

Research Paper

The Relationship between Spatial Configuration and Social Interaction in Tehran Residential Areas: Bridging the Space Syntax Theory and Behavior Settings Theory

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Abstract

The main aim of the current paper is to shed light on space syntax theory and criticize its origins and fundamental thoughts. In order to criticize the space syntax theory, this paper provides computational models of three residential layouts in the city of Tehran, Iran. The main question is how far space syntax theory is able to predict the movement and behavioral patterns of residents in a residential layout in Tehran. In other words, this research explores whether space syntax computational models can cover the behavioral patterns or there are gaps. The hypothesis is that although the configuration of settlements is the primary foundation to natural movements, it demands behavioral settings theory to interpret the behavioral-movement patterns. Comparing the Depth Map models with observations reveals that the configuration of residential layouts has a causal relation with the formation of spatial-physical structure. The integration analysis, based on the space syntax methodological-conceptual framework, is able to predict the general movement patterns of the residents. But when it comes to the behavioral patterns, the synomorphy between physics and behavior can perform a more accurate prediction. The behavioral settings theory by Roger Barker has developed the synomorphy in order to find the adaptations between physical environments and behaviors. The research findings nonetheless support the theoretical understanding that the urban environment's spatial configuration provides a fundamental condition for the movement patterns but barely can offer a good interpretation for the micro-level behaviors by the residents.

Keywords: Spatial configuration, Spatial integration, Space syntax, Spatial-physical, Residential layouts, Neighborhoods.

1. INTRODUCTION

In the last decades of the 19th century, despite the advent of the post-structuralism era in philosophy and arts, structuralism tendencies based on emerging tools such as computer technology demonstrated considerable strength and power in recognizing and analyzing existing conditions (Hillier, Leaman, Stansall, & Bedford, 1976). Therefore, architecture schools around the globe were working to discover the underlying structures in physical design. The powerful emergence of computer technology, along with the development of mathematical knowledge, opened the path for discovering the underlying structures within physical design. In the last two decades of the twentieth

century, Lionel March in the Cambridge School of Architecture and in parallel, Hillier in the Bartlett School of Architecture in UCL made remarkable advances in this area. The results of which remain fruitful to date in architectural studies (Hillier & Leaman, 1974).

At the time, for architects and designers who were the primary decision-makers in the physical design of residential environments, finding a causal model that simulates the relationship between physical design and environmental perception meant finding a framework for a more accurate and comprehensive understanding more on the subject of socio-economic interactions that took place within the artificial environment. (Hillier, Musgrove, & O'Sullivan, 1972). Both research groups focused on the

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geometry of the plans and developed tools for identifying structures. In spite of all the developments that have taken place in this field during the aforementioned time period, there are still no causal models which can describe the influence of physical design on the process of human perception and subjectivity of the human environment. A series of studies has been carried out along the Lionel March's effort, and others were following Hillier. The common feature of both streams is that they base the geometry of the architectural plan and the layout of the housing. But the Hillier stream has come to more concrete and practical results over time, including various topics, space syntax, space composition, shape grammar, and so on (Hanson & Hillier, 1987).

The main question of the present study is how space syntax computational models cover the behavioral patterns in Tehran residential areas or there still exist gaps. Can space syntax reflect the quality of the effect of physical design on social interactions and consequently the spatial distribution of these interactions and the formation of social structures? Accordingly, the main hypothesis of the study is that the space syntax loses its foundations in different cultural contexts and should be used in any cultural context with regard to the specific characteristics of that context in order to obtain desirable, acceptable, and reliable results. The present study is an empirical test of this hypothesis by applying the causal model obtained from convective studies. The main approach of the present study is qualitative and employs a quasi-experimental research method. In addition, the research uses a researcher-made questionnaire and simultaneously cognitive maps to collect data. In the first step, the paper reviews the contextual studies of the subject, examines the relationship between physical design and social interactions, and focuses on the quality of the effect of physical design on the perception of the artificial environment and social structure. In the second step, the three residential environments, with the same formation process over time and the different socioeconomic bases of the residents observed by the researcher, draw linear maps and fill out questionnaires. In the final step, by applying the theoretical empirical models obtained, the authors try to identify cultural gaps that are routinely neglected in the study of space syntax (Hillier, 2005).

2. THEORETICAL FOUNDATIONS:

2.1. Space Syntax: From Theory to Paradigm

What is space syntax and what is not? It is perhaps the simplest question that comes to mind. Currently, in the academic literature of architecture and urban design, space syntax is often regarded as a set of methods and techniques for discovering spatial structures. Chronologically, the answer is that the space syntax in Hillier's mind (Hillier & Leaman, 1973) is just one theory under the subset of the Man-environment-paradigm. The theory evolved over time and became a spatial-morphological approach. Which understand the relationship between the environment and space and possess its own methods, techniques, tools, and

strategies? The glossary combination of space syntax was also introduced in the mid-1970s for the collection of this theory and method (Hillier & Hanson, 1989). At that time, the topic of one field of research was separate from the other fields of definition. Subsequently, the book *Social Logic of Space* in 1984 is a theoretical turning point in the development of this theory. By the mid-1990s, the achievements of the research team at Bartlett suggested that this area of research could be far beyond what was previously thought. The first half of this decade's collection of studies in *Space is the Machine*, was published by Hillier in 1996, and offered practical ways to discover spatial configuration and invited researchers to grow and develop the field. Then, the results of the First International Symposium on Space Syntax in 1997 indicated that its expansion beyond the boundaries of architecture, archeology, and so on, is forming into a paradigm. Today, the theoretical framework and scope of use of space syntax has made it a rapidly evolving paradigm and is expected to bring unique developments in its theory, practices, and techniques every two years. Because of the scope of the paradigm, the description of all its components does not fit into a single text, and the reader must simultaneously study its theoretical foundations in other writings. In the remainder of this study, only the spatial configuration is examined, and the rest of the concepts are devoted to studies beyond the reader (Hillier, 1989).

2.2. Spatial Configuration

Hillier adds the phrase "*a configurational theory of architecture*" in the title of his book "*Space is a Machine*". In other words, he considers configuration as the main root of his theory building. In defining the spatial configuration, Hillier writes: "Configuration is a set of relationships between spaces that exist in a particular situation at a given time. Configuration may provide conditions to facilitate constraints, provide visual and physical connections, while humans use artificial environments to try to structure and control them (Hanson & Hillier, 1987). Hillier adds somewhere else: "Configuration has the same meaning as the constellation in astronomy, so that the constellation outside the properties of each star observes the relationship between them. Spatial configuration in architectural and urban design also studies the relationship between them, independently of the evaluation of spaces individually". But the definition of spatial configuration can be seen in Hillier's language and expression in that the configuration refers to the whole rather than to the components of an architecture. It is a set of relationships between objects that have complex and internal relationships in the overall structure of space (Hillier, 2007). Hillier writes that configuration is a way of formalizing ideas that are simply expressed but lack the language for mathematical and logical expressions. If the spatial relationships are redefined based on what is happening, then there is a configuration where there is a two-way relationship, and while the relationship changes, the configuration changes. This is the formal definition of configuration and can be further illustrated by a simple objective example. For example, the picture shows a first

drawing of a room divided by a wall into two rooms. Room A and Room B with a door that forms the permeability link between the two rooms. Clearly, the permeability relation from A to B is inversely symmetric. The same is true for neighborhood communication. That is, if B is a neighbor of A, then A is also a neighbor of B. This symmetry, which is more of an algebraic property, is not a geometrical definition of the type of relationship we look at. It carefully referenced to the second and third images, which also relate to the third space, where the outer space is the same two rooms. As in the second drawing, both A and B have direct access to C but in the last drawing, only A has direct access. If we want to get to B, we have to go through space A. But we have direct access to A. Thus, in comparing the second and third plots, we can see that the asymmetric relation is formed. In other words, the relationship between B and A has become asymmetric under the influence of third space E. This is exactly the difference in configuration. Different configurations create distinct relationships. Configuration is actually a set of interdependent relationships that are each obtained by relationships with other components.

Geographies or justification graphs actually illustrate this difference between configurations and illuminate their own nature. Geographies or justification graphs actually illustrate this difference between configurations and illuminate their own nature (Hillier, 2007). Using the graphs

as shown in Figure A and D, which correspond to drawing B and E, the configuration can be expressed in abstraction. Compared to drawing A and drawing in the image, spaces B and E are also deep. And their relationship has also been indirect. The numbers that appear next to the graph nodes represent the depth. Conversely, graph d is exactly the same for all three space conditions, whereas in the graph only the conditions b and c are the same and A is considered distinct. This simple configuration of the space can be seen in relation to the culture, society, and economy of an urban context.

In Figure 2, a similar plan with three different conditions is studied. It is clear that the different valves of each other at first glance merely distinguish between openings between spaces. But for a more in-depth examination, the corresponding graphs of the plans can be used. The right column depicts the corresponding graph of each plan. The openings, which at first glance seemed to be simple differences, have now become graphs with very different depths and branches. Configuration is actually a word that can be associated with these graphs. Graphs provide a unified concept of unity for an architecture. By studying the logic of graphs, one can reach the logic governing the arrangement of space. Depth Map software and space layout actually facilitate access to these graphs (Hamed Hamedani Golshan, 2019).

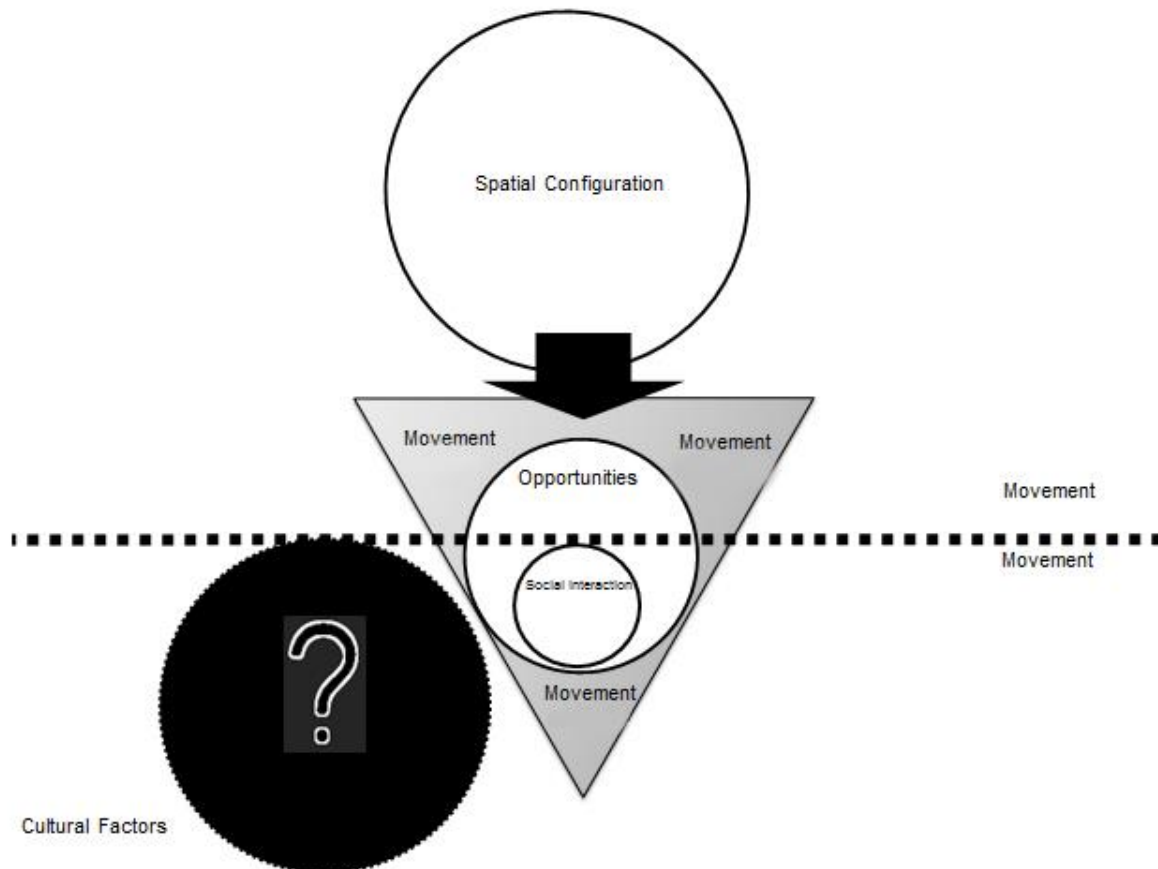


Fig 1. Spatial Configuration in a Simple Visual Expression with the Graph of Each of the Relationships (Hillier, 1996, p. 24)

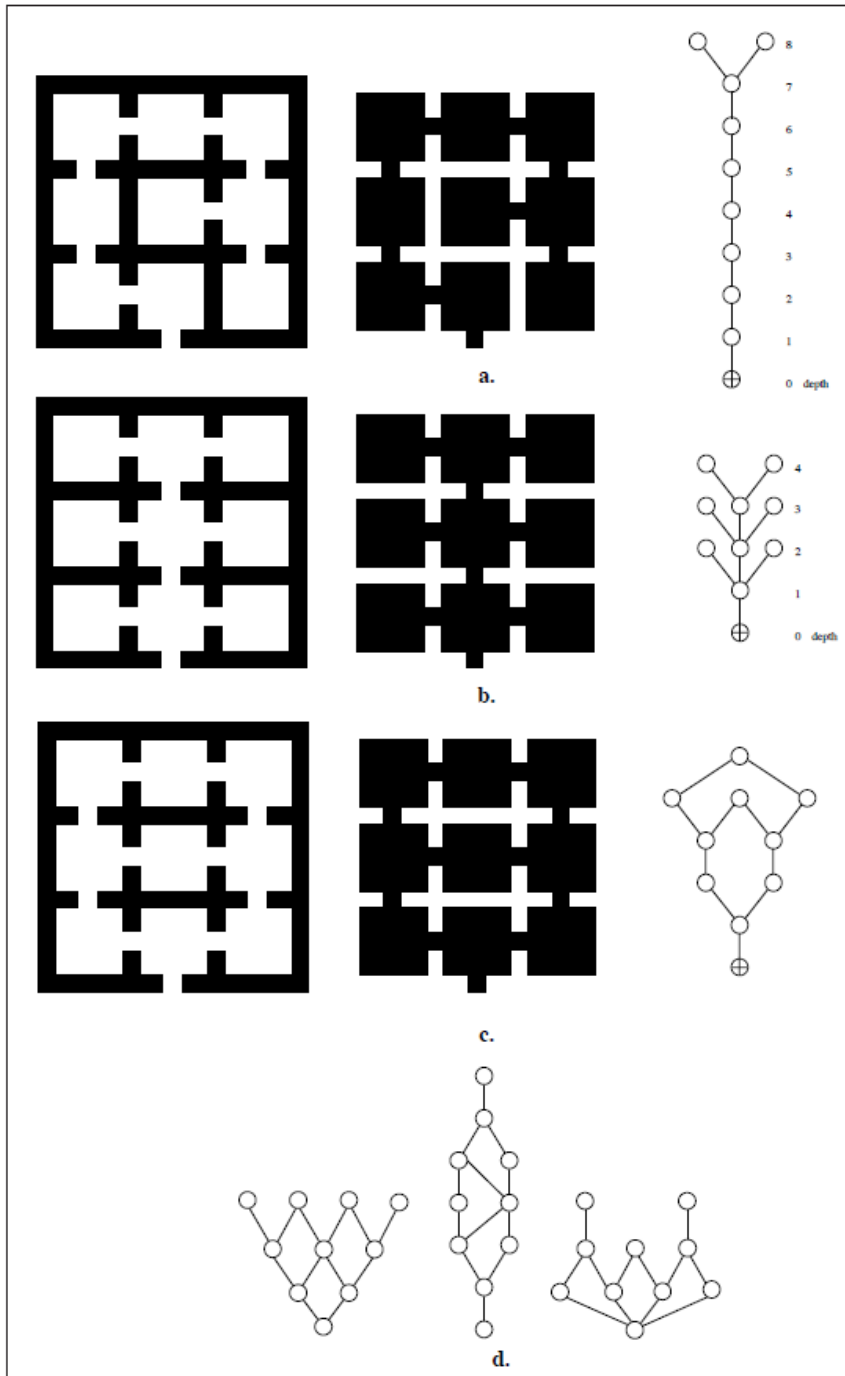


Fig 2. Differences in Different Configurations in the Same Plan with Different Inputs

Allen Penn believes that spatial configuration is not only the driving force of human activity but also of what shapes and organizes spatial cognition. Therefore, studying spatial configuration without discussing spatial cognition is useless. Because configuration actually shapes spatial cognition and organizes it. Spatial cognition is the knowledge and awareness of the existence and relationships between spaces. It's a kind of awareness of structures. Spatial recognition is the acquisition, encryption, storage, retrieval, and decoding of information about the relative position and characteristics of everyday phenomena in the spatial environment. Spatial knowledge encompasses the

human understanding of geographical space (Penn, Hillier, Banister, & Xu, 1998). All of these expressions show that the concepts of spatial cognition and spatial configuration are actually two intertwined and complementary concepts. Concepts wherein it is impossible to deepen one without the other.

2.3. Natural Movement in the Space Syntax Theory:

The birth of the space syntax paradigm is to be reckoned with Hillier's writings between 1973 and 1976. The term space

syntax was also used for the first time in these writings. But several writings in the following years have given rise to maturity in the paradigm. The social logic of space (Hillier & Hanson, 1984), a joint work of Hillier and Hanson, is the first step in this growth and maturity. Thereafter, in 1993, using a paradigm formed in previous discussions, Hillier and his colleagues developed a new theory of human movements in habitats. Prior to this theory, the basic notion of human movement was based on attractors, attractions, or applications. That is to say, human movement in the residential environment was seen as an attractive use-case or attractive architecture. It was assumed that man was moving in the direction in which the attractive use occurred, or the man was in the direction in which particular visual attraction occurred. This pattern of human movement and the charm of two sides of a coin were seen. The cause-and-effect relationship between them was thought to be universal, and the belief that the two were not separated (Hillier, Penn, Hanson, Grajewski, & Xu, 1993).

In 1993, Hillier and his colleagues added spatial configuration as a new theory, and called it the theory of natural movement. This theory emphasizes that the pattern of human movement, as well as the pattern of attractive architectures, are both caused by spatial configuration. In other words, the pattern of movement is derived from the layout and morphology of the residential environment and is the product of spatial configuration and the relationship between spaces. The spatial configuration of a residential environment is itself capable of predicting human movement within the environment. Image 2 illustrates this relationship. On the right side of the picture, the cause-and-effect relationship between the attractions and configuration, and the movement pattern are plotted. On the left, the spatial configuration is considered to be the cause of motility patterns as well as adsorbents, and by highlighting its reciprocal relation, it is shown that motility patterns and spatial adsorbents do not cause spatial configuration and have a direct impact on its occurrence (Hillier, 1999a).

The theory of natural movement depicts a very fatalistic and mechanical movement of man in the residential environment and does not take into account other components. However, the movement of humans in the disadvantaged environment also includes factors such as cultural, climatic, and the mass-space relationship components. In this study, the main vacuum that has been considered and attempted to analyze is the components that have been neglected in spatial configuration but can divert human movement from the straight line or in some way challenge the theoretical foundations of space syntax (Hillier, 1989).

2.4. Global and Local Scale Analysis:

Space syntax analysis allows street networks to be analyzed simultaneously at multiple scales, from macro analysis of whole-system properties (we call it global scale) to micro-analysis of individual street segments, building plots, and public spaces, that is called local scale. Thus, in each study area, we study the whole area as a global scale once and a limited radius analysis once as a local scale analysis.

2.5. Social Interactions:

The relationship between two or more people, which may lead to a reaction between them, is known as social interaction. A physical theme, a look, a conversation, and a connection between people can also be considered as social interactions (Daneshpour & Charkhchyan, 2007). The level of social interaction varies among individuals and its desirable level varies across cultures. This desirable level can be found in people's statements and their normative attitudes towards good social life, congestion and density, social norms and relationships, beliefs and ethics, social classification, solitude, and physical placement(Hillier, 1999b). Some components affect social interactions.

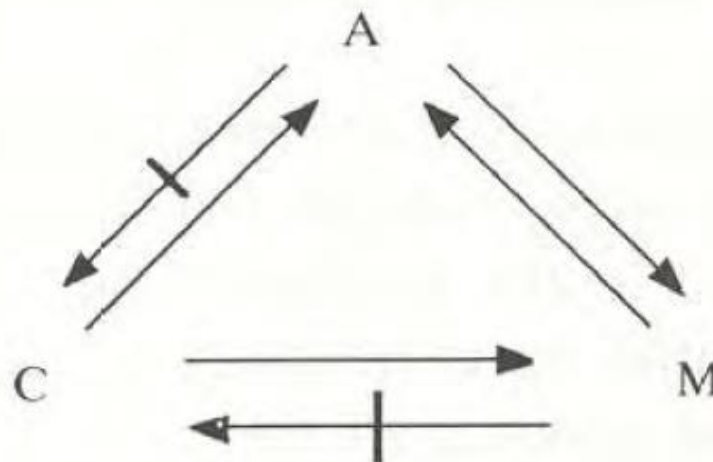


Fig 3. The Causal Relationship between the Spatial Configuration of C, the Adsorbents A, and the Human Movement Pattern M, respectively: Movement, Attraction, and Configuration

2.6. Roger Barker Behavioral Settings Theory

Research into the nature of the environment as a social phenomenon in the late seventies of the twentieth century with the writings of Barker became important to psychologists. Unlike traditional psychologists, where research has not focused on the relationship between human behavior and the physical environment, in ecological psychology this concept has been particularly emphasized. Roger Barker describes how the behavior of humans affects the environment. He applies the concept of synomorphy to the coexistence of spaces and believes that the compatibility between human actions and the physical and social environment of places can be interpreted as synomorphy. Conjugation can also be another equivalent for this word because here the morphology of the place is tied to behavior and the word conjugation is a better indication of this event. Shamin Golrukh has written in detail in a compilation book on this concept. She emphasizes that what influences human behavior in the everyday environment is the body and there is always a mutual relationship between the two. She believes that the impact of situations in which one is exposed to behavior is much more than the personal characteristics that one is exposed to. Consequently, consistency between behavioral patterns and their physical context is the most important feature of a behavioral locus. But, according to the author, Roger Barker's definition of a social phenomenon is the one that occurs as a result of the potential of a physical environment for a particular behavior or pattern of behavior, and therefore the behavioral context is not separate from the physical and behavioral paradigms.

All three are interconnected, and only by expressing them Barker seek to understand the subject. In this study, external realities are links between Barker's behavioral base and Hiller's suburbs, and none of them alone are a good description of the reality of social interactions in residential environments (Barker, 1968).

2.7. A Comprehensive Theory in Environmental Psychology: Behavioral Configuration

Combining the theory of natural movement introduced by Bill Hiller and his colleagues in 1993 with Roger Barker's theory of behavioral basics introduced in 1968 in a book of the same name, a comprehensive theory is developed to study behavioral patterns in urban design. It is more comprehensive and the results are closer and more acceptable to the experimental results. In Figure 4, this new theory and its relation to spatial configuration and behavioral bases are mentioned. On the one hand, spatial configuration based on the theory of natural movement attempts to discover the relationship between the body and the movement patterns. In other words, Barker's behavioral bases also attempt to understand and explore the emerging patterns of anatomical behavior. Spatial configuration through geographies defines this relationship and uses behavioral or synomorphic definitions instead of behavioral bases. The combination of a justification graph and a synomorphic graph can well describe human-behavioral patterns in residential environments and has good empirical accuracy.

Space Syntax

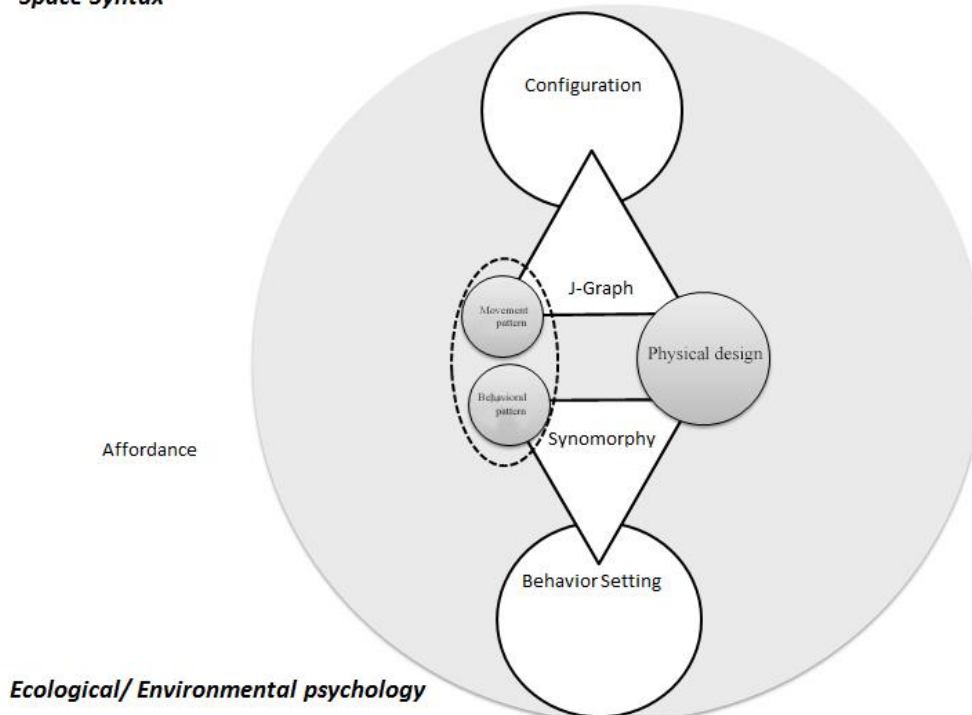


Fig 4. Integrating the Theory of Space Syntax and Behavioral Settings

Previously, some scholars at the biennial space syntax symposium have pointed to the possibility of bridging

theories of environmental psychology and the concept of space and offered a common framework. Daniel Montello,

a prominent environmental psychologist at the University of California, Santa Barbara, said in an essay at the 2007 Symposium in Istanbul that this theoretical framework is accessible and could be a comprehensive theory of environmental psychology (Montello, 2007). In this article, Montello places the analysis of the Isovists in the theoretical framework of this special place and believes that this analysis can show the correlation between location and many psychological components of the environment. The subsystem has deficiencies that prevent it from being able to pull out of a comprehensive theory and psychological barrier. Montello attempts to showcase these gaps with examples from psychologists' research and make suggestions for upgrading space syntax theories and methods.

3. RESEARCH BACKGROUND

Criticism of the theory of space syntax began shortly after its first writings and continues. In the meantime, several writings and personalities have dealt with it more deeply than others and have shown it well. The first was Khadija Osman in 1994 at the University of Florida. After him, Carlo Ratti began a series of critiques of the theory at the University of MIT's School of Architecture in 2003 that were answered by the Bartlett School of Architecture. After Ratti in 2015, another aesthetic criticism was added by Neto. In the literature of Iranian architecture and urban design, Hossein Bahraini and Sodeh Taghabon have addressed the deficiencies of the mentioned theory in a paper which was published in the research projects of Tehran University. Carlo Ratti's critique of the Massachusetts Institute of Technology has attracted a great deal of attention from academics since it is more comprehensive. Here is an outline of the headings and outlines of the review. The rest of the criticisms lie at the heart of this criticism, and all are mentioned here (Hillier & Penn, 2004).

In the theory of space syntax, Ratti has several problems with its principles and method (Ratti, 2004). The first and foremost argument is that the results of this theory are undermined in the context of regular networks, such as Manhattan. The high streets, which usually provide access to most parts of the city, are over-stretched and have very

strong connections in the analyses of space syntax. These elements diminish the role of other design elements and, in the original definitions of the theory, cause serious problems. In the form of a configured space that, in its original definitions, had definite and concrete frameworks, it lost color and the meaning of human space was lost. It should be born in mind that the essence and nature of the initial definition of space are based on human and human communities, based on the place where social relationships are formed. The public spaces of residential environments with high traffic or other uses may not fit into this basic definition.

The second issue to be discussed is when the body of the residential environment is not located on a flat plain. Basics of theory, considering different elevation levels that may occur at the environmental level or in the urban context, actually pave the way for the creation of multiple space shards. The residential environment has always been considered a flat surface without altering the level of equilibrium relationships between spaces. In spite of the reality, the bedrock of biological complexes often has numerous rough nesses.

Other issues mentioned in this method and theory are the disregard for the height of buildings and land use. Open spaces in residential environments cannot be judged accurately, regardless of body height. It is more obvious when part or portions of public space are devoid of a tall building. In these cases, often the coherence of the living space is disrupted and subjected to rules other than those stated in the theory. In other words, the effectiveness of this theory can be seen only in the layouts. As it goes beyond the layout, many issues remain unresolved.

4. CONCEPTUAL FRAMEWORK

This study intends to explore the impact and interaction of social interactions and the spatial configuration of contemporary residential environments in two ways using empirical observations, and to account for the theory and methods of space syntax. The reciprocal relationship between social interactions and spatial configuration, which is also shown in Figure 5, are examined by both space syntax and field studies.

Table 1. Background of Space Syntax Criticism

	Researcher	Year	Emphasize	University
1	Carlo Ratti	2004	Methodology	MIT
2	Vincius Neto	2015	Epistemology	Brasilia
3	Khadijeh Osman	1994	Methods Shortcomings	U of Florida
4	Hossein Bahraini / Soudeh Taghabon	2011	Assessing Theory and Tools without Emphasizing Culture of Experimental Model / Theoretical Model	U of Tehran

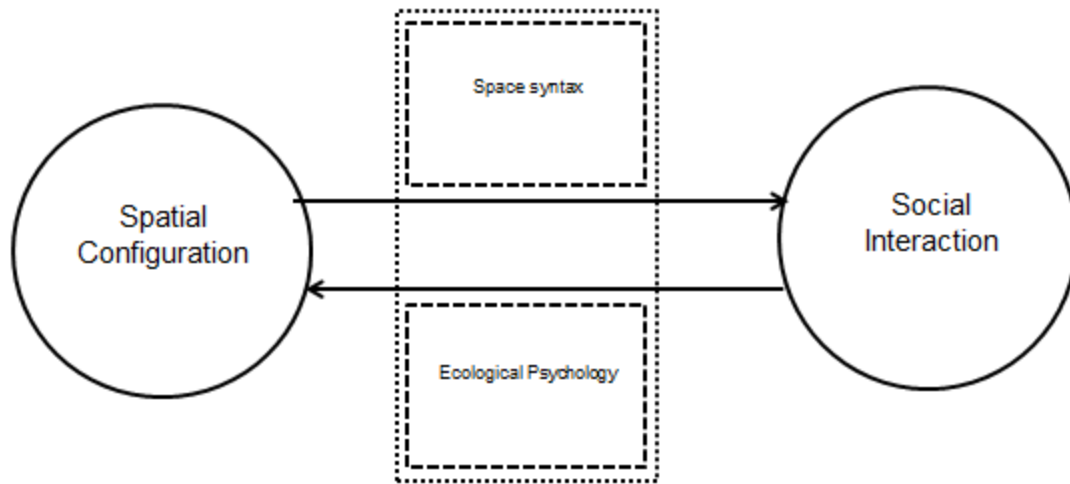


Fig 5. The Conceptual Framework of the Research

5. THEORETICAL RESEARCH FRAMEWORK

Various variables directly affect the opportunity for social interaction. As the first variable, the individual components of a person can either increase or decrease opportunities for social interaction around them. The main variables that can play a direct role in increasing the opportunity for social interaction are illustrated graphically in Figure 6. Cultural, social, personal, and design components are among these. At the same time, architectural design as an independent variable can increase the opportunities for social interaction. This is possible through density, neighborhood, land use distribution, community spaces, and residential layout. Increasing the density increases the opportunities for socialization and social interactions, as well as neighborhoods, distribution of land uses, and the like. All can increase the chance of people being confronted. But the layout of the settlements itself has many variables within itself. For example, the quality of the units, the division of plans, and the spatial configuration of one another can all influence the direct increase of social interactions and activities. Of these components and variables, less research has pointed to the direct effect of spatial configuration on enhancing collective activity. In the present study, the role and direct effect of spatial configuration on activities are discussed.

6. CASE STUDIES

The statistical population of the study areas consisted of three similar residential quarters in terms of housing density, social process, and demographic differences in Tehran. The selection process of the three residential environments was such that many residential environments were designed and executed during the Second Pahlavi period between 1950 and 1960. Thereafter, two similar cases were selected in terms of socio-economic status and one distinct case in order to eliminate intervening variables. Using historical studies, they attempted to select the cases that would have passed through the process of their present-day evolution through similar currents, as well as the

historical backdrop close to each other. But the social context in which they reside is distinct, as the distinct social context has made it possible to assess the effectiveness of the physical design. Thereafter, using available maps and household number and dimension information, net residential and demographic densities were calculated for each neighborhood with similar densities. Finally, since the independent variable is spatial configuration research, the significant difference between spatial configuration and mass organization and open spaces led to the selection of three residential quarters. In Talebi's research (as cited in Hamedani Golshan, Motalebi, & Behzadfar, 2020), Short-lived residential dunes of the Second Pahlavi period have been studied. Narmak and Yousefabad Neighborhoods were selected from among these neighborhoods and Shahrake Gharb was selected as an intervening variable in order to compare social context conditions and to eliminate the effect of social context. The boundaries of the residential dunes studied are shown in Figures 7, 8, and 9.



Fig 6. Narmak

The way the boundaries are drawn is primarily physical, meaning that the boundaries are on the outer edges of the residential docks at the time of construction. There is only an exception for the northern border of Narmak, which is part of the first neighborhood, located just north of the Resalat Highway. The rest of the borders correspond to the

first ones. The reason for this violation was that at the time of this study, the Narmak neighborhood subjective boundary did not include the north of the Resalat Highway.



Fig 7. Yousef Abad

In the Narmak residential area, residential blocks are formed around geometric squares, and tangible and orderly openings have taken place despite the interconnectedness of their outdoor buildings. In Yousefabad, residential blocks have a linear, interconnected alignment, despite the intense topography of some mounds, and the open space is at a minimum. In Shahrak e Gharb Township, open-plan building blocks on all four sides have been designed with a freewheeling design in line with the terrain. Side-streets with a free-curved design and often deadlock are other features of the third sample studied.

The spatial configuration of these residential areas is defined by the relationship between the open spaces of these neighborhoods, taking into account the position of these open spaces relative to each other, which can be abstracted and simplified in most geographies. For this purpose, in the residential open spaces of the axis, the lines with the highest in-depth perspective are selected as the index of each open space. Axes that intersect with each other are considered to be related. By considering a node instead of each space and a connection wherever there is a link between the two spaces, the geography of each of these stacks is plotted, which is the basis for future measurements.



Fig 8. Shahrak e Gharb

6.1. Spatial Configuration in the Residential Areas

The discovery of the spatial configuration of the artifact environment has several techniques and solutions that have been elaborated elsewhere (Hamedani Golshan, 2015). Since these two writings are both produced in the same direction, their study will deepen the implications of the present article. Of the several solutions presented, axial map analysis has been selected for the present study. To deepen this, the reader must master the literature and technical vocabulary of space syntax. The process of mapping axial lines is that every physical space is replaced by a single axis representing the highest line of human vision. It tries to represent the Shahrak e Gharb number of axial lines and the longest of them represents the physical spaces. To depict and analyze this spatial configuration, the DeptMap software, which is the main syntax software, was used. After simplifying the layout map of the residential environments under study, in the AutoCAD software environment, the map has been taken to the DeptMap in DXF format and its linear maps were drawn. In the initial linear maps shown in Figures 4 to 6, the correlation coefficients of open spaces are compared, with red lines showing the highest correlations and purple lines showing the lowest correlations.

6.2. Integration: The main Space Syntax Variable

The interconnected variable is the most important constellation variable. The average correlation for each space is obtained by calculating the average depth of a space, which is discussed in detail in another article. The depth of space is also obtained from the justification graph drawn on the entire residential environment under study. The convergence value of a space is the average number of lines through which all other lines in the whole system can be reached. The lower this mean, the closer the node is to other graph nodes, the more accessible that node is. In a diamond graph that is cited as a reference graph, the degree of integration of the center with the rest of the components is a number. That is, all nodes can be accessed centrally by a bridge or connection. This is the smallest depth and represents the highest degree of overlap in a graph with multiple vertices. The central vertex of a diamond graph has the highest degree of integration with other nodes. The number represents the conjunction in a

diamond graph. But in other graphs, this number is obtained by dividing the average depth of each node by its relative asymmetry. The method of calculating the relative coherence of each space can be studied in detail in Bafna's study (Bafna, 2003).

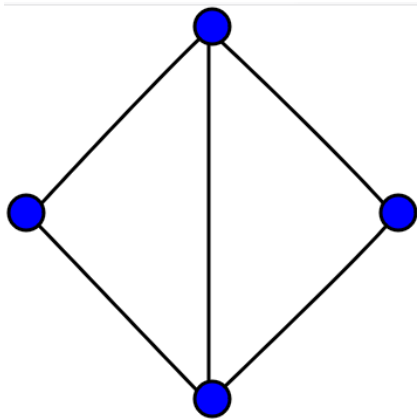


Fig 9. A Diamond Graph of Rank 4
(the Depth of Its Spaces Is Equal to one another and the Degree of Interconnection Is One)

Through intermediate interconnection, the interconnection between spaces can be explored. The greater the coherence of space in a set of spaces and the closer it is to a number, the greater its connectivity with other spaces. In this research, the extent of the interconnection of spaces with other spaces based on the correlation variable is placed at the focal point and measured with an empirical model obtained from observation, cognitive maps, and questionnaires. In areas where residential cohesion is maximized, social interaction is expected to be at its peak, and vice versa.

6.3. Theoretical Model of Space syntax: The Degree of Overlap in Different Layouts of the Studied Neighborhoods

The main hypothesis of the study is that in the theoretical model of space-time, spatial configuration predicts human movement in space and thus simulates human social interactions in space. But due to cultural differences, more careful studies of this natural movement are needed. Cultural differences in different societies lead to movements that do not fit within the circle of direct movement on the straight line from the origin to destination. The first part of the proposed hypothesis needs to provide an interconnected structure that is designed and presented by spatial configuration. This interconnected structure encompasses all open spaces of the residential environment that are open without interference. Spatial configuration depicts an interconnected entity of spaces that can be read and interpreted relative to one another. For example, in Figure 11, the spaces between buildings in Narmak Cove form an interconnected complex, some of which have more central locations than others. The study of spatial configuration is actually the study of the relationship between these spaces with each other in the language of a mathematical topology or the language of graph theory.

Graph theory is actually a tool for reading the relationship between these spaces.

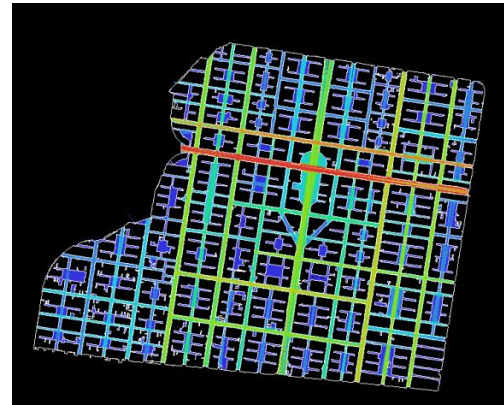


Fig 10. The Global Scale Linear Map of Narmak Residential Neighborhood Simulated in the DeptMap Software

The graph analysis process for open spaces of a residential environment such as Narmak is such that the DeptMap software receives the raw map as a residential open plan. Then, using straight and long lines, it has been tried to connect all points on the environment to that plan. Eventually, the small lines are removed and only the largest right-hand axes in each space remain as the representatives of that space. These lines represent one space, and if they intersect with another line representing the adjacent space, they are considered as the relation between those spaces. Now the graph is forming. Long axes, in the form of graph nodes and their relation to the side line, form the branches of the graph. DeptMap, using colors, displays an overview of graph analysis visually. Here the near-red color spectrum has the highest correlation and the near-blue color spectrum has the lowest correlation (Figure 11).

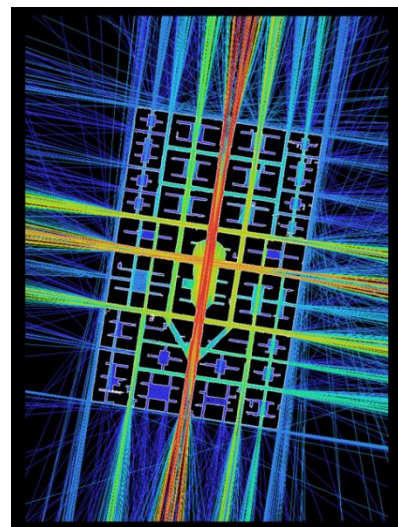


Fig 11. Local Scale Linear Map of the Haft Houz Narmak Square and a Building Block Around it, Simulated in the Depth Map Software

When the boundaries of the Narmak Neighborhood are confined to a residential block adjacent to Haft Houz, the

concordance results are somewhat different (Figure 12). Here the larger interconnected points are centered on the north-south axis and are more in line with what is seen in the experimental model. Boundaries and scales have a clear impact on spatial configuration analysis. When the boundaries of Narmak Koi are based on the initial boundaries, the results of the degree of congruence differ when the boundaries are confined to a residential block adjacent to Haft Houz. The extent of interconnectedness in open spaces is influenced by boundaries and range of ranges. The same can be said regarding Yousef Abad and Shahrake Gharb. When Yousef Abad neighborhoods range was fully analyzed, the Sayyid Jamal al-Din Asad Abadi axis shows the most interconnection, which is the main axis of Yousef Abad (Figure 13). When the boundaries of the study are confined to a building block at the intersection of Sayed Jamal and the Farhang Square, the Ibn Sina axis has the highest centrality in the corresponding graph, resulting in a higher degree of overlap than the rest of the space, eventually reaching the near-red spectrum (Figure 14).



Fig 12. Global Scale of the Yousef Abad Neighborhood Linear Map

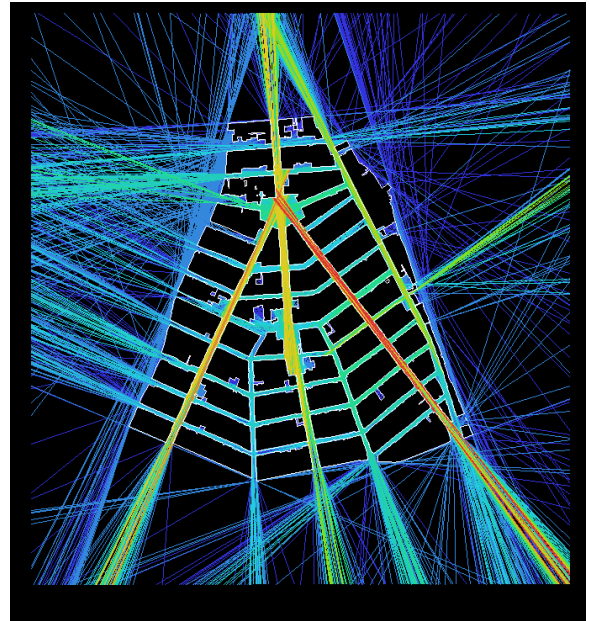


Fig 13. The Local scale Yousefabad Linear Map Limited to the Farhang Square to Sayed Jamaleddin Asadabadi Square

The issue is a bit different about Shahrak e Gharb. When the boundary of the Shahrake Gharb Township complex is selected, the degree of interconnection at the Flamk axis (Figure 16) is maximized, while this axis is essentially neither the center of the present nor the future social activity. The point of this issue can be the obvious difference between the theoretical model of space syntax and the experimental model. In Figure 15, the first phase of the Shahrake Gharb Township is modeled separately in the DeptMap software. The results of this modeling are more in line with the experimental results because, in the open space around the Golestan Business Complex, the focal point of activities and social interactions has been formed. In the area around Sanat Square, as a point of contact between Shahrake Gharb and Tehran, the amount of social interaction and activities is noticeably different from the rest. But in this model, the middle sections also disappear, marked in red, which means a high degree of integration, while social activities are not as prosperous as the other two points mentioned.

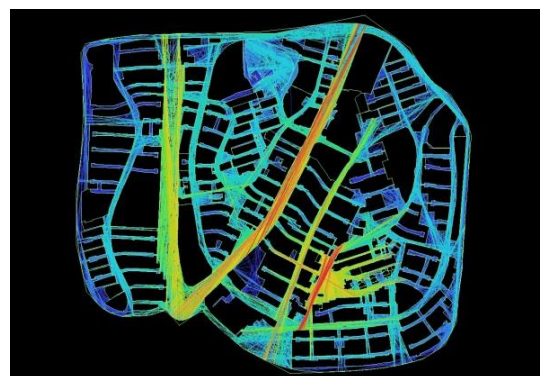


Fig 14. The Local Scale Linear Map of Shahrake Gharb Settlement, Phase I



Fig 15. The Global Scale Linear Map of Phases One, Two, and Three of Shahrake Gharb

The results of spatial syntax modeling show that the choice of study boundaries and study areas has a great impact on the results of the research and the main variable of the study, that is, the degree of consistency. Therefore, the selection of appropriate boundaries for studies is a crucial step in a series of space research studies. On the other hand, studies on some scales show better agreement with empirical facts. Finding this scale requires consideration and scrutiny of the study areas and the social relationships that dominate the outdoors. Therefore, it is important to consider the studies before determining the scope of the research and performing the foreground of the graph, and finally drawing the baseline graph for the area and analyzing it by computer to determine its compliance with the selected scale.

6.4. Experimental Research Model: Finding Behavioral Patterns through Observation

In this section, the empirical direct observation method mentioned earlier is tested in three studied neighborhoods (Narmak, Yousef Abad, and Shahrak e Gharb) in Tehran. In each of the residential dorms studied, the researcher recorded social interaction events at five distinct time intervals during the day and recorded these observations over four months. Social interactions have been consolidated as a Latin letter on the map that represents the type of social activity. These interactions were transformed into behavioral bases using Barker's theories and environmental psychology. According to Barker's theories, different and distinct behavioral sites were identified within the study densities and finally recorded in the form of maps that are presented below. Each of the tabular bases was prepared as shown in Table 2 and the code and type of the baseline and its characteristics were recorded. Eventually, all of the recorded behavioral sites were plotted onto a map.

Some of the social interactions recorded in the observations are: neighborhood meeting, double or multiple dialogue, multiplayer meetings, group exercise, evening

recreation, group walking, group view and matching. According to Barker, any activity that occurs within a body continuously and at different times is considered a synchronous or synovial activity with that body. Therefore, as the activity is recorded, the bodies associated with those behaviors have also been observed, and if these events are repeated at different times, that body and that behavior are known and recorded as sinus morphs or synapses. For this purpose, the observation of the type of time period and the time period of return to space activity are also considered. The area of activity is also specified linearly on the maps. Finally, the type of social action and the age range in which social activity is taking place are also considered.

7. ANALYZING RESEARCH FINDINGS

After data collection, the abundance of images and main corridors of the paths and landmarks referred to for each statistical group were independently extracted and categorized. These images were adapted to each other and finally a behavior map was prepared for each residential quay studied which is shown in Figures 17, 18, 19, and 22. This spatial structure together with the spatial structure map of the environment based on the spatial simulation and configuration of the data form the final analysis and comparison of the research.

7.1. Spatial Configuration Analysis

All three residential quarters studied were not based on the basics of social design, which means that they are not very similar. The predictability of development in the three residential quarters is quite different. In Narmak, the preparation of the land and the plan has been carried out, after which the buyer left. In Youssefabad, the land has only been prepared and then left to the owner, but in the Shahrake Gharb Town, the land was prepared, executed, and finally executed by the executor, and no land was left to the owner. For this reason, the design of the dwelling was carried out in accordance with the design ideas. In Narmak, the private car and the pedestrian have the same passage in Youssefabad, but in the Shahrake Gharb Town parts of the cavalry are completely separated from the pedestrians. The density of these three residential condominiums and therefore the neighborhoods of the residents is very different. Narmak and Youssefabad are similar in terms of building density, but this issue is quite different in the Shahrake Gharb town. This means that the town has retained its initial density in many parts and has not undergone changes over time. The phase of a high-rise town is exactly in line with the initial situation. In the interim, there are also unregulated constructions that did not comply with the Shahrake Gharb Town plan.

Table 2. Direct Observation Table

Type of Code of Conduct		Type of Activity	Continuous Activity	Range Spatial	Spatial Type	Territory	Time Period	Self-Control Program	Behavioral Features
Age	Behavior	Type of Activity	Continuous Activity	Range Spatial	Spatial Type	Territory	Time Period	Self-Control Program	Behavioral Features



Fig 16. Narmak

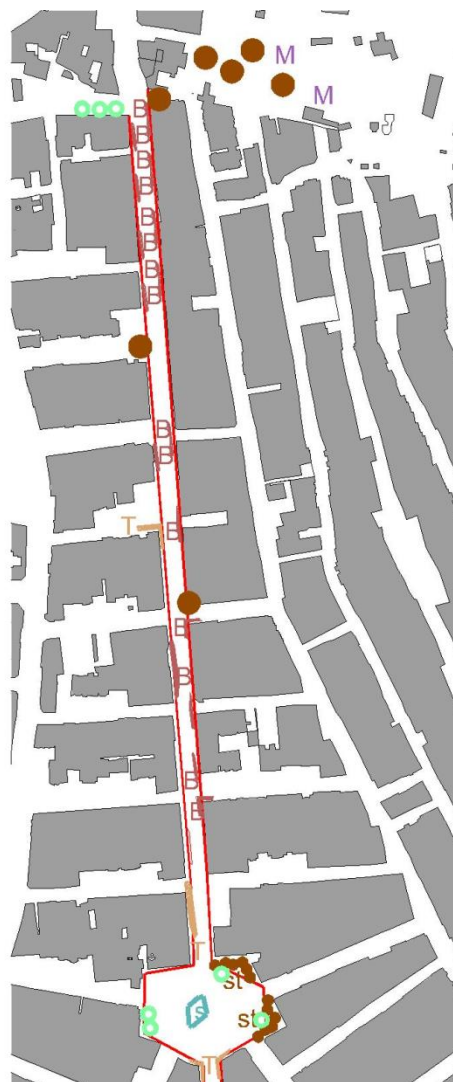


Fig 17. Yousef Abad

7.2. Micro Analysis of Mass Interactions and Spatial Layout

The most important finding of the present study is that the mass relations of each building block extend into a structured, regulated, yet systematic state with the models that came from the spatial configuration of the residential quay mentioned before. These models illuminate the configuration of motion in a residential location. In other words, people move from the private space of their residential buildings because they have an urgent and functional need for social interaction with other people. Moving from a building block to communal spaces may be accompanied by the return of the individual to their own space or leading to a destination beyond the mall. What is common is that the social organization of a residential block reflects these convergences and divergences.

During the course of this study, it was discoverable and intuitive that much of this came from unplanned, unexpected plans between units and centers of population integration. Many of them emerged from internal boiling. In addition, many of these commodities did not fit the intended purpose. That is to say, the individual had come up with a certain socialization intention and had accidentally encountered another social event. Thus, although the

position of these social encounters was largely consistent with that in linear map analysis, identifying the situation alone could not reveal the purpose and make it important. The only location of events and their probability of occurrence were illustrated by linear maps. These maps cannot predict anything beyond, but events and phenomena take shape in different and emerging human forms.

The human activities that take place in these spaces can be classified into two main categories through which the organization of the activities of the revelations is made. The first group of activities was named as the action of unwanted and unplanned activity.

It can be interpreted that from this verb that it can be engaged and initiated at any moment. Examples of these verbs and topics are a friendly conversation with a neighbor, a small shopping, or a group sport. These collective activities immediately attract human attention. More importantly, at any time of the day, someone may feel the need and want to do a little shopping or individual exercise. He starts to move and connect with others.

This activity, the activity of employing someone else, is in your place. The change in attention may occur by a constant member, changing the attention and working orientation outside of one's work.

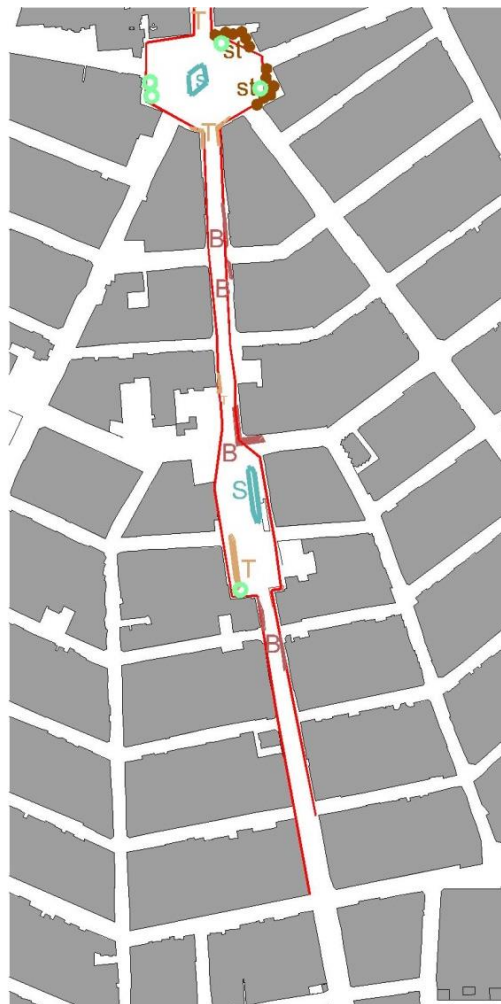


Fig18. Yousef Abad-Farhang

7.3. The Space Syntax Gap Covered by the Behavioral Settings Theory

In expressing the study hypotheses, it was stated that the theoretical model of the space syntactic does not provide for the subcultures to be universally accepted, but this inadequacy is best resolved by applying the theory of Barker's Behavioral Settings. The mainstream of the pedestrian movement in the residential environments studied is represented by space, but occasionally this mainstream becomes the mainstream of the cavalry movement, and pedestrians use other routes for traffic and social interactions. An example of this difference in route selection can be seen in the area of Ibn Sina Yousef Abad Street, as well as behind the Golestan Trading Complex Shahrake Garb. But overall, it can be interpreted that space syntax and spatial configuration are applied to residential docks using infinite radius.

7.4. How to Distribute Behavioral Patterns

Scrutinizing the results obtained from the analysis of the spatial syntax and its concordance with the observations of the behavioral sites, it is concluded that the distribution of the behavioral sites is directly related to the degree of overlap of the residential open spaces studied. Increases in the number of interconnections are visible in the reddish

spectrum. Red parts indicate the highest amount of interconnection among spaces. In the spaces depicted in red, the distribution of behavioral bases has become denser and closer together. In spaces close to the blue spectrum, the degree of interconnection is minimal. In this case, the formation of behavioral sites is rare and its density and frequency are relatively low. Therefore, there is a direct relationship between the amount of outdoor connectivity of the residential environment on the one hand and the distribution of behavioral-motor patterns on the other hand. Concomitant to the environment, the density and frequency of occurrence of the bases significantly decreased. This fact is also quantifiable and debatable.

8. SUMMARY AND CONCLUSION

The main question of the present study is how space syntax computational models cover the behavioral patterns in Tehran residential areas or there are gaps. The answer is no. Space syntax does not have the capability to demonstrate the behavioral patterns of pedestrians. But there can be another complementary theory that gives space syntax this capability. By combining the space syntax theory and behavioral settings theory, we can obtain a comprehensive theory of environmental psychology which is capable of explaining the behavioral patterns of pedestrians (Feng & Peponis, 2021).



Fig 19. Shahrak E Gharb

The central issue that is at the heart of the present research is to find theoretical gaps in the expression of the external realities of social interaction. This became another question during the discovery process, which is to find a theory that is complementary to space syntax and to determine the extent and severity of social interactions driven by spatial configuration (Hamedani Golshan, 2016). For this purpose, the spatial configuration of the studied residential quarters was extracted. At the same time, direct observation of the field's perception of social interactions took place and the location of social interactions was reflected on the residential map. From the adaptation of the maps to the spatial configuration of the residential quay, it was concluded that although much of the social interaction of the inhabitants occurred in areas of high quaternary, some of the social interaction was influenced by other cultural components as well. There is no spatial configuration to match the configuration. Therefore, although spatial configuration may be an appropriate way of understanding social interactions, it needs a complement that carries with it other environmental components and a cover for the gaps in spatial configuration. In addition, some of these gaps are due to the cultural differences and cultural values that lie in the residential environments of our society vis-à-vis Shahrake Gharb, the first of which originates the theory, and secondly, the origins of the residential design scheme (Chiaradia, Hillier, Schwander, & Wedderburn, 2012).

Complementary theories of Gibson's environmental capability and Barker's behavioral bases were discussed as secondary theories, and it was concluded that a combined theory of Barker's behavioral subsystems and behavioral bases best described the external conditions and practical experience. This hybrid theory is broadly subordinate to the kinematic motif patterns and to the Barker behavioral patterns in the micro space, and clearly represents the empirical models derived from the studies. While combining the benefits of the syntax of space, this hybrid theory covers many of its gaps and dark spots and prevents it from reaching results that are far from realities. Where space syntax is not able to provide a clear interpretation of events, Barker's theory of behavioral basing works well and interprets the actual order. The same is true in reverse. In the general kinematic-behavioral flow in residential quays where behavioral bases have no clear interpretation, the theoretical framework of space syntax is able to provide a rational interpretation of existing patterns (Hamedani Golshan, Motalebi, & Behzadfar, 2019).

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