of single variables with the age of urbanization we obtained the results illustrated in the table 3 below. We observe that all block and street front variables that mark the difference between pre and post 1950 urbanism, i.e. those that play a key role in the bifurcation, exhibit the highest correlations, along with variables of size and location (like BV.1 AREA OF THE BLOCK, FV.10 DISTANCE FROM CITY CENTRE and FV.9 STREET CENTRALITY). For example we notice, in the street fronts cohort, the case of FV.3 ACTIVE STREET FRONT RATIO, which appears significantly correlated with age: this proofs the linkage of the street front bifurcation with a crucial change in the relationship between private and public space, which in modern urbanism is no longer mediated by the street. This was explicitly supported by Le Corbusier's ideas to plan for the "mort de la rue" ("death of the street").

Trait	Name	Corrleation with Age
1	Area of the block	0,28355
2	Permeable area (%)	0,39301
5	Building floor area	0,39301
7	Covered area ratio	0,23799
3	Building height in num. of storeys (mean)	0,08587
6	Compaciness	-0,00280
8	Building density	-0,35422
4	Built front ratio	-0,52708

Trait		Corrleation with Age
10	Distance from city centre	0,56954
4	Plot edge on street (mean)	0,22635
1	Street front length	0,14244
7	Accesses in plot (ratio)	0,10173
5	Plot edge on street (st dev)	0,07199
11	Building density	-0,00306
8	Street section (width)	-0,02271
6	Accesses from street (pedestrian ratio)	-0,10210
9	Street centrality	-0,12538
2	Built front ratio	-0,29730
3	Active street front ratio	-0,35808

Table 3. Correlation of variables measuring the urban form of blocks (left) and street fronts (right) with their age of urbanization

The correlation with age is also investigated by grouping all cases in the two cohorts depending on whether they were urbanized before or after the year 1950, then performing a clusterization analysis using the Ward-linkage method over cases described by all possible pairs of variables, and finally measuring the percentage of cases in each pair for which clusterization matched with the age group (figure 10, bottom). We highlight that the clusterization method operates a completely autonomous grouping only on the basis of the behaviours of our variables; therefore what we study here is the extent to which similarities in the urban form across cases as measured with one pair of variables were reflected in their age of urbanization. Results indicate that cases cluster according to age to a great extent: the best hit for blocks (75%) is between the two variables BV.3 BUILDING HEIGHT IN NUMBER OF STOREYS (MEAN) and BV.4 BUILT FRONT RATIO, while the best hit for street fronts is equally achieved at 69% by 3 pairs of variables: FV.1 STREET FRONT LENGTH and FV.4 PLOT EDGE ON STREET (MEAN); FV.4 PLOT EDGE ON STREET (MEAN) and FV.8 STREET SECTION (WIDTH); and finally FV.4 PLOT EDGE ON STREET (MEAN) and FV.11 BUILDING DENSITY. We observe of course that the variable FV.4 PLOT EDGE ON STREET (MEAN), which measures the average length of the edge of plots abutting on the street, is present in all highest hits correlations with age. As noticed before, this variable exhibits in itself a significant and positive correlation with age, meaning that with the passage of time the average length of plot's edge on street has increased. In short, this tells us that plots edge on streets consistently increased after the advent of professionally planned developments after year 1950 and that this trait is highly relevant among the many others measured in this research. Additional findings in this area, not reported here in figures, include the following.

1. Second best score for blocks are about 9 pairs of variables all hitting the age grouping (pre or post 1950) at 70%. These are:
    - BV.1 AREA OF THE BLOCK and BV.2 PERMEABLE AREA (%);
    - BV.1 AREA OF THE BLOCK and BV.3 BUILDING HEIGHT IN NUM. OF STOREYS (MEAN);
    - BV.1 AREA OF THE BLOCK and BV.4 BUILT FRONT RATIO;
    - BV.1 AREA OF THE BLOCK and BV.5 BUILDING FLOOR AREA;
    - BV.1 AREA OF THE BLOCK and BV.6 COMPACTNESS;
    - BV.1 AREA OF THE BLOCK and BV.7 COVERED AREA RATIO;

- BV.1 AREA OF THE BLOCK and BV.8 BUILDING DENSITY;
- BV.5 BUILDING FLOOR AREA and BV.8 BUILDING DENSITY;
- BV.4 BUILT FRONT RATIO and BV.5 BUILDING FLOOR AREA;

2. The same analysis operated with triplets of variables rather than pairs, gives the following results:
    - For blocks, the best triplet is composed by BV.4 BUILT FRONT RATIO and BV.5 BUILDING FLOOR AREA and BV.6 COMPACTNESS; this hits the age grouping at 77%;
    - For street fronts, the two best triplets are composed by FV.1 STREET FRONT LENGTH and FV.4 PLOT EDGE ON STREET (MEAN) and FV.8 STREET SECTION (WIDTH); and by FV.1 STREET FRONT LENGTH and FV.4 PLOT EDGE ON STREET (MEAN) and FV.11 BUILDING DENSITY; both equally hit the age grouping at 69%.

What begins to be delineated here are the sets of spatial relationships (spemes) that, by recursively showing the ability to characterize cases of different ages such that we can group them in two age groups (pre and post 1950) according to their value (allele of spemes), constitute the stock of genetic information (genome) that determine the urban form at the chosen scale (blocks and street front); in short, we are grasping the first clues of what would constitute its spemome. These results are not trivial: for example, we observe that the best triplet for blocks includes one variable, BV.6 COMPACTNESS, which does not show any significant correlation with age, and the same can be said of 3 out of the 4 variables composing the two best triplets for street fronts (table 3). We see here that the form of places is most effectively defined in history by combinations of spatial relationships that, individually, have a scarce capacity to do so. It is not as much the individual spemes alone, as their specific combination into a spemome, which frames the historical identity of places.

Finally, we analyzed the correlation among all pairs of variables in blocks and street fronts. The results are listed in Table 4. Without entering the discussion of every pair, we should emphasize that the way the analysis captures the history of the bifurcation in the evolution of the urban form at the scale of the block and the street fronts is adamant and dense of interesting – and sometimes counter-intuitive – information. For example: at the block level we observe that the building coverage of the block grows with the growth of the block area; we know that both the variables are grow with age (the more recent the block, the higher the values): this combination is consequent to the formation of low rise sprawled suburbs as well as high rise tower blocks, which in fact in the practice of real developments cover the area of the block to a greater extent than traditional urbanism due to the proliferation of service buildings. Again, this is only apparently in contradiction with the growth of permeable areas with age: in traditional urbanism buildings leave more space free in the block, but that space (mostly inner courtyards) is paved more extensively and therefore on average it is less permeable. At the street front level, we see that the linear extension of plot edge on streets grows on average with the distance from the city centre, and both are also positively correlated with age. Moreover, the amount of active street frontage per meter of total frontage grows with the centrality of streets, which is perfectly aligned with the theory of the evolution of urban form from a street-oriented environment where services and shops constitute the mediation between private and public space to a inward-looking fence-dominated environment where the relationship between public and private is in fact made "hard" and effectively negated (Gehl, 1987).

Variable 1		Variable 2		Correl.
1	Area of the block	5	Covered area ratio	0,84044
4	Built front ratio	7	Covered area ratio	0,72160
7	Covered area ratio	8	Building density	0,60846
4	Built front ratio	8	Building density	0,43460
3	Building height (mean)	5	Building floor area	0,38834
3	Building height (mean)	8	Building density	0,32105
1	Area of the block	2	Permeable area (%)	0,30518
3	Building height (mean)	6	Compactness	0,23243
5	Building floor area	6	Compactness	0,22435
1	Area of the block	6	Compactness	0,18285
1	Area of the block	3	Building height (mean)	0,13209
5	Building floor area	8	Building density	0,05520
6	Compactness	8	Building density	0,05508
2	Permeable area (%)	6	Compactness	0,02430
2	Permeable area (%)	5	Covered area ratio	0,02315
4	Built front ratio	6	Compactness	-0,04892
6	Compactness	7	Covered area ratio	-0,06635
2	Permeable area (%)	3	Building height (mean)	-0,11149
3	Building height (mean)	7	Covered area ratio	-0,13570
5	Covered area ratio	7	Covered area ratio	-0,14037
1	Area of the block	8	Building density	-0,21295
4	Built front ratio	5	Covered area ratio	-0,22000
3	Building height (mean)	4	Built front ratio	-0,24942
1	Area of the block	7	Covered area ratio	-0,35419
1	Area of the block	4	Built front ratio	-0,39325
2	Permeable area (%)	4	Built front ratio	-0,54765
2	Permeable area (%)	8	Building density	-0,56702
2	Permeable area (%)	7	Covered area ratio	-0,70128

Variable 1		Variable 2		Correl.
6	Access str. (ped. ratio)	7	Accesses plot (ratio)	0,56215
4	Plot edge (mean)	10	Distance city centre	0,25578
3	Active street front ratio	9	Street centrality	0,22797
4	Plot edge (mean)	5	Plot edge (st dev)	0,21673
6	Access str. (ped. ratio)	9	Street centrality	0,21117
7	Accesses plot (ratio)	9	Street centrality	0,21073
3	Active street front ratio	8	Street section (width)	0,19947
2	Built front ratio	3	Active street front ratio	0,17635
1	Street front length	11	Building density	0,17256
8	Street section (width)	9	Street centrality	0,16932
2	Built front ratio	11	Building density	0,14881
1	Street front length	8	Street section (width)	0,14615
8	Street section (width)	11	Building density	0,14367
1	Street front length	4	Plot edge (mean)	0,13372
7	Accesses plot (ratio)	11	Building density	0,11555
2	Built front ratio	6	Access str. (ped. ratio)	0,09068
1	Street front length	7	Accesses plot (ratio)	0,08771
1	Street front length	10	Distance city centre	0,08589
2	Built front ratio	9	Street centrality	0,07509
5	Plot edge (st dev)	10	Distance city centre	0,03685
9	Street centrality	11	Building density	0,02788
3	Active street front ratio	6	Access str. (ped. ratio)	0,02599
5	Plot edge (st dev)	7	Accesses plot (ratio)	0,02375
4	Plot edge (mean)	7	Accesses plot (ratio)	0,01104
3	Active street front ratio	11	Building density	0,00758
7	Accesses plot (ratio)	10	Distance city centre	0,00586
1	Street front length	9	Street centrality	-0,00492
1	Street front length	6	Access str. (ped. ratio)	-0,00749
4	Plot edge (mean)	11	Building density	-0,00953
7	Accesses plot (ratio)	8	Street section (width)	-0,01429
1	Street front length	2	Built front ratio	-0,01532
2	Built front ratio	8	Street section (width)	-0,02571
10	Distance city centre	11	Building density	-0,03048
3	Active street front ratio	5	Plot edge (st dev)	-0,03476
6	Access str. (ped. ratio)	10	Distance city centre	-0,03944
4	Plot edge (mean)	8	Street section (width)	-0,04306
1	Street front length	5	Plot edge (st dev)	-0,04926
5	Plot edge (st dev)	6	Access str. (ped. ratio)	-0,05308
6	Access str. (ped. ratio)	11	Building density	-0,05639
2	Built front ratio	7	Accesses plot (ratio)	-0,05904
6	Access str. (ped. ratio)	8	Street section (width)	-0,06840
4	Plot edge (mean)	9	Street centrality	-0,07575
8	Street section (width)	10	Distance city centre	-0,08261
5	Plot edge (st dev)	8	Street section (width)	-0,08733
5	Plot edge (st dev)	11	Building density	-0,09057
3	Active street front ratio	7	Accesses plot (ratio)	-0,09233
5	Plot edge (st dev)	9	Street centrality	-0,10124
2	Built front ratio	5	Plot edge (st dev)	-0,10390
1	Street front length	3	Active street front ratio	-0,11670
3	Active street front ratio	4	Plot edge (mean)	-0,16589
9	Street centrality	10	Distance city centre	-0,16680
4	Plot edge (mean)	6	Access str. (ped. ratio)	-0,17372
2	Built front ratio	4	Plot edge (mean)	-0,17478
2	Built front ratio	10	Distance city centre	-0,21110
3	Active street front ratio	10	Distance city centre	-0,35150

Table 4. Correlation of pairs of variables measuring the urban form of blocks (left) and street fronts (right)

6. Conclusions

This research is a study of the evolution of the urban form at the scale of the block and the street front. We have established a framework for the use of the analogy between evolution in urban form and in other areas of life and cultural sciences by proposing that urban form is a special class of cultural product embedded in space and that its unit of coded information, the "speme", gets replicated in social culture essentially by imitation.

We have proposed a broad picture of evolution in urban form identifying in the year 1950 time of its very first "bifurcation", with the "speciation" of two completely different types of urban formations derived form the theories of the "Garden City" and the "Radiant City" that appeared in the first 3 decades of the XXth century and started to generate a massive difference on the ground after the second World War. We have also proposed that the proper unit of analysis for the study of the evolution of urban form, the "individual", is the urban blocks as a composition street fronts.

These two proposal have been then tested against tens of cases analyzed in the past 5 years by students of our courses of Urban Design first in Milan (IT) and then in Glasgow (UK). Students measured the urban form of those cases using a set of variables that then we have further selected in order to eliminate un-necessary redundancy. The dataset formed by the final set of variables was calculated with 8 variables for the measurement of blocks and 11 for that of street fronts. Street fronts have been predominantly picked up from the same blocks selected for this analysis. We have then elaborated statistics to determine to what extent the variables were able to characterize blocks and street front according to their age, and more specifically those belonging to pre or post year 1950, i.e. to describe the bifurcation. Moreover, we wanted to understand what combination of variables (i.e. what "spemome") could best approximate the same age split. A number of ancillary observation have been then highlighted regarding the cross-correlation of pairs of variables and the relevance of variables to the explanation fo the total variance of the dataset in terms of their contribution to the axis determined in the Principal Component Analysis.

Results suggest that the selected variables have a high capacity to describe the bifurcation.

Moreover, the size of the units (area of blocks and length of the street fronts) along with that of plots edge on streets, building density and the occupation of the block edge by buildings are of paramount importance in the generation of the urban form in the passage from pre to post year 1950.

Further research using this same database will be directed in two directions: on one side, we want to refine the age split with a finer definition of relevant historical periods, i.e. <=1860, 1861-1950, 1951-1980, 1981-today; on the other hand, we want to work on the description of the speme alleles in the different urban types at a much finer scale that takes into account densities and land uses, elaborating the average values of the most relevant variables along with their standard deviation.

Finally, a larger significance of this first step into the determination of "the DNA of places" could only be achieved with a study on a much larger evidence from real cases all over the world.

References

Akbar, J. (1988), Crisis in the built ennvironment: the case of the Muslim city, Mimar, Singapore.

Alexander, C. (1965), A city is not a tree, Architectural Forum , 122 (1), (Part I), 58-62.

Alexander, C. (1985), The Production of Houses, Oxford University Press, Oxford, UK.

Alexander C. (2003), The Nature of Order: an essay on the art of building and the nature of the universe, Book 2, The Process of Creating Life, Oxford University Press, Oxford, UK.

Alexander, C. (in print), The Battle for the Life and Beauty of the Earth, Oxford University Press, Oxford, UK.

Appleyard, D. (1982), Livable streets, University of California Press, Berkeley, CA, USA.

Barthelemy, M. (2010), Spatial Networks, arXiv:1010.0302v2

Batty, M. Longley, P (1994), Fractal Cities: A Geometry of Form and Function, Academic Press, San Diego, CA.

Bettencourt, LMA. Lobo, J. Helbing, D. Kühnert, C. West, GB. (2007), Growth, innovation, scaling, and the pace of life in cities, Proceedings of the National Academy of Sciences of the USA.

Boccaletti, S. Latora, V. Moreno, Y. Chavez, M; Hwang, D.U. (2006), Complex Networks: Structure and Dynamics, Physics Reports 424, 175.

Brand, S. (1994), How Buildings Learn: What Happens After They're Built, Viking Press, New York, NY, USA.

Caniggia, G. Maffei, GL. (2001), Architectural composition and building typology: interpreting basic building, Alinea, Firenze, IT.

Calthorpe, P. Fulton, W. (2001), The regional city: planning for the end of sprawl, Island Press, Washington DC, USA.

Cataldi, G. (1997), The Italian school of process typology, Urban Morphology, 1.

CATS (2003), Smart Code version 9.2, The Town Paper Publisher, Gaithersburg, MD, USA.

Conzen, MRG. (1960), Alnwick, Northumberland: a study in town-plan analysis, George Philip & son, London, UK.

Conzen, M. R. (1988), Morphogenesis, morphological regions and secular human agency in the historic townscape, as exemplified by Ludlow, In D. Denecke, G. Shaw, Urban historical geography: recent progress in Britain and Germany (pp. 253-272). Cambridge University Press, Cambridge, UK.

Corbusier, L. (1923), Vers une architecture, Les Èdition G. Crès et C, Paris.

Cullen, G. (1965), Townscape, Architectural Press, Oxford, UK.

Dawkins, R. (2006), The selfish gene, Oxford University Press, Oxford, UK.

Delius, JD. (1991), The nature of culture, In Dawkins, MS. Halliday, TR. Dawkins, R. The Tinbergen legacy (pp. 75-99), Chapman and Hall, London, UK.

Eisenman, P. (2005). CodeX. Monacelli Press, New York.

Ellin, N. (1999), Postmodern Urbanism, Princeton Architectural Press, New York, NY, USA.

English Partnership and Housing Corporation. (2000), Urban Design Compendium, Llewelyn Davies, London, UK.

Fraser, J. (1995). An Evolutionary Architecture. The Architecture Association. London. Available at: http://www.aaschool.ac.uk/publications?ea?intro.html. Visited10 Dec 2010.

Frey, H. (1999), Designing the city: towards a more sustainable urban form, E&FN Spon, London, UK.

Gehl, J. (1987), Life Between Buildings, Van Nostrand Reinhold, New York, NY, USA.

Goodyear, P. Retalis, S. (2010), Technology-enhanced learning: design patterns and pattern languages, Sense Publishers, Rotterdam, NL.

Habraken, J. (2000), The structure of the ordinary: form and control in the built environment, The MIT Press, Cambridge, MA, USA.

Habraken, J. (2005), Palladio's Children: Essays on Everyday Environment and the Architect, Taylor & Francis, New York, USA.

Hall, P. (1996), Cities of tomorrow: an intellectual history of urban planning and design in the twentieth century, Blackwell, Oxford, UK.

Hart, L.,Hooi, J. Romice, O. Porta, S. (2010), Under the microscope: 20 small towns in Scotland, University of Strathclyde, Glasgow, UK.

Hofmeister, B. (2004), The study of urban form in Germany, Urban Morphology 8 1.

Howard, E. (1902), Garden cities of to-morrow, S. Sonnenschein & Co, London, UK.

Hillier, B. Hanson, J. (1984), The social logic of space, Cambridge University Press, Cambridge, UK.

Hillier, B. (1999), Space is the Machine: a Configurational Theory of Architecture, Cambridge University Press, Cambridge, UK.

Innes, J. Booher, D. (1999), Consensus-building as role-playing and bricolage: toward a theory of collaborative planning. Journal of the American Planning Association , 65 (1), 9-26.

Jacobs, A. Appleyard, D. (1987), Toward an Urban Design manifesto, Journal of the American Planning Association , 53 (1), 112-120.

Jacobs, J. (1961), The Death and Life of Great American Cities, Random House, New York.

Jenks, M. Burgess, R. (2000), Compact cities: sustainable urban form for developing countries, Spon Press, London, UK.

Kleihues, JP. (1987), International Building Exhibition Berlin 1987: examples of a new architecture, Rizzoli, Berlin, DE.

Krieger, A. Lennerz, W. (1991), Towns and townmaking principles: Andres Duany and Elizabeth Plater-Zyberck, architects. Rizzoli International Publications, New York, USA.

Lévi-Strauss, C. (1965), Elogio dell'antropologia, Aut Aut, n.88.

Lynch, K. (1960), The image of the city, MIT Press, Cambridge, USA.

Marshall, S. (2008). Cities design and evolution. Milton Park, Abingdon: Routledge.

Marzot, N. (2002), The study of urban form in Italy, Urban Morphology, 6 2.

McGlynn, S. Smith, G. Alcock, A. Murrain, P. Bentley, I. (1985), Responsive environments: a manual for designers, Architectural Press, Oxford, UK.

Mehaffy, M. Porta, S. Rofè, Y. Salingaros, N. (2010), Urban nuclei and the geometry of streets: The 'emergent neighborhoods' model, Urban Design International, 15-1, p.22-46.

Mehaffy, M. (2010), Horizons of Pattern Languages, in Patterns, Pattern Languages and Sustainability, University of Oregon Foundation.

Mehaffy, M. (in print), A city is not a rhinoceros: On the aims and opportunities of morphogenetic urban design, Marshall and Çaliskan (eds), Urban morphology and design, Built Environment, special issue.

Muratori, S. (1960), Studi per una operante storia urbana di Venezia, Istituto Poligrafico dello Stato, Roma, IT.

Neis, H. (2011), Fall 2009 International PUARL Symposium, The PUARL Press, Portland, Oregon, USA.

Newman, O. (1973), Defensible space: crime prevention through environmental design, Macmillan Pub Co, New York, USA.

Newman, P. Kenworthy, J. (1999), Sustainability and cities: overcoming automobile dependence, Island Press, Washington DC, USA.

Pagel, M. (2009), Natural selection 150 years on, Nature, 457 12.

Porta, S. Crucitti, P. Latora, V. (2006), The network analysis of urban streets: a primal approach, Environment and Planning B, Planning and Design (33), 705-725.

Porta, S. Latora, V. Strano, E. (2010), Networks in Urban Design: six years of research in Multiple Centrality Assessment, In E. Estrada, M. Fox, D. Higham, & G. L. Oppo (Eds.), Network science: complexity in nature and technology (pp. 107-130), Springer, London, UK.

Porta, S. Latora, V. Wang, F. Rueda, S. Strano, E. Scellato, S. Cardillo, A. Belli, E. Cardenas, F. Cormenzana, B. Latora, L. (2011), Street Centrality and the Location of Economic Activities in Barcelona, Urban Studies, 1 18.

Salingaros, N. (2004), Anti-Architecture and Deconstruction, Umbau-Verlag, Solingen, Germany.

Salingaros, N. (2005), Principles of Urban Structure, Techne Press, Amsterdam, NL.

Salingaros, N. (2006), A Theory of Architecture, Umbau-Verlag, Solingen, Germany.

Samuels, I. (1990), Architectural practice and urban morphology, In T. Slater (Ed.), The built form of western cities, Leicester University Press, Leicester, UK.

Samuels, I. Panerai, P. Castex, J. Depaule, JC. (2004), Urban forms: the death and life of the urban block, Architectural Press, Oxford, UK.

Schumacher, P. (2010), Parametricism and the Autopoiesis of Architecture, Lecture at SCI-Arc, Los Angeles, September 2010, available at: http://www.patrikschumacher.com/Texts/Parametricism%20and%20the%20Autopoiesis%20of%20Architecture.html. Visited 16 Sept 2011.

Silber, J. (2007), Architecture of the Absurd: How "Genius" Disfigured a Practical Art, Quantuck Lane Press, New York, NY, USA.

Slater, T. (1988), Medieval composite plan towns in England: evidence from Bridgnorth, Shropshire, University of Birmingham, School of Geography. University of Birmingham, Birmingham, UK.

Soddu, C. (2005), Generative Art in Visionary Variations, Art+Math=X conference, University of Colorado, Boulder, 2005

Soddu, C; Colabella, E. (2005), Argenia, a mother tongue in infinite variations, DCC conference workshop, MIT Boston, 2005. Available at: http://www.soddu.it/papers_ucla.htm. Visited Visited 16 Sept 2011.

Sokal, A. Bricmont, J. (1999), Fashionable Nonsense: Postmodern Intellectuals' Abuse of Science, Picador, London, UK.

Steadman, P. (2008). The evolution of designs. Milton Park, Abingdon: Routledge.

The Urban Task Force. (1999), Towards an urban Renaissance, Queen's Printer and Controller of HMSO, London, UK.

Thwaites, K. Porta, S. Romice, O. Greaves, M. (2008), Urban Sustainability through Environmental Design: approaches to time-people-place responsive urban spaces, Routledge, London, UK.

Whitehand, JWR. (2001), British urban morphology: the Conzenian tradition, Urban Morphology 5 2.

Wolfe, T. (1981), From Bauhaus to our house, Farrar, Straus and Giroux, New York.

Figures

Figure 1. Entry path to West Dean Visitors Centre in West Sussex, England. The complex was built under the direction of Christopher Alexander and the Centre for Environmental Structure. Photo by courtesy of dr. Kevin Thwaites.

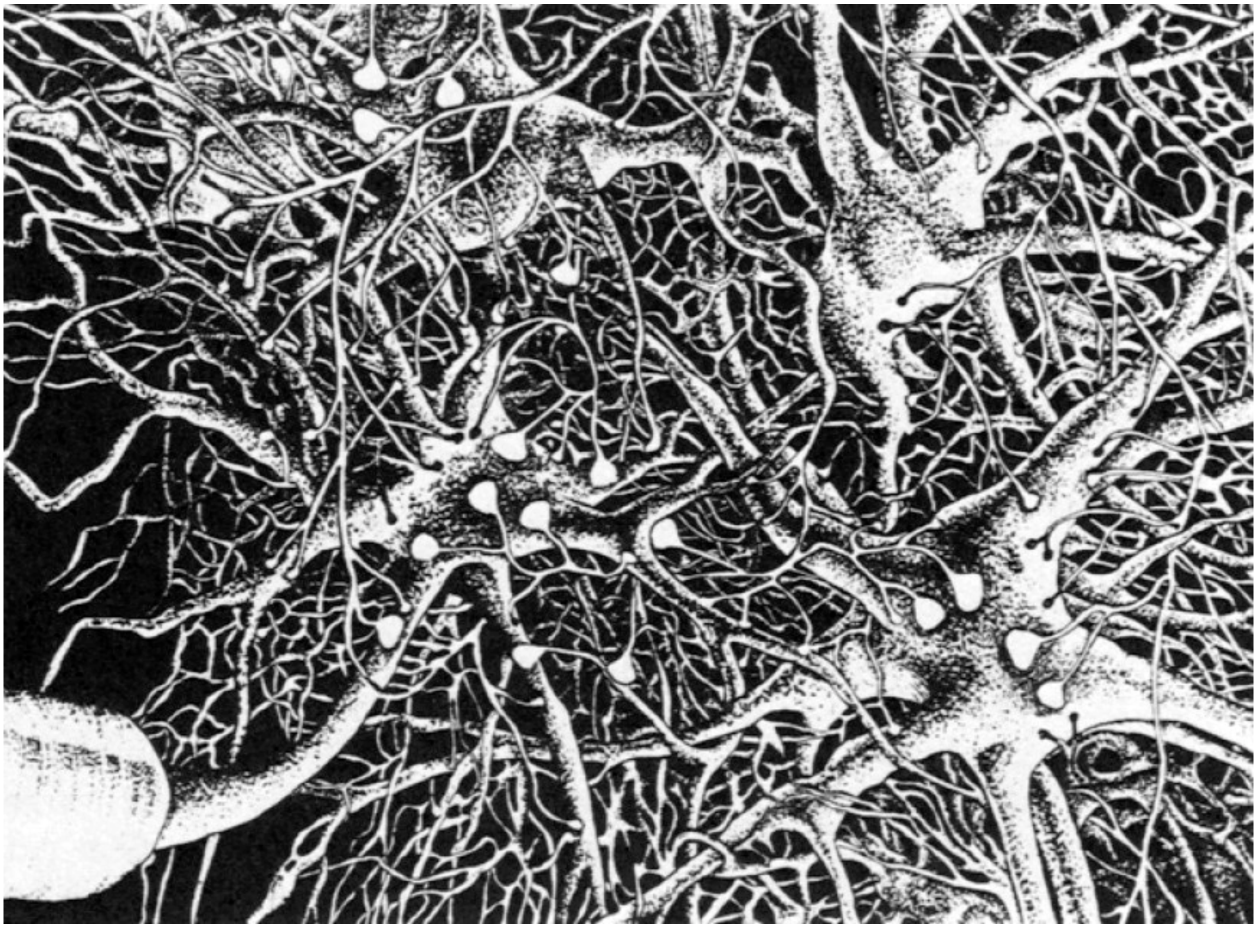


Figure 2. *"A meme as a constellation of activated neuronal synapses lodged somewhere in the brain of an individual"* (Delius, 1991, p. 83).

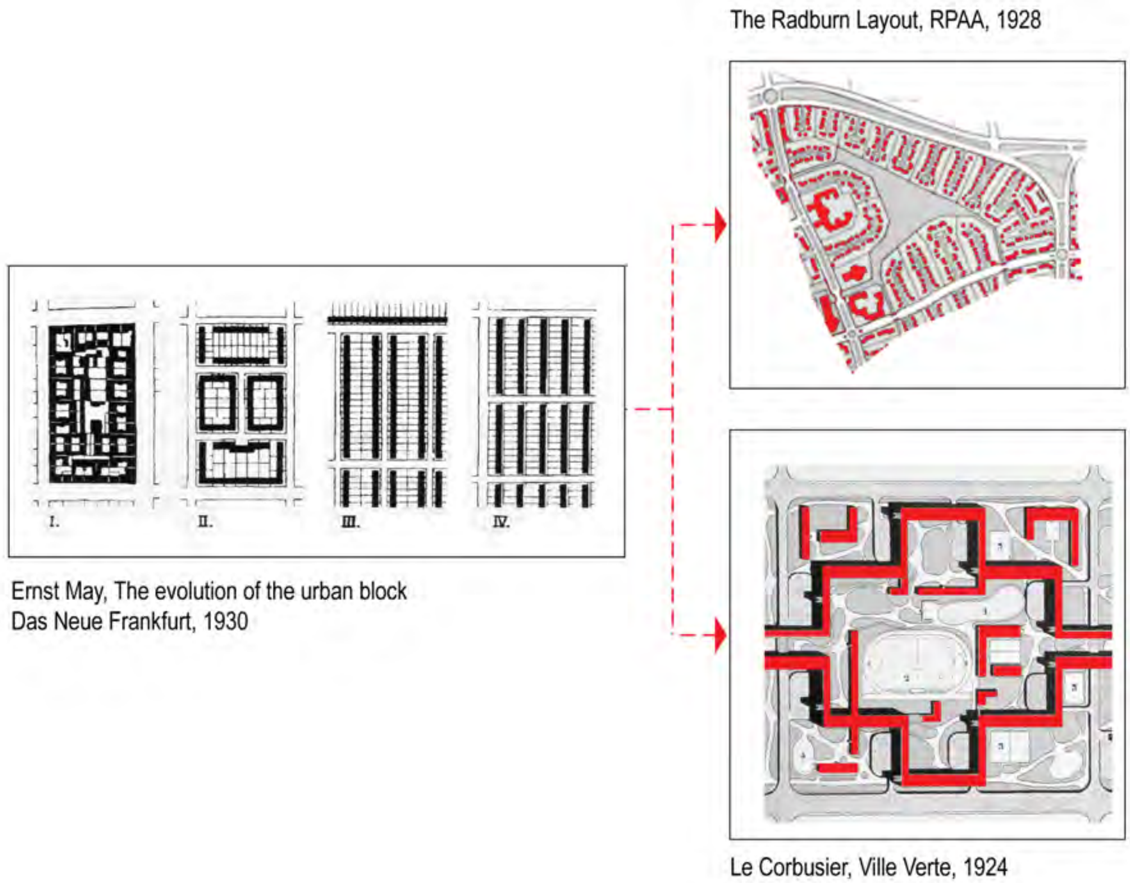
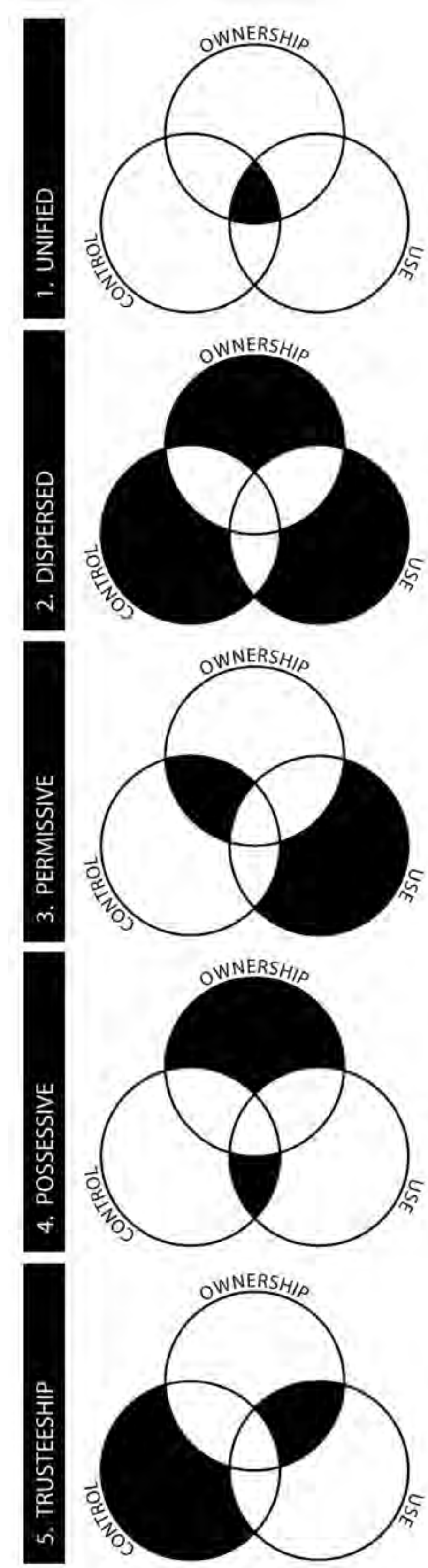


Figure 3. The first “bifurcation” in the history of urban form: the evolution from the pre to the post-Professional Theory of Urban Design (PTUD) city as depicted by Ernst May in 1930 and envisioned by the Regional Planning Association of America (Henry Wright and Clarence Stein, 1928) and Le Corbusier (1924). These two models (the first actually decendant from Ebenezer Howard’s original “Garden City” vision) should be regarded as the two main streams in the theory of urbanism from the formation of the discipline to our days (Hall, 1996).

Figure 4. The five “Forms of Submission” derived by the various combinations of Ownership, Control and Use of spaces by involved parties, redrawn from Akbar (1988), p.19.



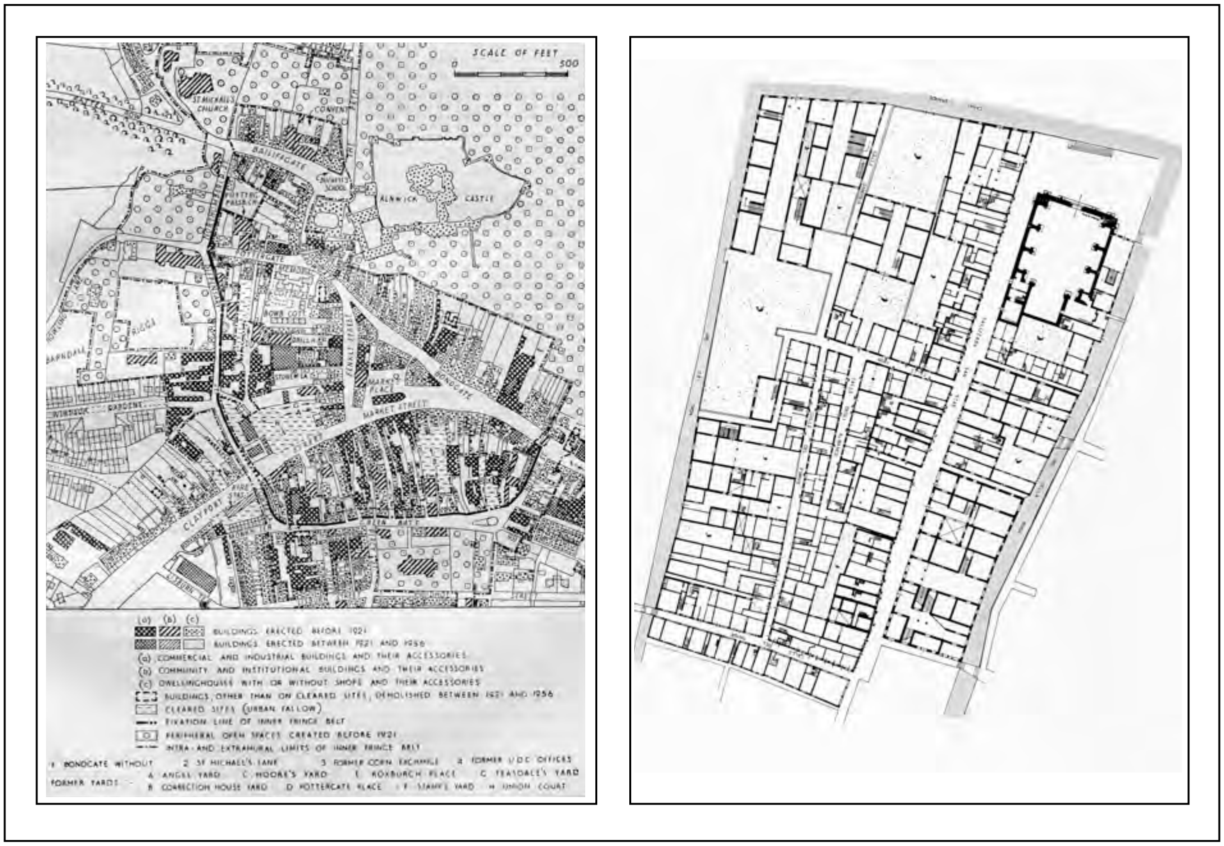


Figure 5. "Classical" town-plan maps drawn from: (a) Conzen (1960) and (b) Saverio Muratori (1960).

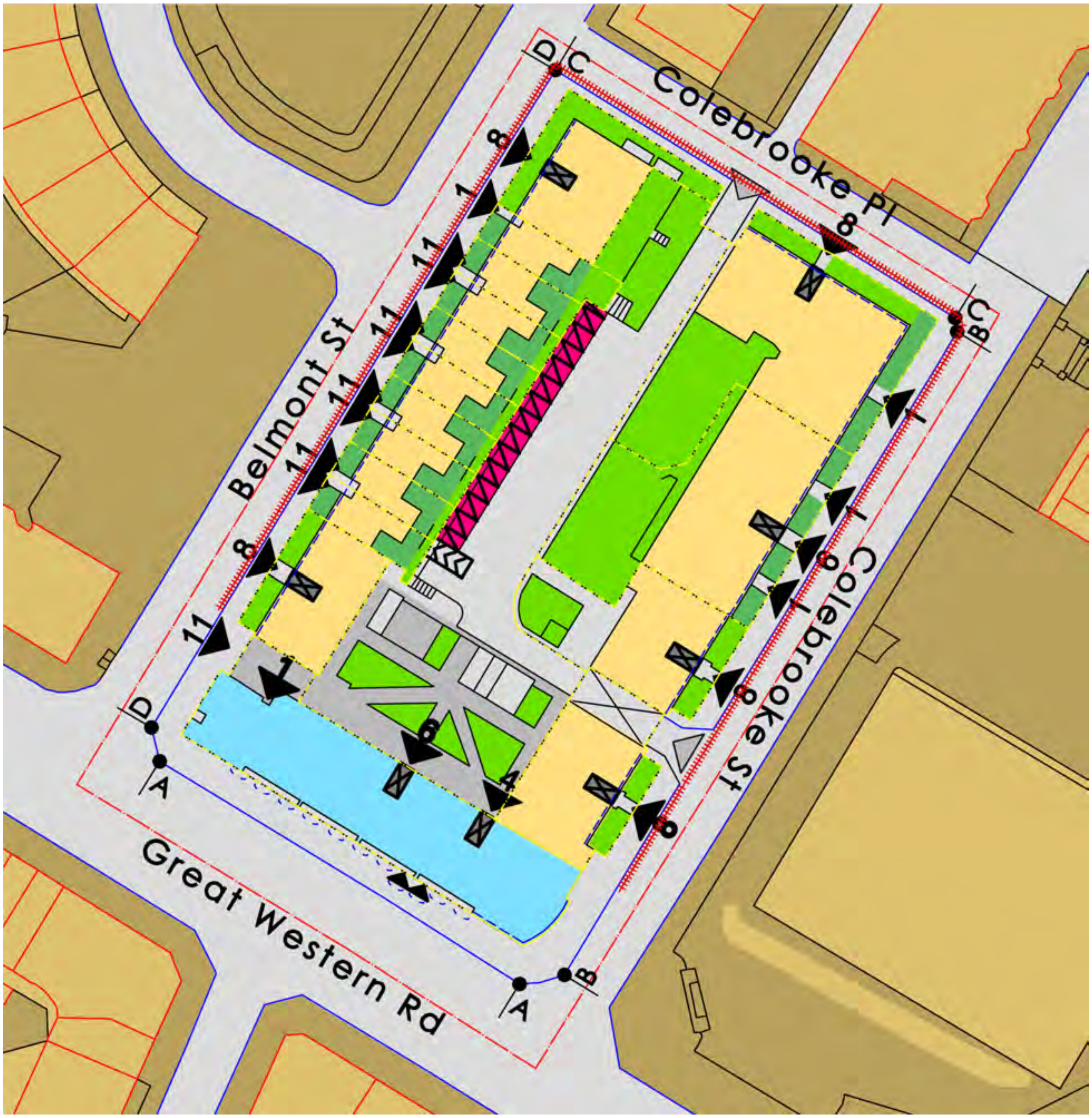


Figure 6a. Town-plan maps used in this research to create the dataset: Plan 1. The plan illustrates the land use and various other characteristics of built and open spaces as well as elements relative to the street front (legend is in figure 7*a*).

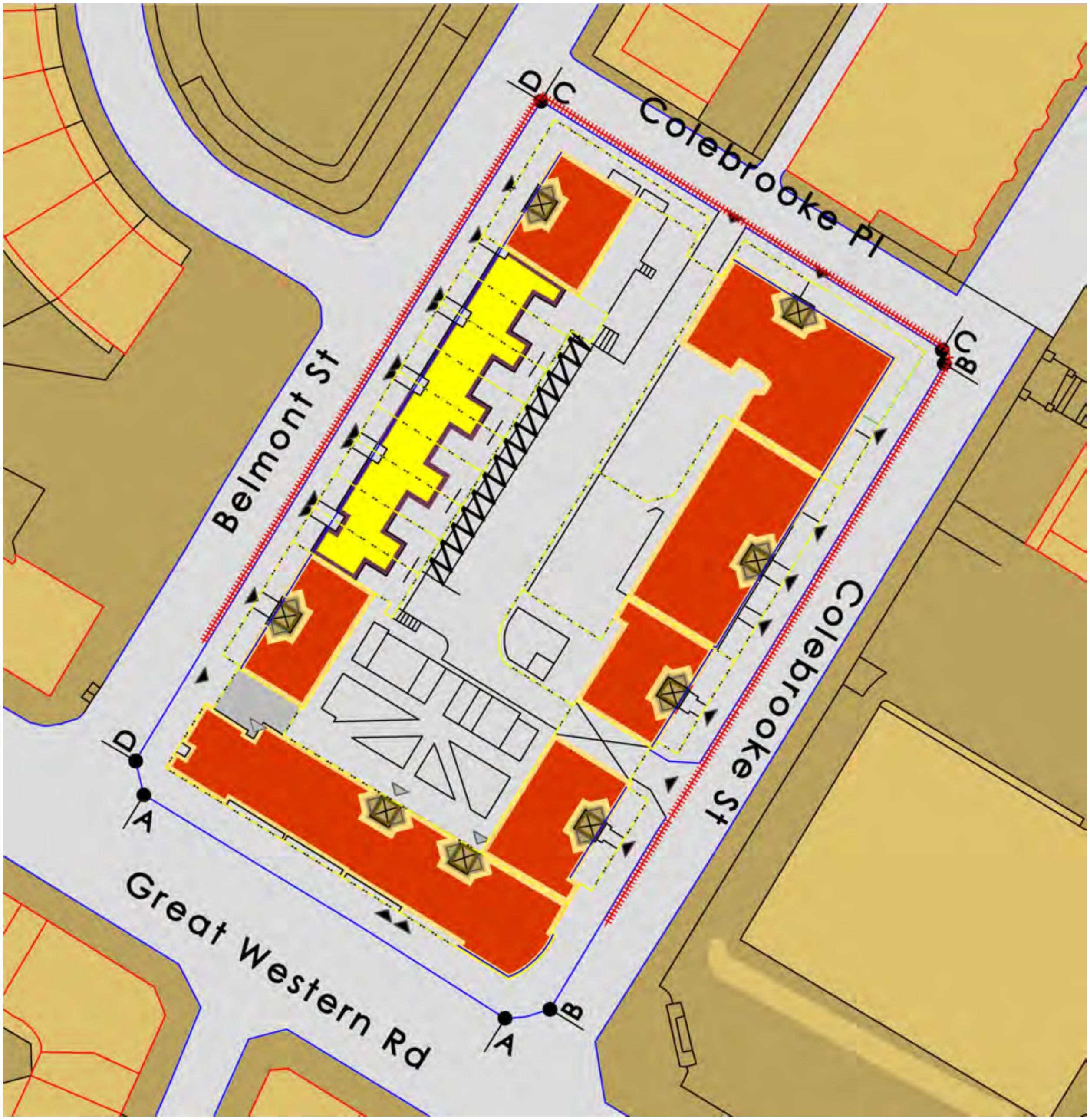


Figure 6b. Town-plan maps used in this research to create the dataset: Plan 2. The plan illustrates building types and accesses (legend is in figure 7b).

Figure 7a. Legend of Plan 1.

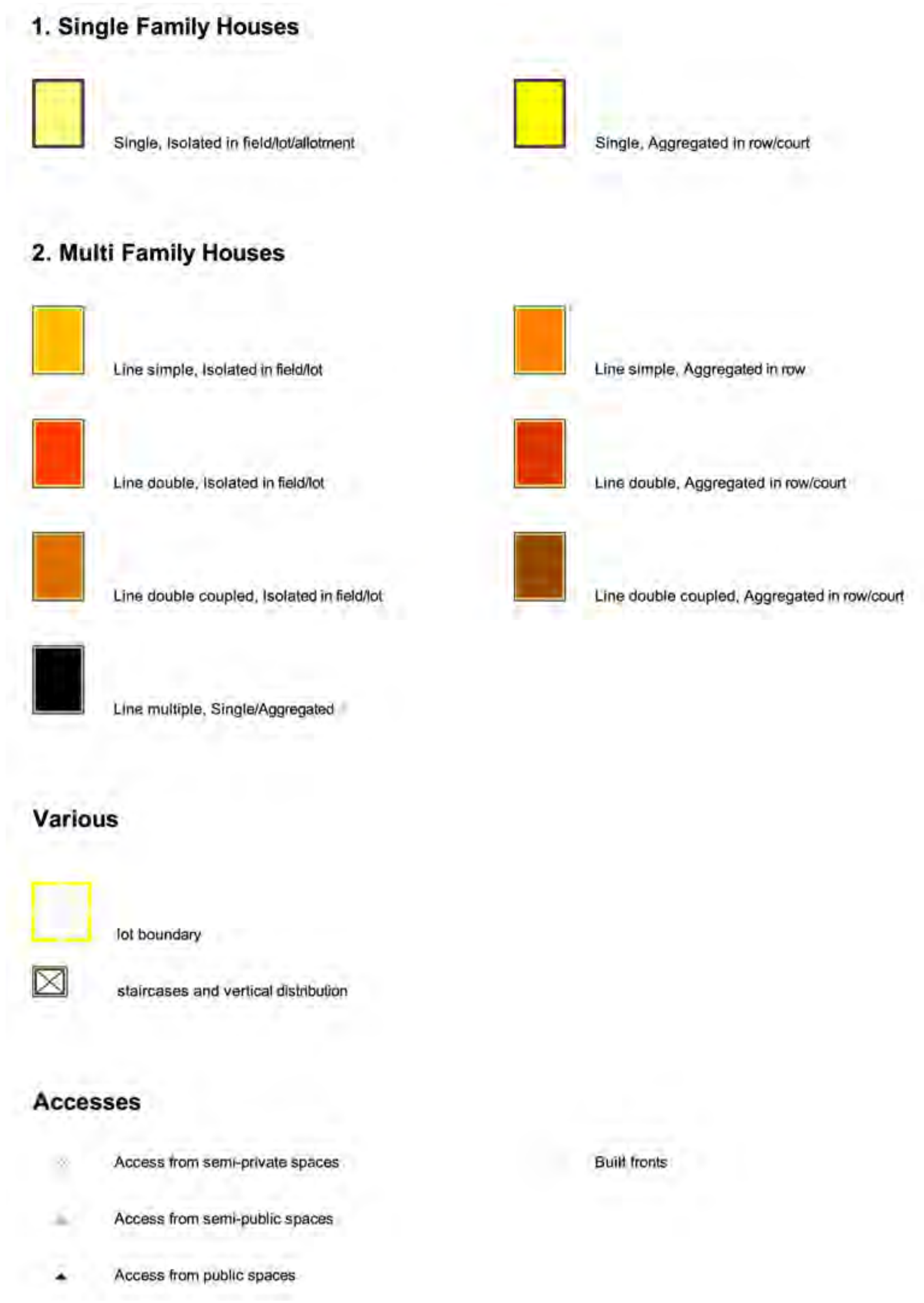


Figure 7b. Legend of Plan 2.

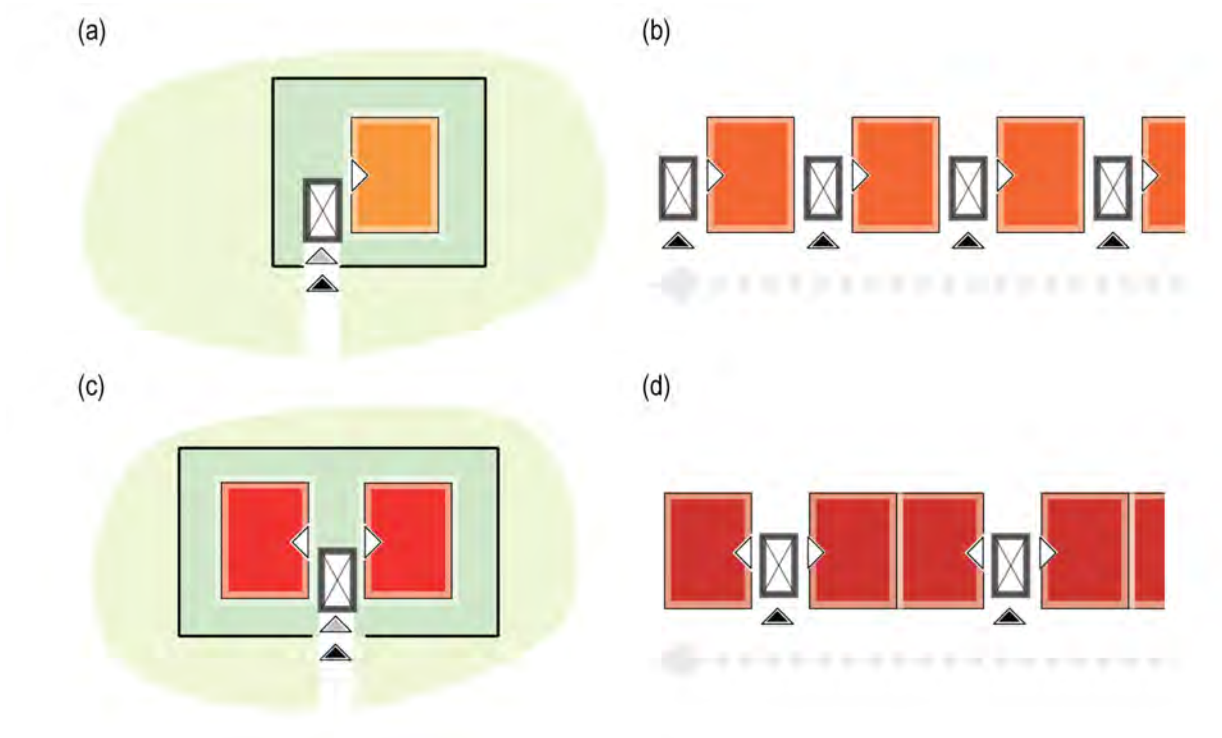


Figure 8. Four illustrative cases of building types: (a) line simple, isolated in field/lot; (b) line simple, aggregated in row/court; (c) line double, isolated in field/lot; (d) line double, aggregated in row/court; (see figure 7b).

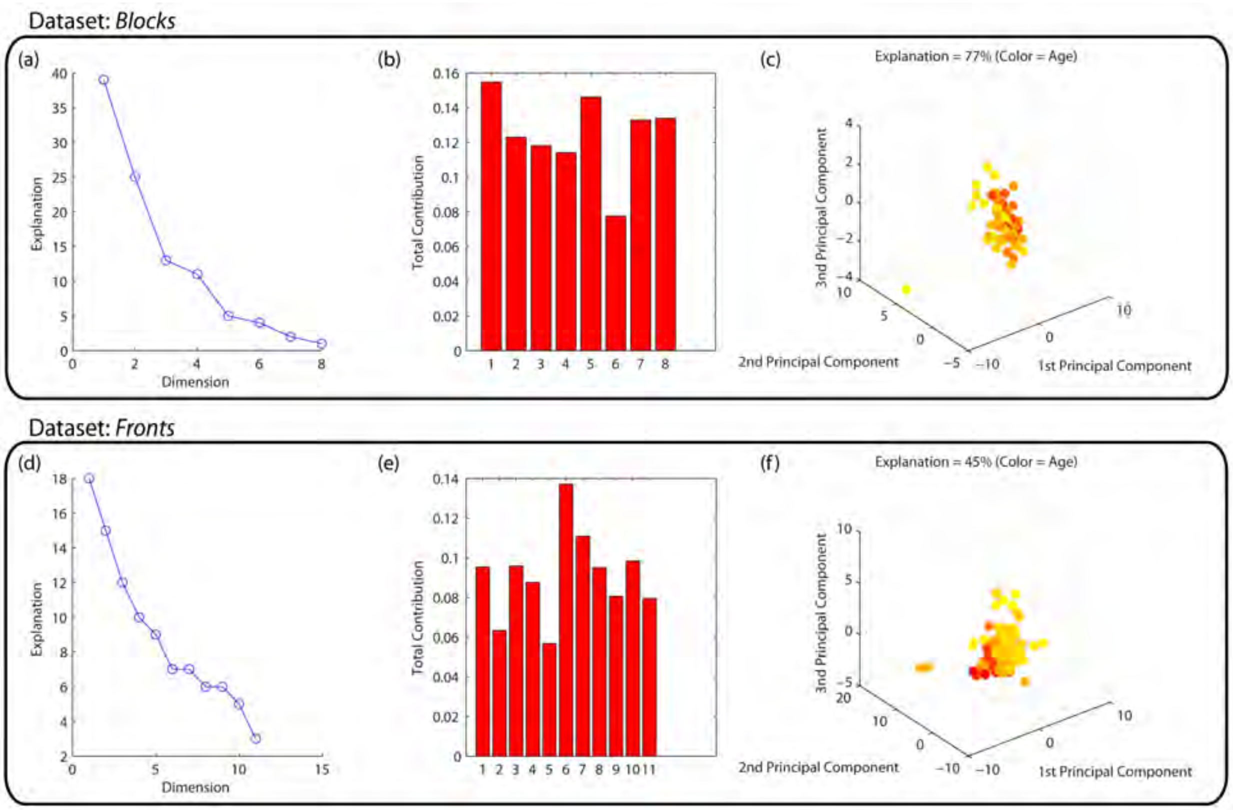


Figure 9. Principal Component Analysis (PCA) for blocks (top) and street fronts (bottom). Figures show: (a) and (b) the contribution of each dimension (variable) to all the 3 axis; (c) the representation of cases in the 3D Principal Components' space according to their age. The age of cases is defined as the moment in history (year) when the blocks have been entirely bounded by streets and the street fronts subdivided in plots, by evidence drawn from historical cartography.

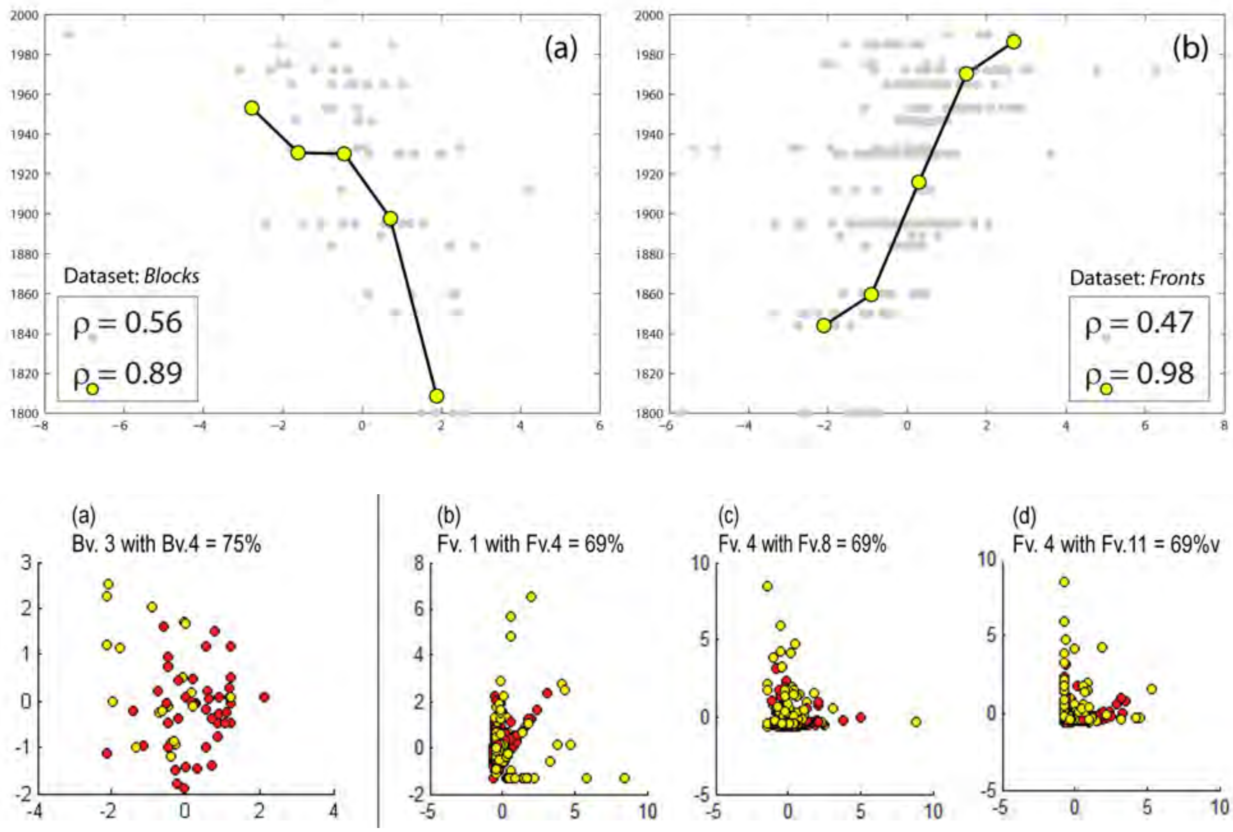


Figure 10. Top: correlation (Pearson index ρ) between the urban form of blocks (a) and street fronts (b) as represented by selected variables, and their age. Grey represents actual values and yellow the average values calculated per year of age. Cases are here represented by their projection on the first PCA component. Bottom: blocks (a) and street fronts (b, c and d) located according to pairs of variables and coloured according to their age of urbanization (pre or post 1950). Cases are then clustered using a Ward-linkage method. The percentage is calculated as the number of clustered cases matching with age.