COHERENCY OF URBAN SPACE:
ANALYZING THE STREET ENVIRONMENTS

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ABSTRACT

**COHERENCY OF URBAN SPACE:
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The insight that complexity theories have brought into the light has evidently changed the way scientific problems are approached and solved. Complex processes are profoundly involved with city-shaping phenomena, and once the complex nature of cities is disregarded while making decisions pertaining to urban development, the resulting urban fabric fails to host and generate life within a strictly imposed pure geometry. Modern cities embody the dynamics of machines with economically motivated optimization dismissing thus pedestrians' experience and consequently having detrimental effects on urban life. Radical ruptures in the development and transformation processes of the modern city during the 20^{th} century ended up with the loss of positive spatial qualities indicating a desirable urban form. Organic forms where life manifests its growth and change in the most natural way are characterized by the coherence of parts into an organized whole. Spatial coherence, abundantly present in natural forms, is the primary indicator of the geometry that enables life and determines the ideal condition for successful complex systems.

Christopher Alexander, for whom 'wholeness' is interchangeably considered as coherence, developed fifteen geometrical principles of the coherent wholes. However, these principles remain on a conceptual level concerning urban design. To that end, the thesis aims to concretize the abstract principles of Christopher Alexander in the context of traditional urban fabric by addressing morphological conditions generating spatial coherence. To collect an inventory from which we can derive knowledge on how to connect the nonliving geometry of the built environment and by focusing on human scale, this study explores spatial components and patterns that produce urban space with coherency, specifically in streets within traditional settlements. The main objective is to analyze spatial coherence of the street environments by tracing conditions that favor urban life in public space.

Keywords: spatial coherence, urban complexity, traditional urban fabric, street environment, urban life

ÖZ

KENTSEL MEKANIN BAĞDAŞIKLIĞI: SOKAK MEKANLARININ ANALİZİ

Shurdhi, Sabrina
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Karmaşık kuramlarının ortaya koyduğu anlayış, bilimsel problemlere yaklaşım ve çözüm biçimini değiştirmiştir. Karmaşık süreçler, kenti biçimlendirme olgusu ile derinden ilişkilidir ve kentlerin karmaşık doğası, kentsel gelişim ile ilgili kararlar alınırken göz ardı edildiğinde, ortaya çıkan kentsel doku, katı bir şekilde empoze edilen saf geometri içinde kentsel yaşamı barındıramaz ve yeniden üretememektedir. Modern şehirler, yayaların deneyimini ortadan kaldıran ve dolayısıyla kentsel yaşam üzerinde zararlı etkileri olan ekonomik motivasyonlu optimizasyon ile makinelerin dinamiklerini somutlaştırıyor. 20. yüzyılda modern kentin gelişim ve dönüşüm süreçlerinde yaşanan radikal kırılmalar, arzu edilen bir kentsel biçime işaret eden olumlu mekânsal niteliklerin kaybıyla sonuçlanmıştır. Yaşamın büyümesini ve değişimini en doğal şekilde gösterdiği organik formlar, parçaların düzenli bir bütün halinde bir araya gelmesiyle karakterize edilir. Doğal formlarda bulunan biçimsel tutarlılık, yaşamı mümkün kılan ve başarılı karmaşık sistemler için ideal koşulu belirleyen geometrinin ana göstergesidir.

‘Bütünlük’ kavramını ‘bağdaşıklık’a koşut ele alan Christopher Alexander, bağdaşık bütünün on beş geometrik ilkesini ortaya koymuştur. Ancak bu ilkeler kentsel tasarım açısından kavramsal düzeyde kalmaktadır. Bu amaçla tez, mekansal tutarlılığa katkıda bulunan morfolojik koşulları ele alarak Christopher Alexander'ın soyut ilkelerini geleneksel kentsel doku bağlamında somutlaştırmayı amaçlamaktadır. İnsan ölçeğine odaklanan ve yapılı çevrenin cansız geometrisini nasıl ilişkilendirebileceğimize dair bilgiyi elde edebileceğimiz bir envanter toplama girişimi olarak bu çalışma, özellikle geleneksel yerleşimlerdeki sokaklarda bağdaşık bir kentsel mekan üreten mekansal bileşenleri ve örüntüleri keşfetmeyi amaçlamaktadır. Bu noktada temel amaç, kamusal alanda kentsel yaşamı destekleyen koşulların izini sürerek sokak çevrelerinin mekansal bağdaşıklığını çözümlemektir.

Anahtar Kelimeler: mekansal bağdaşıklık, kentsel karmaşıklık, geleneksel kentsel doku, sokak mekanı, kentsel yaşam

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CHAPTER 1

INTRODUCTION

1.1 Context and Problem Definition

The constant growth of the fabricated world, though at different paces, depending on the location and time, has incubated transformation, which instead of facilitating the wellbeing of the users, has fostered ill conditions of the urban form. The ergodic character of cities as complex systems has driven in many cases a replacement of old structures with new ones, which while upgrading several attributes of the urban form have demoted critical spatial qualities that contribute to the actual life in cities. One of the latest concerns revolves around the fact that the 'end results' of the previous and many of the ongoing planning and urban design practices have led to alienating spaces within the city, neglecting thus everyday experience, and creating an urban form less and less habitable for its users. The 20th century's practices of architecture and design were criticized by Christopher Alexander who deems them as "against life, insane, image-ridden, hollow" (Alexander, 2002, p. 6). What has been reflected on long enough to drive a change in the means of solving architectural and urban design problems is the lack of geometry that fosters urban life in modern cities and a loss of spatial coherence stemming from top-down decisions and practices. The city, just like a living organism has a multitude of dimensions and dynamics hosted in it. It does not only supply the space for holding together its constituents but also dictates the inner forces of their interactions. It grows, adapts, and evolves. Although urban systems have a remarkable resemblance with biological systems, their emergence is more than just a cell undergoing intrinsic changes, and hence some level of control, but one which places human experience at the core is required.

Notwithstanding the complex nature of cities and the multitude of agents involved in the dynamics and structures of a city, many of the actions taken to produce a "better" form in the last decades were based on optimization. Since the behavior of a multitude of agents is in a continuous state of change the morphology and the public space itself are in a constant process of evolution. Evolution in cities is not to be merely defined as growth or expansion. In other words, there are pruning rules of selection guiding the process of formation and reformation of cities, which when become the subject matter of a wrongly imposed "order" disrupt the coherent "living" geometry of the cities. To put it briefly, coherence, as it pertains to the part-whole relation centering human scale, has been disregarded in the imposed rules, and not only cities but their inhabitants too have been treated like machines to be optimized. The underlying rationale for the optimization approach was primarily economic. The assumption that urban systems should reach a state of equilibrium resulted from the ambition to trace reasons and consequences in the past and was a necessity for analyzing the normal "cost/benefit" of a decision (Allen, 2012). This optimization aiming at an equilibrium state of the urban systems does not provide a solution to all the problems that cities pose, because it excludes the complex nature of urban systems embodying a plethora of dynamics.

On several occasions, modern planning has led to undesirable and unfunctional results when compared to those of conventional 'unplanned' urbanism (Marshall, 2012). One of the underlying reasons for triggering developments not suitable for the human scale is the mechanistic reductionist approach to problem formulation methodologies and their translation to design, which lack the positive spatial qualities embodied in traditional settlements. Therefore, it has become obvious that the way planning and design are conducted has to undergo several changes, given that these reductionist approaches have dismissed many important qualities accounting for a good urban, a situation which has resulted in fragmented urban pieces that fail at generating a coherent whole. The inherent complexity of cities, significant in determining urban performance and long seen as a problem to be solved by modern planning and architecture has finally become the trend in many generative algorithms intending to produce a successful urban form by design. Complexity is now presented as an answer to the challenges that today's cities present. However, incorporating complexity theories in urban design in a manner that both processes and structures attributed to a good urban form accommodate users' needs not only as a mere distribution of aggregated functions but, especially, by offering a spatial structure that brings about qualities of a good urban form, depending mainly on the condition of coherence, is a work on progress. In this aspect, how to approach design that generates more coherent urban forms has become the quest of designers of various domains and scales. The research problem at the core of this study, focusing mostly on the streets as urban life incubators, is to explain coherence as the main unifying principle that leads to an ideal condition of urban complex systems and helps characterize a successful urban form structurally at any scale.

1.2 Aim of the Study and Research Questions

This research will focus on tracing spatial coherence, embedded in various contexts of traditional urbanism practice, which can be further used as a basis for developing a framework of spatial analysis and generation of urban codes that aim at achieving spatial coherence by design within a complex urban system. The incentive for such a study is the undeniable lack of organization in an endless juxtaposition of spatial elements, whose composition results in abrupt boundaries within public space with no variety of use and experience to offer, treating humans simply as parts of the machine the city is now. Attempts have been and are continuously made for optimization and one cannot negate how detrimental this approach has been to the quality of life offered in public spaces. No less than 70 years ago Jane Jacobs (1961) argued that cities should be approached as problems of organized complexity, elucidating that no part or attribute of a city is independent and as such, there is no irrational emergence as it pertains to urban form and actions hosted in or through it.

As no part or feature of a city can be self-contained when any growth or transformation project that deems otherwise is superimposed the result is spatial incoherence and fragmentation reflected on multiple scales of the urban life. This fragmentation exists evidently and manifests in public space, making streets and squares not so welcoming for the pedestrian who struggles to make sense of occasionally too complex or too repetitive and monotonous surroundings.

The necessity for some intrinsic level of organization to this inevitable complexity in order to sustain wholeness emphasizes the significance of coherence as a desired state in urban form. To that end, the importance of spatial coherence will be outlined by framing the issue of 'how coherence contributes to better urban space within the context of a rich complexity by performing as a quality of human-oriented urban design'. Next, coherence will be traced in traditional settlements from a morphological perspective. Once a strong association of spatial coherence with the positive impact on human life is established and supported by a theoretical framework and examples from existing patterns, the main question of ' how spatial coherence can be maximized in urban public space" comes forth. On the grounds that natural life grows bottom-up, coherence is to be sought on the lowest scales relevant to urban design. In this context, elements and patterns indicating spatial coherence will be extracted from streets in traditional settlements, which have the potential to be later utilized to provide a proscriptive coding as regards generating coherence by design.

1.3 Methodology of the Research

To answer the questions at the core of this research, a morphological definition of spatial coherence and how it emerges from the complexity of the built form is established. One main hypothesis of this study is that the morphology of traditional settlements enables us to derive established rules for coherence in urban form. As such, spatial coherence will be analyzed in the mezzo-scale built environment of the streets, as a significant subject matter of urban design. This descriptive research will employ three different streets as case studies which are selected based on the distinct spatial qualities they comprise, focusing mainly on the type of the boundary as defined by their street frontages.

Two complementary approaches for generating coherent urban wholes, involving fifteen structural features delineated by Christopher Alexander in his book *The Nature of Order* and eight general rules for geometrical coherence proposed by Nikos Salingaros, will be descriptively examined through a systematic analysis of three streets in the traditional urban fabric, employing images retrieved from Google Earth. The concrete example of each abstract geometrical property defined by Alexander will be highlighted in eye-level images of the streets. Once concrete examples of each geometric property and rule of coherence are identified in existing streets, they will be collected in an inventory which may later be employed to establish a programmatic design approach to introduce coherence in public spaces devoid of it, generate it from the ground up in new developments and reintroduce urban coherence there where it has started to decompose.

1.4 Structure of the Research

This study comprises five chapters. **Chapter 1** outlines an introduction of this research by addressing the context and the problem definition, the study's objectives, research questions, methodologies, and structure. The next chapter, **Chapter 2** provides a theoretical framework for understanding spatial coherence as an outcome of complex generative processes that give rise to cities. Firstly, the relevance of complexity theories to urban systems is explained and then complexity is established as a precondition for generating coherence. One important highlight of the chapter is that a strict order imposed via top-down planning does not generate urban forms that support life, as life grows bottom-up. **Chapter 3** elaborates on a conceptual framework for spatial coherence in public space by explaining the intrinsic mechanisms of coherent wholes, which are emergent and proscribe the future states of the system. In chapter 3 Christopher Alexander's fifteen geometrical properties of coherence are explained and addressed in the context of the City. **Chapter 4** analyses street environments to trace spatial qualities that generate spatial coherence in public space. Having acknowledged that emerging traditional towns embody a higher degree of spatial coherence, the three streets are part of traditional towns, the urban fabric of which bears several resemblances but are also different due to the changing local context. Finally, **Chapter 5** addresses the limitations of the study and issues that this research could help solve in further studies concerning the resurrection of public space.

CHAPTER 2

COHERENCE AS AN OUTCOME OF URBAN COMPLEXITY

The complexity of cities accounts for processes embodied in various configurations and patterns of the urban fabric, which characterize the morphology of cities and add on the city's general spatial quality. Çalışkan and Mashhoodi (2017), as they establish a morphological definition of coherence, emphasize that spatial quality is the product of "complex interactions among components of an urban form" (p. 124). Furthermore, they suggest that the most fundamental condition of urban fabric's spatial quality is coherence. Coherence, concomitantly a spatial property of an emerging urban form is therefore pre-conditioned by the general complexity of a system, assisting incrementally to generate a good form.

Complexity cannot be explained without change occurring with time as it urges for adaptation to the evolving needs of society. This change, signified by urban dynamics, is echoed in the production of space within the city, giving thus rise to an emergent urban morphology that results from a coherent behavior of the system's constituents, often viewed as the antithesis of morphology being the product of a large-scale order imposed at once. Acknowledging Salingaros' (2000) idea that complex interacting systems enable us to understand the coherence of urban form, this chapter will explain complexity as a necessary condition to generate coherency of space in cities. To that end, it is noted that to address urban complexity properly within the context of urban design, the main focus should be on the processes of growth. Firstly, definitions of complexity and coherence, as well as other terms relevant to complexity theories of cities will be construed and lastly, coherence as an outcome of complexity will be explained.

2.1 Complexity and the City

The relevance of complexity theories to urban systems has been a central point of urbanism debates since the realization that answers to city-related problems were to be sought in the complex nature of their systems and not by simplifying the problem via abstraction or reduction. Before outlining the adoption of complexity thinking in urban design practice within the context of generative urbanism some basic definitions of complexity and associated terms are provided and how these terms relate to coherence in urbanism will be delineated in the following sections.

2.1.1 Definitions of Complexity

Complexity has changed the way scientific problems are solved. The fact that complexity has been adopted by a variety of fields has led to situations where its generality has been viewed as ambiguity regarding its practicality (Haken 2012). As such, having a single formal delineation of complexity has proven difficult, given the variety of scales and the domains that his notion has substantially influenced. However, there are a few key concepts and principles that guide complex systems globally. Gershenson (2008) highlights the corporeality of interdependent interacting constituents of complex systems by formulating complexity as follows:

> Etymologically, complexity comes from the Latin plexus, which means interwoven. A complex system is one in which elements interact and affect each other so that it is difficult to separate the behavior of individual elements. Examples are a cell composed of interacting molecules, a brain composed of interacting neurons, and a market composed of interacting merchants. More examples are an ant colony, the Internet, a city, an ecosystem, traffic, weather, and crowds. In each of these systems, the state of an element depends partly on the states of other elements and affects them in turn. This makes it difficult to study complex systems with traditional linear and reductionist approaches. (p. 4).

Baranger (2000) claims that biological systems and systems associated with people are "ideal" complex systems and in an attempt to explain the meaning of complexity he lists the six most quintessential characteristics of complex systems as follows:

1. Complex systems comprise many parts that interact in a nonlinear way.
2. There is interdependency among the parts of a complex system.
3. Each scale in a complex system possesses a structure.
4. Complex systems incubate emerging behavior that manifests itself on larger scales, which leads to the ability of a complex system to self-organize.
5. Chaos and non-chaos interact in complex systems, a feature that gives rise to self-organization
6. An interplay between competition and cooperation exists in complex systems.

One should note that the complex form of the natural and built environment is contingent on the interplay between order and disorder. Based on this interplay the derivation of more comprehensive definitions of complexity to describe the structure and dynamics of systems pertaining to various domains is possible. Shiner et al (1999) interpret complexity in terms of order and disorder and organizes different conceptions of complexity into three categories.

Complexity of category I increases as order decreases. Category II relates to complexity as a convex function of order and disorder, where the peak of complexity is the midpoint of the graph. Finally, Category III views complexity as order of structure bringing forth self-organization and emergence. Boeing (2018, p. 3) regards category II as the 'Jacobsian balance between structure and variety". Paralleling this thought, Tümtürk (2018) maintains that "cities' organized complexity stands somewhere in between order and disorder" (p. 50). Given the definition of coherence as the integration of diverse elements that create a unified whole, one can assume that the second category of complexity is also a representation of coherence as the peak point between order and disorder.

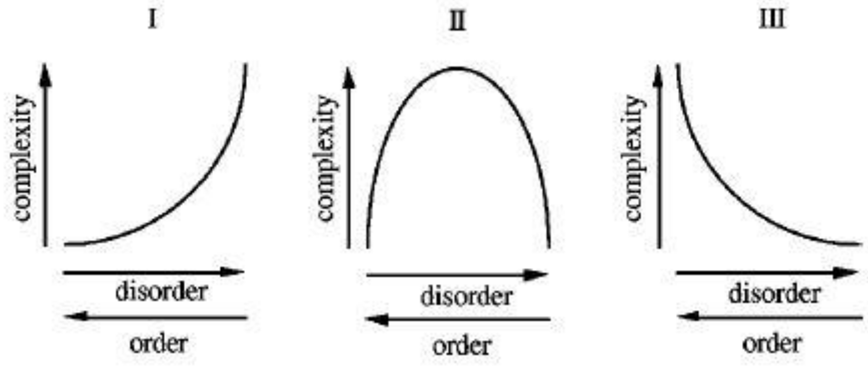


Figure 2.1: Three categories of complexity as a function of order and disorder (Shiner, 1999, p. 1459)

2.1.2 From Simplicity to Organized Complexity and Coherence in Urbanism

Anything simple on its own is capable of bearing complexity when combined with another simple entity, leading thus to a more sophisticated state of the system they constitute. The concept of complexity is strongly associated with systems especially the dynamic ones as its main aim is to explain how systems grow, adapt, and evolve through emergences. To have a clear understanding of complexity in the field of city planning and urban design, it is important to explain why cities fall under the category of organized complex systems and how organized complexity manifests itself in regional and urban scale.

Warren Weaver, in his influential paper entitled “Science and Complexity”, discussed how problems of simplicity, disorganized complexity and organized complexity differ from each other. The main aim of this paper is not to suggest that problems of complexity overweight problems of simplicity as Weaver clearly acknowledges the scientific and technological breakthroughs that two-variability enabled. Instead, he focuses more on justifying why determining the kind of a problem is important for the application of the right methods and techniques while approaching and formulating solutions. Weaver defines problems of simplicity as two-variable (at most three or four variable) problems, which prevailed in physical science in the seventeenth, eighteenth and nineteenth centuries (1948).

Disorganized complexity involves problems with a large number of variables, where each variable acts and behaves independently of the others. Problems of disorganized complexity require techniques based on statistical mechanics and probability theories. The independence of the variables is the main property of disorganized complexity that distinguishes it from organized complexity. As delineated by Weaver (1948), problems of organized complexity comprise relevant variables, "interrelated in a complicated, but nevertheless not in helter-skelter, fashion" (p. 539). The notion of organized complexity brought a new perspective to life sciences, and it was Jane Jacobs the first one to assert that planning should adopt organized complexity to the understanding of the city.

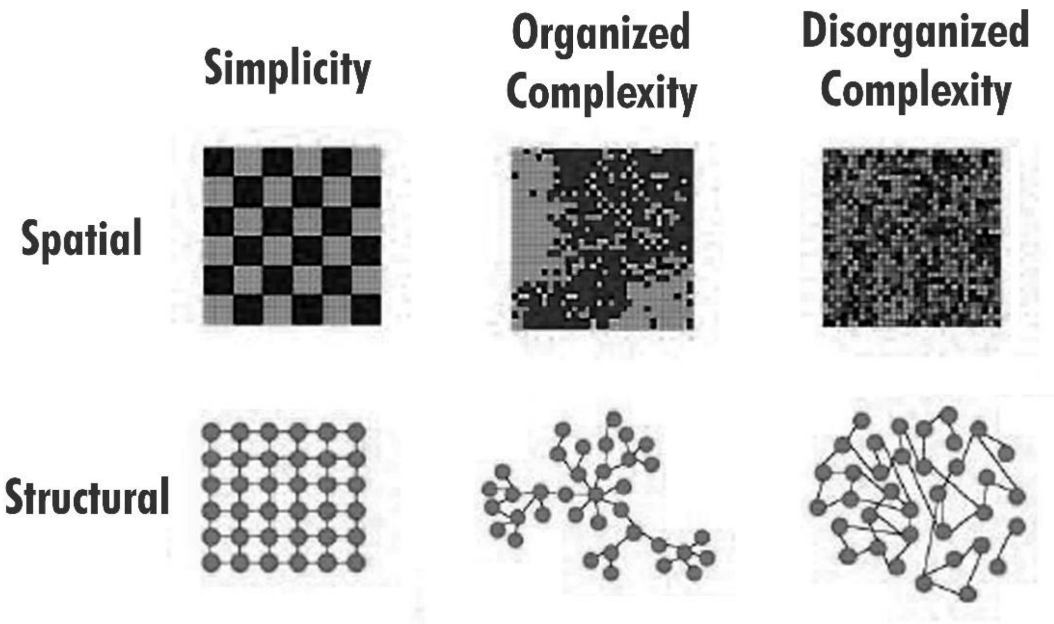


Figure 2.2: Spatial and structural representation of simplicity, organized complexity and disorganized complexity (Madhur et al,. 2010, p. 397)

In a quest to understand what the imposed order of the twentieth century urbanism is devoid of Christopher Alexander wrote “A city is not a tree” in 1965. Criticizing a tree-like hierarchical structure of cities, he proposed a more complex mathematical abstract structure of cities (semilattice), which contains overlapping units. The structure of tree is simple and derives its prominence from the desire for order and neatness arising out of straight and perfect symmetry, whereas the semilattice is complex and “living”. Subsets of a semilattice, which can also be defined as units of the city, are receptacles consisting of fixed concrete objects co-operating and facilitating and interaction of the user with the environment. An example of overlapping units is snapshot from a street corner in Berkeley:

> “For example, in Berkeley at the corner of Hearst and Euclid, there is a drugstore, and outside the drugstore a traffic light. In the entrance to the drugstore there is a news rack where the day’s papers are displayed. When the light is red, people who are waiting to cross the street stand idly by the light; and since they have nothing to do, they look at the papers displayed on the news rack which they can see from where they stand. Some of them just read the headlines, others actually buy a paper while they wait.
>
> This effect makes the news rack and the traffic light interactive; the news rack, the newspapers on it, the money going from people’s pockets to the dime slot, the people who stop at the light and read papers, the traffic light, the electric impulses which make the lights change, and the sidewalk which the people stand on form a system – they all work together” (p. 2)

Alexander (1965) assesses this kind of units as coherent, based on “the forces which hold its own elements together and the dynamical coherence of the larger living system which includes it as a fixed invariant part” (p. 2).

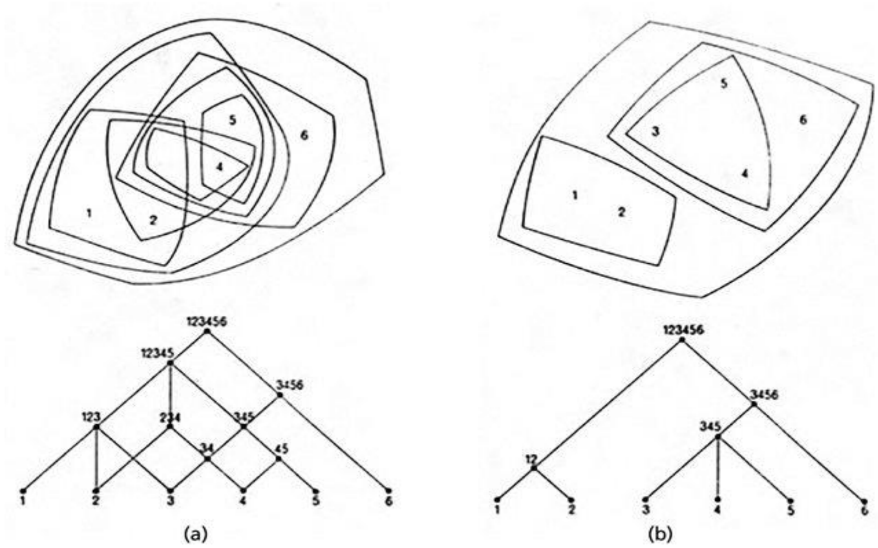


Figure 2.3: Abstract diagrams of semilattice and tree-like structures of cities (Alexander, 1965, p. 3-4)

A city with a semilattice structure is not a city of isolated or segregated parts and as identified by Marshall (2012) semilattice enables synergy, the quality by which the whole is greater than the sum of its parts. With respect to spatial coherence a semilattice structure is associated with how the field-like effect of centers' geometrical properties overlap to reinforce life within urban space.

2.1.3 Urban Emergence and the Interwoven Whole

Complexity, as regards both processes and structures, is tightly associated with the concept of emergence, a property of any complex system, whose occurrence is observed on the macro levels of a system and leads to novelties denoting uncertainties for the future states of the systems. Goldstein (1999) defines emergence as "the arising of novel and coherent structures, patterns and properties during the process of self-organization in complex systems" (p. 49). He formulates coherence as a property of emergence and an impetus for manifesting interwoven wholes with a tendency to maintain a sense of identity through time. The interwoven whole emerges as a higher-level unity with coherence spanning and correlating lower-level individual parts. As opposed to the notions of "gestalt" and "whole before its parts" emergence as a construct does not assume a pre-given coherent entity (Goldstein, 1999, pp. 51-52).

In the aspect of cities and urbanism, a parallelism of this conceptualization of the "whole before its parts" can be made with morphology as a pre-conceived product of master planning and design, which does not allow for urban coherence to emerge incrementally. Therefore, many researchers interested in the subject have highlighted the urge for addressing the processes a city embodies (Jacobs, 1961; Alexander et al, 1979; Mehaffy, 2008; Helie, 2009; Allen, 2012). Given that cities are an exemplary of complex systems both their dynamics and structures as interwoven wholes are of emergent character. Batty (2009) argues that urban morphology emerges from simple spatial decisions, from which an emergent character of the city's form can be implied. The above constatations hint that an overall optimization of urban systems revolving around equilibrium is not likely, which complicates the formulation of a goal state. Allen (2012) suggests that choices and decisions of a large number of agents engaged in the process of decision-making drive the ever-evolving state of complex urban systems. However, sustainable development might comprise short-term goals of planning at some level and timescale (Batty & Marshall, 2012). Helie (2009), who claims that the phenomenon of emergence accounts for production of order from random actions of a series of individuals, maintains that the process involved in a city's growth is more of an indicator of sustainability than morphology. Similarly, spatial coherence as a quality of urban form is an emergent condition, and it contributes to the generation of Jacobs' "organic whole" into which a number of factors are interrelated as she delineates in her influential work The Death and Life of Great American Cities (1961).

2.1.4 Self-organization and Coherence in Urban Systems

As discussed in the previous section, compositional and configurational qualities of complex systems, such as coherence, fail to take the shape pre-determined by conventional master planning. Instead, they emerge as multiple agents cooperate through positive feedback in the process of self-organization over time, a process which characterizes complex systems. The internal mechanism of ordering autonomously in complex systems is associated with self-organization (Tümtürk, 2018). Self-organization occurs through coordination of the system's constituents interacting locally and thus generating order in the larger global scale. The generated order in complex systems, not objects of top-down control, is of spontaneous nature. According to Helie (2009), spontaneous order emerging out of the actions of a large number of "individuals acting in pursuit of some other end" enable human artifacts "to arise as if by an act of nature" (p. 76). Tümtürk (2018) asserts that while accounting for different properties of complex systems, emergence and self-organization often co-operate, as the phenomenon of emergence brings about novelties bottom up, object to self-organization manifested in a large-scale coherent structure. According to Batty and his team (1997, as cited in Mehaffy, 2008) "remarkably coherent structures" can be built "by following relatively simple rules" (p. 61).

The idea that cities are self-organizing systems was firstly introduced in 1999 by Juval Portugali in his seminal book *Self-organization and The City.* He shows how the dynamics of the city create a gap between individual agent's behavior and later lead to "the emergence of a spatial cognitive dissonance, which in turn leads to the emergence of a new socio-cultural spatial entity" (p. 172). Helie (2009) describes "this property of the city to adapt to change as a form of time-complexity, where the problems to be solved by the system at one point in time are different from those to be solved at a later point in time." (p. 83-84). According to him, arising developments and new buildings are not random, but rather programmed as individuals inhabiting a particular place realize the need to adapt their current building sets as a solution to changing environmental conditions, which can be an outcome of external events or result from processes involved in urban growth. These events and processes trigger a state of disequilibrium, succeeded by movements in the urban tissue aiming to respond to random change. The above processes are mostly embodied in spontaneous cities whose every incremental movement "is a local adaptation in space and time that is proportional to the length of the feedback loops and the scale of disequilibrium" (Helie, 2009, p. 84). One can infer that the morphology of a city describes spatial configurations and patterns of the city as temporal snapshots. Batty (2010) also supports this reasoning by arguing that planning should be short-term oriented and should revolve around incremental changes. Acknowledging that every city involves a certain degree of emergence and self-organization, the role of the planner becomes a matter of concern when the contemporary practices of planning are considered. Savini (2017) describes the role of the planner as the social task to demystify, mobilize and generate "coherence across complex social dynamics" (p. 4).

Another important aspect to be considered while addressing self-organization of complex systems is finding unifying principles, which has always been at the core of scientific endeavor throughout various disciplines. To explain how self-organization occurs in complex systems Hermann Haken developed synergetics. As opposed to thermodynamics, which deals with closed systems that can reach a thermal equilibrium, synergetics attempts to find unifying principles that explain behavioral patterns of complex systems far from equilibrium, in which there is a continuous input of matter, energy and/or information, which are referred to as control parameters (Haken, 2012). On the account of this, with the continuous input several configurations of numerous individual parts of the system arise, giving the whole a specific structure governed by the generated order parameters. Haken (2012) states that the interaction between the order parameters can be of a competitive, cooperative, or coexisting nature, and thus the determination of the behavior of the system's constituents occurs via the enslavement of the individual parts by the winning parameters . However, he notably highlights the fact that self-organization is highly associated with circular causality, in which while the order parameters regulate and organize the behavior of the system's constituents, and the latter determine the behavior of the order parameters via coordination.

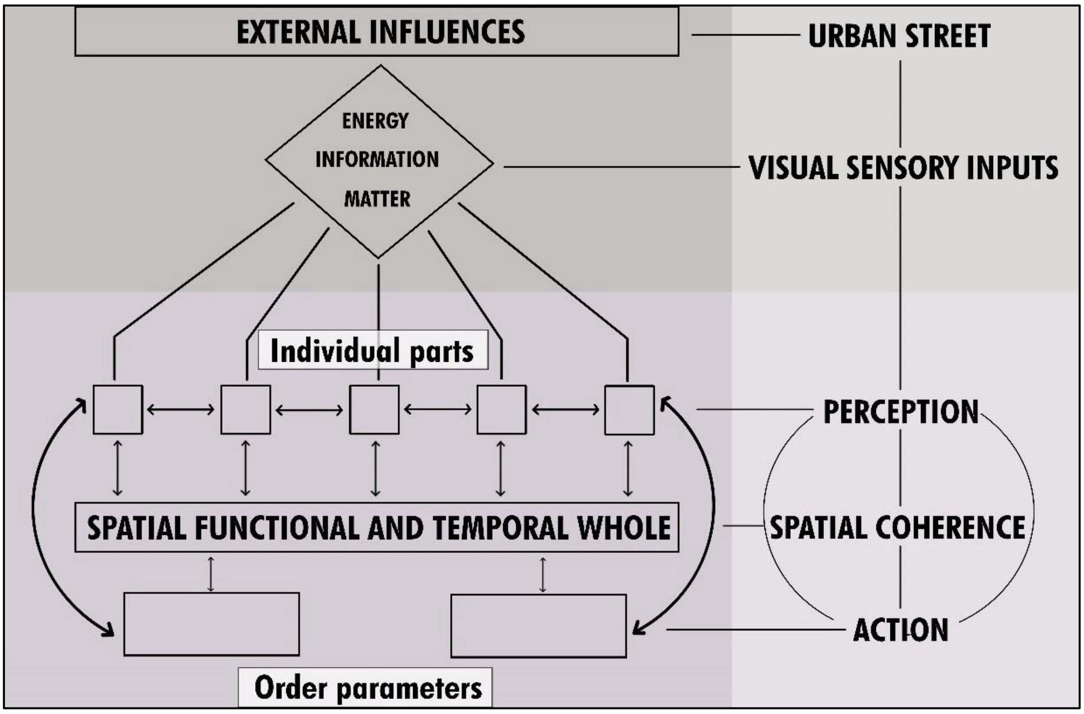


Figure 2.3: Spatial coherence as a perceptual emergence

As a form of complexity reduction of a minimal erroneous nature, the results from synergetics may prove facilitative when dealing with perceptual qualities as emergences and pattern recognition. In the case of spatial coherence, synergetics has the potential to help with the understanding of how specific order parameters can lead to a wholly coherent urban space when perceived visually and spatial coherence, itself, acts as an order parameter governing the perception-action cycle of pedestrians in streets.

2.2 Incorporation of Complexity Theories in Urbanism and Urban Design

The problem of complexity in planning and design does not resemble the quest of a puzzle when one seeks a solution. As a matter of fact, all the pieces are given, but what is missing is the bigger picture. A city's" picture" can remain static in an undefined lapse of time. The only undeniable truth is that this picture is for sure not permanent. Nonetheless, this does not stop one from questioning the problem of complexity and come to an understanding of its concrete outcomes. Cities are themselves dynamic entities in which any attempt of control of the largest scale, and consequently implementation will only lead to an 'end' result to be defined as nothing more than a capture in time of a superposition of different time-space entities.

Baranger (2000) defines dynamical systems are systems whose configuration is apt to change in the course of time. Writ largely dynamical systems comprising of a multitude of interacting components, urban systems are characterized by the capacity to bring about emergent phenomena and to self-organize and adapt to the everchanging needs of populations. In essence, cities are complex because of a series of emergences since the primordium of civilization. Therefore, treating a city as an evolving system with no set boundaries in the long term eases the formulation of the problem. There is always an openness to the dynamics that shape life in cities. It has been established that complexity theories in urban studies deal with both the processes and structures. As complexity itself suggests, there exist several building blocks of its manifestation, particularly in cities.

One might argue that the transition from nomadism to sedentarism is the main development which gave rise to the cities as we know today. And this idea is closely related with an agricultural base as the origin of civilization, laying the foundation for the long-term evolution of cities in the aspects of spatial, social, and economic dynamics. This is in accordance with what Childe (1963) suggests in *Social Evolution* where he claims that the start of cities is marked by an agricultural base evolving from nomadic pursuits and which is the main force sustaining cities to begin with. Jacobs(1969) disagrees with Childe's view claiming that putting agriculture at the core of cities' origins is an oversimplified explanation of how cities emerged. She bases her idea on the fact that urban pursuits are not dependent on the rural economy and agricultural novices emerge from cities; therefore, agriculture did not precede cities. Nonetheless, the explanation of how cities have emerged involves far more complex processes which cannot be reduced to a single line of history.

Complexity theories were incorporated in urbanism in the mid-twentieth century. The general mantra that “ the whole is greater than the sum of its parts” abstracted the idea that, within the framework of general systems theory, individual entities were evidently agglomerations of lower scale elements with an integral organization, exhibiting a pattern and order in the larger scales (Batty, 2008, p. 4). At the core of complexity in urbanism lies the similarity of social systems with biological systems, firstly addressed by Jacobs (1961) who suggested that cities are problems of organized complexity to be approached bottom up, in accordance with how natural life grows.

An iconic figure in architecture and urban design, Christopher Alexander built up influential works in his endeavor to seek morphogenetic processes and patterns that create a coherent built environment promoting human life. Originally, his quest in this aspect started with *Notes* on the Synthesis of Form (1964, 1973), in which he outlines the process of adapting form to the context of human needs and demands, centered on the idea that at the core of a design problem stands the good fit ensemble comprised of form and its context, a work which he was to revise later on to create a better understanding of processes giving rise to life forms. In this framework, Alexander was also one of the first to point out the structural resemblance between animate and inanimate entities in his prominent work of 2002, *The Nature of Order*. As Portugali (2012) highlights, it was this resemblance that made complexity paradigm generally applicable to various domains of study including that of cities. The central idea in *The Nature of Order* was to identify that specific kind of order that gives life to the built environment by exploiting properties of the natural coherent wholes.

2.2.1 Conceptualizing the Complexity of Cities

Jane Jacobs and Christopher Alexander are two important figures of planning and urban design disciplines who pioneered complexity theories of cities. To this day Jacob’s organized complexity encourages urbanists in the challenging work of addressing contemporary issues of urbanism as conditioned by complexity. Nonetheless, establishing a sophisticated framework for complexity in urbanism and how properties of complex systems are applicable to planning and design problems are of central interest in urban studies. Padgham (2017) scrutinizes the discernibility of complexity in urban systems by focusing on three characteristics of complex systems that are relatable to cities: scales and hierarchies, dependence on initial conditions and discontinuity, and causality and emergence. Every individual in the city possesses agency with the capacity to shape phenomena in urban systems, which in turn influence various morphological aspects of a city. Individual decisions constitute the driving mechanism of emergent conditions in the interwoven whole. However, the emergent whole imposes a top-down causality on low order dynamics through positive feedback.

In addition, scale and hierarchy are integral properties of complexity manifested in cities embodying morphological structures on various levels. Simon (1962) denotes that often complexity takes the form of hierarchy, positioning thus hierarchy at the center of complexity's architectural structure. He emphasizes the interrelation of scales and the "near-decomposability" of the hierarchical systems. Decomposability is also given prominence to in Salingaros' paper about urban coherence where he explains that "coherent systems cannot be completely decomposed into constituent parts"(2005, p. 294). Marshall (2009) explains that the similarity of patterns manifested in structures and functions from the smallest to the largest spatial scales when observing the form of cities is profound. This similarity implicitly indicates the presence of a fractal hierarchy. Others disagree with this similarity, given that each particular scale fosters processes of different character in complex systems, which cause different patterns to emerge at different scales(Wu, 1999; Padgham, 2017). Cities as integral entities encompass several scales whose constituting elements interact with each other not only within the same but also with other constituents across scales. In urbanism, scale presents a major challenge especially in the matter of exercising control and applying design processes, since it has been widely acknowledged that boundaries between spatial scales are blurred.

To implement the conceptions of complexity in the field of city planning, the idea to recognize the town as a coherent entity and not just a collection of its constituents was indispensable (Batty & Marshall, 2012). This conceptualization is in line with the mantra of complexity, the whole is more than the sum of its parts. Batty and Marshall(2012) argued that to rationalize town planning , given the paradigm shift encompassing various scientific domains, the planner's role was to provide exactly what made cities greater than the sum of their parts. Many adjectives have been used to describe the character and the complexity of the urban systems which have enabled formulations of city-related problems from different perspectives, among which are 'of organized complexity', 'wicked' and 'generic'.

Organized complexity, as it has been explained formerly, is associated with a great number of interrelated variables and is certainly a descriptor of city-related problems to shape city planning decisions. However, one should note that the number of variables approximating infinity in city planning and design problems has made it exceedingly difficult in the discipline of planning to write perfect equation. In the age when a convergence of cultures and traditions are addressed under the guise of equity and primarily economically motivated optimization, it becomes a quest to acknowledge the complexity of the urban systems while considering them as living. Accordingly, the approach referring to cities as living systems should be based on the complexity that characterizes them with emergences occurring from the bottom-up. As such, one of the earliest works addressing cities as living organisms is that of Reclus (1895), in which he adopts terminology from biology, particularly to address cities' growth. Jane Jacobs (1961) argues that the problems that a city displays can only be solved once they are approached to as problems of organized complexity, problems of life sciences.

Marshall (2012) elaborates on Jacobs' formulation by describing four kinds of complexity, namely, artefactual complexity, system complexity, biological complexity, and ecological complexity, which help to articulate the nature of urban complexity on different scales (see Figure 2.4). Artefactual complexity is associated with designed objects, whose composition is pre-determined, facilitated by an unchanging and known whole. Objects possessing artefactual complexity are machines, buildings and other complex works of art. While biological complexity may resemble the artefactual one in the aspect of finity and the closed state of the system, it differs from artefactual complexity since there is no designer's hand involved creating living organisms, but they emerge from within themselves, and may change in time.

One noteworthy feature of living organisms is that they tend to maintain homeostatic equilibrium, that is, they show some resistance to environmental change. It is this feature and the openness of the system which helps us draw a distinguishment between biological and ecological complexities. The open-endedness and the dynamic nature of ecosystems (embodiments of ecological complexity) makes them unpredictable as they evolve through adaptation. Finally, Marshall (2012) identifies system complexity in association with artificial open systems, which are open-ended, evolutionary, and emergent.

To reach a state of coherency, an urban system must embody all four kinds of organized complexity in the respective scales. This approach needs to be incorporated into conceptualizing city-related problems at a variety of scales, as it has long been established that optimal solutions to planning and design have proved to be impractical. In this respect, Rittel and Webber (1973) classify problems of planning as 'wicked problems". Although their essay focuses more on the social and political aspects of planning, their work is significant as it highlights the uncertainty of urban systems in the long term.

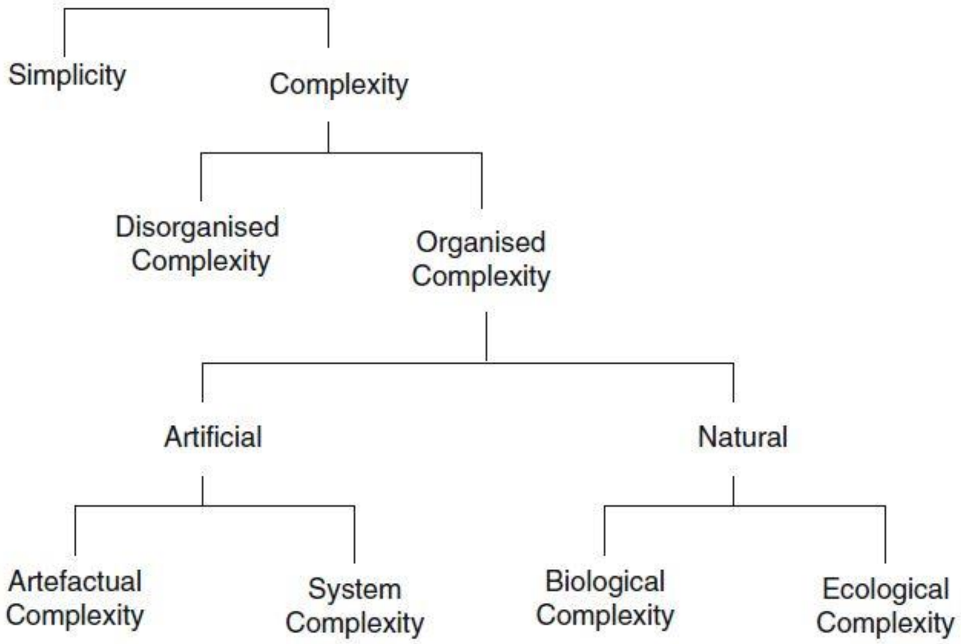


Figure 2.4: Four kinds of Organized Complexity (Marshall, 2012, p. 197)

Acknowledging Rittel and Webber (1973), who focus on the impracticability of 'optimal solutions' to problems of planning and design, city-related problems are often referred to as 'wicked problems.' Wicked problems are characterized by the following properties:

1. Wicked problems cannot be definitively formulated due to the large amount of information needed to fully understand these problems
2. Wicked problems lack a stopping rule as there is always a chance to do better
3. There are only good or bad solutions to wicked problems, not true or false
4. Solutions of wicked problems cannot be immediately or ultimately tested, attributable to the waves of consequences their solutions generate
5. Every attempt to solve a wicked problem is of significant importance, as learning by trial and error is not an option; hence wicked problems' solutions are one-shot operations
6. Potential solutions to wicked problems are not enumerable or exhaustively describable
7. Wicked problems are characterized by an essential uniqueness

8. Wicked problems are approachable as symptoms of other problems
9. The discrepancy in representations of wicked problems is rooted in too many interrelated variables
10. Planners are not allowed to be wrong, in the sense that the impact of their decisions affects lives of multiple people

In other words, one can infer that it is the complex nature of cities as characterized by interrelation and interdependence of constituents and conditions, emergence, and self-organization, accounting for classification of city-related problems as wicked problems. Comprehensive planning approaches prevailing in the 20th century, fail to treat cities as wicked. Modernist approaches focused on functionalism and imposition of a rigid large-scale order have generated generic cities, which are simply a blueprint as if cities were machinelike, replicated with no consideration of context and experience. Marshall (2009) distinguishes cities not only from machines, but also from works of art and organisms.

Deriding the fragmented outcomes of modernist planning, Koolhaas (1995) theorizes convergence of 20th century cities and objects of artefactual complexity. He identifies the generic city as striped of its identity, accommodating only " the primordial and the futuristic", held together by the residual, lacking diversity, where the streets are dead, and life and growth happen only vertically in non-interacting skyscrapers, issuing from tabula rasa in the pursuit of " overly ordered sections" with an aesthetics of a "free style", where the roads belong only to cars and which marks the death of planning (p. 1252- 1255). With this diagnosis, Koolhaas ridicules the outcomes of conventional planning resulting from mechanistic reductionist approaches and which are to be held accountant for the creation of alienating fragmented spaces that do not embody life and diversity.

2.2.2 Mechanistic Reductionism in Planning and Design

The tendency of human beings to reduce the phenomena in their surroundings helps them have a better understanding of how systems work. However, this reductionist approach towards the environment has proven detrimental concerning the qualities of good urban form. As Anderson (1972) suggests, reducibility of everything to simple fundamental laws does not insinuate that the reconstruction of the universe is bound to commence form those laws. In contrary, the creative forces guided by the complexity of natural systems which have proven to be of success when describing both processes and patterns in various fields of study are those to consider when constructing and reconstructing. Therefore, complexity, which is the main driving force sustaining the functionality of urban systems, is not to be successfully handled via reductionist approaches.

It is human nature to simplify not only representations of their surroundings, but also the assumptions made to seek solutions to urban related problems. In years planning and urban design models have based their solutions on reductionist assumptions, which instead of easing the 'path to' the expected success in the 'final outcome' has only constricted the 'path of' progression with complexity. Bhat and Salingaros (2013) views reductionism as menacing and defines it as the philosophy behind the contraction of complex systems in both society and science to the lesser single causalities. Provided that there is a recognition to the quintessential complexity of cities, the historical association of planning with a reduction as regards complexity has not been effective (Marshall, 2012). In planning and particularly in the scale of urban design , top-down decisions have manifested themselves as problematic disorganized complexity where incoherence generating competition for space is the thriving mechanism. Therefore, one can conclude that reductionist approaches to planning and design problems are a significant cause of fragmented urban form, which does not promote processes that generate urban life.

2.2.3 Overview of the Implications of Complexity on Coherence in Urban Morphology

All the emergences in social and economic dynamics of cities shape morphology constituents. Allen (2012) referred to cities as representations of gradual accumulations of layers in succession manifesting collective activity and desires, which structure and are structured by other, ever-receding, cities with an effect to a global extent. He points out that one of the implications of structural changes is that the patterns of growth and their primary drivers evolve over the years. It is not only the multiplicity of agents involved in the morphology formation, but also their co-evolving behavior and the change speed of interdependent systems within systems that contribute to a continuous pattern of transformation with their emergences in urban form.

Urban morphology, an evolving outcome of man's work in an initially natural setting not only provides the space for emerging behaviors but also evolves accordingly. Cities grow from the bottom up. Responding to the environment is the key factor in emergent behavior that led to the cities as we know them today. Cities evolve displaying a recurring regularity and there exists similarity to some extent between processes (Batty, 2003). The tribes' common 'trysting place' of Reclus (1895), where material and informational exchange have an origin that resembles to a new matter, or a particle created by interactions of other particles. Alexander (1964, 2002) suggests that complexity originates and develops from bottom up. Batty (2010) explains this by implying that the structure of the system emerges from its constituents, but this does not resemble a simple mathematical operation of addition.

In this essence, determining constituent parts of a city is a matter of wholes and nested centers and not simply entities which have been juxtaposed. Alexander (1966) defines the physically stable part of a city system in which "the changing parts of the system-people, newspapers, money and electrical impulses- can work together" as a unit of the city (p. 2). Alexander's unit of the city, which happens to be a subset of a semilattice is of a fractal nature. This fractal nature of constituents and wholes highlights the idea that a complex and coherent system cannot be simply decomposed to units that stand separately without losing the system's intrinsic characteristics.

Marshall (2012) discusses why complexity is desirable in planning and design and suggests that it can benefit urban design in the aspects of perceptual richness, functional capacity, and synergy. Perceptual richness is highly present in squares and streets of traditional settlements with a traditional organic fabric. As advocated by many observers of the urban form a street or a square with a rich visual complexity is more aesthetic and pleasing than simpler environments with an exclusive order (Sitte, 1889, 1965; Rapoport, 1990; Marshall, 2012). Given that the line separating architecture and urban design is blurred due to the overlapping domains, a rich perceptual complexity begins with architecture enclosing the street and the square. Salingaros (2014) asserts that the success of architecture depends on the visual, emotional, and visceral connection of the user with its complexity.

Another important implication of complexity in urban design is associated with its functional capacity. According to Marshall (2012), the capacity for functionality that a complex design displays is greater than the one offered by a simple design. Streets and squares of different sizes and qualities ensure a certain degree of efficiency for the whole urban system due to the variety of functions that they may host. Lastly, synergy, which is the quality of the whole as something greater than the sum of its individual parts requires heterogeneity for the individual parts to complement each other and cause a larger scale emergence (Marshall, 2012). Synergy is also at the core of Alexander's idea of wholes and centers whose quality cannot be determined by isolating the individual parts.

The well-known mantra 'The whole is more than the sum of its parts', though implicitly, lays the foundations for understanding how complex systems of any kind work and evolve. Batty (2009) agrees that a simple addition of the parts is not enough to assemble the cities as wholes. Cities evolve from the bottom up and the control mechanisms of top-down planning have failed in sustaining growth due to the fact that the complex nature of cities perplexes the anticipation of change, indicating that there is no obvious explanation as to what bottom-up processes result in several desired and undesired states of the whole.

In the discipline of planning many scholars have agreed to the fact that the traditional top-down planning has created 'urban maladies' in its endeavor to seek solutions to problems of a 'wicked nature'. While cities' growth might lead to the unwanted result of sprawl and all the drawbacks that come with the package, some researchers might view growth simply as a necessity to sustain development and thus bring about novices in the city life. Reclus (1895), an anarchist geographer, highlights the importance of distinguishing the causes of origin and growth of a city, and those responsible for their decay, disappearance, and transformation**.** He views cities' growth as a development of society rather than a malady and considers diminishing cities as a sign of civilization at danger. More than a century later, what Reclus questioned as regards the nature of cities' growth reawakes issues that require solutions by planners and designers. The answers to what exactly cause a city to grow, or decay are constrained by the conundrum of ambiguity.

Growth and change are predestined in cities since they imply an evolution and adaptation to new states. Reclus (1895) described the complex aftermath of a plethora of causes in cities not as a pathogenic growth:

> Yet it is easy to show that this monster growth of the city, the complex outcome of a multiplicity of causes, is not altogether a morbid growth. If, on the one hand, it constitutes, in some of its incidents, a formidable fact for the moralist, it is, on the other hand, in its normal development, a sign of healthy and regular evolution. (p. 3)

Larkham & Conzen (2014) state that lack of transformation suggests stagnation, which according to them commonly relates to a failure of responding to transforming social and economic trends, demands and opportunities. While urban growth is inevitable, one cannot neglect the fact that unsustainable practices of planning and design have damaged the coherent tissue of the built environment. Mehaffy (2010) notes that growth is not something homogeneous, since there exist sustainable forms of growth in the natural world designated for a dynamic equilibrium as opposed to runaway growths resulting in collapse or decay (p. 192). He believes that a great deal of the answers to developing the kind of growth that is adaptive and makes places better with regard to several spatial qualities, is to be sought in nature and especially embodied in human traditions with their rich collective intelligence. On the other hand, Hern (2008) compares cities' growth patterns to malignant lesions. According to him:

> Malignant Neoplasms in organisms have several characteristics: a) rapid, uncontrolled growth; b) invasion and destruction of adjacent normal tissues; c) metastasis (distant colonization); and differentiation (loss of characteristic cell and tissue appearance unique to each kind of tissue).(Hern, 2008, p. 4)

Batty (2009, p. 18) asserts that the physical artifacts of cities defined by the built environment are seemingly in a state of equilibrium. Similarly, Hillier (2012) distinguishes between the pace of change of two systems; the physical system , which is composed of buildings connected by streets, roads and infrastructures and the human system, consisting of activity, flow (movement) and interaction. Nonetheless contemporary cities' geometry resembles less and less that of their antecessors and the main determinant of this change is by and large the critical loss many of the spatial qualities of a good urban form, including coherence.

2.2.3.1 Emergent Urbanism versus Planned Urbanism

In the aspect of discussing coherence and its degrees in urban complexity two patterns of growth are noteworthy: emergent and planned. According to Batty and Longley (1994) from ancient times there has a been a classification of towns and cities as those with a ‘natural’ or organic’ growth and those with an ‘artificial’ or ‘planned’ growth. Nilsson and Gil (2019) attribute this classification of cities and towns not only to growth but also to the resulting morphological pattern. Distinguishing between the two presents difficulties as there is no town purely organic or purely planned. Organic and planned growth are within the same continuum (Batty & Longley, 1994). However, in *Fractal Cities* Batty and Longley define some distinct properties which differentiate emergent cities from the planned ones by and large. These properties are summarized in table 2.1.

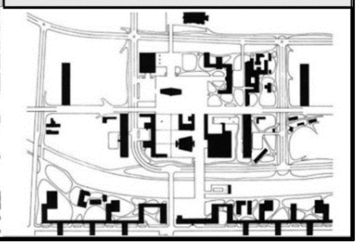
PROPERTIES	EMERGENT URBAN FABRIC	PLANNED URBAN FABRIC
GROWTH PATTERN	INCREMENTAL ASSEMBLAGE	IMPOSED ORDER
FORCES	INDIVIDUAL DECISIONS	CONTROL AND COMMANDS
OPERATIONAL SCALE	INDIVIDUAL PLOT	FROM ENSEMBLE TO TOWN
FORM	IRREGULAR	REGULAR
CHARACTER	GENERIC/ ORDINARY	PARTICULAR/ STANDARIZED
CHANGE	GRADUAL	SUDDEN
FIGURE-GROUND		

Table 2.1: Emergent Urban Fabric as opposed to Planned Urban Fabric

Emergent cities are characterized by a slow development and the nature of their growth reflects on the quality of urban public spaces within the city, such as streets and squares. Medieval cities are a good example of emergent growth. Camillo Sitte

(1889, 1965) notes that streets in old cities have grown slowly in proportion to the gradual development of important communication routes which connected the countryside to its natural centers. “The metairie or chateau has become a village, the village, a market town, or city”(Sitte, 1889, 1965, p. 60). He explains further that in the Middle Ages walls had to surround most of these groups of houses, which impeded their expansion. With some exceptions, most medieval cities emerged incrementally where there used to be Roman camps or ancestral villages, causing the pattern of their streets to be in no way arbitrary as it was mainly a result of orientation and of events, and comply with the topography. Organically growing towns seem to fit their natural landscape more comfortably in that if decisions are smaller in scale, they reflect the properties of nature more closely as well as reflecting more intense concerns at the local level (Sitte, 1889,1965).

Organic does not necessarily imply unplanned in the context of urban morphological processes. Batty and Longley (1994) argue that it is a profound order which manifests itself as the irregular and messy form and shape of cities, which they attribute to fractal geometry. Kostof (1991) depicts the organic city as:

… ‘chance-grown’, ‘generated’ (as against ‘imposed’), or, to underline on of the evident determinants of its pattern, ‘geomorphic’. It is presumed to develop without the benefit of designers, subject to no masterplan but the passage of time, the lay of the land, and the daily life of the citizens. The resultant form is irregular, non-geometric, ‘organic’, with an incidence of crooked and curved streets and randomly defined open spaces. To stress process over time in the making of such city-forms, one speaks of ‘unplanned evolution’ or ‘instinctive growth’. (Kostof, 1991).

On the other hand, planned urbanism has been characterized by a visual order, which has been the prominent doctrine of planned development where imposition of simple and regular geometrical forms based on the Euclidian geometry has prevailed (Batty and Longley, 1994). Irregularity in urban fabric has mostly been interpreted as disorder and as a problem requiring a solution which can only be provided by imposing order, as an indicator of good quality urban form. However, it is worth noting that the pure geometry of the last century's development with its underlying 'exclusive unity' has weakened the socio-geometric structure of the public space in cities. Salingaros and Pagliardini (2016) criticize the geometry of suburbs and apartment blocks as representations of the nonfunctional and irrecoverable urban fabric. They indicate a loss of the urban geometry which accounts for sustainability of human society. Therefore, lately there has been a consideration of organic pattern as desirable in cities, which has led to an endeavor to emulate them in planning (Kostof & Tobias, 1991). Organic forms have for long been characterized by the coherence of their parts: they have a unity beyond mere aggregation (Kostof , 1979, p. 9).

Another important aspect that helps distinguish traditional emergent patterns from the "artificial" and planned ones is their geometry and structure. In general, the geometry of planned settlements is grounded on Euclidian geometry and the structural is strictly hierarchical, characterized by smooth curves and straight lines, whereas the geometry of organic settlements satisfies properties of living geometry with a semi-lattice structure, which accounts for a higher degree of the coherence.

2.3 The Condition of Coherency

Humans' adaptive nature, apart from adjusting the natural environment by deliberately designing artifacts to ensure comfort and satisfaction, tends to habituate to the surrounding in time, losing thus the awareness of the deteriorating impacts that it might have on their physical and mental wellbeing. However, as we live through the everyday life moving through or sojourning the space, there are occurrences when one realizes that the place in which they are trying to subsist does not provide comfort any longer, mostly as coherence is no longer a quality of our urban public realm. Streets and squares do not invite users to sojourn any longer, and lingering has been replaced by rushing through to reach an appointed destination. As such coherence is not only a condition that we aim to ensure the success of a complex system on the largest scale. It is a condition which fosters human scale within the complexity that urban systems present. In this framework, one should address how implications of complexity give rise to the condition of coherency in urban fabric.

There exists some degree of confusion as it pertains to the definitions of complexity and coherence in general and in the field of urban design specifically, which will require some elaborated explanation of terms in relation to other urban qualities and one another. Coherence, broadly defined as the quality of creating a unified whole, is what generates the order so profoundly tackled by Alexander in his seminal four books on *The Nature of Order* (2002-2004). Considered as a fundamental property of good urban form, coherence requires a more explicit formulation and concretization as regards its relationship with the complexity in public space. It should be discussed as an aspect of complexity in design and not as its opposite with respect to the spatial and perceptual dimension.

By its very nature, when freed from economic and political constraints, urban form hypothetically presents an infinite number of possible resultants and emergents, that notably do not always enable the desired performance. Whether it is by design or not, urban form is clearly a result of man's work, which makes it an artefact. Steadman (2008) argues that coherence, an indicator of an organized relationship between the constituents of a biological organism, can serve as a descriptive criterion for similarities in the qualities of a well-designed artefact (p. 4). Çalışkan and Mashhoodi (2017) suggest that the the normative criteria to obtain an effective performance in terms of functionality or aesthetics of urban design are indicated by quality measures of morphology, and among many other form-based concepts in morphology they consider coherence as one of the main normative concepts in the framework of urban design.

Although having been recognized as an essential quality of good urban form, coherence has not been elaborated on since long in planning and urban design. Robert Venturi (1966) diagnoses the absence of coherence in orthodox modern architecture implicitly by claiming that modern architects "advocated the separation and exclusion of elements, rather than the inclusion of various elements and their juxtapositions”(p. 13). Perceptual complexity of structure and form has been disregarded in contemporary architecture and planning, practices of which have been predominantly embodying replications of two prominent models, the Garden City, and the Radiant City. These two models have triggered a bifurcation difficult to reverse in urban life, where one struggles to connect with the lifeless built form. It should be noted that without complexity there is nothing to cohere, considering that everything is simply a unit in the uniform aggregation. Salingaros (2000) shares the same thoughts with Jane Jacobs and Venturi on the significance of complexity for spatial coherence, as he asserts that diverse elements and functions are requisite for coherence in both the small and the large scales.

2.3.1 Urban coherence as an emergent construct

Coherence is a desirable quality of any creation of humankind, as it is not determined by the sum of the creation’s individual parts. It emerges as a meaningful, satisfying whole once separate musical notes come together in a beautiful symphony, once words come together to produce an unforgettable story, or it may unfold though its centers as we walk through or sojourn in old streets and squares of Rome. The Aristotelian view of works of art and living beings revolves around the central concepts of wholeness, integrity, and unity of the structure and suggests that the whole will be impair if any part is to be removed. The beauty of the organic wholeness in a well-designed artefact and in a living organism resides in the fact that just as the parts are related to the whole harmoniously and proportionally the whole is related to its parts (Steadman, 1979, pp. 8-9). Coherence is about placing the right element in the right space-time continuum, and it generates a functionally and aesthetically successful whole. Abundantly present in nature, coherence is the condition that triggers contemplation of beauty in the organic form which leads to users’ satisfaction. In essence, coherence is a condition arising from emergent phenomena and reconciliates complexity and order in urban form.

Although two dimensional representations of the urban fabric, such as figure ground diagrams give significant information concerning cities' operationality, many other aspects, around which 'life between buildings' revolves, remain obscure. One of them is spatial coherence, which Salingaros (2000) associates with the success of urban space in terms of exuberance and effectiveness embodied in its structure. Alexander's ideas in *The Nature of Order* were an impetus for Salingaros to look for unifying structural principles of generating coherence in urban form, whose fundamentals are derived from biology, economics, and computer science. According to Alexander(2002) it is the dazzling geometrical coherence and its meaning in our minds that invokes the presence of order. As one finds themselves in any urban setting, it is the coherently arranged complex urban spatial elements that generate a pleasant place for the users to connect with their environment in the human scale by providing the right information at the right time in that the user shall not be bombarded with information or made devoid of it.

Ewing and Clemente (2013) select coherence as one of the measurable qualities of urban design and relate it to a sense of visual order. According to them the degree of coherence is determined by 'consistency and complementarity in the scale, character, and arrangement of buildings, setbacks, street furniture, and landscaping'(p. 27). Furthermore, the expert panel in Measuring Urban Design (Ewing & Clemente, 2013) used repeated elements, such as building setbacks, similar building masses, landscaping, and street furniture to describe coherence and highlighted that ordered diversity was necessary so as not to make the design monotonous. Çalışkan and Mashhoodi (2017) provide a morphological definition of coherence and assert that "coherence of urban fabric in the sense of the proximity of all constitutional elements within a layer or layers of urban fabric can be considered as the very basis of the functional efficiency and vitality of human activity, use and movement in the built environment" (p. 139). They suggest an analytical method to measure morphological coherence based on the above definition and a layering approach. According to findings of their research, the quality of fine grain should be viewed as "a supplementary condition for morphological coherence" (p. 138), as they maintain that coherency does not stipulate smallness of the constituents. Instead, coherence depends more on a low range variation in a fine-grain layout. Çalışkan and Mashhoodi (2017) conclude that, coherence of the urban fabric establishes the basis for the functional efficiency of the human system which includes activities, uses and movements in the built environment.

2.3.2 Rules for Generating Urban Coherence

Salingaros (2000) draws inspiration from structural principles formulated in computer science, biology, and economics to yield significant insight with respect to generating coherence of urban form. According to him, the lowest scale from which a tight interaction among constituents initiates the assemblance of complex large-scale wholes is the natural structure of materials. As such, he maintains that to generate coherence in the large scale, the small scale should embody diverse elements and functions. Salingaros suggests that coherence in urban form accounts for positive qualities in urban regions built in the past, whose geometry is connected on the whole, a property missing in the products of contemporary urban practice. Identifying geometry as the primary source of great built environments, Salingaros bases the principles he describes in his essay, "Complexity and Urban Coherence" on Alexander's fifteen geometrical properties of coherent wholes. Paralleling Alexander's ideas, Salingaros considers the morphology of traditional cities and towns as geometrically coherent. In this framework, he speculates on the shortage of contemporary design and development rules with respect to generating urban coherence, seeing that their results lack complexity and connectivity.

The main postulate of Salingaros' work is that the success of the urban form with respect to the instigation of efficiency, livability and a psychologically nourishing human environment is dependent on geometrical coherence. In other words, geometrical coherence accounts for the quality of life in and between the buildings. Defining a city as a network of paths, Salingaros (2000, p. 2) states that "a coherent city must also be plastic, i.e., able to follow the bending, extension, and compression of paths without tearing" and for that "the urban fabric must be strongly connected on the smallest scale and loosely connected on the largest scale". The idea of strong connections on small scales and loose ones on large scales is derived from universal structural principles of biological forms and laws of physics. At the core of Salingaros' theoretical approach to urban coherence lies the interaction of objects' geometrical field of objects which Alexander distinguishes from other physical forces. Meanwhile, Salingaros describes this geometrical field as a function of information which is determined by how shapes, surface textures, patterns, colors, and details intensify information they embody via combinations. In this sense, introducing the notion of coupling as the primary condition for generating coherence, Salingaros proposes theoretical rules originally developed in domains of science, with the objective of assembling components of urban fabric into coherent wholes.

Rule 1: Coupling

This rule indicates that components of the same scale couple to form a module. An analogy can be drawn between the character of the modules with Alexander's idea of centers, as both centers and modules are parts of a nested hierarchy. Salingaros (2000) states that modules should not contain elements that are not connected, and these connections are dependent on the shape and position of the coupling elements. What we understand from Salingaros' description of couplings, is that they are not only geometrically driven, but that components that couple also intensify one another visually, structurally, and functionally. It is undeniable that coupling elements require a high degree of juxtaposition, but simply placing empty elements in proximity fails to generate modules. On this account, one should note that some kind of interaction between two elements is essential for coupling, a conception applicable to the way elements of a city are materialized into spatial coherence. According to Salingaros components of a city have an obligation to couple on the smallest scale to generate urban coherence, a feature which products of contemporary urban design approaches are devoid of. One can derive from Salingaros' simple explanation of coupling that it is a recursive rule to be applied progressively across various scales of the urban fabric. However, a more specific explanation description of how a successful coupling occurs is explained via two other rules which are concerned with diversity and boundaries.

Rule 2: Diversity

Acknowledging no coupling occurs between similar or identical components, this rule is strongly related to the property of contrast, as formulated by Alexander (2002). To generate a module, two elements of the same scale must contain contrasting properties, to complement each other via mutual reinforcement. Salingaros (1995, 2000) emphasizes that " order on the smallest scale is established by paired contrasting elements, existing in a balanced visual tension". Within the framework of urban space, components of the smallest scale comprise everything which is accessible to a pedestrian at arm's length. Jacobs (1961) highlights the important role that small blocks play in generating diversity in a city, as regards the mix of uses. However small blocks possess advantages not only in terms of convenience but also in terms of experiential perspective of the users. Considering that the coupling between solid and void in public space takes shape depending on the character of the boundary enclosing the street and the square, modules of contrasting couples assemble to generate two main types of coherent boundaries, a boundary imbued with strong centers comprising of ornaments, and a boundary which couples with the void of the public space via interlock.

Rule 3: Boundaries

In consideration of the fact that spatial and visual qualities of streets and squares as public spaces are dependent on the geometrical properties of the bounding structures, the rule of boundaries is the main rule in interest of this research. Therefore, spatial coherence in public space is tightly associated with the spatial qualities of the boundaries. According to Salingaros (2000) boundary elements enable coupling between different modules and he highlights the fact that internal elements of modules do not connect. In a street, every single element in the boundary provides a stimulus for the pedestrian and Salingaros (1998) asserts that a coupling does not occur only between components of the built environment, but also between the pedestrian and the information embodied in the built structures. Boundaries and which are plane or continuous straight lines dividing regions are not the rule but an exception in living cities (Salingaros, 2000). Using the term interface, Salingaros (2000) defines two successful types of boundaries which resemble "either a permeable membrane with holes to allow for interchange, or a folded curtain with an edge that looks like a meandering river on a plan" (p. 10). According to him, the permeability of interfaces in urban space can be attained via arcades, colonnades, or gaps in rows of houses and shops that provide cross-paths. On the other hand, folding or convolution of the boundaries occurs when impermeable edges of buildings couple with the space they bound via interlock. Both these kinds of boundaries enable transition spaces, and consequently, encourage a variety of human activities. Salingaros (2000), establishing that urban coherence is tightly associated with the quality of human scale, emphasizes "perforations or gaps are useful when they occur on the scales 1 m-3 m corresponding to the size and physical movements of a pedestrian" (p. 11). About the interlock type of the boundary, Salingaros describes it as a useful coupling on all scales of the urban fabric, ranging from 1 cm architectural elements to semi-enclosed plazas created by urban folding.

Rule 4: Forces

Forces are responsible for holding elements together and thus when applied accordingly have the capacity to generate coherence. Salingaros (2000) states that the strongest interactions between elements should occur on the smallest scale and the largest scale is characterized by weaker interactions among elements. Since connections that enable the creation of urban coherence are dependent on strong forces that hold elements of small scale together, imposing strong forces on large scale generates pathologies. Excursing into physics Salingaros (2000) provides valuable insight as regards the nature of urban couplings occurring on various scales.

> Every force f arises from differences in some field U, which represents either a geometrical quality or a function. It is easy to see where U becomes greater through concentration or intensity. The force f is defined as negative spatial

> derivative of the potential energy *U* of its field, *f* = -*dU*/dr. This equation gives a stronger force where the difference the difference in potential is larger. A difference in potential translates into the urban context as a difference in qualities within a short distance; implying a stronger coupling force whenever there is greater contrast in qualities such as texture, color, or curvature of the interface. (p. 21)

Using the above formula Salingaros explains the shortcomings of twentieth-century urbanism by formulating that zoned region are devoid of coherence and that edges of functions vertically concentrated are unusable.

Rule 5: Organization

Organization of the large scale depends on well-defined structure of smaller scales. The necessity for this rule arises from the fact that well-established couplings on small scales do not always succeed in generating a large-scale coherence. On the grounds of this, Salingaros (1995, 2000) suggests that for a large-scale order to emerge elements should be related to each other at a distance in a way that entropy is reduced. However, reducing entropy might lead to the loss of local connections between modules formed by couplings on the small scale. If we try to apply the same rules of couplings on the large scale the result is juxtaposition of homogeneous zones, and thus small-scale couplings are destroyed. We have already established that coherence cannot emerge without complexity and zero-entropy zoning is not the right way to generate a large-scale spatial coherence. According to Salingaros (2000) long-range alignment forces, weaker than short-range coupling forces is the underlying principle of urban organization. The conclusion that we can derive from the above explanation is that alignment in urbanism should occur in a way that strong couplings of the low scales are not compromised.

Rule 6: Hierarchy

This rule indicates that " a system's components assemble progressively from small to large" and "this process generates linked units defined on man distinct scales"

(Salingaros, 2000, p. 4). As such coherence emerges sequentially from the small scales to the large ones. A coherent urban system is full of small, intermediate, and large scales, whose connections depend on short-range and long-range forces as prescribed by previous rules. Once this rule of assembly is considered elements will be connected across the scales. Salingaros (2000) maintains that cities are assembled from coupled units on various scales, which are successive. For connections among scales, he identifies a scaling factor approximately equal to 2.7

Rule 7: Interdependence

Large scale is dependent on the small scales it embodies, not vice versa (Salingaros, 2000). Therefore, one can draw the conclusion that small scale coupled elements that cohere can exist independently from a larger scale containing them, but coherence in the large scale cannot exist without strongly coupled elements on lower scales. After having addressed the existence of a higher degree of spatial coherence in emergent traditional towns, it has once again become clear that no spatial coherence can be generated via a strictly imposed large-scale order, since life grows bottom-up. The rule of interdependence allows for a change in urban elements on the small scale, which indicates that in

Rule 8: Decomposition

Decomposing a coherent system into its constituent parts cannot be fully accomplished (Salingaros, 2000). This is due to the not-separateness of coherent wholes, which characterizes traditional urban settlements. If one attempts to disentangle the system, various types of units will arise, any of whose removal would result in the loss of the urban system’s complexity. This is not the case with the products of the twentieth century urbanism, as they are easily decomposable into parts, which when removed can be easily replaced. Once again, we remind that the whole is more than the sum of its parts. The rule of decomposition can also be interpreted via the idea of overlapping units that the semi lattice structure of cities comprises.

CHAPTER 3

SPATIAL COHERENCE

In search of spatial coherence embodied in the public space, the question of how the coherence of the parts generates streets and squares with positive physical qualities arises. Coherence together with the physical attributes that it enables contributes to making place out of space. Given that human space is by large organized based on sight, this chapter starts with the discussion of how space turns into place by endowing physical attributes that facilitate a variety of human activities engaging user experience. Next, it addresses the idea that a city is not a work of art, albeit incorporating artefactual complexity in certain scales. To that end, it is established that spatial coherence is a condition that emerges when the pre-existing whole proscribes newer additions and transformations.

A work of art is an outcome of command-and-control processes, exhaustively the opposite of what a city is. A work of art is by large aesthetically driven and aims at controlling the whole, but a city as a whole has an emergent character and is of a spontaneous order arising from ordinary life. This does not imply that one cannot seek beauty in the built environment, granted that it is not the main drift of development or transformation. Christopher Alexander (2002) tracks down beauty in the ordinary life occurring in the built form, not necessarily confined in the strict Euclidian geometry, the application of which accounts for morphological aspects of modern urbanism and in particular a tree-like structure of cities. In his contributory paper, “A city is not a tree”, he recognizes that “there is some essential ingredient missing from artificial cities” as he deems them to be unsuccessful (1965, p. 1). What is missing is the presence of overlaps, which consolidate the spatial coherence of the built environment.

Sitte (1889, 1965) points out that ‘our mathematically-precise modern life’ does not favor an artistic development of city building the way ‘life in former times’ did. The life that Sitte instances is the everyday life driven by biological needs developing in the voids enclosed or verged by buildings. It is the ordinary life of a spontaneously grown city, shaped by both deliberate human actions and the consequences of the unintended human will, which concretize into a kind of order or regularity. Hayek (1967) uses the concept of spontaneous order, “the result of human action but not of human design” to describe the latter phenomenon. Ikeda (2017) defines spontaneous order from a social perspective as “a stable set of relations among individuals that emerges unplanned from their collective interactions and that is sufficiently coherent to enable them to form and and carry out their plans with a reasonable expectation of success” (p. 80).

Alexander(2002) distinguishes between biological life and the feeling of life in things, places, and events, which reveals a degree of consistency in the eyes of the users, implying thus that there could be objective knowledge and measurability developed on the basis of the degrees of life he seeks to define. The quality of life is stronger in structures with a coherent wholeness (Alexander, 2002, p. 89). In many instances, Alexander uses the notions of wholeness and coherence interchangeably. In traditionally developed cities or as Alexander refers to “cities which develop organically”, though, this wholeness from which the condition of coherency stems, emerges and cannot be designed. According to Alexander et al, “each of these towns grew as a whole, under its own laws of wholeness” (1987, p. 1). This insight is the rationale behind generative urbanism with focus on process and emergence; hence one can assume that the city as a whole emerges as life unfolds, which by enabling the condition of spatial coherence generate places.

3.1 From Spatial Coherence to Place

This section focuses on the use and of space and how spatial coherence with the visual qualities it enables affect user's experience as they carry out their outdoor activities. Given that ordinary life involves a variety of activities public space should facilitate the user's needs in this aspect. Jan Gehl (1971, pp. 9-28) defines three types of outdoor activities which require specific physical qualities: necessary activities, optional activities, and social activities. He discerns that in streets and poor-quality public spaces, activities taking place come across as rushing toward a destination, whereas in a good environment there exists the possibility for a rich variety of human activities. According to him life between buildings consists of an entire spectrum of activities driven by an opportunity to see, hear, and meet others. It should be noted that life between buildings is strongly influenced by the quality of the outdoor spaces. Both Sitte (1889, 1965) and Salingaros (2000) attribute the poor quality of the contemporary public spaces to the lack of indoor-outdoor connections, namely transitional spaces acting as receptacles of emergent activities and contributing thus to the quality of public space by broadening the spectrum of activities. Human scale plays an important role and is highly disregarded in contemporary streets, characterized by huge distances between buildings and lack of transitional spaces, resulting largely from an imposed top-down order.

Batty and Longley (1994, p. 11) establish that humans have had a sense of order even before modern times, although their empowerment to impose order has been tremendously affected by technological developments. One requires order to facilitate life and all of its forms. However, order in contemporary cities does resembles the order that promotes efficiency of machines more than the life of its inhabitants. The physical setting of our environment has strong impacts on what people experience physiologically and psychologically as they carry out their daily activities in the city, whose morphological features and components encourage rushing instead of lingering. Sitte views lingering as a recharging activity while one struggles with their existence.

> To linger! If we could but linger again in those places whose beauties never wane; surely, we would then be able to endure many difficult hours with a lighter heart, and carry on, thus strengthened, in the eternal struggle of this existence. The irrepressible gaiety of the southerner on Hellenic shores, or in lower Italy and other happy regions, is primarily a gift of nature, but the ancient cities, in harmony as they were with the beauties of nature, also acted with a gentle yet irresistible power upon the temperament of the people. Anyone who has enjoyed the charms of an ancient city would hardly disagree with this idea of the strong influence of physical setting on the human soul.(Sitte, 1889, 1965, p. 3)

Gehl (1971, p. 63) emphasizes the importance of senses as regards human perception of spatial conditions and dimensions. However, we are not able to fully understand the complexity of what happens in one's mind while in a public space, so we can only talk of conjectures on the perceptive mechanism of the user at this point. Embodied Aesthetics, which involves a bodily basis of aesthetic preference, draws its main ideas from the claim that body has several important roles in mean-making activity. In other words, there where pedestrians can find an opportunity to linger and sojourn, there is a high aesthetic appreciation. Therefore, it can be implied that public streets where attraction exists offer a possibility to explain and validate the impact of some physical components of the built form on human perception.

People interact with urban spaces through their bodies while moving and through their minds while seeing (Hillier, 2012, p. 141). To generate coherence in any kind of creation the qualities of visual complexity and humans scale are prerequisites. As regards the perceptual capacity of humans Miller (1995) establishes the momentous concept of "chunks", which sets some limits on humans' capacity to process information. He claims that the amount of information and variance define the same notion and emphasizes the idea that along with an increase in the variance increases the amount of information that we cannot dismiss. The larger the variance is, the more uncertain people are about what to expect as they receive a large amount of information and the smaller the variance is, the less information people acquire.

Thagard (2000) draws attention to the incompleteness and the ambiguity of the sensory inputs as regards vision establishing that are not simply taken and transformed directly into interpretations engaged in conscious experience (p. 57).

Ideally, every space regardless the scale exists to facilitate its users' needs. Space cannot serve as a mere collection of stimuli to guide humans' activities but is also a subject to their power of decision-making. Yet the conundrum of producing a built environment, whose physical elements stimulate human behavior and action in a way that the experiential realm is not dismissed is a prevailing quest in planning and design. As pointed out by Rappoport (1990), there exist specific settings that support certain activities or behavior patterns. Benno Werlen (1993) highlights the difference between action and behavior by drawing attention to the indiscernible cognitive aspects of human activity as a focus of behaviorist theories and the intentionality of human actions, which he claims are largely disregarded in reductionist approaches, and therefore human activities shall not be abstracted based on the definition of behavior. Space use, also appointed as a collection of operative qualities has three definitions, chosen and emphasized by Verovsek et al. (2011). Deeply contributive to the urban space's experiential/perceptual value, these qualities are a) easy accessibility – diverse modes; b) easy mobility within and through the space and in particular c) allowed and endorsed sojourning of users resulting from the attractiveness, amenities, and functionality of space.

Acknowledging that a preferred space is characterized by a considerable volume of users engaging in a variety of activities, to identify what makes a certain public space preferrable one should look into places where people linger and sojourn. It is of great importance to consider a spontaneous order, rather than an order imposed by control and control and command as humans' intuitive sense and artistic ideas of order are not adequate due to erroneous foundations upon which they are based (Alexander 2002). The whole with the coherence it inheres emerges on various levels and domains of the city life.

3.2 The Whole Emerges

One cannot deny that city-based processes stipulate a level of organization. To quote Jane Jacobs: " Cities happen to be problems in organized complexity, like the life sciences." (1961, p. 433). This does not imply that a city is a product of Marshall's artefactual complexity, as its organization does not stem from a design process conducted by the hand of a single professional. Rather, its organization takes the shape of coherence, a distinguishing quality of living organic forms whose growth derives coherence from emergence, a characteristic of spontaneous city as explained by Helie in his paper of 2009 "Conceptualizing the Principles of Emergent Urbanism". The main idea here is not at all to claim that works of art lack coherence, but rather to establish that the condition of coherency in a city has an emergent character similar to that of natural organic forms, which result from natural processes and enable the sustainability of life while accommodating change for adaptation.

Batty and Longley (1994) explain that urban problems are discernible as a destructed visual order and harmony due to the fact that people's immediate knowledge of cities is visual. This has shaped the quest of architects, planners, and designers in years. One prominent work focusing on the aesthetic quality of cities and public spaces (squares and streets) in particular is *City Planning, According to Artistic Principles* by Camillo Sitte (1889, 1965). Sitte (1889, 1965) emphasizes the idea that city planning should not treat cities as a purely technical concern since this approach does not encompass all aspects of the city related problems (p. 4). According to him the artistic aspect of cities possesses equal importance, and the main focus of his work is to analyze both ancient and modern cities in a purely artistic and technical manner, aiming to identify compositional elements leading to enchanting effects and harmony, or dullness and disunity. However, one should note that appreciating a city's artistic qualities, does not mean that a city should be tackled as a piece of art, as all those good qualities that mesmerize us in traditional historic cities have evolved incrementally to facilitate the needs of their inhabitants

In her groundbreaking book *The Death and Life of Great American Cities* Jane Jacobs argues why the process of art cannot result in life:

> Artists, whatever their medium, make selections from the abounding materials of life, and organize these selections into works that are under the control of the artist. To be sure, the artist has a sense that the demands of the work (i.e., of the selections of material he has made) control him. The rather miraculous result of this process-if the selectivity, the organization, and the control are consistent within themselves-can be art. But the essence of this process is disciplined, highly discriminatory selectivity from life. In relation to the inclusiveness and the literally endless intricacy of life, art is arbitrary, symbolic, and abstracted. That is its value and the source of its own kind of order and coherence. To approach a city, or even a city neighborhood, as if it were a larger architectural problem, capable of being given order by converting it into a disciplined work of art, is to make the mistake of attempting to substitute art for life. The results of such profound confusion between art and life are neither life nor art. They are taxidermy. (1961, pp. 372-3)

Acknowledging that the coherent urban whole emerges and is not e mere product of urban design, one shall recognize the need for a shift of design paradigm to morphogenetic and generative methods revolving around processes, which Mehaffy (2007) asserts that "cannot be frozen in a standardized master plan" (p. 58). The downsides of preconceiving the end state of the city as a whole are not a new realization. Batty (2007) addresses this condition the formal adaptations resulting agent-based generation of organically related parts operating in a complex way. As Ikeda (2017) maintains, "a city outgrows the elements designed at its beginnings or later in its history" (p. 84). In other words, the need for adapting the built environment is never definitely met, as everything in the systemic material world is in an ever-evolving state and so is the whole.

To explore the insights of apprehending urban form as an outcome of a combination of ‘top-down’ planning and ‘bottom-up’ processes, in his paper, “A City is Not a Rhinoceros”, Mehaffy (2011) examines and contrasts four contemporary approaches centered around generative planning methods including parametricism, generative codes and codex, adaptive morphogenesis, and generative urban codes in the New Urbanism.

Similarly, in reparation for the shortcomings of design-oriented master-planning in terms of functionality, “organicity”, intricacy, iterativeness and adaptability, Marshall (2012) identifies an “engine of complexity” which comprises planning by design, planning by coding and planning by development control. These three kinds of planning complement one another and when applied to the purpose they approximate coherence generating processes of growth similar to those in emergent cities. Although there has been considerable criticism of planning by design, being that a city embodies artefactual complexity at certain levels, Marshall (2012) justifies application of design coordination in some intermediate scales, such as a neighborhood unit. However, he questions the capacity of design to deliver functional complexity in relation to the whole, which is independent, adaptive and comprises numerous independent parts, like it is the case with cities. In this regard, planning by coding succeeds in solving problems failed by blueprint developments. Codes may be of prescriptive or proscriptive character and can be used generatively, by specifying how parts come together in an aggregate urban form (Mehaffy, 2008; Marshall 2011, 2012). Another kind of planning, integral to the system planning of the engine of complexity is planning by development control, which Marshall (2012) views as a kind of artificial selection aiming at optimizing individual utility and operates together with generative design.

Mehaffy (2011) makes a distinction between generative design methods whose main drift is an artistic goal aiming at producing desired aesthetic effects and those whose primary intention is to successfully attain “a form of complex problem-solving” (p. 480). Among the generative methods contrasted by Mehaffy (2011) Alexander’s adaptive morphogenesis is noteworthy for understanding coherence not simply as a designed state, but rather as a whole with coherent parts emerging at each step of the process, as his insight centered around the idea that geometric properties result from morphogenetic processes. Paralleling Jane Jacobs' thoughts on approaching a city as a work of art, Mehaffy asserts that these two different kinds of generative methods are not to be applied interchangeably and depicts art as a 'doorway' with a connective function on its own to always serve the needs of a city. To that end one must firstly realize who are the parties intended to benefit from the outcome of urban design and attempt to preconceive the conflicts that might arise due to differential interests. Mehaffy (2011) explains that on several occurrences urban design might be the result of a "morphogenetic script', and yet no 'real organic functional relationship of the parts is achieved' (pp. 481-2).

Imposing a certain shape on a town formation stifles the generation of complex relations of parts with one another and with the whole, and does not leave room for growth and change, such as additions with respect to adaptive response to the environment. Mehaffy (2011) is critical of formalist morphology for this exact reason. In this respect, Ikeda (2017) suggests that a designer should "leave substantial room for adjustment over time" (p. 81). Giving the city a final form as if one were to deal with artefactual complexity will have to result in tabula rasa urbanism over time.

Artefactual complexity of designed objects transcends only if these objects can be integrated functionally and structurally into a larger coherent whole. As it is in the case of many architectural products and proposals, the fact that a building is complex in itself does not indicate that it contributes to spatial coherence and functions with the whole in a complex way. Many examples can be found among the products of deconstructivist architecture, which is about expanding the options of formal outcomes "to encourage new interactions among its users", often weakening the formal values of unity. To give an instance, we can make use of Daniel Libeskind's proposal for an addition to the Victoria & Albert Museum in London, in which he makes use of fractal self-similarity. The proposed building is complex in itself but does not contribute formally to the coherent condition of the existing fabric (Figure 3.2)

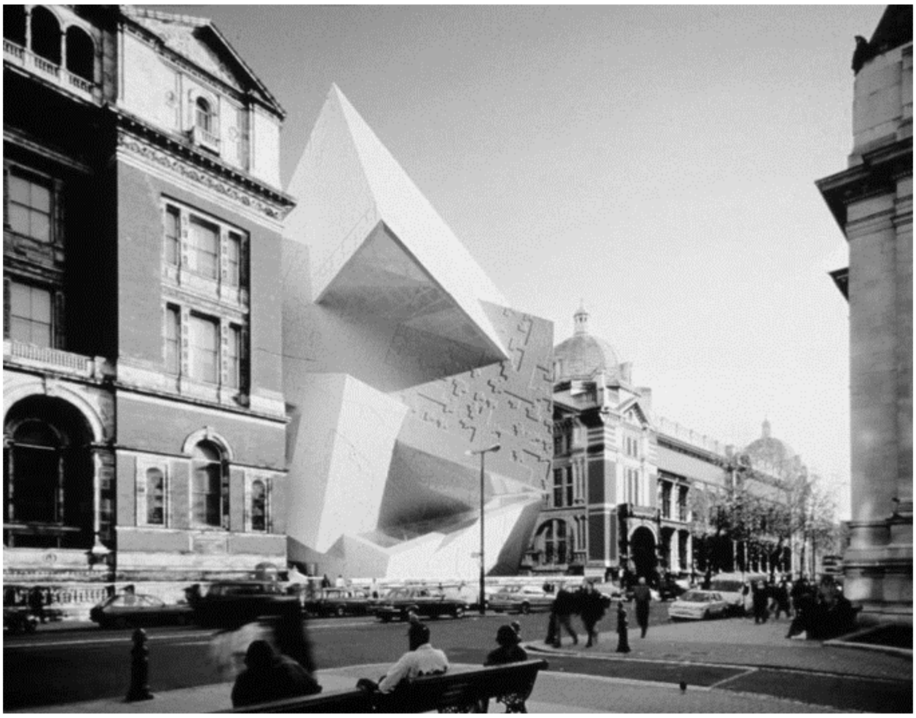


Figure 3.1: Libeskind's proposed addition to the Victoria & Albert Museum, London, 1996 (Source: Url1)

Libeskind's proposed building, albeit its intrinsic complexity, is not coherent as regards its relation to the whole. To explain this project's negative impact on spatial coherence, we can borrow the notion "contradiction juxtaposed", coined by Venturi. "Contradiction juxtaposed" differs from "contradiction adapted", which is "tolerant and pliable", "admits improvisation" and ends in an impure whole. On the other hand, "contradiction juxtaposed" is "unbending", "contains violent contrasts and uncompromising oppositions" and "ends in an unresolved whole" (Venturi, 1966, p. 45). The proposed addition to the Victoria & Albert Museum is formally an example of "contradiction juxtaposed", a violent juxtaposition in relation to the whole, which in this case is the street. It does not cohere with the neighboring units in terms of form, since the processes involved in its creation are not shared.

Helie (2009) addresses the issue of generating a geometrically coherent landscape and argues that if new building programs are not premeditated, the way to obtain a harmonious geometric order depends on shared generative processes, an idea whose foundations were initially laid by Christopher Alexander and his team in *A New Theory of Urban Design* in 1987. According to Alexander et al (1987), "when we look at the most beautiful towns and cities of the past, we are always impressed by a feeling that they are somehow organic" (p. 2). The feeling of "organiceness" that Alexander et la prescribe is not simply an analogy, but rather a "specific structural quality" of old towns growing as a whole, under their own laws of wholeness. Alexander recognizes that these laws are not respected in modern developments due to the lack of the right discipline intending to create wholeness and takes upon himself to propose a new approach to urban design, a method which is generative, concerned with processes and responsible for wholeness. The actual structure of a city embodies internal laws, which when observed and deliberated may serve as a pattern to continuate processes of growth and creation that resemble those highly present in nature. Although the final state of the whole is never known, it triggers an impulse towards wholeness, the quality of cohering with gradual change.

Alexander et al (1987) identify three essential qualities of the whole, which are incremental growth, unpredictability, coherence, and its ability to invoke feelings. The fact that planned developments are devoid of these qualities due to a disregard of shared processes is emphasized in A New Theory of Urban Design, and consequently, Alexander and his team initiate the quest of determining processes that generate wholeness in the city, processes having the single goal of healing (making whole) the city (1987). Based on this premise, they define seven simple rules with their own subrules, summarized as below:

- *Piecemeal growth* preconditions wholeness by emphasizing the fine grain of the building increments, which Çalışkan and Mashhoodi (2017) define as "a supplementary condition for morphological coherence" (p. 138).

This rule also suggests the application of a diversity of projects' sizes and a reasonable distribution of functions.

- *The growth of larger wholes* highlights the obligation of each building increment to facilitate the formation of at least one larger whole in the city, which emerge slowly and spontaneously. Subrule 2.4 states that the context of the larger centers already existing should govern the acts of constructions undertaken by individuals. On the other hand, subrule 2.5 outlines three phases through which the larger centers go: (1) the provision of clues for a new larger center by certain increments, (2) the delineation of structures by additional increments, and (3) the completion of the centers by sequences of supplementary increments. One main specification of this rule is that each increment should contribute to the formation of at least three larger centers, indicating that centers are interwoven and overlapping.
- *Visions* are associated with healing the existing structure through firstly experiencing the proposed projects and then expressing them as visions. At the core of this rule, lies the necessity to assess the ability of each increment to cohere with the larger center. Furthermore, visions define " the life and activity which is to occur in some new increment of growth" (Alexander et al, 1987, p. 63).
- *Positive urban space* ensures that no leftover is created with the additional increments by explicitly stating that "every building must create coherent and well-shaped public space next to it" (p. 66). To that end, this rule, placing space at the center of focus, includes the prescription of the necessary relationships between buildings, pedestrian space, gardens, parking, and street. One particularly important implication of this rule is that "buildings surround space" and not the other way round. This rule will be thoroughly addressed due to its relevance to the main concern of this study, which is to say street.

- *Layout of large buildings* addresses the internal wholeness of the buildings and specifies the necessary processes for generating this wholeness. To quote Alexander et al:

  > The entrances, the main circulation, the main division of the building into parts, its interior urban spaces, its daylight, and the movement within building, are all coherent and consistent with the position of the building in the street and in the neighborhood (p. 77).

  Based on this rule the height of the building is to be decided based on the adjoining buildings.
- *Construction* is concerned with buildings' structure and details which generate centers in themselves. Subrules with respect to details include specifications about heights of stories, roof lines, windows, and bays.
- *Formation of centers* governs geometric properties of centers, and its main aim is to ensure that "a building as a volume, or any increment of a building, or even any small detail, is capable of cooperating with the space adjacent to it, and capable of making wholes which include both the building and the space" (Alexander et al, 1987, p. 92). The geometric properties of centers addressed in this rule are presented in a more refined version in Alexander's later publication, book one of his four-volume work, *The Nature of Order*.

Alexander's definition of nested centers and wholes provides a significant framework with respect to generating spatial coherence within the built environment. The quality of public space is closely related to the degree of wholeness it embodies and triggers. The whole does not only emerge, but it also preconditions its further growth by proscribing.

3.3 The Whole Proscribes

In the previous section we have discussed that the whole emerges through self-organization and a degree of freedom, and so does coherence at each step of the ongoing processes of growth in emergent cities. As much as it has been established that freedom is at the core of agent-based complex, models one should not disregard the fact that the whole proscribes. To quote Robert Venturi:

> An architecture of complexity and accommodation does not forsake the whole. In fact, I have referred to a special obligation toward the whole because the whole is difficult to achieve. And I have emphasized the goal of unity rather than of simplification in an art "whose … truth [is] in its totality." It is the difficult unity through inclusion rather than the easy unity through exclusion…The whole is dependent on the position, number, and inherent characteristics of the parts (1966, p. 88).

While Venturi (1966, p. 16) embraces "messy vitality" over "obvious unity" he addresses the significance diversity tacitly, but his idea of complexity and contradiction in architecture has an obligation towards the whole, truth of which is in its totality or implied by its totality. Venturi's unity is does not exploit the tools of simplification which occur mostly via exclusion, it rather targets the difficult task of inclusion. According to him an architecture of complexity and contradiction is bound to include rather than exclude, which he explains by the phenomenon of "both-and" referring to the relation of parts to the whole. To be specific, an architecture of complexity and contradiction "can include elements that are both good and awkward, big and little, closed and open, continuous and articulated, round and square, structural and spatial" (Venturi, 1966, p. 23).

Another attribute of the whole that Venturi (1966) addresses in the last chapter of his seminal work, *Complexity and Contradiction in Architecture*, is inflection of the fragmented parts. Inflection in architecture is associated with an implied whole resulting from the nature of the individual parts, which inflect toward whatever is outside them to maintain continuity. The fragmentation Venturi refers to provides diversity with respect to function. It insinuates small size of the built increments, but at the same time these increments work in cooperation with each other to achieve a perceptual whole. Although the main focus of Venturi's work is architectural scale, he does not disregard the implications of inflection in the urban fabric. While in architecture uninflected elements fail to contribute to the coherent whole, in towns inflection is associated with the position of elements uninflected in themselves. He gives the example of Piazza del Popolo to illustrate how characteristically uninflected separate wholes such as the twin churches become inflected and generate coherence via asymmetrical position of their single towers which are themselves symmetrical.(Figure 3.3)

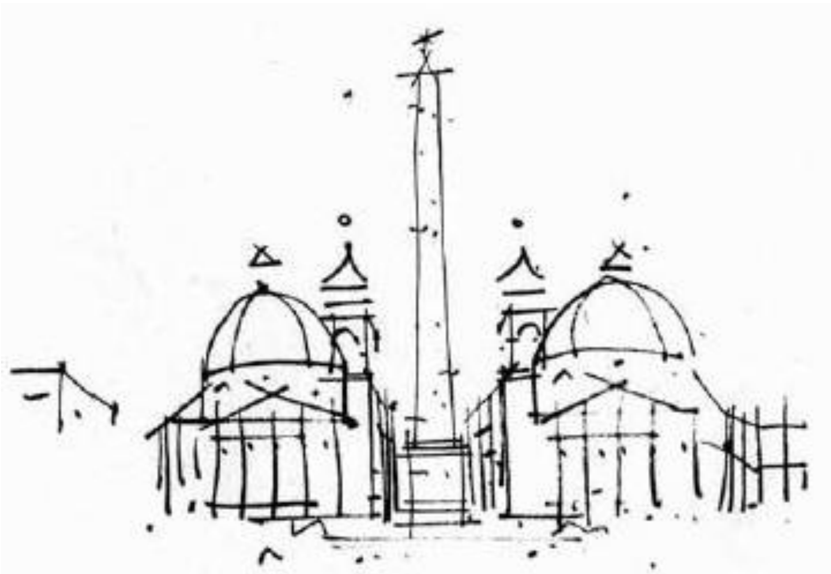


Figure 3.2: Sketch of twin churches in Piazza del Popolo (Venturi, 1966)

In addition to Venturi’s conceptualization of urban inflection, when we consider the notion of individual elements inflecting outward from a morphological point of view, we can address convolution or in other words folding of the buildings enclosing public space. This folding occurs via setbacks in the vertical and horizontal bulks of the buildings enclosing a given public space.

Venturi (1966) explains that “in the context of the piazza each building is a fragment of a greater whole and a part of a gateway to the Corso” (p. 92). What we understand from Venturi’s description of the fragments in a greater whole is that we can compare them to Alexander’s definition of wholes and centers which are wholes themselves. Architecture of complexity and contradiction allows for a degree of freedom in form and architectural detail, which can be interpreted as often resulting from individual freedom for additional increments. However, the pre-existing whole governs the magnitude of this freedom with respect to morphology and architectural detail.

The degree of individual freedom that incremental growth of the complex whole is bound to embody is best described via proscriptive rules as to what the context of the existing whole ‘tolerates’ in favor of spatial coherence. Before we refer to significant contributions with respect to proscriptive urban coding, a distinction between prescriptive and proscriptive coding will be made. To prescribe means to dictate and to designate by defining in detail what should be done in a given situation. Prescriptive rules and codes do not allow for flexibility; hence they stifle the freedom that incremental bottom-up development embodies. Modern master planning is highly prescriptive given that its top-down mechanism presents a preconceived end result of the urban form. To proscribe, on the other hand, means to prohibit and proscriptive coding, while enabling a higher degree of flexibility as to what needs to be done under certain circumstances, it provides a framework of prohibitions. Hakim (2014) maintains that proscriptive codes “evolve over long periods of time and rely on accumulated experience” and are partly pertinent to customary laws (p. 11). Proscriptive coding contrary to the prescriptive one involves a bottom-up mechanism and allows for adaptive incremental growth.

Besim Hakim (2014), in *Mediterranean Urbanism,* demonstrates how the preexisting whole is to be treated cautiously while adapting it in response to emerging needs of its inhabitants. He collects culturally developed codes and studies their impact on the form of traditionally built environments. In a similar manner to Alexander, Hakim (2008) while analyzing the content of Byzantine and Islamic codes, identifies an underlying goal that governs the coherent unity of morphological components pertaining to changes in the built environment:

> The goal is to deal with change in the built environment by ensuring that minimum damage occurs to preexisting structures and their owners, through stipulating fairness in the distribution of rights and responsibilities among various parties, particularly those who are proximate to each other. This ultimately will ensure the equitable equilibrium of the built environment during the process of change and growth (p. 24).

As regards change in the built environment, there are constraints with respect to the rights of the proximate neighbors not to suffer from damages to the buildings in their ownership. In general, these constraints address social and economic integrity, moral integrity, and tranquility of the neighbors. Hakim (2008) highlights the importance of the neighboring properties' preexisting conditions on the determination of several constraints in relation to change. The public realm in the underlying intensions included in treatises of Julian and Ibn al-Imam, as interpreted by Hakim, must not be made susceptible to damages resulting from activities and waste embodied in the private realm.

In his paper of 2008, "Mediterranean Urban and Building Codes: Origins, Content, Impact and Lessons", Hakim selects four specific codes that affect the shape of the built form with implications on the public realm in Mediterranean traditional towns. These codes include specifications about party walls of abutting buildings, finas, visual corridors and sabats. The feature of abutting buildings present in traditional towns leads to a compact form of the built environment. Furthermore, construction of buildings abutting each other contribute to well defined street boundaries. Fina, a concept pertaining to Islamic societies, refers to an invisible space with width of about 1.00-1.50 m, adjoining the exterior walls of a building and streets or access paths (Figure 3.3). Fina has a vertical extension and “the owner or tenant of the building has certain rights and responsibilities associated with his fina” (Hakim, 2008, p. 28). The concept of fina allows for growth to adapt the changing needs of the owner properties, following proscriptive rules as regards the positioning of the additional spaces and rooms.

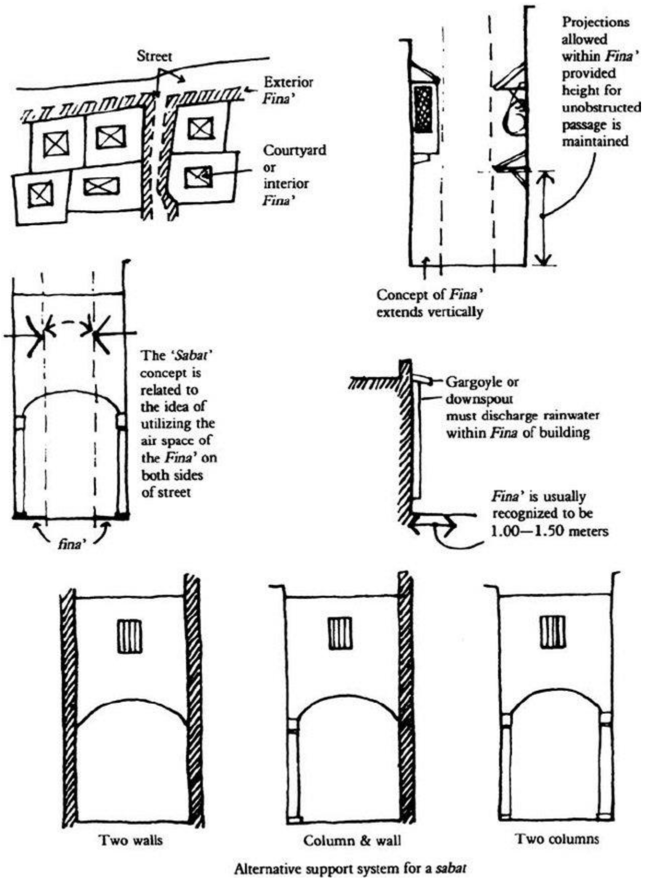


Figure 3.3: The concepts of 'fina' and 'sabat' (Hakim, 1986)

One important proscriptive code with significant impacts on the public realm of the built environment is concerned with overlooking and views. Hakim (2008) explains that in Muslim societies privacy preservation from visual intrusions was of primary importance, whereas in Byzantine societies the main drift was to preserve pleasant views. Sabats are additional spaces that bridge two opposite buildings. This kind of additional rooms are abundant in streets of traditional towns. As it will be discussed later in this chapter, the above concepts will be of significant importance in tracing coherence in the public realm of streets. Codes and regulations concerning abutting walls, finas, visual corridors and sabats help generate a coherent whole via proscription.

3.4 Geometrical Properties of Coherent Wholes

The whole of Alexander always appears as a coherent structure with a certain character. Wholeness is “the source of coherence which exists in any part of the world” (Alexander, 2002, p. 90). Working with intertwined scales, as well as creating perceivable groups of elements in space is of necessity since “ the wholeness is made of parts; the parts are created by the wholeness” (Alexander, 2002, p .84). Every entity, regardless of the scale has its wholeness. Centers are in themselves wholes and cohere with other centers to create coherence in a larger scale. Generation of coherence is conditioned by the creation of perceivable chunks, or else referred to as discernible wholes by Alexander (2002), which are both visually and functionally, centers (p. 84). Looking for unifying properties of coherent wholes found in nature and manufactured objects, Alexander identifies fifteen geometrical properties that bring about the feeling of life in a thing, a thing highly dependent on its cohering centers that help each other.

These properties are of both compositional and configurational character. Some of them serve as catalysators of coherence between the geometrical centers. To increase the degree of life in an urban setting the design necessitates coherence, which defines a desirable condition of urban form’s geometry, when experiential perspective of the user is accounted for in the built form. As a matter of course, a geometry-based coherence is the key to create form that places humans at the center of its functionality and resurrect those parts of the city not so successful in this aspect. The following structural properties will be discussed with examples in the context of public space focusing on urban streets and squares.

Levels of scale

Levels of scales as a geometrical property is associated with the presence of centers of a variety of sizes within the coherent whole. Forms with life embody centers of different scales, which are beautifully ranged and “exist at series of well-marked levels, with definitive jumps between them” (Alexander, 2002, p. 145).Centers that Alexander defines are reinforced by other smaller or bigger centers. A wide range of sizes is not the only indicator of levels of scale as in order for it to be achieved well-defined size proportions of neighboring centers are to be established. To put it succinctly, both size and position of centers is of significance to achieve levels of scale. Alexander (2002) suggests that “to intensify a given center we need to make another center perhaps half or quarter the size of the first” (p. 149).

Cities comprise a wide range of centers, which succeed in generating coherence when these centers reinforce each other formally and functionally. Components of urban morphology include streets, squares and urban blocks, whose form depends on the city’s morphogenesis. From a morphological perspective with regard to urban space, levels of scale manifests itself in typical compositions and configurations of morphological components. An abstract representation of levels of scale in a hypothetical urban fabric as regards the geometric layout of open and built space is shown in figure 3.4.

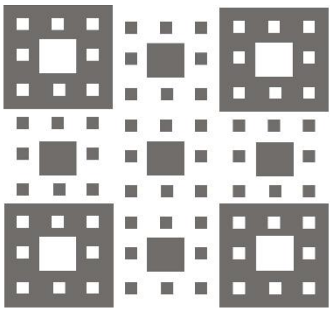


Figure 3.4: Abstract diagram of levels of scale representing open spaces which are embedded in the solid of the built and whose size and position reinforce each other

An example of urban fabric embodying levels of scale is the town of Toledo in Spain, known for its transition from a Muslim to a Christian town. The typical unit of Toledo's urban fabric is the traditional block characterized by squares of irregular shapes, narrow winding streets and various sized courtyards within the blocks. Squares that emerge within the route of the streets reinforce each other in terms of connectivity. The geometric layout of the open spaces has emerged over time conditioned by incremental growth and continuous repetition of similar additions constrained by the street pattern and codes of Islamic culture (Figure 3.5).

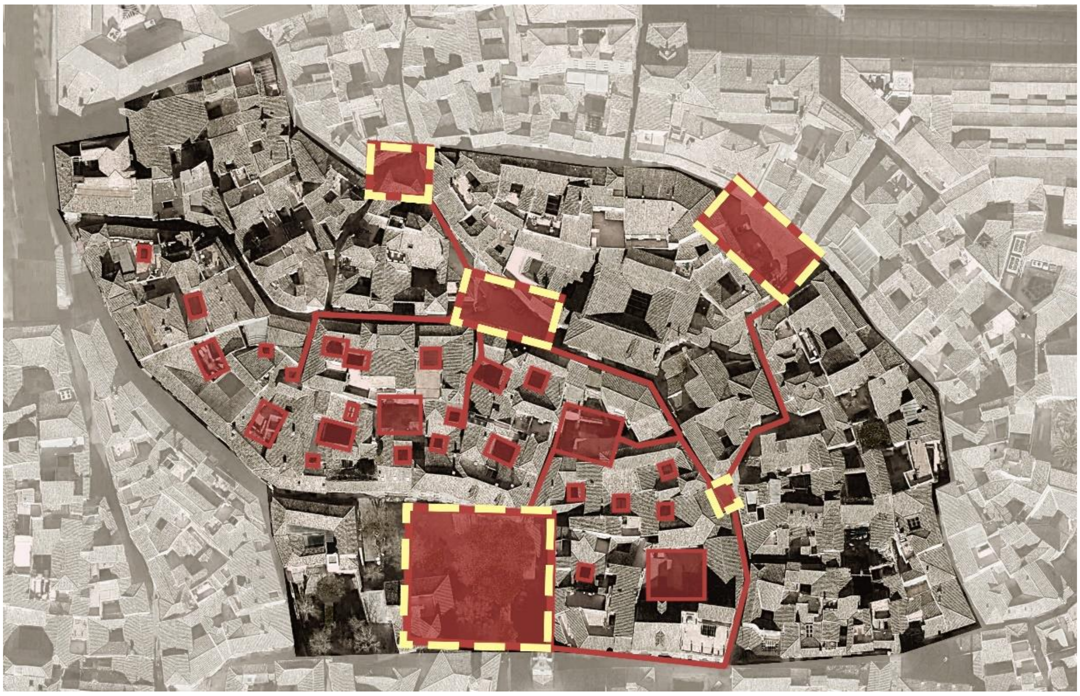


Figure 3.5: Levels of scale in the geometric layout of open spaces in Toledo, Spain (Google Earth, 2022)

Strong Centers

Without centers there can be no wholeness. Alexanders states that for the whole to to have a living structure it should embody strong centers which trigger a filed-like effect. Nested centers diversify progressively in size and strength in such a way that they create zones of increasing intensity that culminate in a strong center. In other words, all other centers strengthen each other successionally with one common goal, which is to intensify the primary center. What underlies the notion of strong centers is the the necessity for a principal structure subsidized by other structures. It is noteworthy to establish that as a property strong centers is pre-conditioned by the property of levels of scale, since without a variety of centers with respect to their sizes a strong center cannot be intensified. A simple visual representation of the effect of strong centers is shown in figure 3.6.

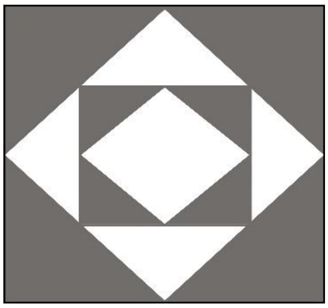


Figure 3.6: Abstract diagram of strong centers illustrating subsidiary centers reinforcing the primary center

In essence, this property can be easily understood if we observe the growth of centers in the natural forms in our surroundings as centers of progressive scales cooperate through their overlapping visual fields to reinforce the primary center. An example could be a chestnut leaf whose leaflets of different sizes emphasize the strongest center, the leaf itself, center of a whole. The leaflets are subsidiary structures of the principal center, the chestnut leaf. With respect to urban morphology, one can associate the property of strong centers with the presence of smaller public squares along a street which leads to the main public square. The quality of squares as centers and stronger centers does not depend solely on the different range of sizes, but also on the geometrical properties of the buildings bounding these squares, as buildings too are centers themselves. Traditional urban fabric of the city of Rome provides a rich ground for deriving examples of strong centers of the urban public space. Figure 3.7 shows small squares orienting towards the stronger center, which is Piazza Farnese.

Figure 3.7: Strong Centers as public squares in via di San Paolo alla Regola, Rome. Smaller squares emerge in the street and culminate in a stronger center, Plazza Fornesse (Google Earth, 2022)

Boundaries

Centers are not only strengthened by other smaller centers. Another significant geometrical property of spatial coherence is the presence of boundaries, which Alexander (2002) identifies as highly discernible in traditional architecture. Boundaries surrounding a center have a two-fold purpose: (1) to intensify the center which they bound and (2) to unite the center with its surrounding. Distinct boundaries highlight the distinctiveness of a center. While surrounding and enclosing, they separate and connect the center with the world beyond it in various geometric ways. One should keep in mind that a successful boundary is of the same order of magnitude as the center which it bounds (figure 3.8).

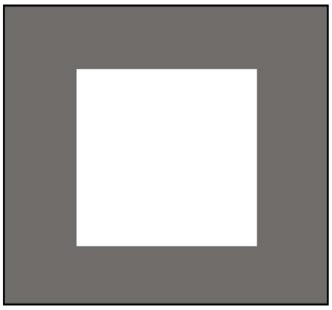


Figure 3.9: Abstract diagram of the concept of boundary which shows a boundary of discernible size in relation to what it bounds.

Alexander asserts that "if a boundary is very much smaller than the thing being bounded, it can't do much to hold in or form the center" (p. 159). As boundaries reinforce centers, centers reinforce boundaries. One should note that according to Alexander's description of boundaries, they constitute of centers and are centers themselves. He identifies two geometrically successful boundaries that work by alternately repeated interlock or by comprising centers embodying a feeling of similarity with what is beyond the boundary (Figure 3.9).

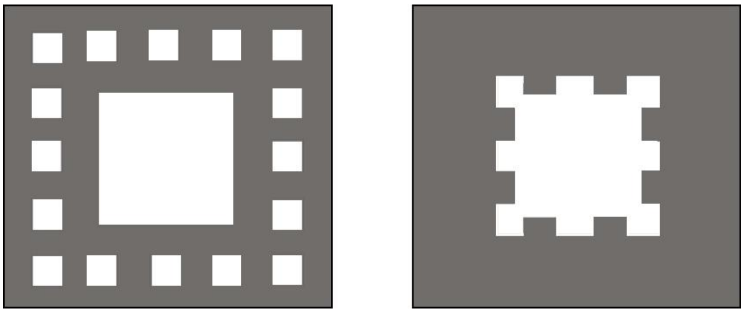


Figure 3.8: Abstract representation of boundaries with strong centers (on the left) and boundaries with alternating repetition of interlock (on the right)

These two distinct geometrical boundaries play a significant role in generating spatial coherence in an urban street, as they induce a coupling between the void of the street and the solid of the buildings enclosing the street. Interlock together with alternation enable an indoor/outdoor transition via volumetric centers as intermediate spaces, and boundary with strong centers indicates a particular type of transition, which helps us conceive what might be on the interior as an extension of the detailed centers. With boundaries as a geometrical property of coherence, the discussion of spatial coherence within the public space elevates to the third dimension as the volumetric perspective of urban morphology is included.

In the context of streets and squares boundaries account for the degree of enclosure, which is spatial definition of the public space by buildings, walls bounding individual plots or trees and other elements of the urbanscape. When the rule of the boundaries as prescribed by Alexander is complied with, the heights of the buildings enclosing the street should be proportionally related with the width of void. Buildings are obliged to define space rather than just sit in space (Appleyard & Jacobs, 1987). The proportion of the building heights to the width of the street they bound is not the only indicator of a successful boundary. Street Frontage as a boundary should comprise strong centers to induce coherence (figure 3.10).

Figure 3.10: Boundary with strong centers and levels of scale resulting from an aggregate of small plots, in Sint Amandsstraat, Bruges (Google Earth, n.d.)

The quality of spatial coherence in an urban street or square is also defined by buildings interlocking with the void of the street, sometimes creating smaller open spaces merging with the street and . The centers as smaller open spaces surrounding the bigger void, the street, or the square, serve as indoor/outdoor transitions and their optimization depends on alternating repetition of the interlocks. In streets, the interlock of the boundary with the void often occurs via projecting bay windows or balconies (Figure 3.11).

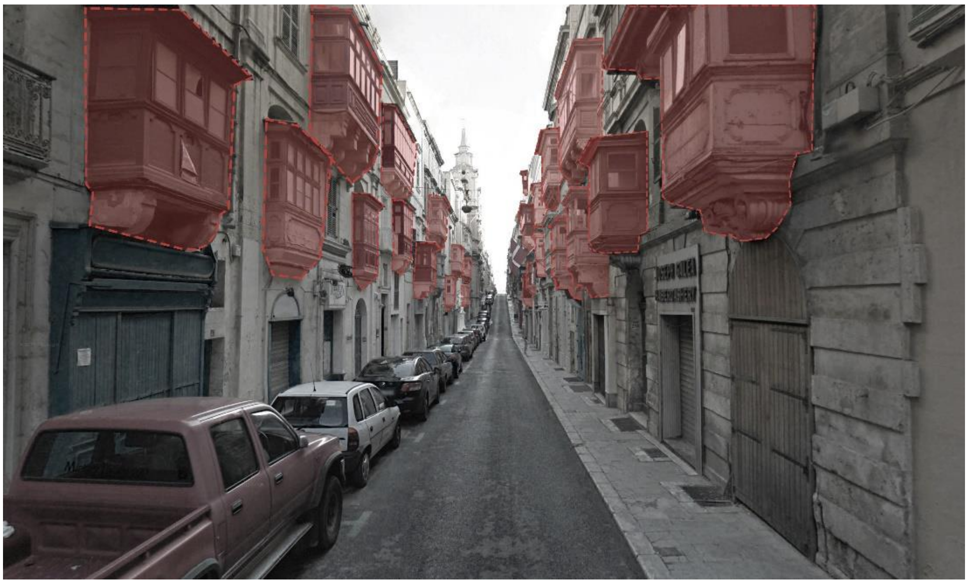


Figure 3.11: Interlock of the street frontage with the void of the street in Saint Paul Street, Valetta (Google Earth, n.d.)

Alternating Repetition

Repetition is necessary to generate spatial coherence. Ewing and Clemente (2013) highlight the implication of repetition in “the continuity of the design and thematic ordering” (p. 23). According to Alexander (2002) repetition helps centers reinforce each other. As much as it is a necessary to generate coherence, repetition, especially through a disorganized or not so well-organized application of symmetries might jeopardize the level of spatial. on the grounds that it would lessen the degree of spatial coherence rather than reinforcing it, there should be some kind of restrictions to the use of repetition. The repetition of centers should not be brutal or monotonous (Alexander, 2002; Salingaros, 2011). In nature repetition always adapts to local condition and monotonous repetition is an indication that no adaptation has taken place (Mehaffy, Kryazheva, Rudd & Salingaros, 2020). Coherence generating repetition occurs primarily via interlocking systems of centers that create a kind of rhythm and occasionally, subtle geometrical variation of the repeated centers also helps generate spatial coherence (Alexander 2002). An abstract representation of alternating repetition is demonstrated in figure 3.12.

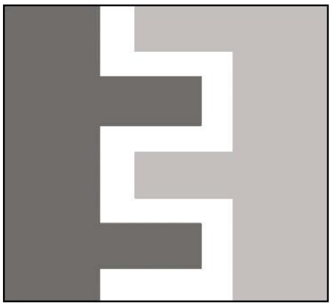


Figure 3.12: Abstract diagram of alternating repetition via interlocking systems of centers that interact with each other via interlock or the overlap of the field effect of the centers they comprise

In the context of public space as part of the built environment, alternating repetition can be discerned in the boundary of the street or the squares where systems of strong centers are interlocking units are alternatingly repeated (Figure 3.13)

Figure 3.13: Alternating repetition through groupings of columns in Via Santo Stefano, Bologna (Google Earth, n.d.)

Establishing an understanding of why monotonous repetition is not satisfying, Salingaros (2011) introduces two solutions of successful repetition (1) symmetry breaking and (2) grouping centers into clusters of three or four. He asserts that both these solutions originate from traditional architecture. Further on Salingaros identifies a simple formulation of alternating repetition encompassing symmetric groupings on various scales: ABABABABABABAB…. whose sub symmetric groupings could be as ABA, BAB, ABABA, BABAB, etc. Subtle variation using the notion of gradient can be applied to the modules in alternating repetition to induce a more coherent geometry. Models of alternating repetition with symmetry and gradient can be used to define boundary of streets and squares (Figure 3.14).

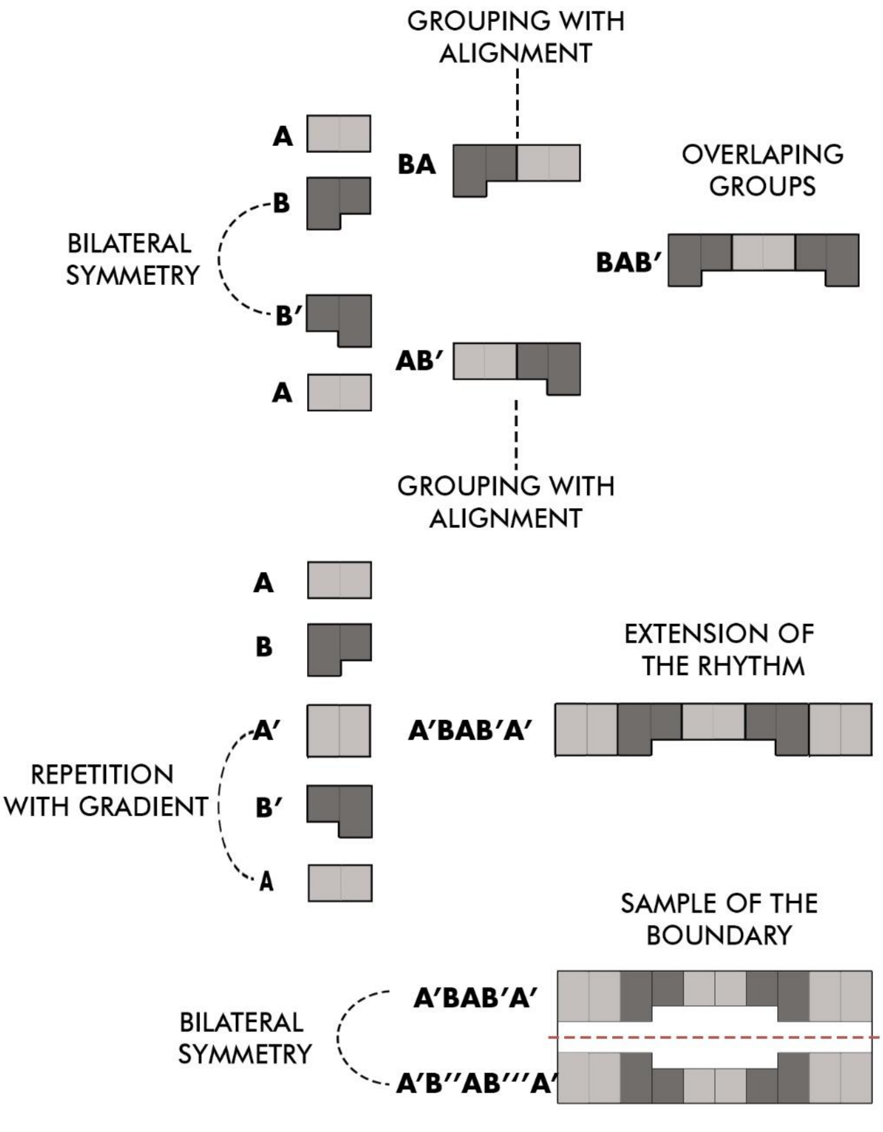


Figure 3.14: Alternating repetition creating a square with rhythm via groupings of sub-symmetries

Positive Space

Positive space occurs when no leftover space occurs from an adjacent shape of the center. Without positive space it is impossible to generate spatial coherence. Alexander (2002) states that a whole has life when "every single one of its component parts and spaces, is whole, well-shaped and positive" (p. 173). Positive space is also a precondition to the geometrical property of strong centers. Both the solid and the void comprising a center should be positive, and this rule applies to three dimensional compositions as much as it applies to two dimensional ones. Being a not so admirable product of modern planning, buildings ascending up high into the sky and simply resting on the ground compromise the coherence and character of positive spaces within the city, which Alexander (2002) depicts as social spaces the glue of our common public world. An abstract diagram of positive space is shown in figure 3.15.

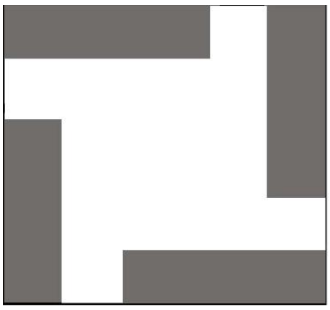


Figure 3.15: Abstract diagram of the concept of positive space representing that no leftover space emerges after the application of the solid in the void

To illustrate the discernibility of positive spaces within the urban fabric Alexander uses the Nolli plan of Rome in which every built and unbuilt bit in space is positive (figure 3.16). He explains:

> An almost archetypal example of this positive and coherent state of space may be seen in the 17th century Nolli plan of Rome. In this plan each bit of every street is positive; the building masses are positive; the public interiors are positive. There is virtually no part of the whole which does not have definite and positive shape. It is a packing of definite entities, each of which is definite and substantial in its own right. This has come about, I think,

because each of these places- whether street, square, or block of buildings- has been shaped over time by people who cared about it, and it has therefore taken a definite, cared-for shape with meaning and purpose. Each of these entities has been formed by the slow deliberate strengthening of centers (Alexander, 2002, p. 174)

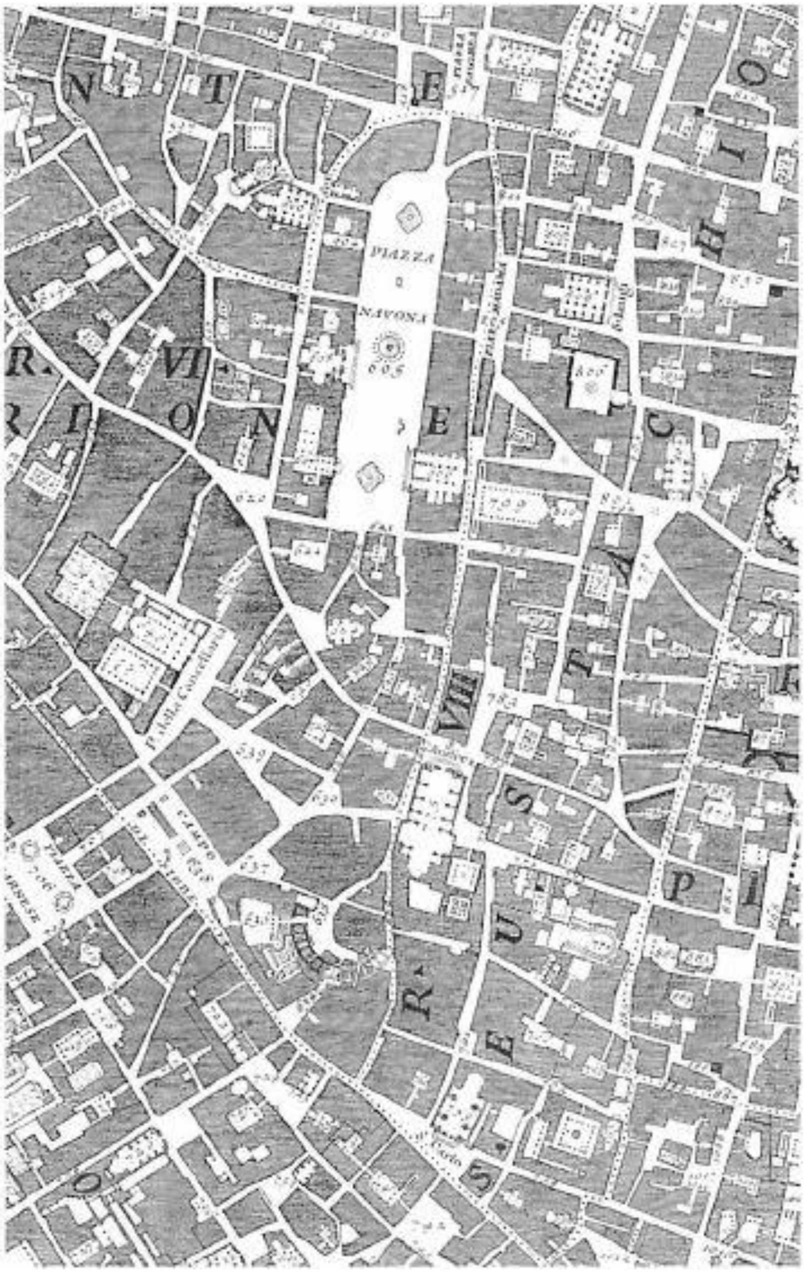


Figure 3.16: The Nolli Plan of Rome where a series of positive spaces are discernible (Alexander, 2002, p.173)

Positive space is a property that designers should look for in every dimension of the urban space. Spatial coherence stipulates that three-dimensional space does not include any meaningless leftover.

Figure 3.17: Illustration of positive three-dimensional space at the entrance of Plaza Mayor on Calle de Toledo, Madrid. The plaza itself is a prominent center of positive space and there is no meaningless three-dimensional leftover and useless space in the passageway to the plaza.

Good shape

This rule stipulates that every discernible part of the design of any scale must have a good shape as it is their good shape which gives life to the centers. Alexander (2002) suggests the use of the most elementary and simplest figures of pure geometry combined in complex ways to conceive the illusion of organic shapes. In other words, the complexity with respect to the shape of larger wholes should arise from the simplicity of shapes comprising their lower order centers.

He indicates that good shape can be easily understood as a recursive rule as centers whose good shape is a result of other centers with good shape. For that, the property of positive space acts as an emerging supplementary property which enhances the property of good shape in a design. Alexander explains that to achieve good shape the following principles are essential:

1. Good shapes embody internal symmetries.
2. Constituting centers have bilateral symmetry.
3. Centers are well defined.
4. Positive spaces result from the use of good shapes.
5. Good shapes are distinct from their surroundings.
6. Good shapes are relatively compact which indicates that the jumps from scale to scale vary between 1:1, 1:2 and 1:4.
7. Good shapes are characterized by closure and completeness.

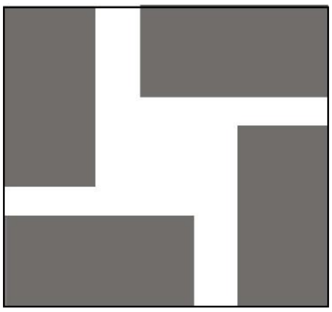


Figure 3.18: Abstract diagram of good shape in which both parts and the space between parts have good shape.

Built environment emerging from traditional urbanism more than often satisfies the property of good shape within various scales. The shape of the individual small plots in traditional towns is relatively simple, yet an aggregate of them appears complex and organic. The structural strength of the traditional blocks is dependent on the good shape of its constituent plots. As a whole they seem complex, but its parts are by and large basic geometrical shapes such as squares and rectangles with subtle variations due to concerns related to the local context necessitating adaptation. The property of good shape is not confined only in the built but also in the space it defines, which is positive.

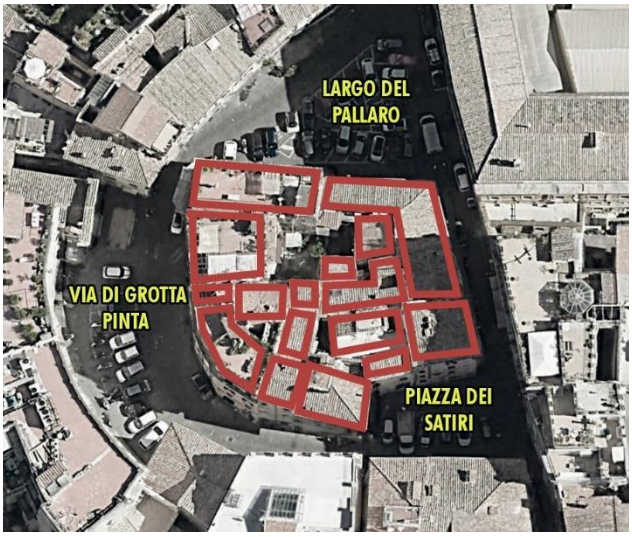


Figure 3.19: Good shape in traditional urban fabric, Rome. Though the whole is reminiscent of an organic natural pattern, when we have a closer look, we can see that its parts have simple geometric shapes.

Local Symmetries

Alexander (2002) reflects on the significance of local symmetries in a coherent design. However, he states that a large symmetry rarely generates coherence, and it should be broken in accordance with local context provided that life arises locally. According to Alexander (2002), "the most coherent patterns are the ones which contain the largest number of local symmetries"(p. 188). He came to this conclusion after an experimental study he conducted with "black and white paper strips to measure their coherence as felt, experienced, perceived and remembered by different experimental subjects" (p. 188). The results of his experiment showed that there was consistency of the relative degree of coherence perceived in each pattern by the subjects, indicating that coherence is not a subjective quality whose perception varies from person to person. The main finding of this experiment was that what the most coherent patterns had in common was the high degree of local symmetries. One should note that this experiment was not carried out with consideration of perceived coherence in space on two dimensional patterns. However, it helped shed light on establishing the relation between coherence and local symmetries in general. Overall symmetry does not generate coherence, but it is the overlapping of symmetrical segments that contribute to the state of coherency in the whole. A design is more coherent when local symmetry between centers work to reinforce each other and generate a larger center.

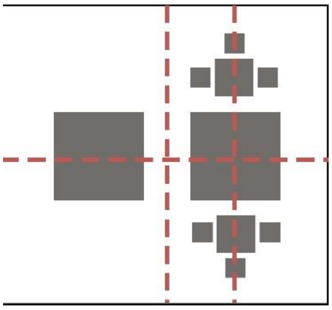


Figure 3.20: Abstract diagram of local symmetries which contribute to an overall spatial coherence

In the framework of built environment symmetry plays a significant role in generating spatial coherence. However, symmetry reaches a saturation point when applied recursively without any breaks. Mehaffy et al (2002) recognize the importance of breaks in symmetry with respect to many fields, including physics and they explain that a relentless form of symmetry not breaking to conform adaptation is oppressive and an indicator of a faulty process of generation. Acknowledging that an overall symmetry is not preferrable, a relevant application of it can be traced when it occurs spontaneously in local and human scales.

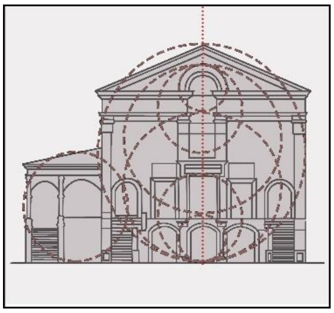


Figure 3.21: Visual representation of symmetry breaking in a building with levels of scale and strong centers

Mehaffy et al (2002) view "symmetry-breaking" as "a key generator of a more complex form of order" and they state that a series of cooperating smaller-scale symmetries work together to generate coherence. While sojourning or passing through public space, one can contemplate the numerous overlapping symmetries in façades of the buildings bounding a street or a square. Given that our field of view is limited, not being able to see beyond the boundary we are restricted in experiencing local symmetries in street frontages and do not perceive how symmetry breaks in the planimetric level. Yet we can see the symmetry breaking in abutted buildings, which are bilaterally symmetric in themselves. Occasionally symmetry is broken on the ground floor, where on one side of the vertical axis there are one or more windows and the door on the other.

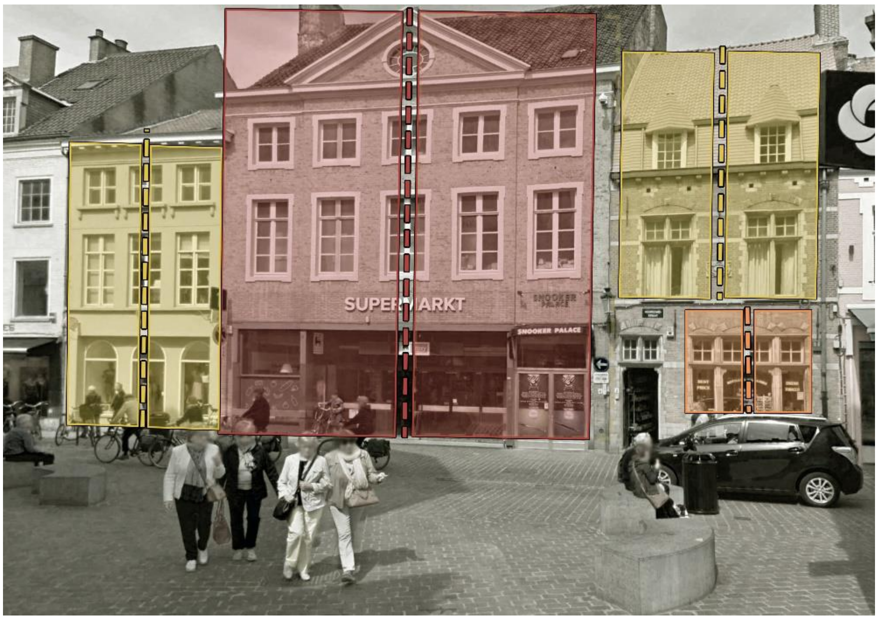


Figure 3.22: Small-scale bilateral symmetries of windows, doors and architectural ornamentations and broken large-scale translational symmetry as buildings come together to bound public space in Sint Amandstraat, Bruges (Google Earth, n.d.)

So far, we have discussed seven of the fifteen fundamental geometrical properties of coherence, which provide us with both compositional and configurational logic of wholeness. Each of the properties has been exemplified with respect to public space within traditionally built urban fabric both on the planimetric and on the eye level. Many aspects of these properties are overlapping, and it is their interrelation which enables the generation of spatial coherence.

The relationship between the geometric properties of coherent wholes with regard to the public space in cities can be explained via containing, reinforcing and generation.

Establishing the complex interrelation between the properties of levels of scale, strong centers, boundary, alternating repetition, positive space, good shape and local symmetries is essential to depict and create spatial coherence. Given that public space (streets and squares) is the primary interest of this study, the main focus is to use these properties to firstly generate coherent boundaries of positive space with good shape (figure).

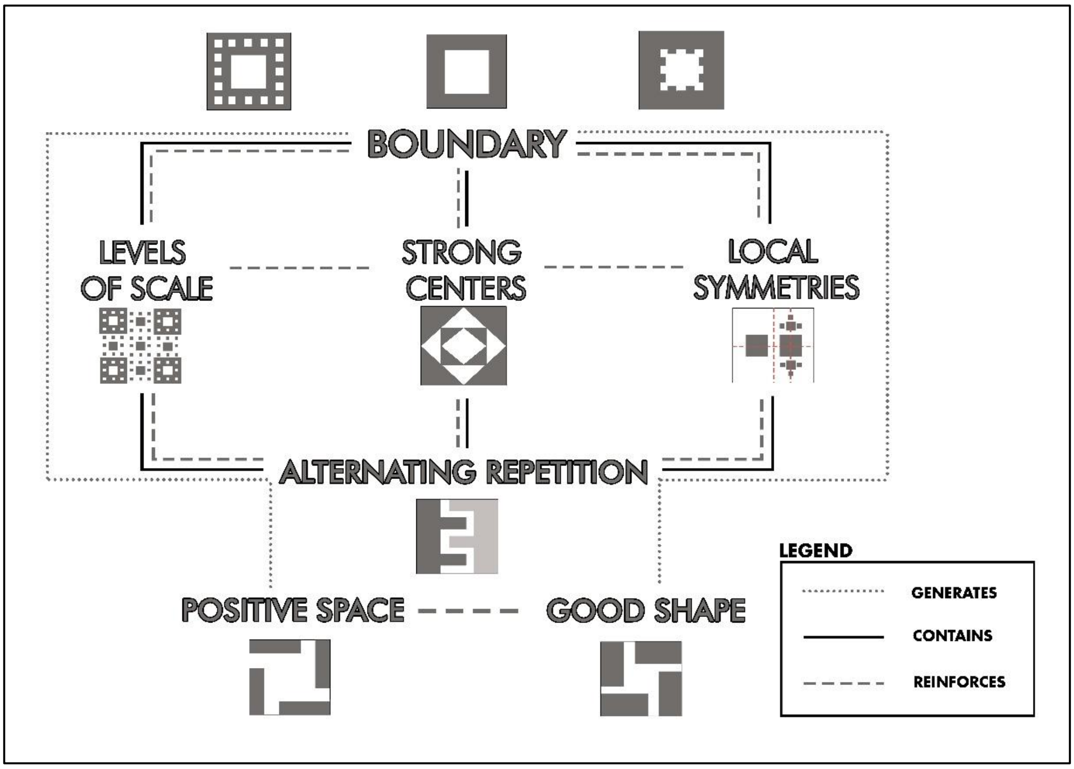


Figure 3.23: Interrelationship of the first seven geometric properties with respect to generating spatial coherence in streets and squares.

De*ep Interlock and Ambiguity*

Interlock comes into being when centers are interwoven with each other and with their surroundings to the point when disentangling the two without compromising coherence becomes an intricate task. Alexander (2002) explains that a center enmeshed with its surrounding achieves more life as the centers and their boundaries interpenetrate each other. In other words, centers are reinforced via interlock (Figure 3.24). He gives examples of volume interlocks created by arcades and galleries which when frequented triggers ambiguity of whether one is indoor or outdoor.

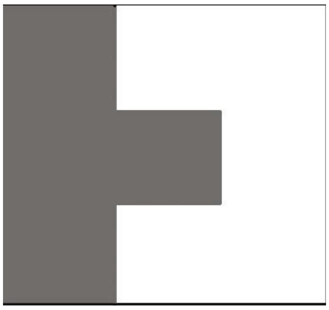


Figure 3.24: Abstract diagram of deep interlock and ambiguity representing the interpenetration of the solid and void into each other, giving rise to the ambiguity of belongingness

These volume interlocks generate interior/exterior transitional spaces where one cannot tell whether the space belongs to the building or the void. Similarly, in his paper on "Complexity and Urban Coherence", Salingaros (2000) addresses the necessity of distinct elements to attain urban coherence, among which he highlights traditional interior/exterior connective elements of the urban fabric, such as Hellenistic stoa, Roman porticoes, and retractable street canopies. He asserts that without the intermediate space, "the indoor/outdoor transition is too abrupt, and the connection is lost"(2000, p. 4). A great example of deep interlock and ambiguity is the ground floor of Palazzo della Ragione in Bergamo, which serves as a passageway connecting two open squares, Piazza Vecchia Bergamo Alta and Piazza Duomo.

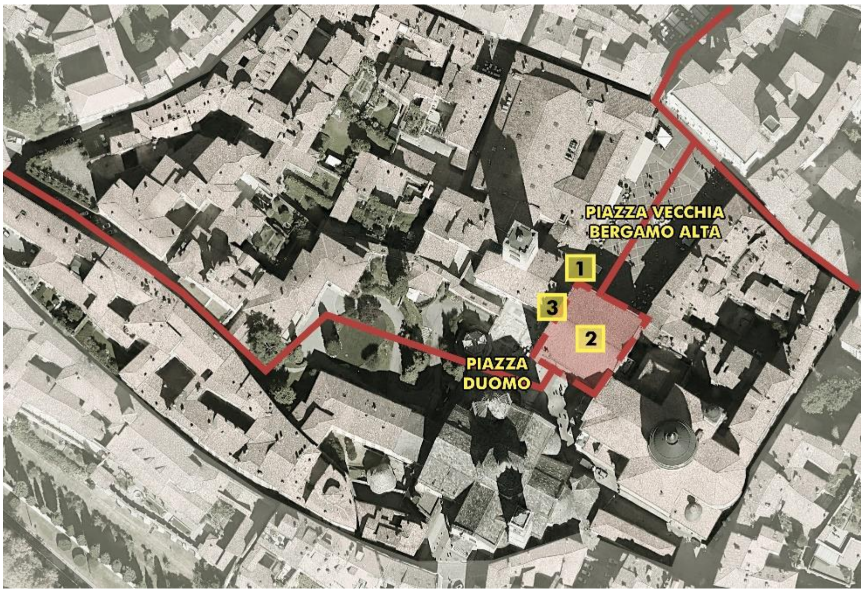


Figure 3.25: Passageway with deep interlock and ambiguity through the ground floor of Palazzo della Ragione in Bergamo, Italy

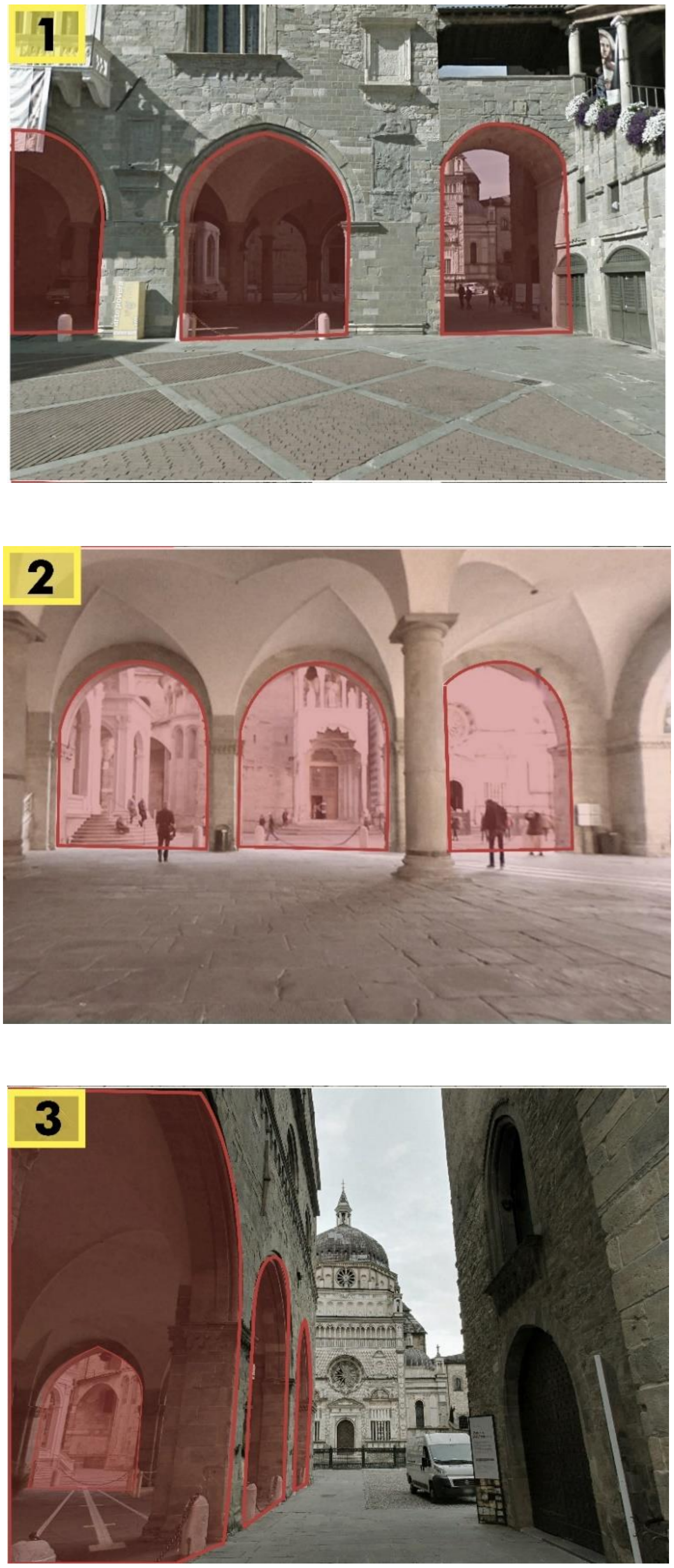


Figure 3.26: Eye level views from different positions inside and in the surrounding of Palazzo della Ragione (Google Earth, n.d.)

Contrast

Contrast is a property which acts as a catalyst of differentiation and distinctness. Alexander (2002) takes notice of the fact that “life cannot occur without differentiation” and “unity can only be created from distinctness” (p. 200). He maintains that each center is composed from visible opposites which may take many forms, one of which is the contrast of colors in adjacent components. Another prominent form of contrast is the one between solid and void. Contrast between two opposite entities bears something new, leading thus to a kind of unity between contrasting elements, which complement and intensify each other. To put it simply, instead of separating, contrast unites and strengthens coherence of parts (Figure 3.27). Therefore, Alexander suggests using contrast recursively to unify various centers. Salingaros gives a significant importance to contrast while proposing the idea of generating modules via couplings. Given that each perceivable element in the built form has a field like effect, we can make an analogy between the unity that contrast induces in architecture and urban space with what we know form physics and chemistry, that opposites attract each other and often bring novice. The force of attraction occurs on components of the smallest scale discernible by the human eye, which work together simultaneously and progressively to generate spatial coherence.

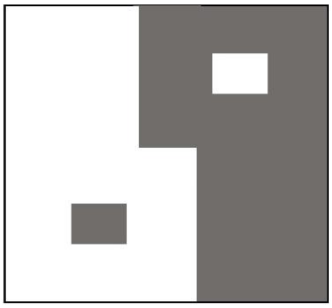


Figure 3.27: Abstract diagram of ‘contrast’ representing the unity of contrasting qualities within wholes and centers

In the boundary, a window frame bounding a number of panes or an empty component, the glass contrasts with the wall in terms of color or texture (Figure 3.28). On several occasions it shows itself volumetric differentiation between the frame and the wall, embodying ornaments. Two buildings of the same character may contrast each other in color and those become complementary while progressively contributing to a coherent state of the public space. Sometimes contrast occurs in space through the interlock of the solid and the void when arcades, portici, gallerias or even projected bay windows and balconies cohere to generate a space of life in streets and squares.

Figure 3.28: Window frames contrasting in color with the wall (on the left) and adjacent buildings contrasting in color, Bruges

Gradients

Gradients as a fundamental property of coherent wholes entails qualities that "vary softly, slowly, subtly and gradually across the extent of each thing" (Alexander, 2002, p. 205). Gradients imply change of quality with respect to size, spacing, intensity, and character of centers as adapted to conditions. Alexander views gradients as "the natural response to any changing circumstances in space" (2002, p. 206). To rephrase it, in nature no sudden or abrupt change occurs. Quite the contrary, the variation occurs progressively, appearing as a series of graded centers (see Figure 3.29). Alexander explains that "in something with life, there are graded fields of variation throughout the whole, often moving from the center to the boundary, or from the boundary to the center" (2002, p. 207). Smaller centers work together to generate gradients which strengthen the primary center.

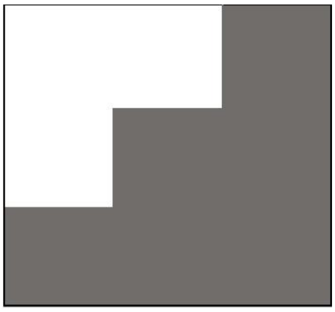


Figure 3.28: Abstract diagram of the concept of gradient representing gradual change in a certain quality of the wholes and centers

Often the gradient marks the beginning of a boundary, sometimes discernible and sometimes perceivable. A cornice as a visible boundary reinforces the center it bounds via gradients of ornament, upright variation in windows' sizes in a building indicate an invisible boundary between the floors of the building. In public space gradient manifests in the form of transition from the private to the public or the vice-versa, which often indicates the existence of intermediate transition spaces. Furthermore, as shown in figure 3.30, graded variation occurs within the boundary of the street or the square, defined by by the buildings embodying levels of scale, strong centers, breaking translational symmetry and alternating repetition in their

Figure 3.29: A simple application of gradients in the size of the windows descending with the floor level, in Sint Niklaasstraat, Bruges (Google Earth, n.d.)

ornaments and architectural details discernible by the human eye as one passes through space.

Roughness

Alexander (2002) argues that a thing cannot be a whole without embodying a kind of morphological roughness that originates from craftwork with the little inaccuracies that characterize it. Roughness induces coherence via subtle variations that are often intentional when fabricated by human hand, in an endeavor to adapt to locally occurring constraints (Figure 3.31).

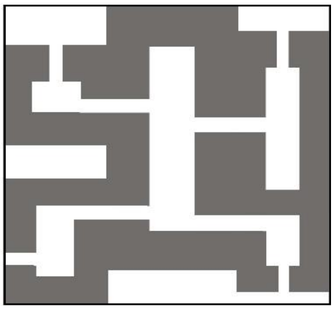


Figure 3.30: Abstract diagram of 'roughness' representing adaptation of the shape and form to constraints based local conditions

One should note that roughness is not a property to be achieved by perfect regularity of a strictly imposed order which disregards adaptation to the changing conditions. Moreover, the quality of roughness denotes individuality and uniqueness of a design, as two things with roughness can never be perfectly the same. As much as roughness is highly abundant in natural patterns, we can observe its implications also in traditional urban fabric. According to Alexander (2002, p. 211), "roughness can never be consciously or deliberately created" but it emerges as a product of abandoning what matters less and embracing what matters most in the process of creation. Roughness is about fitting the given or the preexisting whole with the help of modifications which are necessary to adapt with the already existing constraints and thus reinforce spatial coherence. In urban fabric of emerging traditional towns, roughness can be observed in the shape of the streets, urban blocks, and the open spaces of various scales (see Figure 3.32).

Figure 3.31: Roughness is highly discernible the urban fabric of Rome, where local conditions such as topography and existing structures have played an important role in the emerging new structures.

Echoes

As a fundamental geometric property of coherence, ‘echoes’ plays a significant role in generating similarity of form without falling into blatant repetition. All the shapes involved in a design should have angles of the same family to create harmony (see Figure 3.33).

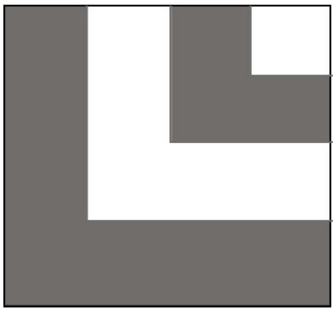


Figure 3.32: Abstract diagram of echoes showing similarity of angles in the shapes of the whole’s physical attributes, accounting for harmony among centers

However, as Alexander (2002) contends echoes do not arise merely by superficial similarities among shapes. Instead, it emerges and reaches its prominence “in functional or practical cases where the similar structural geometry derives from deep similarities of process that have created it (p. 221). When functions are taken in consideration, based on the conditions that they necessitate certain geometric rules should be followed, which applied recursively “will create a feeling of familiar angles, lines, shapes, not for formal reasons, but simply as a result of careful adherence to functional requirements” (Alexander, 2002, p. 221). As such one can conclude that more than shape or geometry, echoes address functional effectiveness of the form. In a settlement formation if all the buildings comply with the constraints that the local context poses, such as slope or sun, they will have the geometrical property of echoes although they may have not been designed and constructed by the same hand. What generates echoes among them are the shared generative processes by the individual agents, of which spatial coherence emerges.

The Void

Without the void no creation of center cannot occur and thanks to it a living form can reach a balance between the details of centers and emptiness, which triggers a sense of calm. According to Alexander, “in the most profound centers which have perfect wholeness, there is at the heart a void which is like water, infinite in depth, surrounded by and contrasted with the clatter of the stuff and fabric all around it" (2002, p. 222). In other words, the quality of the void is essential to generate balance with contrast and particularly in a city, the void is perhaps one of the most important qualities. What happens in the void, which functions as a receptacle of life within the urban fabric, is a concomitant of the geometrical qualities contained in its boundary.

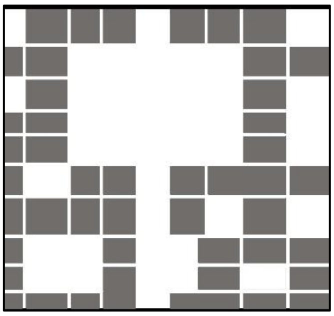


Figure 3.33: Abstract diagram of the void as a contrasting quality with the fuzziness of the surrounding

Simplicity and Inner Calm

The quality of simplicity and inner calm is associated with the geometrical simplicity and purity of the form, and it often is related with the void. This quality arises when nothing unnecessary that would compromise the condition of coherency is employed (Figure 3.35). Every single center that exists in the system is of essence and has the obligation to support other centers of upper and lower scales generating thus coherence. Simplicity and inner calm can be found in complex forms too, provided than no inessential element is included in the design. To quote Alexander:

> In a living whole which is correctly made, there is a special simplicity. For example, the thick low wall with a broad top is the most solid, easiest to make, and will last the longest. When the main lines of the building are drawn simply, they will tend to give big reference to a few big things: the sun, the view, the slope. The simplicity of this response allows a deeper relationship between the person and the landscape to form; and thus, creates more nourishing conditions (2002, p. 228).

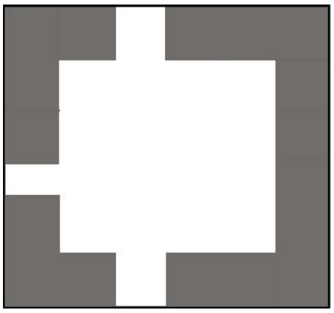


Figure 3.34: Abstract diagram of inner calm and simplicity of the form, where no part is unnecessary

Not-Separateness

A profoundly coherent form is composed of centers which cannot be isolated or separated from other centers in their surroundings (see Figure 3.36). Not-separateness is a synonym of connectedness and formally this quality indicates that centers, constituents of the whole, melt with their neighboring centers to create unity.

Alexander (2002) considers not-separateness as the most significant of the fifteen fundamental properties.

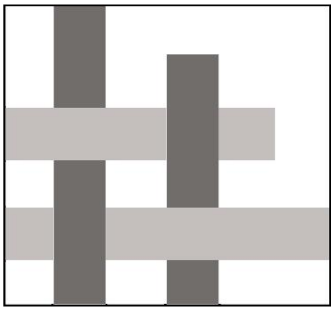


Figure 3.35: Abstract diagram of not-separateness representing centers merging with their surroundings

According to him things which possess wholeness are indistinguishable from their surroundings as they melt humbly and harmoniously, without letting go of their character. The structural terms of this property indicate the degree that each center is connected to the whole world, by which decomposing the whole becomes a difficult task, as one cannot tell the end of one thing and the beginning of the other. In the context of the public space the quality of not-separateness depends on how the boundary components connect with each other and the void that they enclose. Abrupt edges do not serve the quality of not-connectedness well. Alexander (2002) asserts that on the grounds of various functional reasons, pervasive connectivity that unites the inner side of a systems with other systems outside of them indicates a coherent state, hence more life.

CHAPTER 4

ANALYZING SPATIAL COHERENCE IN STREET ENVIRONMENTS

Streets are the main catalysts of urban life, for which they have been of significant interest to many researchers (Rudofsky, 1964; Jacobs, 1993; Ewing & Clemente, 2013). It is the aggregate of the overlapping field-like effects pertaining to each spatial attribute contained in the built form that generate spatial coherence of the public space. The main aim of this chapter is to trace spatial coherence within existing streets of traditional built environment by concretizing the geometrical properties and rules of urban coherence as defined by Alexander (2002) and Salingaros (2000). The research revolves around the hypothesis that traditionally emergent towns enable us to derive spatial coherence in urban space. Given that the research focuses on the street environment a significant importance is given to the boundaries of the streets, on which urban life depends.

In this respect, three streets,(1) ‘Via dei Giubbonari’ in Rome, (2)‘Via San Vitale’ in Bologna, and (3)‘Yildirim Caddesi’ in Balat, Istanbul were selected as case studies, based on the distinct spatial qualities of their boundaries, or, in other words street frontages, which are boundaries with strong centers and boundaries with alternating repetition of interlocking units. The first two streets were initially recognized for their positive spatial qualities by Allan Jacobs in his prominent book of 1993, *Great Streets*. The third street, ‘Yildirim Caddesi’ was selected due to the distinct spatial qualities of its boundaries with alternating repetition of interlocking units, resulting from volumetric projections of balconies and indentation of the entrances. The three streets will be analyzed and described on both planimetric and three-dimensional level to address coherence both in the urban fabric as viewed from the top and urban space from the eye of the pedestrian

4.1 Case Study 1: Via dei Giubbonari

Based on Alexander's conceptual definition of successful boundaries via dei Giubbonari falls under the category of streets whose boundary's success depends on the strong centers it embodies. Furthermore, As maintained by Salingaros (2000), a boundary of an urban space should be permeable, an attribute which this street contains, as a result of small plots comprising the traditional urban blocks. Via dei Giubbonari is an ancient street in Rome, which Jacobs (1993) identifies as "a still great medieval street" (p. 20). According to him this winding street attracts pedestrians through its funnel-shaped widenings at each end. The street has always been a commercial street where the ground floors of the buildings function as shops. This has resulted in a high number of entrances on the ground floors, accounting for transparency of the public space and thus a high volume of pedestrians using the street.

The street is less than 300 meters in length, bounded by building fronts of approximately 19 meters long and varying in heights. The width of the street varies from one end to the other and occasionally merges with squares along it. Jacobs (1993) describes the street as relatively narrow, and there is a sense of mystery and ambiguity as to what to expect next while one sojourns in or passes through the street due to its winding shape. Although the buildings in themselves are not of a remarkable character, the structural and functional success of the street as a public space is highly associated with the coherence of its constituents, which is what makes the street inviting to users.

The boundary of this street is imbued with strong centers, doors (approximately every 5 meters on the ground floor) and windows, which cohere with each other, albeit the differences they embody. In other words, there is unity with variety along the façades of the buildings which enclose the streets and the emerging squares. On the façades, architectural ornaments of the same scale couple with each other via contrasting colors and textures, as do two abutting buildings along the street. As Jacobs (1993) states, "wall thickness and building solidity are made clearly evident by their visible contrast with the glass panes in them” (p. 21). The ground floor of the buildings bounding via dei Giubbonari are used as shops which create a strong functional coupling with the upper floors used as offices or residences.

As it pertains to the formation of spaces in the urban fabric, they are a result of plot urbanism and of an emergent nature. Furthermore, the boundary of via dei Giubbonari is characterized by permeability of the built form as it is highly connected with other intersecting streets leading to open public spaces of various size and character. The permeability of the boundary with respect to connections can be observed in figure 4.1. In addition, the urban fabric surrounding the street is spatially, morphologically, and visually coherent, given the relationship of the urban blocks with the streets. The street, highlighted in yellow (see Figure 4.1), starts with a square (Piazza Benedetto Cairoli), which becomes narrower to mark the beginning of the street.

Overall, the fabric surrounding Via dei Giubbonari is characterized by levels of scale in terms of building sizes, echoes and good shape of the blocks which define and embody the void of the street and squares and the void of the open spaces as courtyards embedded in the blocks. Roughness of the fabric has resulted from incremental growth and topography related constraints. Another discernible coherence-related property in this street environment is the not-separateness of the churches and palaces from their neighboring buildings. Occasionally, gradient is discernible in the varying sizes of plots which vary due to adjust to the topography or preserve existing pathways and streets. The street has funnel-shaped openings at both ends.

Along via dei Giubbonari a smaller square emerges in front of a church, which has created another void with positive space for the abutting restaurants to welcome the users. In the middle of the street the well-defined “piazza Campo dei Fiori” serves as a marketplace. Smaller squares along a street provide space for a diversity of activities and help keep pedestrians attracted and interested in walking through or sojourning in the street. They intensify bigger squares as bigger centers as they encourage a higher volume of pedestrians through the void.

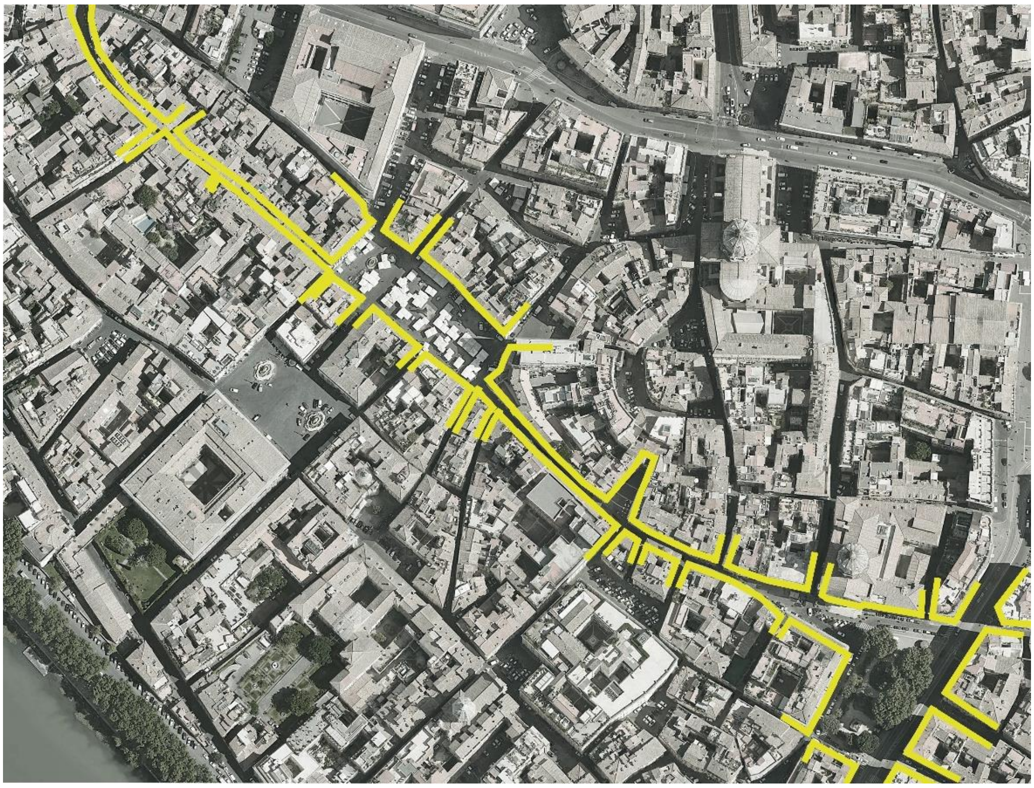


Figure 4.1: Via dei Giubbonari in Rome, an ancient street characterized by permeability of its boundary on the planimetric level and strong centers comprising the bounding buildings on the eye level of the pedestrian

4.1.1 Mapping and Visualizing Spatial coherence in Via dei Giubbonari

To address spatial coherence on a three-dimensional level in street environments, eye level images of via dei Giubbonari have been retrieved from Google Earth. Geometrical properties of spatial coherence conceptualized by Christopher Alexander and explained in chapter 3 will be highlighted in each image. The properties are occasionally overlapping and inseparable as they complement each other in generating spatial coherence. Therefore, one image, as observed by the pedestrian in the public space, may contain more than one concept. Street view according to the pedestrian perspective is mapped in figure 4.2

Figure 4.2: Map of Spatial Coherence in via dei Giubbonari showing sections of the street visible from the eye of the pedestrian

Figure 4.3: The void as defined by piazza Benedetto Cairoli, which marks the beginning of via dei Giubbonari. Spatial coherence of this part of the street is defined by strong centers with levels of scale on the facades of the buildings that constitute the boundary. (Google Earth, n.d.)

The void at the beginning of via dei Giubbonari, piazza Benedetto Cairoli, is in contrast with the articulated façades which contain the property strong centers with levels of scale (see figure 4.3). The void satisfies the properties of positive space, good shape and simplicity, as nothing that surrounds the square is unnecessary. What happens in the void is defined by the coherence of the physical attributes of the surrounding buildings. The centers on the facades of the buildings, as defined by windows and doors echo through the similarity of their shapes and employ the property of 'gradient' as the openings decrease in size on the higher floors.

On the left of piazza Benedetto Cairoli there is a church which, albeit subtle variations in its architectural ornaments is not separate from the other buildings in the boundary (see figure 4.4). The property of strong centers can be observed clearly on the entrance of the church, where doors with levels of scale reinforce a stronger center, the door in the middle. The stairs that take you to the main door, project into the void, creating thus an example of interlock. Furthermore, there is alternating repetition of volumes going in and out of the void on the façade of the church, an attribute that distinguishes it from the neighboring buildings which lack such a remarkable volumetric differentiation of architectural ornaments on their facades.

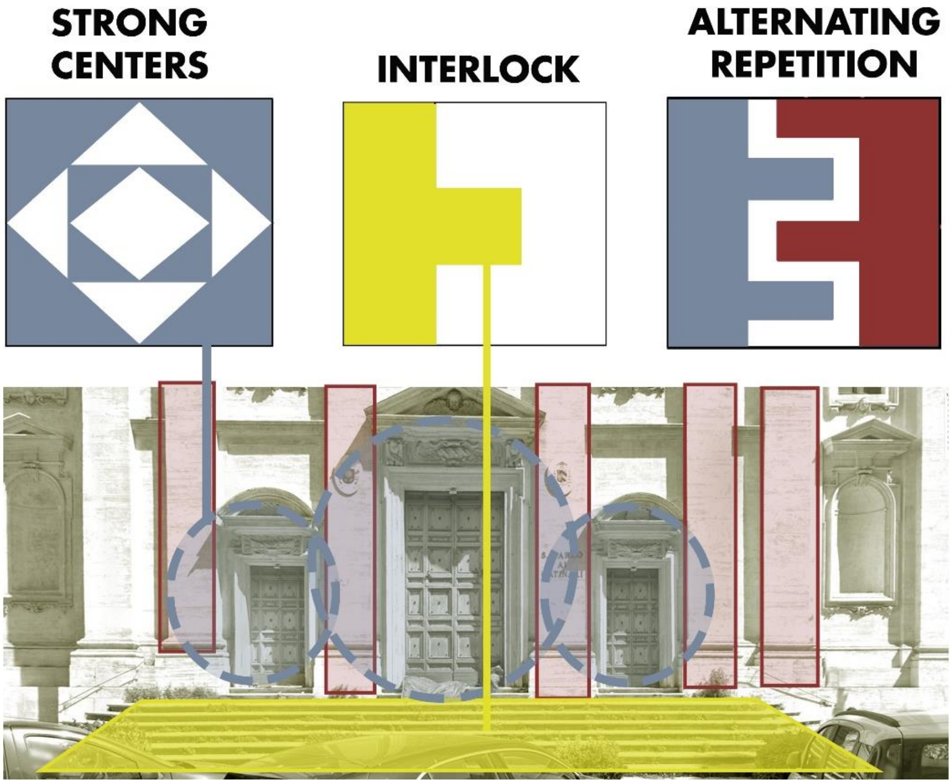


Figure 4.4: The entrance of the church in the surrounding of the square employs the properties of levels of scale, strong centers, alternating repetition and interlock

The boundary of strong centers continues along the street. On some facades, centers (windows and doors) reinforced by boundaries are discernible, a property which Alexander (2002) explains as boundaries within boundaries (see Figure 4.5). Elements comprising the boundaries of the windows, namely the pediments and the shutters couple with the window (an empty element), and couple with each other via a common third element, which Salingaros (2000) describes as induced coupling among elements of the same scale. "Boundaries within boundaries" helps achieve levels of scale on the facades of the buildings enclosing via dei Giubbonari. Overall, the centers are characterized by echoes of angles in their boundaries and are alternatingly repeated in terms of size on each floor. In addition, there is contrast in texture and color of the ground floor with the upper floors. Contrasting qualities of the facades on the ground floors help achieve human scale. Sometimes the contrast in color is observed between two abutting buildings (see Figure 4.6)

Figure 4.6: Illustration of "boundaries within boundaries" on the building facades along via dei Giubbonari (Google Earth, n.d.)

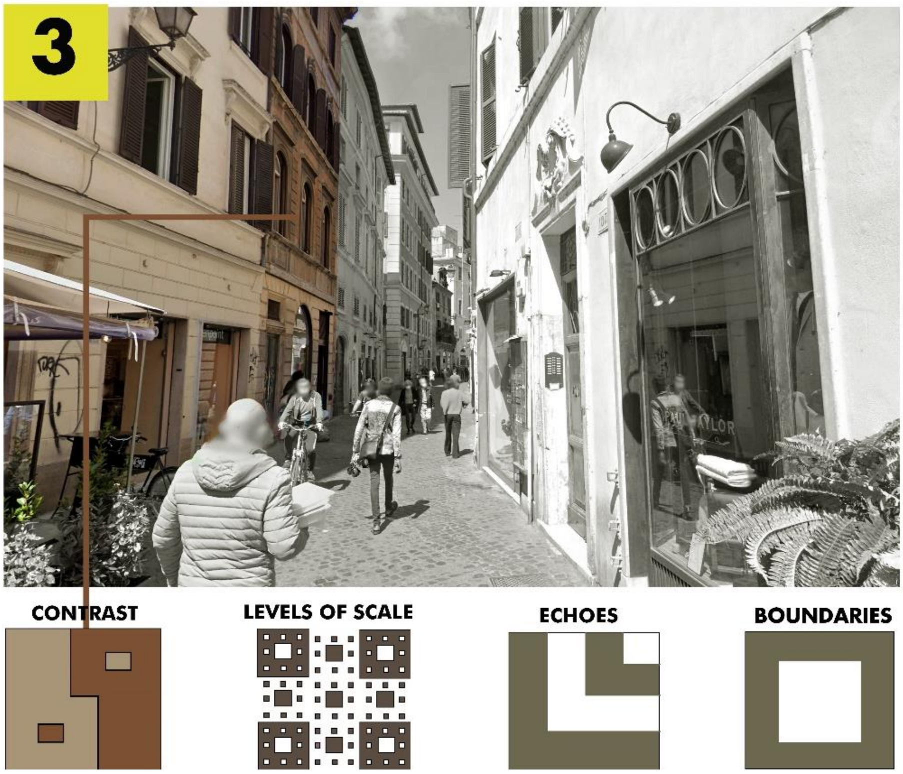


Figure 4.5: Two abutting buildings contrasting in texture and color in via dei Giubbonari. The facades contain levels of scale and echoes (Google Earth, n.d.)

The property of contrast is not only achieved via contrasting colors and textures in via dei Giubbonari. As one moves along the street other examples of contrast of a more spatial character emerge. Especially, where streets paths and streets intersect with via dei Giubbonari we can observe a different kind of contrast which occurs between two different facades of the same building. Given that the façade is not a component of the smallest scale to be considered in a street analysis other geometrical properties of coherence can be involved in achieving this kind of contrast. Occasionally, on one of the façades the architectural ornaments are well articulated and intricate as a result of the application of levels of scales and boundaries, whereas on the other façade architectural ornaments occupy less surface area and not every center is defined by boundaries (see Figure 4.7)

Figure 4.7: Two contrasting facades of the same buildings facing different streets (Google Earth, n.d.)

A more frequent type of contrast occurs with respect to the concept of boundaries within boundaries. Boundaries of windows and entrances are in contrast with the walls of the buildings in terms of color and texture as they indent towards the void.

The principle of echoes seems to be applied only with regards to the kind of center being bounded, as it is the case with the example provided in figure 4.8 where boundaries of entrances employ a shape different from the boundaries of the windows.

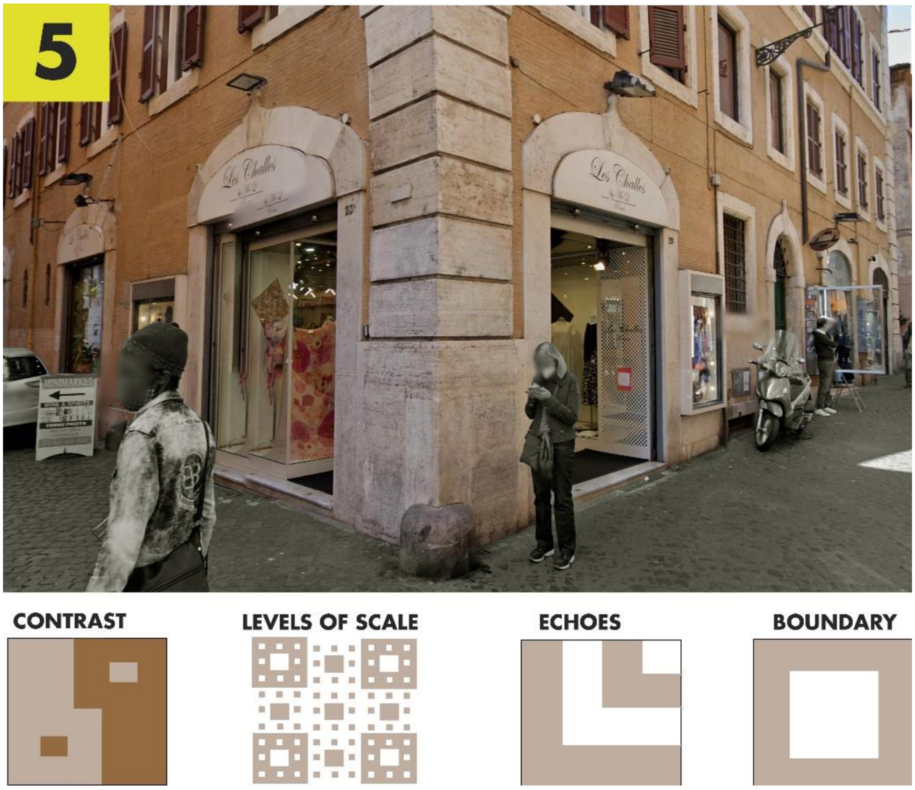


Figure 4.8: Cornices and boundaries with qualities that are in contrast with the walls as they induce coupling via a common third element on the scale of ornamental detail (Google Earth, n.d.)

As one lingers in the street, a small piazza, Largo dei Librari, comes into sight. Walking down one can observe the presence of the concept of gradient on one edge of the square. Buildings descend in size as they get closer to a small church which merges with the buildings it abuts complying this with the geometrical property of not-separateness. On the two sides of the buildings bounding the square the principle of boundaries within boundaries is discernible, while the facades satisfy the property of levels of scale via the articulation of architectural ornaments. The square itself is a typical positive space, which expands the range of activities to occur in public space as people enjoy a coffee or a meal provided by the shops and restaurants on the ground floors (see Figure 4.9).

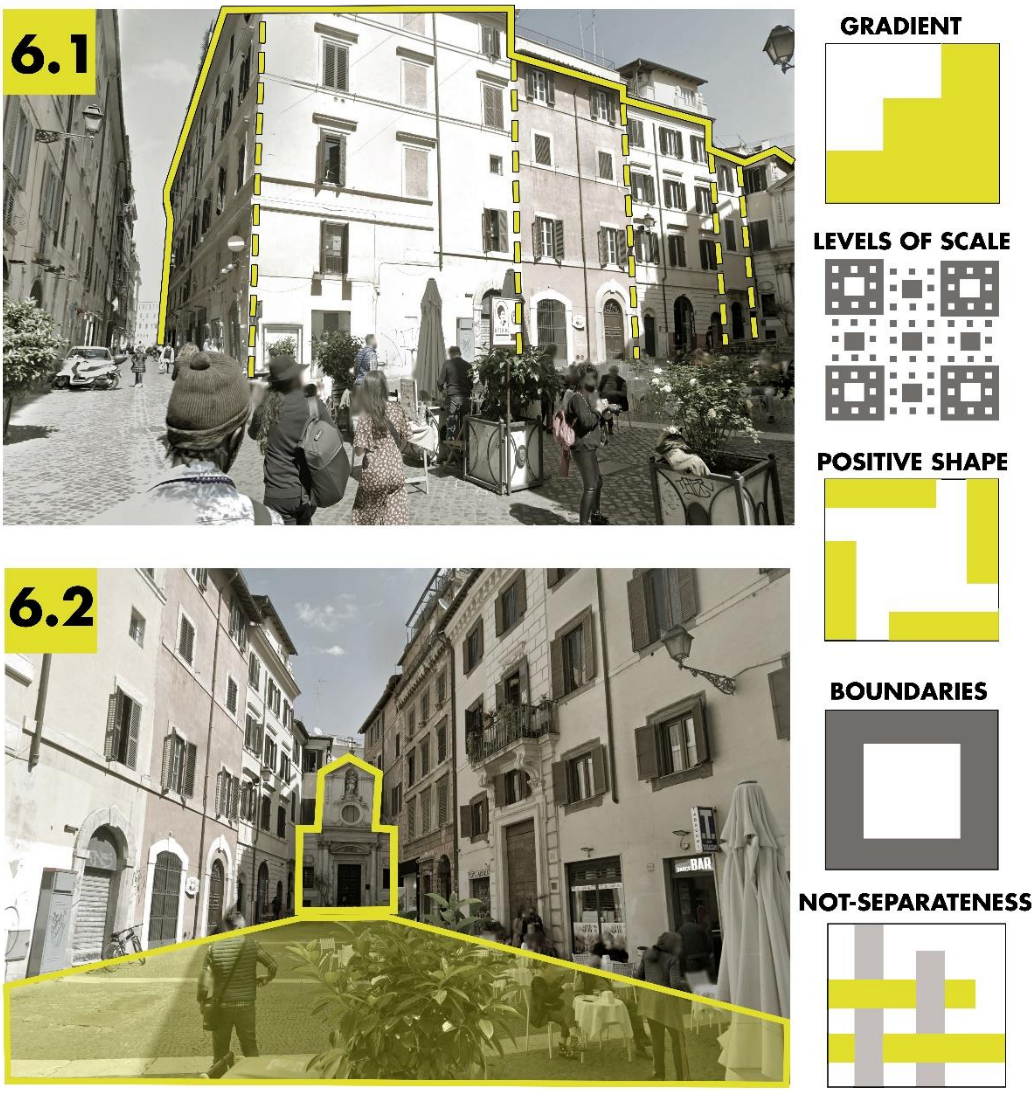


Figure 4.9: Piazza Largo dei Librari bounded by a small church and abutting buildings, where gradient and not-separateness are prominent spatial qualities

Along via dei Giubbonari some of the facades lack levels of scale and have a lower degree of transparency when compared to the street frontage opposite to them. This condition gives rise to presence of contrast on the boundary of the street, as one façade is intricate and articulated, whereas the other is characterized by a higher surface area of the wall (see Figure 4.10).

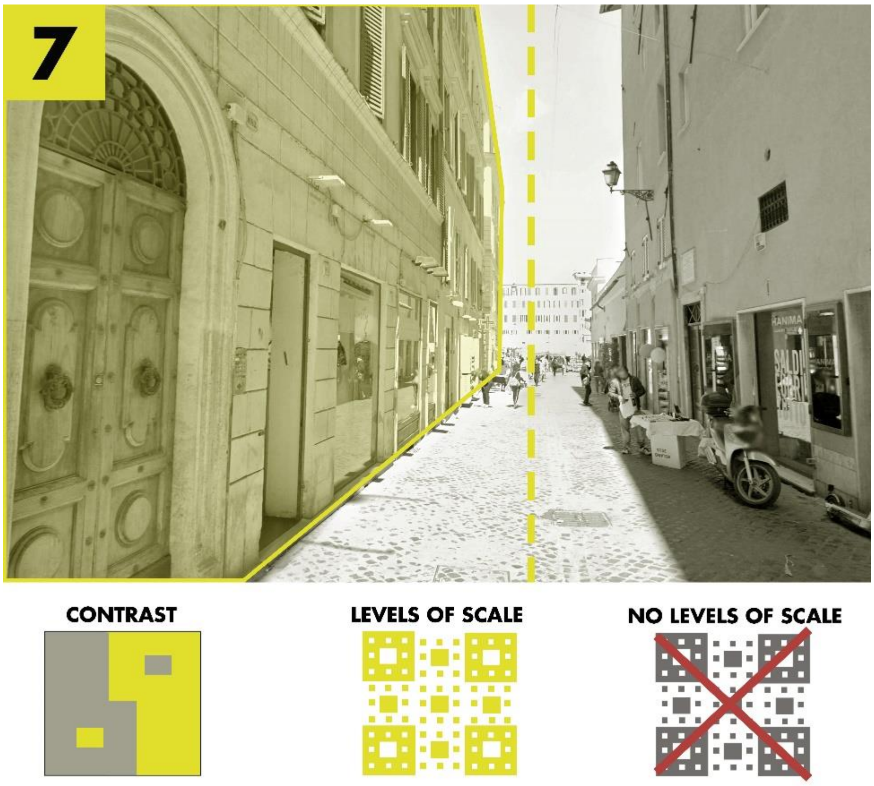


Figure 4.10: Contrast with respect to the articulation based on levels of scale of two opposite street frontages

Piazza Campo de Fiori, merging with via dei Giubbonari, is the most prominent void of good shape and positive space in this street environment, which serves as a marketplace. As one has just entered the piazza, can view buildings of no architecturally remarkable characteristics enclosing and defining the void. The buildings vary in height and width, which leads to gradient of the change in these two physical qualities (see figure 4.11).

Jacobs (1993) described what happens in Piazza Campo dei Fiori as follows:

> On the Via dei Giubbonari, in the early morning, say 6:30 or 7:00 A.M., the first sounds and activities are generated by the market at the Campo dei Fiori. The opening noises are from the market stalls that are set up every morning, from some cars going to it, and from the first shoppers. Window shutters are

opened and some few doors and window grates, mostly metal, are opened at the bars or at the *alimentari*. There are few people. Some walk toward the bus routes on via Arenula., some to the market, and some to the morning coffee (pp. 27-32).

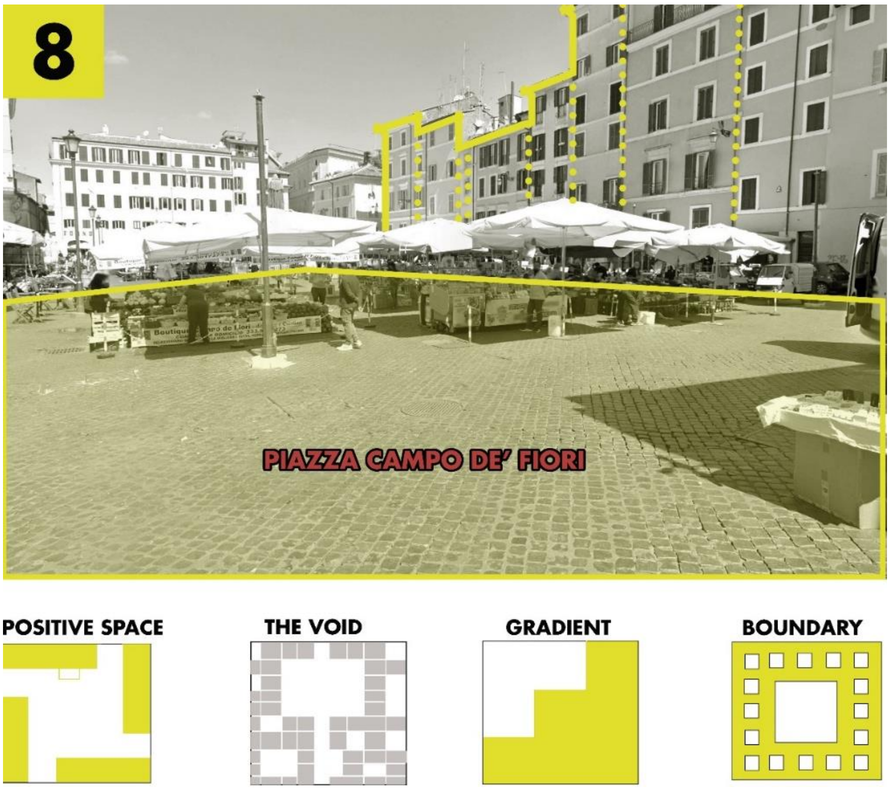


Figure 4.11: View from the entrance of Piazza Campo de' Fiori. There is gradient with respect to the buildings surrounding the square (Google Earth, n.d.)

Although the plots vary in size, there are no abrupt changes in the heights and the widths of buildings that face the street. There is smooth transition of the spatial qualities concerning the masses between abutting buildings. Another spatial quality that prevails is the property of local symmetries on the boundary of the square. The opening and the closing of the shutters at different times of the day accounts for the generation of some kind of 'boundaries within boundaries' and induces coupling between the walls and the empty elements which are the glass panes of the windows. There are other streets that take the pedestrians in and out of the squares, so every part of the system is well connected. In figure 4.12 such a connection is discernible. However, the narrowness of the street creates a sense of mystery and ambiguity as one cannot know beforehand where the street takes you. It can only be experienced as one decides to take that path.

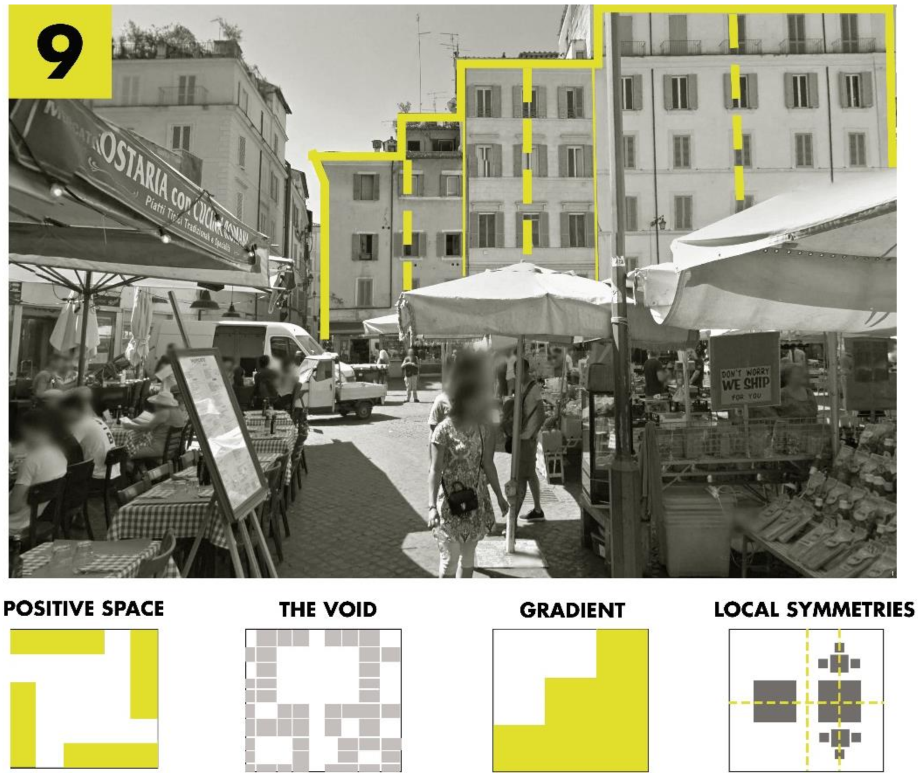


Figure 4.12: Eye level view from within piazza Campo de' Fiori. Pedestrians linger to discover what the stalls of the marketplace offer them (Google Earth, n.d.)

Occasionally on the boundary of the square there is contrast as it pertains the direction of the elongation of the building masses, a contrast founded based on the verticality and the horizontality of the buildings enclosing the square (see Figure 4.13). The ground floors on many of the buildings emphasize the human scale by the application of a different texture and color.

One can also observe how some terraces which account for several human activities in the spaces which have emerged through incremental additions in time. It looks like the void has penetrated into the built, a void defined by achievement of gradient and translational symmetry as the spatial additions grow smaller (see Figure 4.13). This condition enables a smooth transition not only horizontally but vertically too. The lines that separate the sky from the buildings are not abrupt and they have created interior/exterior transitions which contribute positively to spatial coherence in public space. Life that occurs in the interiors is smoothly conveyed in the exterior space that is both separate and united with the void of the square.

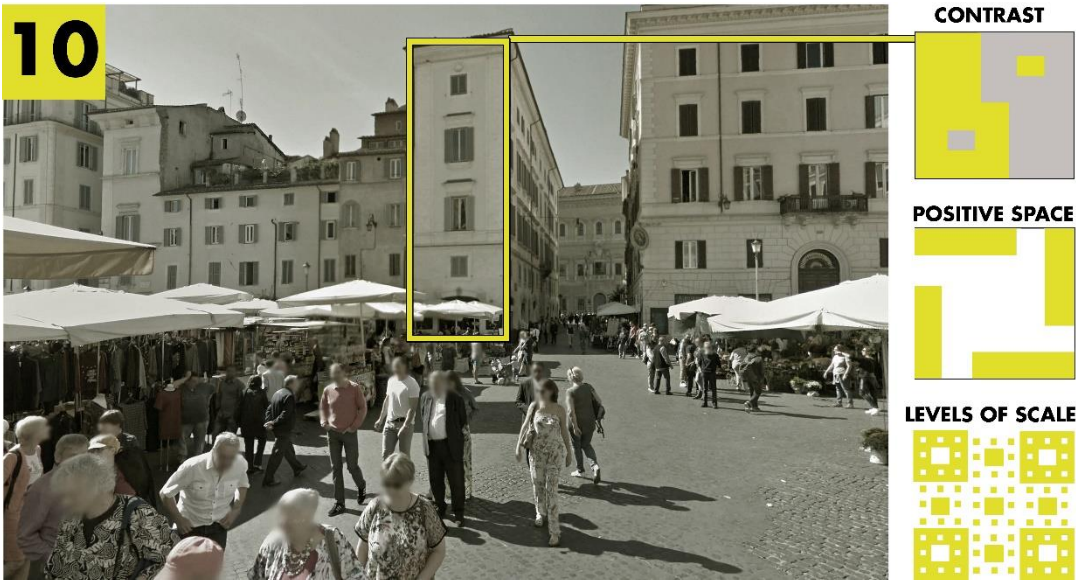


Figure 4.13: Contrast between the spatial qualities of the building masses. Transition spaces that merge with the void of the piazza Campo de' Fiori (Google Earth, n.d.)

As one leaves the main square on via dei Giubbonari the spatial qualities on the facades of the buildings are characterized by roughness. What can be assumed is that these spatial qualities emerged in years and were not pre-determined by design. The openings functioning as windows and doors are different in shape, size and position, a condition arising due to gradual adaptation of the built space to the needs of the inhabitants. The facades are not perfectly symmetrical, yet they are articulated and characterized by boundaries of the openings, a quality that generates the property of not-separateness as the buildings are well connected with each other. On this part of the street the prime example of interlock achieved via two opposite buildings merging with each other through an additional room that connects them (similar to the outcome that the concept of ‘sabat’ in Islamic societies generates). This kind of merging indicates a feeling of ambiguity and deep interlock as one walks through the street, which together characterized by narrowness and enclosure makes one feel is if they were inside. The details on some of the doors achieve levels of scales through their intricacy. The buildings are at most three story high and though there is no considerable indentation of volumes projecting into or out of the void of the street (see Figure 4.14). The solid volume connecting the opposite buildings also represents achievement of a three-dimensional positive space which creates a passage. A similar condition with regard to spatial coherence is observed in the rest

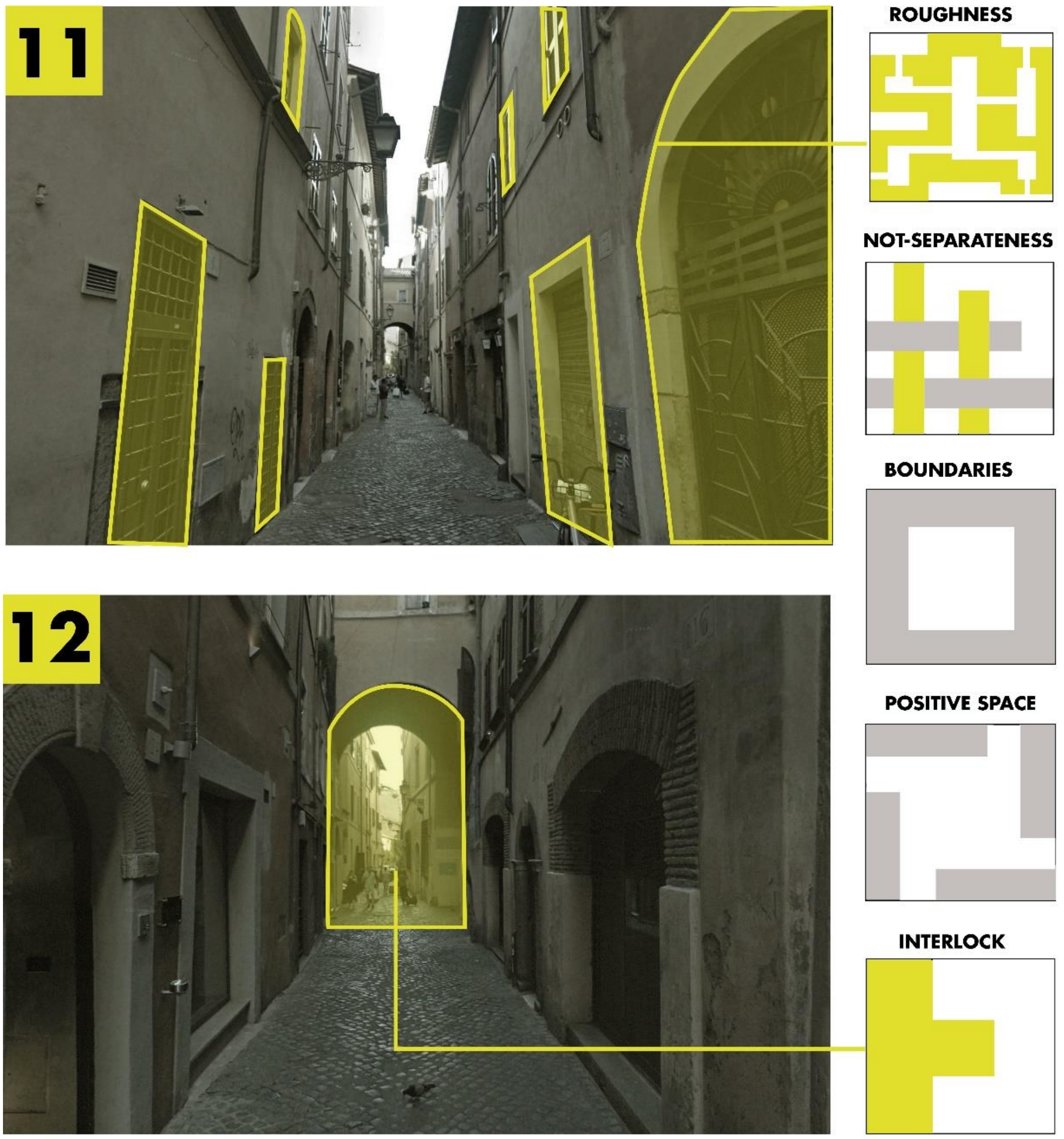


Figure 4.14: Views from via dei Giubbonari representing roughness of the architectural ornaments with regard to their size, shape and position, and the concept of deep interlock and ambiguity (Google Earth, n.d.)

of the street environment as one approaches the end of via dei Giubbonari where simplicity and inner calm prevails (see Figure 4.15).

Figure 4.15: Simplicity and inner calm in the continuation of via dei Giubbonari where the principle of roughness prevails (Google Earth, n.d.)

4.2 Case Study 2: Via San Vitale

Via San Vitale is located in Bologna, the city known for its canopied streets, portici, which comprise almost the whole urban network in the city of Bologna. Portico is an architectural element that gives meaning to the presence of the void. Its geometrical and physical qualities, become a source of pleasure while one transits toward their destination. At its finest forms are porticos, arcades and patios met at the Palladio Architectural style, as they acquire perfect geometry, repetitive symmetry, they grow tall and narrow achieving so most of the spatial coherence indicators for the urban fabric. Today's UNESCO's "City of Porticoes" and the strategic center of the Emilia Romagna region of Italy is the city of Bologna ("Bologna, the City of Porticoes," 2019).

Contemporarily produced urban space has become devoid of portico, and consequently the rhythm generated by alternating repetition of modules that constitute a portico which result in a hypnotizing effect has been lost. However, some of the oldest and finest architectural styles have reckoned the ability of this architectural and urban element to provide a coherent built environment. The city has for about 9 centuries now received delightful praise about its urban fabric. Bologna accounts for 42 km long portico and arcade spaces inside the gates and more 20 km outside , as well as for both the longest (Portico of San Luca) and the largest (Portico of the Basilica of Santa Maria Dei Servi) porticoes in the world (Centre, n.d.). Porticos, arcades, and galleries representing at times the boundary, the alternating repetition, having levels of scale, echoes and contrast in void and plain can in many ways provide a coherent and fine urban built environment (Martin, 2013).

Via San Vitale in Bologna is one of the many streets distinguished by porticoes that extend along the whole street, symbols of the city of Bologna. Jacobs includes porticoes among great elements that produce great streets. Porticoes create a permeable boundary where there is alternating repetition of the solid of the arcades' columns and the void of the bay. This type of boundary enables separation and unity with the surrounding, as it separates the vehicular road from the pedestrian circulation.

There are two underlying reasons behind the emergence of porticoes. Firstly, they are an outcome of emergent urbanism as people adapted their buildings to adjust their need for more space. The columns of porticoes provided structural support for the building. Jacobs (1993) explains that building upper floors over the streets followed by the construction of columns to support the upper floors was a tradition in Bologna. Nowadays, the importance given to the portici by the community reflects “the social tradition that put the interests of the community above private interests (Jacobs, 1993, p. 124). Secondly, porticoes are a good adaptation to the climate since, winter is extremely harsh, and summer is extremely hot in Bologna. They offer shelter throughout the year.

Jacobs (1993) distinguishes a group of five canopied streets in Bologna, which he describes as spines of their surrounding quarters, each leading to a city gate. Although the five streets share common spatial qualities, there exist some differences which have arisen due to the variety of the communities occupying the buildings along the streets. In general, as one walks along these streets, the pace becomes more intense toward the center of the city and occasionally the continuity of the portici is interrupted by buildings that used to be there before the portico as a spatial element emerged.

Via San Vitale together with via Zamboni, Strada Maggiore, Via San Stefano and Via Castiglione lead to Piazza di Porta Ravegnana, where two towers serve as landmarks. As one walks in the covered street experiences a sense of ambiguity arising from the feeling of being both inside and outside. Porticoes, thus enable the formation of interior/exterior transitions which is a critical indicator of spatial coherence. The permeability of via San Vitale is not only a three-dimensional quality present along the street. One a planimetric level, the well-connectedness of the street is supported by frequent intersection of other streets and paths. The presence of void in the form of squares and piazzas is not as allocated as it is along via dei Giubbonari in Rome (see Figure 4. 16).

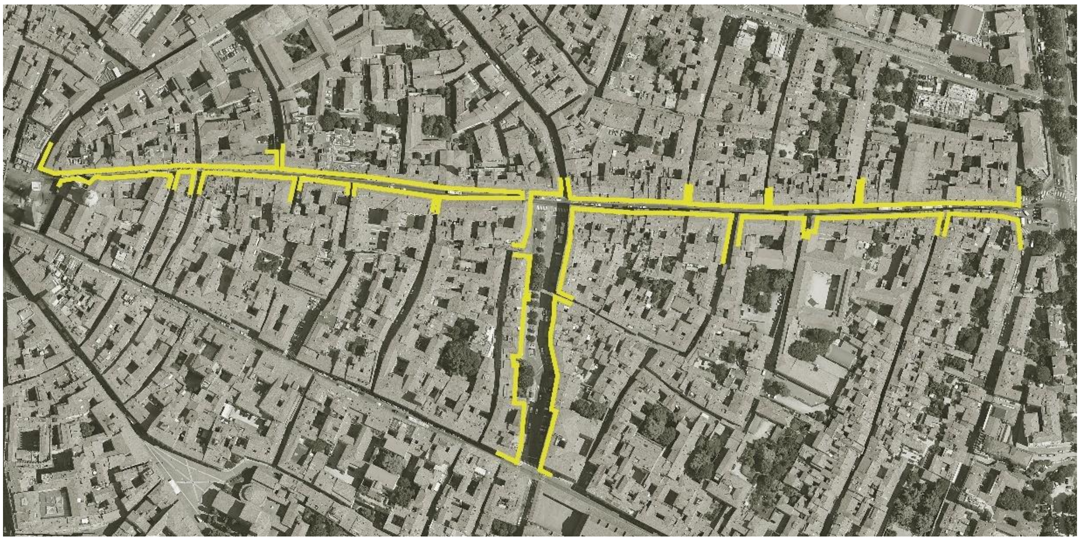


Figure 4.16: Via San Vitale in Bologna, one of the many canopied streets of the city (Google Earth, n.d.)

4.2.1 Mapping and Visualizing Spatial Coherence in Via San Vitale

Overall, the fabric surrounding via San Vitale is dense and the open spaces mostly take the form courtyards. There is one prominent square, piazza Aldrovandi, which merges with the street perpendicularly. Positive space arising from good shape of the built environment prevails in the fabric. The quality of roughness is discernible all throughout the fabric as each structure has been built to fit in the pre-existing whole. Based on similar processes of creation all the buildings are characterized by the quality of echoes. The principle of not-separateness predominates both the solid and the void of the fabric. Each urban block achieves levels of scale as small plots come together to give rise to the traditional block with courtyards of various sizes. Several plots are smaller than others and their size changes gradually, indicating the presence of gradients in the fabric, a condition also echoed in the size of the urban block. Figure 4.17 shows the figure ground of the urban fabric in the surrounding of via San Vitale.

Figure 4.17: Figure ground map of the urban fabric surrounding via San Vitale in Bologna

Via San Vitale starts with a gate, Porta San Vitale, which is a remnant of the medieval city walls. The gate reinforcing the void of positive shape in it stands there as if its main aim were to give a glimpse of what the pedestrian will experience walking along via San Vitale. Contrast of the solid and the void achieves the basic unit of interlock to be repeated all along via San Vitale (see figure 4.18).

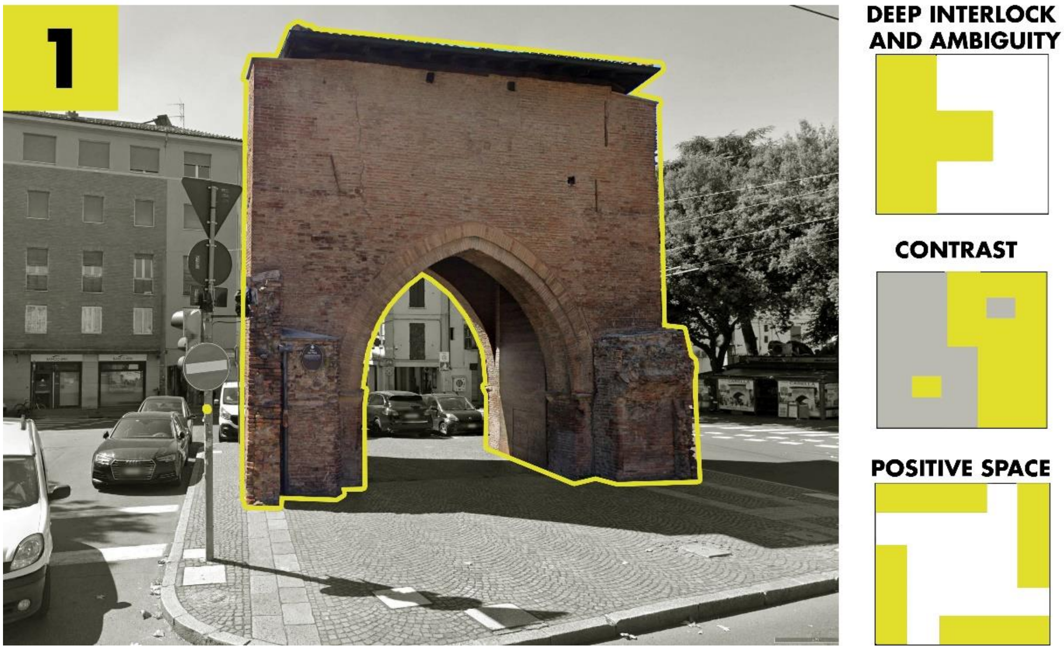


Figure 4.18: Porta San Vitale, the basic unit of interlock (Google Earth, n.d.)

The street achieves its pervasiveness via alternating repetition of the interlocking units, arcades, whose arrangement on the ground floors of the buildings enclosing the street give rise to the portici. Echoes exists only on the same floor, as shapes on the arcades are of different angles with the shapes of the windows. The boundary of the street is highly permeable, and the inside of the porticoes provides a smooth transition from the public to the private or from the exterior to the interior. The facades of the buildings embody local symmetries, whose repetition involves subtle variations along the street (see Figure 4.19). Although each building consists of similar elements and modules, they are not blatantly repeated.

At first glance, it looks like that there is a single building running along with the street, but once one notices the subtle variations on the boundary, it becomes clear that the definition of the whole street can be simply put as ‘unity with diversity’, what spatial coherence aims to achieve. The road is not frequented by the pedestrians because porticoes serve as pedestrian circulation paths. Therefore, throughout the images there will be cars resting on the road.

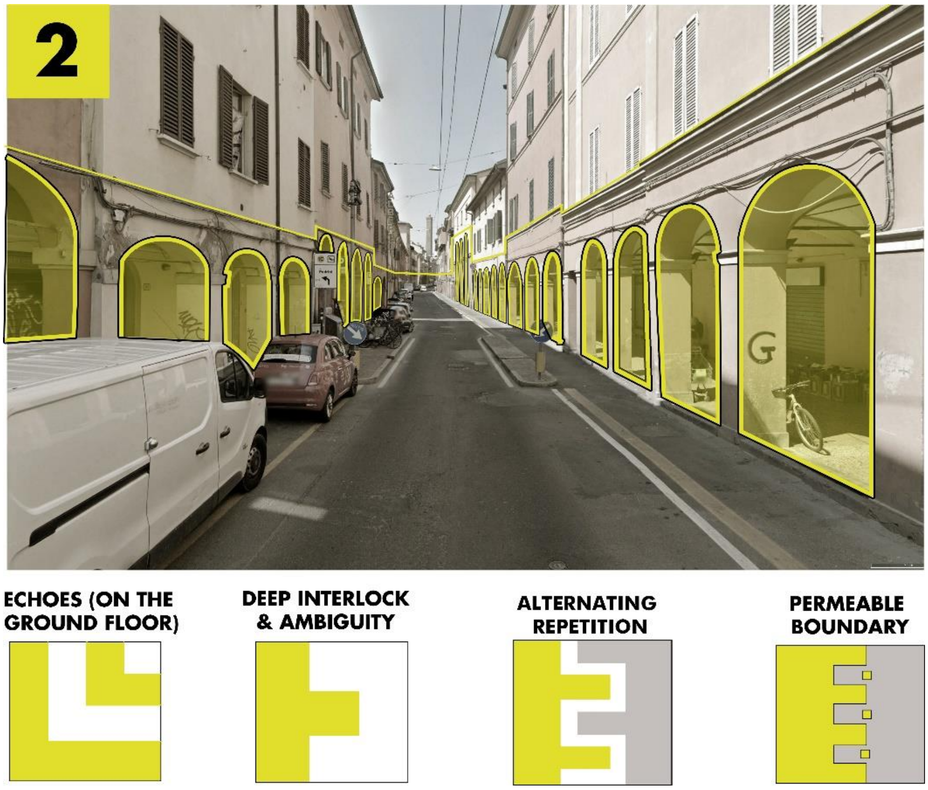


Figure 4.19: The beginning of via San Vitale, of a highly permeable boundary achieved via alternating repetition of interlocking units. The application of echoes is done separately on each floor. (Google Earth, n.d.)

The buildings are aligned along via San Vitale and apart from the ground floors there is no volumetric variation on the upper floors. Occasionally, there is variation on the setbacks of the buildings, and consequently on that of the porticoes. The porticoes continue uninterrupted and sometimes they environ all the edges of a building, especially where a perpendicularly intersecting path exists (see Figure 4.20). On this kind of paths, usually, the principle of contrast with regard to the intricacy of the façade achieved by solid-void interpenetration is observed. The portici is applied only on one edge of the street and the other edge defines a more abrupt boundary. Yet the pedestrian can enjoy a sheltered walk towards a certain destination using the sheltered edge of the street.

Figure 4.21: The continuation of portici on a path perpendicularly intersecting with via San Vitale and building setback variation (Google Earth, n.d.)

Buildings of special functions such as churches and museums are merged in the fabric and achieve not-separateness, although there exist the property gradients applied to their porticoes (see Figure 4.21).

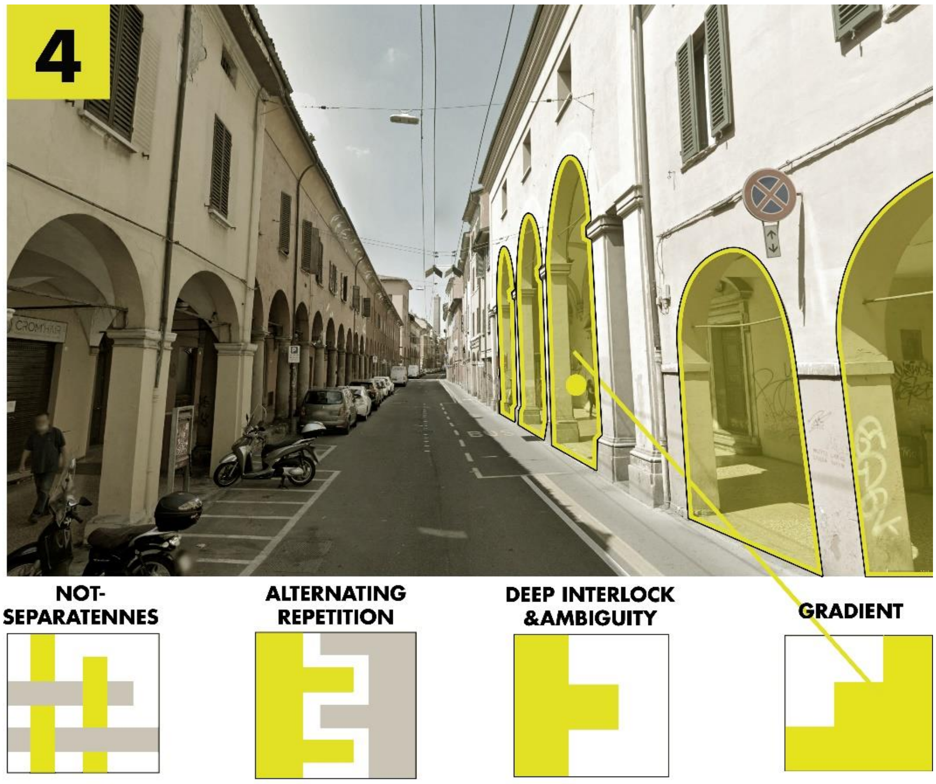


Figure 4.20: Gradient applied on porticoes in via San Vitale, Bologna (Google Earth, n.d.)

Despite the fact that rounded semicircular arches prevail in porticoes, there are some exceptions, where flat rectangular arches are applied (see Figure 4.22). In this case we can identify the application of echoes vertically on the same building and a break on the echoes of the ground floor. Nonetheless, this condition is not frequently repeated along via San Vitale.

Figure 4.22: Echoes applied vertically on the same building but contrasting with the shape of the neighboring porticoes, (Google Earth, n.d.)

Over some of the intersecting paths, there small overpasses that connect the opposite buildings. This condition achieves inductive coupling via a common third element (see Figure 4.23). Deep interlock and ambiguity is applied on all the edges of the space, with a smooth exterior/interior transition. All the vaults echo each other in terms of shape and angles, a property which gives rise to spatial coherence.

It should be noted that, the facades are not quite intricate, and levels of scale might not be perfectly achieved among the range of the elements. However, spatial coherence is mainly accomplished through the repetition of the vault on the ground floor level. Moreover, there is no overall symmetry of the emerging structure, but each component is characterized by local symmetries as it can be seen in figure 4.23. Local symmetries contribute to the generation of spatial coherence without instigating boredom as one uses the space.

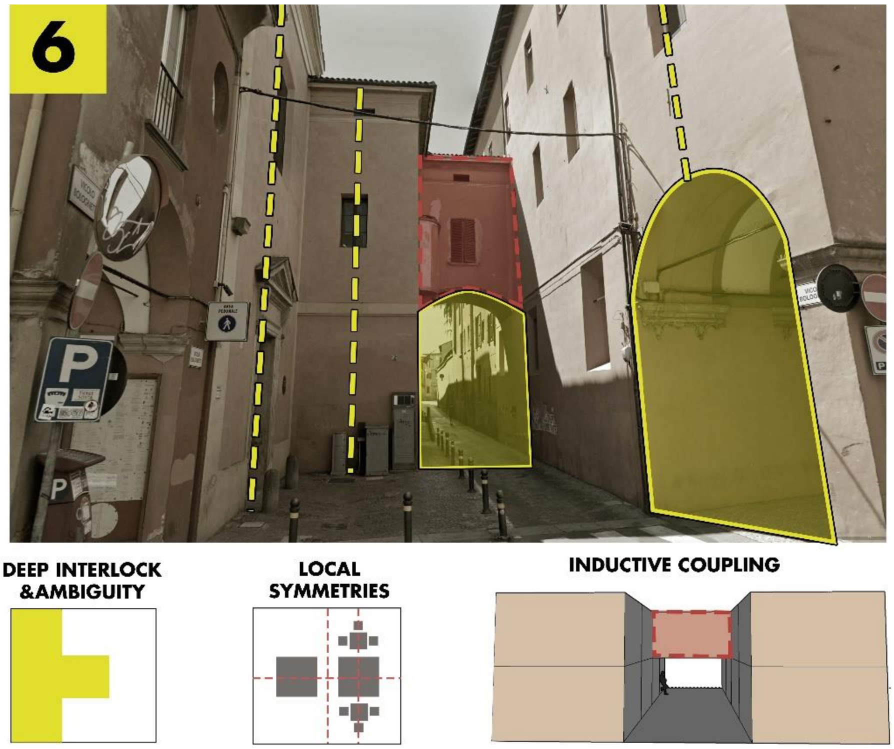


Figure 4.23: Inductive Coupling via a common third element which satisfies the properties of interlock and local symmetries (Google Earth, n.d.)

On several buildings, elements comprising the porticoes have contrasting qualities (see Figure 4.24). Gradients is achieved via variation in heights of the bays. Usually, the change in the heights of the bays between columns marks the transition into a building with a specific function, a church, a library or a museum.

Figure 4.24: Color contrast between the components of the portico (Google Earth, n.d.)

Another achievement of the property of echoes is observed in the shape of the vaults and the gates on the ground floor (see Figure 4.14). This condition is frequently discernible along via San Vitale. Echoes strengthens neighboring centers and enable a kind of repetition which is not blatant and boring.

F**igure 4.25**: Application of echoes on arches of the vaults and gates (Google Earth, n.d.)

Some of the facades achieve better levels of scale via boundaries of openings which have contrasting qualities with the walls. In addition, the columns of the arcades contrast in color and texture with the walls of the upper floors (see Figure 4.26). The generation of coherence in this kind of modules occurs via the application of boundaries within boundaries, which have contrasting qualities with elements in their adjacency. Facades that employ boundaries within boundaries usually tend to satisfy two important geometrical properties of coherent wholes, levels of scale and strong centers.

Most of the buildings along via San Vitale lack intricacy of detail, yet they achieve a remarkable degree of spatial coherence via couplings from floor to floor. The richness in centers present on the ground floors makes up for the less detailed upper floors. Nonetheless, some building facades stand out with respect to the architectural ornaments that are part of their design. These ornaments can be found sometimes only on the ground floor or expand vertically on the facades.

Figure 4.27: Levels of scale achieved in a building with portico (Google Earth, n.d.)

Levels of scale due to an intricacy of details on the façades of the buildings enclosing the street can be observed in figure 4.27 as well. The columns of the porticoes have a texture which is different from the rest of the building.

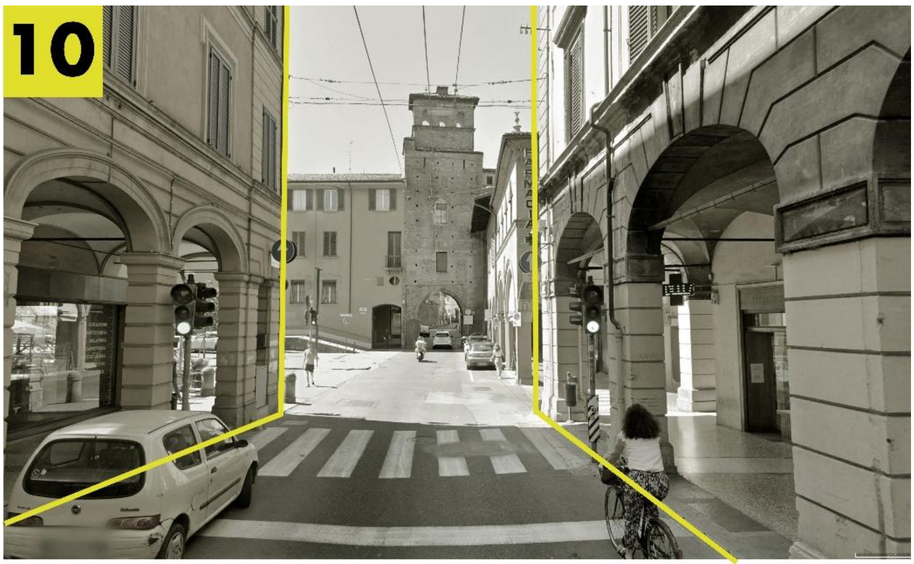


Figure 4.26: Intricacy of the surfaces of porticoes' components (Google Earth, n.d.)

The most prominent void merging with via San Vitale is piazza Aldrovandi, whose boundary does not bear the same spatial qualities with the street (see Figure 4.28).

Figure 4.28: Piazza Aldrovandi, the void (Google Earth, n.d.)

Leaving behind the square one passes through an old tollgate, so distinct in texture, which arches over the street echoing the porticoes in shape (see figure 4.29). The passage through the tollgate is an extension of deep interlock and ambiguity which defines the spatial qualities of the whole street's boundary. Figure 4.30 provides a

Figure 4.29: The passage through the old tollgate (Google Earth, n.d.)

better understanding of how the old tower contrasts with the rest of the boundary, but still merges with them achieving not-separateness. The tower contrasts with the buildings it abuts in terms of texture and intricacy of the architectural details. The façade of the tower is much plainer when compared to that of the adjacent buildings.

Figure 4.30: The old tall gate contrasting and merging with the neighboring buildings (Google Earth, n.d.)

At relatively infrequent intervals, the street has boundaries of different qualities, boundary with levels of scale and strong centers on one side and the permeable boundary arising from the alternating repetition of interlocking units (see Figure 4.31).

Figure 4.31: Two different kinds of boundaries along via San Vitale (Google Earth, n.d.)

However, the case explained in the previous image is not quite common in via San Vitale. The boundary reacquires its pervasive quality (see Figure 4.32).

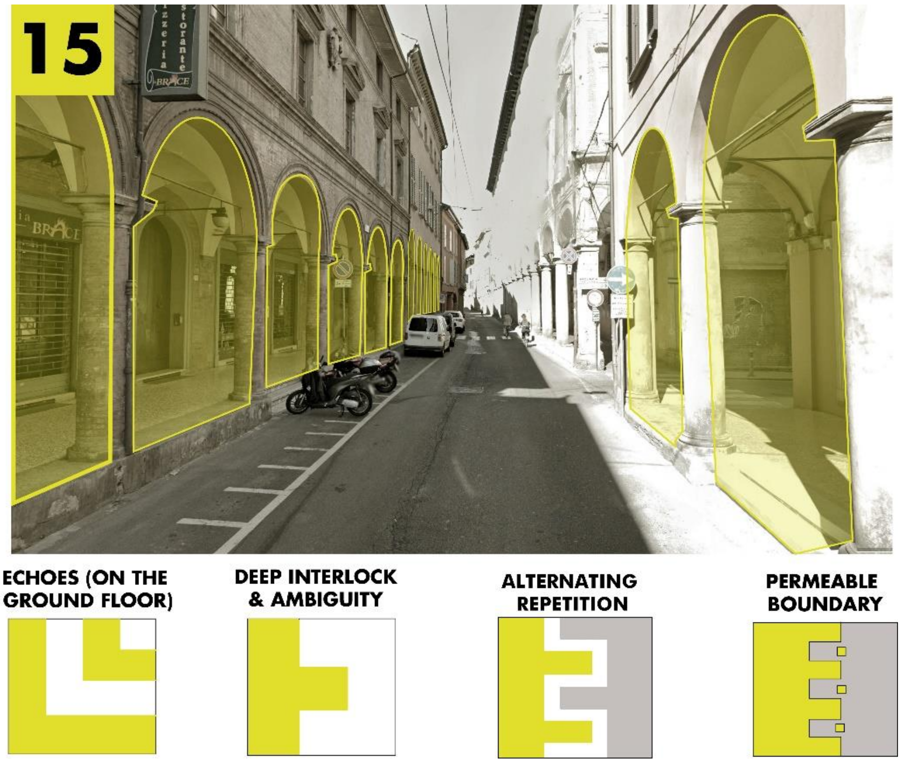


Figure 4.32: The continuation of the pervasive boundary on both sides of via San Vitale (Google Earth, n.d.)

Elements and spatial qualities echoing vertically are not frequently encountered, yet present in Via San Vitale (see Figure 4.33).

Figure 4.33: Application of the geometrical property of echoes vertically (Google Earth, n.d.)

Other examples of contrasting qualities on the two opposite edges of the street can be seen in figure 4.34.

Figure 4.34: Two different kinds of boundaries along via San Vitale (Google Earth, n.d.)

As one approaches the walls enclosing of the church 'Chiesa dei Santi Bartolomeo e Gateano' the left edge of the street becomes plainer with no application on levels of scale or alternating repetition (See Figure 4.35). There is still some transparency on the ground floor level due to the shop entrances. On the other hand, the right edge preserves its permeability on the ground floors.

Figure 4.35: Two different kinds of boundaries along via San Vitale (Google Earth, n.d.)

Via San Vitale ends with Piazza di Porta Ravegnana defined by a boundary which is both pervasive and characterized by the properties of levels of scale and strong centers (see Figure 4.36).

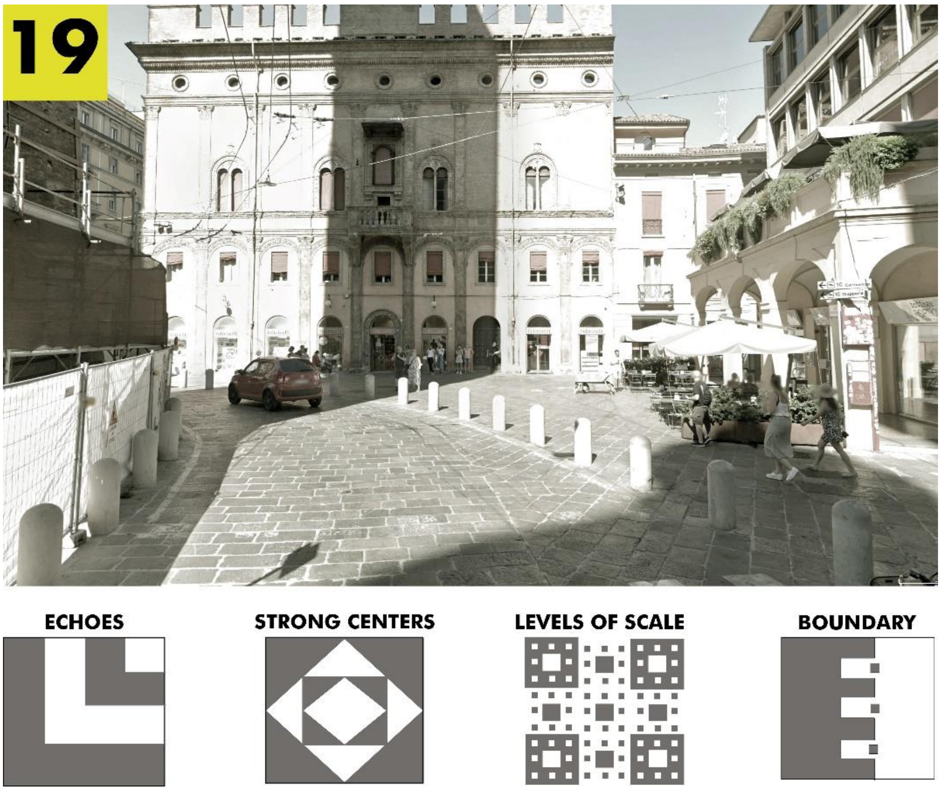


Figure 4.36: Piazza di Porta Ravegnana, the void Via San Vitale leads to (Google Earth, n.d.)

4.3 Case Study 3: Yıldırım Caddesi

Yıldırım Caddesi is located in the district of Balat in Istanbul, whose local context is distinguishable from the surrounding districts, making it a cultural heritage for Istanbul. Balat is an old Jewish quarter and has been part of restorative and rehabilitative preservation projects. Historical houses of Balat generate a special kind of street boundary, where there is solid-void interpenetration along the street. This type of boundary can be defined as a convoluted boundary, which provides a gradual transition from the public to the private via emerging intermediate spaces. The interior/exterior transition is a result of bay windows, which are solid volumes projecting into the void of the street. In short spatial coherence in Yildirim Caddesi is achieved via a folding urban interface, emerging from the alternating repetition of interlocking units.

Although this description places Yildirim Caddesi in the same category of boundary with Via San Vitale, when analyzed their differences are easily recognizable. There is no separation between the vehicular and pedestrian circulation as it is in the case of via San Vitale and many of the built environment occasionally hosts human activities which it was not originally meant for. Most of the void present along the street has arisen due to demolition or damage of the fabric. Nonetheless the emerging void is actively used by the community as retail and commercial shops on the ground floor of the buildings have laid tables and chairs to offer an experience of dining outside.

The plots comprising the urban block are characterized by the fine grain, but the overall definition of the urban block cannot be described by the courtyard typology. Yildirim Caddesi is relatively long and narrow. Its winding shape creates a sense of mystery and ambiguity as to what to expect next, as one walks along the street. Similarly, to via dei Giubbonari the street starts with a funnel shape which attracts pedestrians into it, without revealing everything that the street has to offer in terms of experiences. The small plots generating the boundary of Yildirim Caddesi have provided a high connectivity of the street with the rest of the district (see figure 4.37).

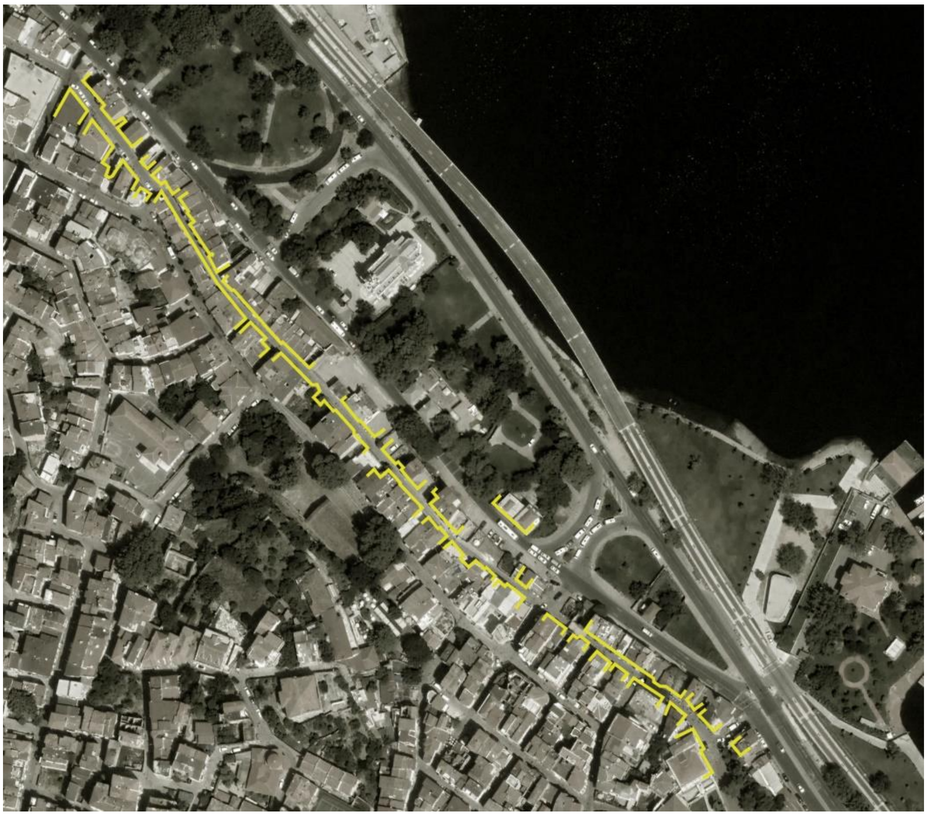


Figure 4.37: Yıldırım Caddesi in Balat, Istanbul (Google Earth, n.d.)

4.3.1 Mapping and Visualizing Spatial Coherence in Yildirim Caddesi

To analyze spatial coherence and address the geometrical properties of coherence as described by Christopher Alexander, images that show eye-level view of the street from the pedestrian perspective have been retrieved from Google Earth and the spatial qualities present in the view have been highlighted. Due to the intricacy of the facades, on several occasions a group of spatial qualities will be shown in the same picture as they interrelate by reinforcing each other in achieving spatial coherence of the public space. The position of the pedestrian within the street is mapped in Figure 4.38 which also shows the figure ground analysis of the urban fabric surrounding Yildirim Caddesi.

Figure 4.38: Figure-ground map of the urban fabric surrounding Yıldırım Caddesi in Balat, Istanbul

At the entrance of Yıldırım Caddesi, one catches a small glimpse of the atmosphere that the street has to offer as it unfolds a variety of details long it. The boundary starts to fold right next to a building which embodies strong centers and levels of scale based on the intricacy of its architectural ornaments. This building does not include interlock of the volumes, yet it achieves its coherence via the cohering elements of its façade.

The boundary starts to fold via solid-void interpenetration, and example of interlock, generating thus intermediate positive spaces that enable a smooth indoor /outdoor transition. This condition is alternatingly repeated along the street. The buildings as modules whose floors have coupled with the void of the street via interpenetration are not separate from each other as none of them compromises the rhythm of the convoluted interface. Overall, the architectural details achieve the spatial quality of echoes, a principle which reinforces spatial coherence on a wide range of scales.

Figure 4.39: Entrance of Yıldırım Caddesi where one can see the change in the character of the boundary as it starts to fold and create intermediate transition spaces via interlocking units arising from solid-void interpenetration (Google Earth, n.d.)

Most of the open spaces merging with the street and being used actively by the pedestrians are typical of emergent positive spaces, considering that they have not been premeditated but have arisen due to damages in the urban fabric (see figure 4.40).

Figure 4.40: Positive spaces emerging along Yıldırım Caddesi (Google Earth, n.d.)

Occasionally the boundary becomes plainer in terms of the volumetric differentiation and in these cases, coherence is achieved via contrasting qualities of the echoing constituents, which exist in terms of color (see Figure 4.41).

Figure 4.41: Variation in the kind of the boundary of the street (Google Earth, n.d.)

Passages and coupling via a common third element in the environment of Yıldırım Caddesi does not occur via two units connecting with an added built space, but via connecting vegetation elements (see Figure 4.42). This creates an effect of being inside of a room as the void of the street is enclosed on the four sides.

Figure 4.42: Three-dimensional positive space serving as a passage in Yıldırım Caddesi (Google Earth, n.d.)

A remarkable corner building achieves levels of scale with strong centers resulting from both architectural ornaments and volumetric variation generated by vertical setbacks on the façade. This building stands out but also merges beautifully with the surrounding, giving thus rise to not-separateness. The ground floor of this building functions as a café on which an application of echoes different from the one on the upper floors is observed (see Figure 4.43). Although the sidewalk environing this building is quite narrow, the projecting volume over the sidewalk has created the perfect conditions for a transition space, where we can see users sitting and enjoying a meal, a coffee, or a conversation. This recognition enables us to derive a conclusion that projecting volumes facilitate a variety of uses of transition spaces in public space. The volumetric enclosure invites people to use the emerging positive space efficiently. Standing right in front of Naftalin Café one can observe the continuation of the convoluted boundary as balconies of the abutting buildings project into the void of the street (Figure 4.43).

Figure 4.44: Emerging positive space as a result of projected volumes on upper floors and the continuation of the folding boundary (Google Earth, n.d.)

Along the street, sometimes the void of the street penetrates into the solid of the buildings as a result of indented entrances. These kinds of space enable the emergence of another unpremeditated activity such as sitting and resting, a necessity of the ordinary life (see Figure 4.44). Once again, the importance of transition spaces for the generation of a rich variety of activities in public space is highlighted by this example.

Figure 4.43: The void of the street penetrating into the solid of the building, creating a transition space where activities like sitting and resting emerge (Google Earth, n.d.)

As one keeps walking down the street the folding boundary where more buildings that interlock with the void of the street appear (see Figure 4.45) . some of the facades have been completely covered by vegetation creating a contrast in texture along the boundary

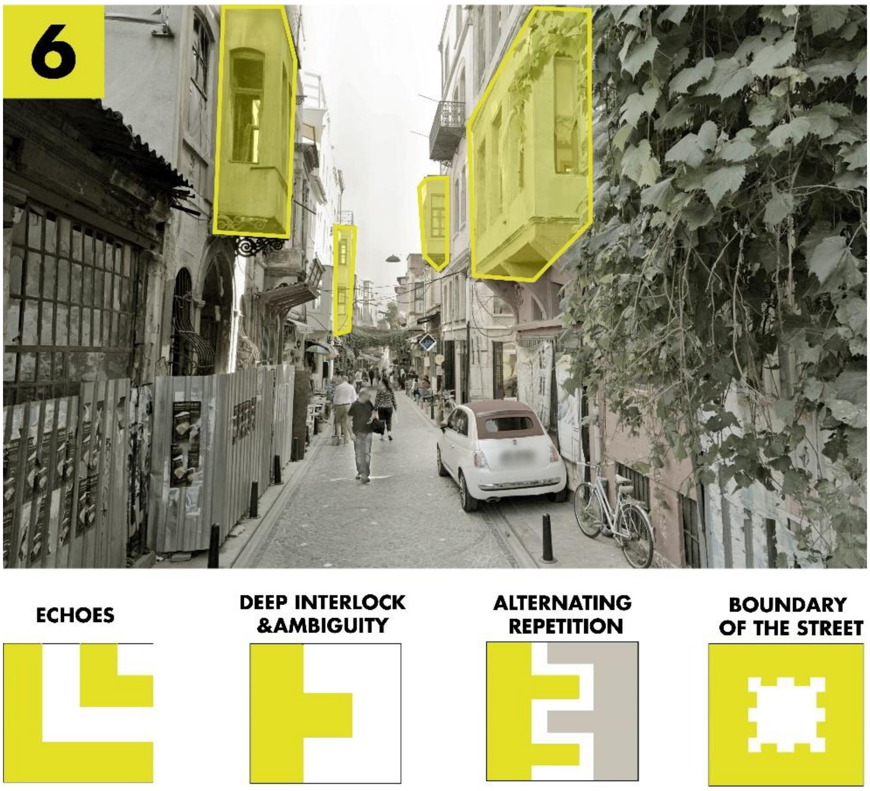


Figure 4.45: The continuation of the folding boundary along Yıldırım Caddesi (Google Earth, n.d.)

Occasionally there is discontinuity in the fabric which causes a contrast between the opposite edges of the street (See Figure 4.46). One edge of the street is characterized by the folding boundary, whereas the other age is characterized by the void serving as a positive space. Another quality of the street that is worth mentioning is the color contrast between abutting buildings that occurs frequently in this environment. An example of abutting buildings contrasting in color and reinforcing each other via alternating repetition is shown in figure 4.46.

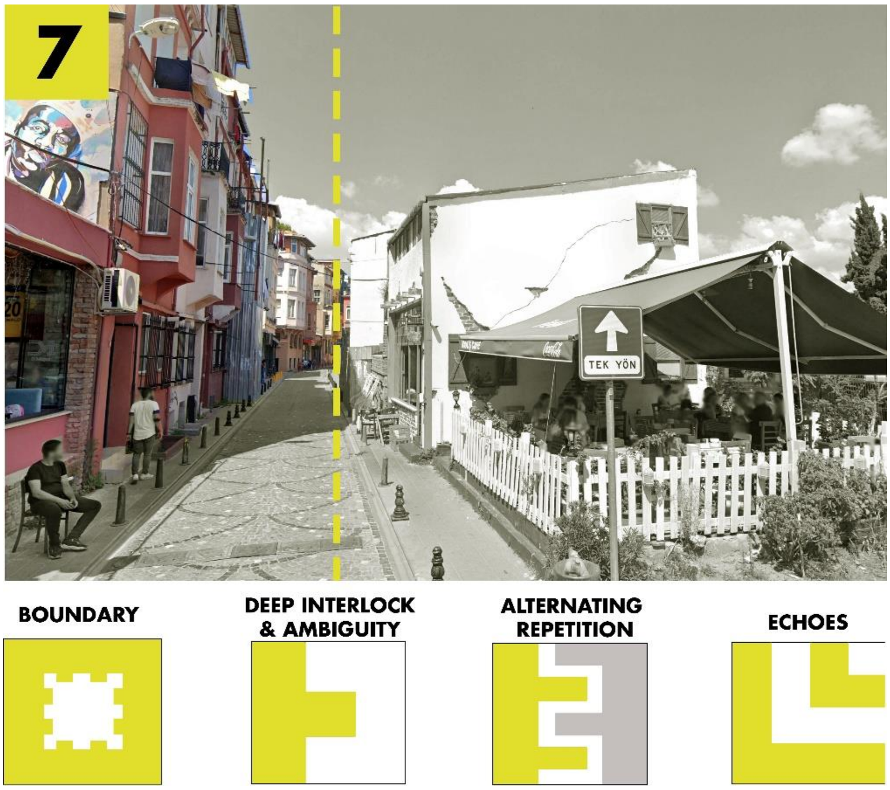


Figure 4.47: Contrast of the qualities of two opposite edges of the street (Google Earth, n.d.)

There where buildings have been demolished one can discern empty facades contrasting with intricate facades. These examples prove that forms that are coherent are difficult to decompose without losing inherent characteristics of the system.

Figure 4.46: Intricate facade contrasting with an empty facade in Yildirim Caddesi (Google Earth, n.d.)

A similar condition is observed in figure 4.48 where there exist two empty facades interrupting the folding boundary.

Figure 4.48: Empty facades interrupting the folding interface of the street's boundary (Google Earth, n.d.)

In Figure 4.49 the facades comprising the boundary are not empty but still interrupt the folding interface.

Figure 4.49: Interruption of the folding boundary (Google Earth, n.d.)

The folding boundary with alternating repetition of interlocking units that couple on the building scale via contrasting colors reappears in the street environment (see Figures 4.50).

Figure 4.50: Continuation of the folding boundary in Yildirim Caddesi (Google Earth, n.d.)

Some sections of the boundary achieve spatial coherence through modules coupling with each other via contrasting colors. The modules are already coupling with the void of the street via interpenetration (see Figures 4.51 and 4.52).

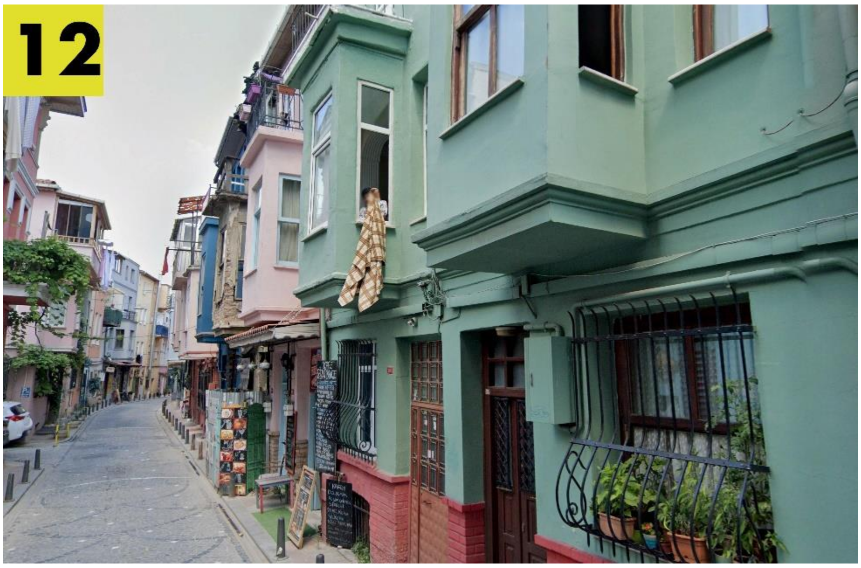


Figure 4.51: Building modules coupling with each other via color contrast (Google Earth, n.d.)

Figure 4.52: Continuation of the folding boundary where contrasting colors are applied to induce coupling between the ground floor and the upper floors (Google Earth, n.d.)

Every emerging void is given a use that crates functional coupling with the street and the buildings the void is defined by (see Figure 4.53). The ground floors of the buildings are of commercial use. The street facilitates circulation of the pedestrians, and the void becomes a different kind of receptacle where people sit to eat.

Figure 4.53: Void coupling functionally with the street in Yildirim Caddesi (Google Earth, n.d.)

Towards the end of Yildirim Caddesi the folding boundary seems to have an in finite continuity due to the winding shape of the street. The same effect occurs for pedestrians walking in both directions (see figures 4.54 and 4.55).

Figure 4.54: "Infinite" continuity of the folding boundary (Google Earth, n.d.)

Figure 4.55: Entrance into Yildirim Caddesi from its other end where the folding boundary seems to continue to infinity (Google Earth, n.d.)

CHAPTER 5

CONCLUSION

This research draws its main motivation from a common effect that both professional designers and everyday users of the public space in contemporary cities experience as they carry out their life-sustaining activities in the built environment. Urban public space has lost many positive qualities that facilitate a wide range of human activities essential to conduct life. Planning and urban design have played a significant role in not only in the formation of certain urban morphologies but also in shaping the activities that take place within space.

The history of city planning consists of many movements, which have presented a variety of approaches concerning the solution of city-related problems. However, these approaches, often disregard the inherent complexity of the urban systems, seeking to impose a certain order on the outcomes of space generating processes. The formation of successful cities is highly dependent the complexity of processes they embody and driven by the mantra "the whole is more than the sum of its parts". One should not dismiss the fact that there is always a pre-existing whole, defining the initial conditions of an urban system, which should not be damaged by newer developments.

As a result, disregarding dependence on the initial conditions of the whole in decision-making concerning future developments of the cities has led to a fragmentation of the built environment, with severe impacts on the urban life within public space. In contemporary cities both path dependence and discontinuities are observable in phase transitions as delineated by growth on the agricultural landscape and transformations of the existing urban fabric in the guise of planning to adapt form to evolving needs of communities. The latter predominantly causes distortions in the geometric coherence of cities which determines the condition of future growth and developments.

These two models are not just exemplary of how control and command should not be applied in cities as wholes, but they have also been the key model to shape the growth pattern of cities, especially in the twentieth century. In an endeavor to present solutions to a given problem as designated by the hand of a single designer, they have destroyed a myriad of positive spatial qualities that constitute a good urban form. Structurally, functionally, and spatially successful urban environments have emerged as a result of actions pertaining to a great number of individuals, whose main goal is to adapt their living environment incrementally according to their needs. Consequently, the emerging public space has prospered in hosting urban life, which indicates a variety of activities within the built environment, and not simply rushing through the void.

To sum up, public space is still suffering from the adverse ramifications that these models have encouraged. The main normative criterion of a good urban form is spatial coherency, which represents the prerequisite condition of the built environment to incubate urban life. Urban form resulting from the contemporary approaches of modern planning, is devoid of spatial coherence. Consequently, streets have lost the role they used to have in traditional towns, where people could sojourn and linger, and where there were no roads serving simply as capillaries to carry out volumes of people as fast as possible benefitting only the efficiency of a system that views humans as machines to be optimized.

Nature is imbued with forms that host life, characterized by a specific kind of order that does not resemble that of the machines, formulated to maintain efficiency of mechanical systems and based on human reductionist understanding of universal phenomena. Forms that incubate life are distinguished by coherence of their components from the smallest to the largest scale. As such, one can assume that coherence as preconditioned by the processes of complexity that gives rise to these kinds of forms is the main indicator of life received and sustained in space. In the scope of urban design, many positive spatial qualities are associated with the coherence of morphological elements that comprise the built environment and give rise to a variety of open public spaces within the city. In addition, spatial coherence accounts for unity that includes variety, an important concept that brings together diverse components of urban systems, necessary for their sustenance within the framework of ever-evolving conditions. The quality of life in urban public space depends on the degree of spatial coherence that the space embodies. In the light of this discussion, the need to address spatial coherence in contemporary urbanism approaches becomes a necessity, given that no improvement has been made in this aspect, albeit the prominent criticism that the products of the 20th century urbanism has received. Coherence, an indispensable condition of natural systems, emerges thanks to shared generative processes of growth and development.

In nature growth occurs incrementally and there is gradual adaptation to the ever-evolving local conditions. This kind of growth is best echoed in emergent urbanism of traditional towns, which also manifest a higher degree of spatial coherence within their built environment. On the other hand, modern planning has, by large, generated outcomes devoid of spatial coherence. In his endeavor to seek a resemblance between forms that incubate life in nature and fabricated objects that ignite the feeling of life within the user or the observer, Christopher Alexander collected fifteen geometrical properties that generate 'wholeness', a term which he uses to indicate coherence of the parts with each other and with the wholes. However, these principles remain on a conceptual level when the practicality of urban design is considered. To that end, these abstract concepts to be regarded while aiming to generate coherence, need to be addressed in the scope of urban design, by providing concrete examples. Accordingly, this research focuses on tracing the concrete spatial examples of coherence generating principles within the urban public space. Having acknowledged that traditional towns enable us to derive spatial coherence as their growth bear resemblance to the patterns and complex processes of growth in nature, the street environments selected as case studies are found in traditionally emerging towns. As such, the concrete examples of the abstract principles, which according to

Christopher Alexander, generate ‘wholeness’ are traced in these three street environments.

After the analysis of the three selected streets, we have generated an inventory of how spatial coherence of emergent nature unfolds in the street environments of traditional towns. The conceptual framework provided by Christopher Alexander indicates that each of these street environments embodies spatial coherence in a quite distinct manner.

Given that the main aim of this study was to identify and trace spatial coherence in public space, streets and squares, the subject matter of the research was the street environment, whose boundaries as defined by the buildings are composed in different levels of coherency, depending on the local context. Focusing on streets for people, we have identified three types of street boundaries successful in terms of spatial coherence, which are:

1. Boundaries with strong centers -in the case of Via dei Giubbonari-
2. Permeable boundaries of streets -in Bologna, the case of via San Vitale-
3. Folding boundaries -in the case of Yıldırım Caddesi-

From the above-mentioned types of boundaries, the last two ones enable a smoother indoor/outdoor transition. The analysis has demonstrated that the increase in the variety of spaces gives rise to a higher variety of activities in streets, as it is in the case of Yıldırım Caddesi. On the other hand, the first type of boundary couples strongly with the perception of the pedestrian in terms of the information it provides via its strong centers with level of scales.

It is noteworthy to mention that public space embedded in traditional towns has spatial attributes that we can no longer find in streets and squares resulting from many contemporary approaches in urbanism. Mostly, these spatial attributes, indicators of spatial coherence have emerged and not been designed. One important implication of emergent urbanism is that the pre-existing whole is paid attention to anytime there occurs incremental growth. The pre-existing whole proscribes the physical attributes of the additional increments. However, one should not forget that to enable incremental additions within the built environment, the space for adaptation should be available to begin with and urban design codes should be regulated accordingly to allow for adjustment and adaptation to the ever-changing needs of the society, for which the concept of fina would prove helpful.

To sum up, the main contribution of this research is an inventory of concrete examples of geometrical properties that generate spatial coherence in the street environments to be employed later on, in generating a framework for spatial coherence by design. However, there are certain limitations that need to be addressed and to be built upon on further studies researching the condition of coherency within the built environment.

Firstly, this research focuses on the street environments found in traditional towns which are analyzed to understand how spatial coherence unfolds in the urban public space. The concrete examples of geometrical properties that account for spatial coherence in urban space are revealed in streets and squares of towns in whose formation local conditions and cultural aspect have played a significant role. Nonetheless, spatial coherence is a normative criterion that is not only present in traditional towns. Occasionally we can find the addressed geometrical properties of coherence in modern and planned cities as well, where they may exist separately or in groups of interrelated properties which contribute to a certain degree of coherency in urban space. Moreover, other cultural contexts may achieve spatial coherence differently, that is to say these spatial qualities may take different forms in different local contexts.

Secondly, instead of only addressing the existence of the spatial qualities on the street environment, the research has a potential to develop a tool that assesses and measures spatial coherence in urban space. In addition, the research provides a framework for developing generic codes to produce spatial coherence by design, which can be further concretized based on the local context of the target area. These codes could be used to reconnect the fragmented geometry of the cities lacking with the basic condition to host urban life and would enable the gradual transformation of the modern fabric towards higher spatial coherence.

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