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### Original Research Article

## A study of Space Syntax in Understanding the Spatial-Social System of Contemporary Housing Case Study: Single-Unit Dwellings in Isfahan\*

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### Abstract

**Problem statement:** Space syntax refers to a set of theories and techniques concerned with understanding spatial configuration and its impact on the formation of social relations in architecture and urban environments. The present study investigated cases of contemporary housing in Isfahan to explore the overall structure of contemporary housing and examine whether space syntax analyses have managed to play an influential role in understanding the relationship between spatial configuration and behavioral patterns. It also manifests the spatial-social structure of contemporary housing in Isfahan. It would appear that space syntax has been generally quite effective in understanding the relationship between built space and residents' behaviors; however, the vital role of each space's unique attributes cannot be overlooked.

**Research objective:** The present study seeks to investigate the capabilities of space syntax in predicting social interactions based on a space syntax analysis of contemporary housing.

**Research methods:** To achieve research goals, five cases of single-unit dwellings constructed over the recent decade were examined through justified graphs and VGA analysis. Interviews with dwellers were then held to develop behavioral pattern maps based on the components of interaction establishment. These maps were later compared through logical reasoning, based on which the manner of interaction establishment between space configuration and individuals' interaction in the formation of the contemporary housing's spatial-social system was compiled.

**Conclusion:** Space syntax analysis at a general and macro scale can prove beneficial in setting boundaries and forming behaviors based on the interactions between the components of contemporary housing. However, its efficiency declines at a smaller scale when the audience develops a closer relationship with space components, in which case environmental analyses become more effective.

**Keywords:** *Contemporary Iranian House, Spatial Configuration, Space Syntax, Integration.*

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## Introduction

As the lifestyle changed in the contemporary era, spatial and consequently social relations in the Iranian house underwent gradual change and transformation. Furthermore, the contemporary lifestyle and its requirements do not allow for the complete formation and configuration of space based on traditional patterns, as new spatial patterns have provided a different context for the formation of social behavior. The present study adopts the space syntax theory as the basic theory to explore spatial patterns and examine their consistency with the social interaction and behaviors of residential unit dwellers. This theory was first introduced by Bill Hillier (1984) as Space Syntax. He proposed a set of quantitative techniques and theories to understand the configuration and systems latent at the heart of space (Peyvastehgar, Heydari & Kiaei, 2017, 2). Since Hillier and Hanson investigated a wide range of living spaces such as tents, Mongolian native houses, and English houses, emphasizing the relations between configuration and residents' behavioral patterns in their book "Decoding Homes and Houses" (Hillier & Hanson, 1984), many scholars have taken advantage of this theory to explore the secrets laying in the spatial structure of houses and have managed to extract and analyze the genotypes of residential patterns found in various regions. Discovering the patterns latent in the spatial organization of houses has helped find meaningful relationships between cultural and lifestyle patterns in each community and the formation of spatial configurations in their residential spaces. These underlying organizations in the space must be compared alongside the formation of relations between dwellers of these spaces to find meaningful connections between humans and space: Spatial patterns are largely influential in regulating the constituent components of social behavior. Understanding spatial configuration is thus key to analyzing spatial-social systems.

## Research Method

The foundation of architectural space syntax is the

quantification of qualities found in the architectural space. Thus, the present study employed a combination of qualitative and quantitative methods and collected the required data through secondary research, computer analysis, and interviews. After the theoretical foundations of space syntax and the tools employed in the quantitative portion of the present study to examine the quality of spatial patterns were introduced, five single-unit dwellings in Isfahan province that met the contemporary urban planning regulations in terms of the establishment were situated in the same climatic region, and were constructed over the recent decade were investigated and analyzed. Firstly, justified graphs of all five units were mapped to examine the spatial relations and, particularly, the concept of depth in the studied houses. In the next step, plans of the houses underwent VGA analysis with DepthMap software, and analytical maps of spatial connectivity and integration were developed separately. The results of the analyses were used to examine the spatial structure of each unit based on important space syntax parameters, including integration, connectivity, and depth. Interviews were then held with dwellers of the studied units, based on which their activity maps were drawn based on the four constituent components of interaction: privacy, personal space, territory, and crowding. Results were paired with the behavioral patterns and interactions of the dwellers in each space to investigate and analyze the efficiency of space syntax. Fig. 1 demonstrates a brief account of the research method.

## Research Background

Researchers such as Rapoport (1969) have defined space as a cultural factor possessing meaning and have thus argued that space organization patterns need to be investigated as a tool to understand the relationship between built spaces and cultural and semantic aspects (Thungsakul, 2001). In 1984, Hillier and Hanson published a book entitled "The Social Logic of Space" where they introduced a syntax theory for space organization in buildings and

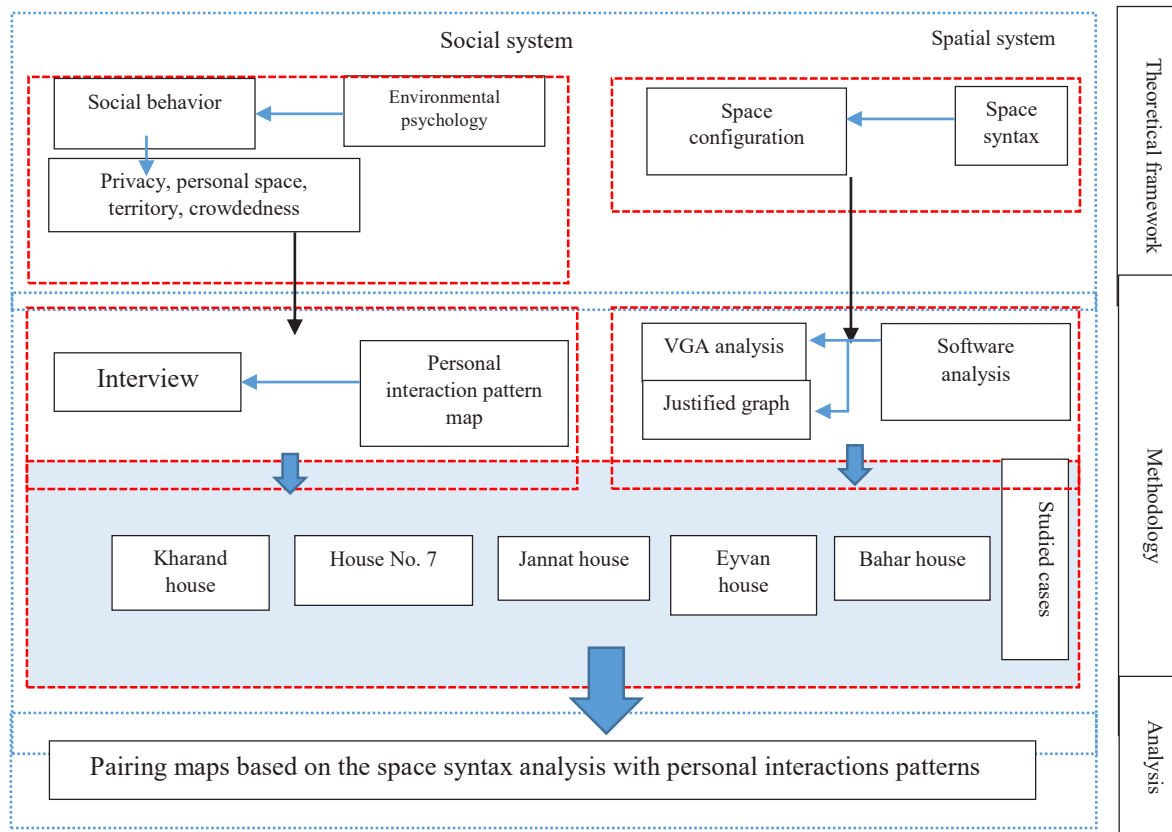


Fig.1. Research flowchart. Source: Authors.

dwelling. In this book, they argued that buildings, cities, and towns had specific spatial features translated into sociology roles. In 2007, Hillier published a book entitled “Space Is the Machine” in which he expanded and elaborated on his theories. He suggested that behaviors such as interaction, meeting, residence, gathering, and avoidance are not features of people but rather configurations or patterns formed by groups of people. He suggested that understanding the relationship between people and space lies in the relationship between individuals’ configuration and spatial configuration, rendering space configuration as the most crucial factor in building culture in cities and buildings (Hillier, 2007). Social and cultural aspects of the house are thus understood through the configuration of its space (Byun & Choi, 2016).

Many studies have examined the spatial structure of housing by space syntax parameters. A study concerned with the investigation of traditional and contemporary housing in Antakya, Turkey, through space syntax using the parameters of integration,

connectivity, and depth found that the private space created by the means of courtyards in traditional houses was being undermined in the contemporary housing in the region. This analysis indicated the distinction of spaces through doors rather than spaces (Ergün, Kutlu & Kılınç, 2022). A VGA analysis of traditional houses in Qatar, which was investigated in a study performed by, pointed out the dependence of housing spatial structure on cultural patterns. Analysis of traditional houses in Qatar revealed that privacy, gender separation, and hospitality had direct impacts on the shape of the built environment. Moreover, traditional houses were found to be strictly under the influence of cultural and Islamic norms (Al-Mohannadi & Furlan, 2022). Several researchers in Iran have also sought to study spatial configuration based on space syntax. Peyvastehtar et al. investigated spatial differences and spatial values in traditional Iranian houses. They employed qualitative and quantitative methods and developed and compared justified graphs, concluding that cultural features such as privacy were directly

associated with the concepts of depth and ring in justified graphs (Peyvastehgar, Heydari & Kiaei, 2017). Heidari et al. also performed a study on the impact of the module on functional efficiency using space syntax, concluding that traditional houses with large modules outperformed fine-module houses in terms of efficiency (Heidari, Akbari & Akbari, 2019). Another study explained the principle of privacy through the analysis of behavioral patterns in housing spatial configuration in a regional context (Alitajer & Nojourni, 2016). This study adopted the methodology of comparative analysis of modern and traditional houses in Hamedan through computer simulation seeking to investigate the influence of privacy over time. The authors concluded that the difference between modern and traditional houses was rooted in the integration and equivalence of all spaces in a house versus hierarchical access to the spaces.

The studies carried out so far have reached a consensus over the fact that understanding the spatial configuration of houses in any region of the world can reveal the nature of its cultural relations to a great extent. However, it would be ignorant to consider configuration as the sole factor involved in the formation of behavioral patterns. Ratti (2004) and (Montello, 2007) pointed out the weaknesses of space syntax and the importance of examining metric components in space syntax analyses. From this perspective, metric components such as direct and distance and environmental components such as climate and topography influence the relationship between spatial configuration and mobility, and behavioral patterns, and overlooking them would reduce the credibility of space syntax. Dideban, Pour Deyhami & Rismanchian, (2013) performed a study on Dezful neighborhoods, defining spatial recognition as the process of a human's perception of geographical space, and concluded that an appropriate measure responding to both spatial configuration and spatial recognition of the built environment was needed to understand them simultaneously. Various built environment analysis

methods have been proposed to quantify spatial configuration and make it more tangible, most of which rely on physical and visual aspects, metric distances, and geometrical aspects of configuration. These methods are generally incapable of observing the "spatial configuration-social behavior" relationship (Mohareb, 2009). Hamedani Golshan, Behzadfar & Matlabi (2020) conducted a study using Roger Barker's behavioral settings theory and behavioral data survey in two neighborhoods in Tehran seeking to address the deficiencies of space syntax to develop a deeper insight into spatial-behavioral patterns and concluded that examining space from the two theories' perspectives and pairing the results yielded reliable results. The two aforementioned studies generally examined the relationship between spatial configuration and behavioral patterns in urban spaces and employed axial space syntax analysis, which highlights the importance of performing two-way VGA and environmental analysis.

### Space Syntax in Architectural Analysis

The built environment is both the result of society and has an impact on it. Space syntax is concerned with the understanding and investigation of this relationship. Space syntax has developed a set of techniques to provide a simple demonstration of urban and architectural space (Major & Dalton, 2018). This method seeks to define spatial models and present them as graphical shapes to facilitate scientific interpretation of the desired spaces (Mustafa & Hassan, 2013, 445). This theory indicates that the features of spatial structure and configuration are more influential factors in the formation of human activities compared to the physical features of space (Hamdani Golshan, 2015, 88).

Understanding the pattern of various geometrical elements created by cities and buildings through the examination of variables obtained from space configuration is a specific definition of space syntax (Abbas Zadegan, 2002, 66). Depending on the type of

analyzed space, these geometrical components could be a line, convex space, or a point. Space syntax is thus examined in two approaches. The first approach considers the main and fundamental characterizing idea of space as the primary factor in understanding it, so linear spaces are used for mobility and convex spaces are used for social activities, and the visual realm of the audience is defined based on their mobility and angle of perspective. This approach indicates that the geometrical character of a space defines the type of human activity in it. However, the second approach places a greater significance on the connection between spaces –i.e., space syntax) compared to their geometrical features when it comes to forming human activities. In the next stage, space syntax analyzes the pattern of these spaces' composition and the connections between them by turning it into a graph (Rismanchian & Bell, 2010, 52). The connection between spaces and their social features is graphically demonstrated in convex maps. In theory, convex maps are concerned with enclosed spaces with limited perception and mobility whose connections are demonstrated as nodes and edges (Lee, Ostwald & GU, 2017).

The existence of relations between the mathematical definition of space and the presence of individuals in it has been confirmed in space syntax. Spatial models of human activities are not random but rather indicate the presence of a specific type of spatial order (hierarchy) in communities that use certain realms. However, it must be noted that space syntax cannot predict the behavior of individuals and is rather used to analyze the impact of spatial configuration on various types of collective behavior (Lamprecht, 2022). In fact, the endpoint of space syntax can be defined as understanding the relationship between humans and space. Configuration is the concept of considering a set of components as a whole rather than considering them individually. According to Hillier, the application of configuration leads to an understanding of genotypic inequality. Inequality genotypes are common patterns found in how various functions are distributed in a house (or any

other space). There are common grounds for various and unequal types of spatial relations that are deeply connected to living patterns in each building (Hillier & Vaughan, 2007). The primary goal of space syntax researchers is to discover the social relations in space, such as the formation of private spaces and the degree of privacy and publicness in a space.

### Space Syntax and Environmental Psychology

Space syntax defines and explains the configuration of built space including buildings and street networks as separate and connected fragments. The configuration has been proposed as a concept to explain the environmental psychologic features of places such as how people experience them, move in them, and perceive them (Montello, Waller, Hegarty & Richardson, 2004). Space syntax is focused on the topologic connection of space components within built spaces to justify focused behavioral and mental patterns. This connectivity is thus considered crucial in understanding this relationship. However, it is important to note that space syntax overlooks the metric features of space such as height, direction, distance, etc. in each space and within the separated components of space to a large extent (Montello, 2007).

Space syntax has proven credible in proposing a quantified language to define the spatial arrangement of spaces. Various theoretical and practical reasons indicate the environment has been psychologically converted into spatial components that are visually accessible units of place. Humans can split or name fragments of space easily in essentially continuous places, without physical demarcations or boundaries. This zoning is probably a human worldview characteristic concerning space and place in the form of cultural groups and/or historical periods (Friedman & Brown, 2000). Space syntax is promising and efficient as a part of a comprehensive environmental psychology theory, especially when combined with isovist and visual analyses. This combination clarifies the interaction of object



and mind and defines the built environment as an experienced perception.

Space syntax provides a diverse and rich set of quantitative indices used to define spaces in various ways that are potentially associated with various psychological responses such as behavioral capabilities (particularly path selection during movement), navigation and lack of navigation, acquiring spatial knowledge, perceived knowledge, privacy, and social interaction. However, space syntax has several defects as a comprehensive environmental psychology theory. One prevalent criticism of space syntax is that it manifests inconsistencies when implemented in existing built environments. For instance, the integration feature has been proposed to make changes in the pedestrian movement current, memorability, and functional importance of spaces in a building or city. However, activities carried out to attract more individuals are generally implemented in more integrated places rather than random places, whether they are the bottom-up decisions of business owners or top-down decisions made by managers and planners. A humorous cliché suggests that the three important factors involved in the value of a house or the success of a commercial space are “Location, location, location” (Montello, 2007). More integrated places are probably more familiar to ordinary people and are perceived much faster compared to a new place. As space syntax suggests, this must stem from the fact that more integrated places are more connected to other places; however, it is also because the destinations that need to attract the largest number of people are generally situated in more integrated places. Hence, more integrated places are more often visited, and more frequently visited places stick in one’s mind, even if integration has played no direct part in their memorability.

Space syntax downplays the role of specific physical features of the environment that are associated with human psychology. Space syntax has visibly reduced the importance of metric features of arrangements including direction and distance. “Cognitive space...

is topologic rather than a metric space.” (Penn, 2003, 30). However, various conceptual and empirical considerations suggest that individuals are sensitive to the metric features of spatial organization. Choosing optimal paths generally requires metric knowledge. Distance knowledge is still metric even if it is knowledge of the travel time.

Individual differences are vital to understanding environmental psychology, while space syntax largely overlooks these differences. Moreover, the shape of the visible space around apparently plays a key part in spatial learning and navigation (Hermer & Spelke, 1996). Still, the environmental distinction is an important predictor of how individuals organize the environment mentally and maintain their navigation. The signs in the place, completeness, clarity, and readability of the sign all influence navigation and spatial knowledge.

### Genotype, Housing, and Social Behavior

Residential space genotypes cannot fully reflect social behaviors and living patterns in the residential environment due to the contradictions inherent in space syntax which overlooks the physical and metric features of space. Altman (2003) suggested that the components regulating social behavior were privacy, personal space, territory, and crowding, and considered the social system in each group to have stemmed from how these four components were formed. A social system at the housing scale is formed between the dwellers of the house and is the result of choices made by family members to connect. This relationship may sometimes be aimed at establishing interactions with other members just as much as it might be aimed at solitude.

Spatial configuration is a prominent factor in the formation of interactions and relationships between individuals living in the same house. Housing genotypes found based on the research of Hillier and Hanson in their book entitled “Social Logic of Space” indicated that configuration was the primary factor in the formation of specific behavioral patterns in those spaces (Hillier & Hanson, 1984).

However, the bonds made within this social system depend on the quality of the space components as well. Several studies have been performed on the family life scope seeking to investigate the role of the physical environment in providing solitude. For instance, the presence of windows and blinds is quite effective in keeping noise out and restricting the view. Components of the building such as doors, fences, walls, and signs prevent the invasion of privacy (Altman, 2003). The formation of the social system and behavioral pattern of the residents in a dwelling can be understood through the relationship between activity and space. Space can take on various roles depending on the activity, and can thus influence human relations as a factor of dispersion or accumulation, separation or integration, and absorption or repulsion of activities (Moghnizadeh Tarshizi, Abdmojiri & Madahi, 2019, 102).

What imposes the space of a house on the behavior of its dwellers leads to the formation of privacy, personal space, territory, and crowding patterns. The spaces in the house have both metric and topologic features, and the sum of these features can clarify the dual space-behavior concept in the house. However, by how far would we find the configuration and topologic features of space to shape human behavior if we were to accept the approach of space syntax theorists? As a result of the prolonged relationship with its dwellers, a house carries a rich sum of meaning and memory that could reduce the impacts of spatial configuration. To further clarify the aforementioned, identification of the four social behavior patterns could help reveal their degree of adaptation to or deviation from the space syntax criteria.

## Case Study

Five single-unit dwellings in Isfahan were studied to examine the spatial structure of houses in the contemporary era and investigate the relationship between spatial configuration and social system in residential spaces. All studied projects were constructed over the recent decade and were

selected based on the inclusion criteria of map accessibility, access to dwellers, being a single-unit dwelling, identical climatic conditions, similar cultural contexts, and compliance with similar urban planning regulations. Cases were first analyzed using space syntax techniques and tools and were then paired with the dwellers' behavioral patterns.

### • Eyvan House: Shahin Shahr, Isfahan

The Eyvan House projected is a reconstruction of a historical single-story building in Shahin Shahr, Isfahan province. This building was designed and constructed in three stories seeking to showcase the overlaying of open, semi-closed, and closed areas. The initial idea of the project was to use the northern view of the project without having the residents being visible from the outside. This goal was accomplished by building a vast porch in the northern portion of the building and using a semi-transparent surface. The open spaces of the house include the entrance garden, roof terrace (sleeping porch), and veranda which do not undermine the privacy of the building despite their multitude (Fig. 2).

Fig. 3 demonstrates the justified graph of Eyvan House. A close inspection of this graph suggests a final depth of six in the house, which was attributed to the terrace and upstairs (separate bedroom). The terrace space functions as the completely private space of the house and is an introverted element. Furthermore, most public spaces in the house had a depth of three while more private spaces had greater depths, suggesting the designer's consideration of privacy in the house. As Table 1 indicates, the highest connectivity and integration were observed in the ground floor and the living room and kitchen areas at 2,738 and 21.36 units, respectively, indicating the significance of these spaces on the ground floor in the overall structure of the house. These figures were revealed to have an inverse relationship with the stories so smaller figures were recorded in higher stories.

Fig. 4 demonstrates how integration and connectivity relate to the ground floor in Eyvan



Fig. 2. Eyvan House architectural plans. Source: .www.caoi.ir

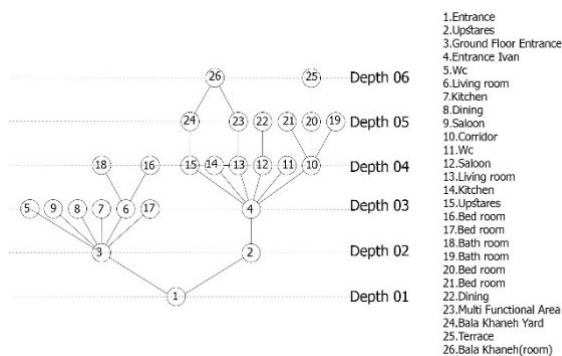


Fig. 3. Justified graph of Eyvan House. Source: Authors.

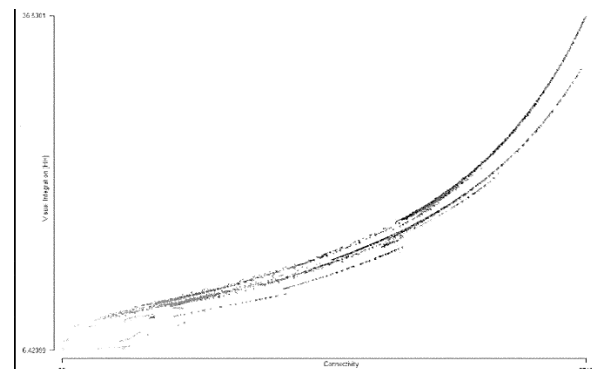


Fig. 4. The relationship between integration and connectivity. Source: Authors.

House. As connectivity increases, integration grows in almost the same proportion. In other words, the readability of spaces in the house is largely influenced by the view provided from various points of the house to other words, suggesting that the spaces establish weak or strong bonds with one another depending on the continuity of their view.

### • House No. 7: Najaf Abad, Isfahan

House No. 7 is situated in the only garden remaining in Najaf Abad, Isfahan. To respect the garden, the building has a setback on its northern side, demonstrating a deep break in the mass. A symbolic staircase climbs to the upper floor yard and descends to the ground floor

yard. One of the prominent features of this project is considering open spaces or yards in both stories. The gap in the space divides the interior space into two separate functional zones. Both stories include private areas on the south and public areas on the west (Fig. 5). As Fig. 6 demonstrates, the spaces in House No. 7 have been split into two sections from the entrance as most spaces have a depth degree of four. This suggests that one would have to pass through four spatial steps to get to most of the spaces in this house. The deepest –i.e., most private- parts of the house are not the bedrooms, but the terraces are considered as a private space for respiration. A study of the connectivity and integration



Table 1. Integration and connectivity figures obtained from DepthMap software in Eyvan House. Source: Authors.

Connectivity	Integration	
	Ground floor	
2738	36.21	Max
86	8.57	Min
	First floor	
1937	15.73	Max
310	5.05	Min
	Second floor	
1413	21.05	Max
111	3.99	Min



Fig. 5. House No. 7 architectural plans. Source: www.caoi.ir.

in House No. 7 reveals that the largest figures were observed on the ground floor and the public living room space that is connected to the kitchen (Table 2). A comparison of integration and connectivity figures in this house Fig. 7 reveals that these two components do not follow a linear trend in this house. In other words, one could suggest that the most frequently used spaces in the house where the movement is most concentrated are not necessarily related to other points of the house through connections and views and are rather a function of their location compared to other spaces of the house.

• Bahar House: Najaf Abad, Isfahan

Situated in Najaf Abad, Isfahan, Bahar House was designed and constructed in two stories per the employer’s needs. The designers have been forced to split the house into two sections due to the different progression directions of the parcels on the east and west of the plot. The eastern wing is larger than the western wing and the wings are separated by a staircase situated between them. This spatial separation has been reflected in both function and arrangement of the spaces upstairs so public spaces (kitchen, Living room, and reception room) have been situated in the east while

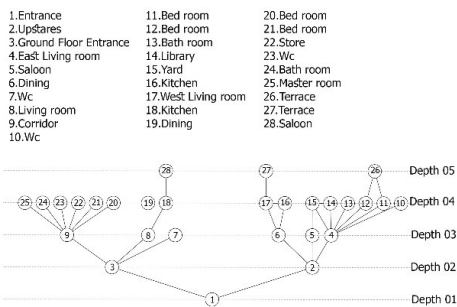


Fig. 6. Justified graph of House No. 7. Source: Authors.

private spaces (bathrooms and bedrooms) are in the south. To better connect the two stories, a portion of the private spaces upstairs has been allocated to avoid this (Fig. 8).

Most micro-spaces in Bahar house are situated at depth levels of three and four. A glance at the justified graph of the house (Fig. 9) indicates that the two public spaces of the house –the living room and reception room- are at a depth of two while other spaces have been designed to have a greater depth. However, one could suggest that the Bahar house is highly permeable. Besides, the highest degree of integration and connectivity in this house was observed in the living room and kitchen area (Table 3). The placement of a void at the center of Bahar House places a further emphasis on the central area in the spatial structure of the house since the two ground and first floors have the greatest connectivity and integration between the spaces. The justified graph confirms this argument as it indicates the void space to be an organizing element establishing connections between the depth levels of three and four (where most micro-spaces are located).

The diagram illustrating connectivity and integration

Table 2. Integration and connectivity figures obtained from DepthMap software in House No. 7. Source: Authors.

Connectivity	Integration	
	Ground floor	
3071	13.35	Max
80	3.16	Min
	First floor	
2355	24.04	Max
82	5.74	Min

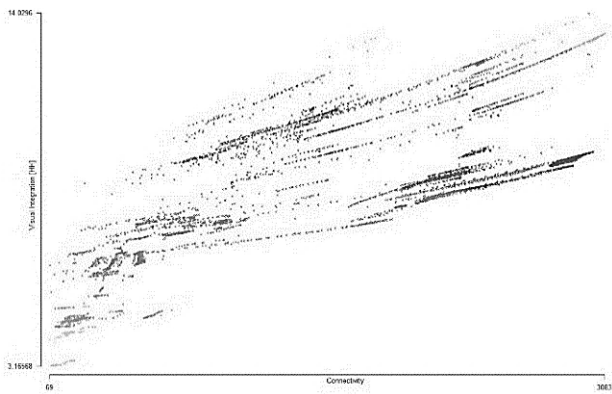


Fig. 7. The relationship between integration and connectivity. Source: Authors.



Fig. 8. Bahar House architectural plans. Source: www.caoi.ir.

Table 3. Integration and connectivity figures obtained from DepthMap software in Bahar House. Source: Authors.

Connectivity	Integration	
	Ground floor	
1166	19.57	Max
58	5.88	Min
	First floor	
969	15.29	Max
29	4.12	Min

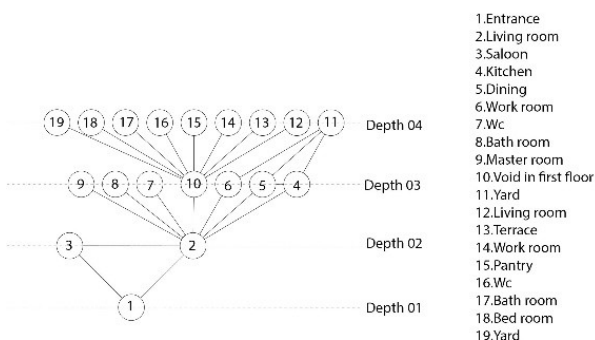


Fig. 9. Justified graph of Bahar House. Source: Authors.

in this house suggests a linear connection between the two components as integration increases with connectivity (Fig. 10).

### • Jannat House: Isfahan

This project was constructed in three stories on a 110m<sup>2</sup> plot shaped like an incomplete trapezoid in the Abbas Abad neighborhood, Isfahan. Living in this house entails the use of three stories as the upper floor includes the bedrooms and bathrooms, the middle floor contains the living room and kitchen, and the ground floor is composed of a large hall used as the guest reception room (Fig. 11).

Jannat house has the simplest justified graph among the five studied houses as its micro-spaces have been situated on three floors (Fig. 12). The spaces in this house have been connected through the smallest number of spatial intermediaries at a depth of three in

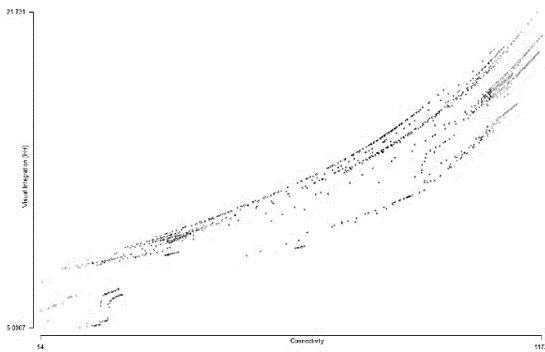


Fig. 10. the relationship between integration and connectivity. Source: Authors.

the case of most functions. The strongest connectivity and integration were observed in the reception space and basement (Table 4). To justify this, one must note that the basement space has been designed in an integrated form with minimal complicatedness in the plan to increase connectivity to all points, resulting in its considerable level of integration. The diagram comparing connectivity and integration in Jannat house suggests a relatively linear relationship between the two components (Fig. 13).

#### • Kharand House: Isfahan

Kaharand House in Isfahan is a project with a modern design and a traditional name. This project has sought to include the courtyard encompassing elements such as water, light, and privacy besides providing green space in a modern house. The project has been designed and constructed in three stories with each floor containing all the spaces found in an ordinary house. The ground floor is well connected to the courtyard, and a considerable portion of the built area has been cut on the first floor to allow more space for the yard (Fig. 14).

The design of three separate stories with all the spaces found in a house has led to the separation of the justified graph in Kharand House into three clusters. The noteworthy point regarding the justified graph on the house is the presence of rings in two of the clusters. Rings are observed in justified graphs in cases where space is repeatedly used. The spaces falling into the ring include the courtyard, kitchen, and living room in the first and bedrooms and terraces used as backyards in the most private zone of the house (at a depth of six) in the second ring (Fig. 15).

The largest figures for integration and connectivity in Kharand House were observed on the ground floor and the space between the living room and dining room (Table 5), which accentuates the significance of connection in the more public spaces of the house. The diagram comparing integration and connectivity in this house indicates the dispersion of these two components, suggesting that the influential spaces in the spatial configuration of the house are those with fewer views in some cases and those with more views in other cases, indicating no fixed direct relationship between these two factors. It can particularly be observed that the maximum connectivity is found in the point with a relatively low integration (Fig. 16).

#### • Investigating the relationship between space Syntax and dwellers' behavioral patterns

The study of cases using justified graphs and integration maps of each house largely reveals the overall spatial structure of the studied houses. However, one would need to develop an understanding of the dwellers' behavioral patterns to find out whether these analyses are consistent with reality and to what extent the interaction and relations of the dwellers with one another are influenced by the configuration. To this end, dwellers of the studied houses were asked to specify their zones of activity on maps dividing the spaces into several groups based on the components of interactions. These spaces included spaces the respondent considered their private area (P), spaces where the respondent tended to sit together and participate in conversations (ST), spaces where the respondent is away from their private space but maintains their private territory (SP), spaces where the respondent would be present in only for specific purposes such as eating and exercising (A), spaces where conversations are held while participating in a specific activity (AT), spaces considered to be reserved for guests (G), and spaces where movement occurs (W). Notably, service spaces such as restrooms were overlooked in this analysis as their function and level of activity were clear. The dwellers were thus asked to classify the spaces in their house based on the mentioned classification and mark the private and public areas in the house with colors green and blue,



Fig. 11. Jannat House architectural plans. Source: [www.caui.ir](http://www.caui.ir).

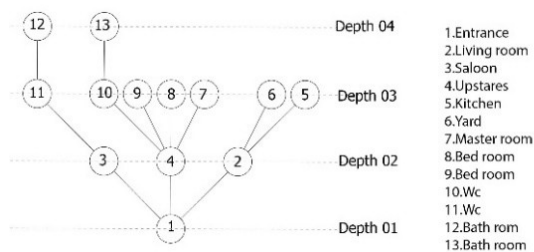


Fig. 12. Justified graph of Jannat House. Source: Authors.

respectively, on the behavioral pattern map indicated in Table 6. Ultimately, completed behavioral maps of the dwellers were compared to the integration and spatial structure analyses presented in the section on the case studies as demonstrated in Table 6.

A study of the integration and justified graphs in the studied houses and comparing them to the dwellers' behavioral patterns reveals that configuration is largely associated with the private and public boundaries of the house. Placement of spaces at larger depths with lower integration (marked blue on integration maps) with the privacy specified by the residents and placement of public areas at smaller depths with higher integration (marked red on integration maps) significantly indicated the direct relationship between the arrangement of space components and behavioral patterns. In the case of Jannat house, this association between the configuration and behavioral patterns indicated defects in the relationship between these two factors. Jannat house was constructed on a smaller plot of land, as a result of which

the public and private boundaries of the house were drawn through differences in elevation. Meanwhile, the justified graph of the house indicates the public hallway space and private spaces such as bedrooms to have been placed at the same depth. The concept of depth thus appears to have remained inefficient in this house. In this case, integration maps and comparison of the integration across stories managed to provide a more accurate definition of public and private zones in the house. The basement floor (a public area) was revealed to have the highest integration while the upper floors had the lowest integration (Table 4).

The study of cases indicates less consistency between VGA analysis and behavioral patterns in cases where a linear relation was observed between the two parameters of integration and connectivity based on VGA analysis. The integration-connectivity diagram in Eyvan and Jannat Houses suggested that increasing view to specific points was associated with greater integration, leading said points to find a more prominent role in connecting the components of the house and thus be used more often. However, this application was merely relevant to connection and movement and left no significant impact on behavioral patterns. To justify this, one could argue that the vaster the convex spaces get, the more intense the linear relationship between integration and connectivity becomes. In this case, activity patterns would be defined more based on the quality and

Table 4. Integration and connectivity figures obtained from DepthMap software in Jannat House. Source: Authors.

Connectivity	Integration	
Ground floor		
1973	64.22	Max
81	4.67	Min
First floor		
1094	41.41	Max
134	6.26	Min
Second floor		
693	12.54	Max
50	3.63	Min

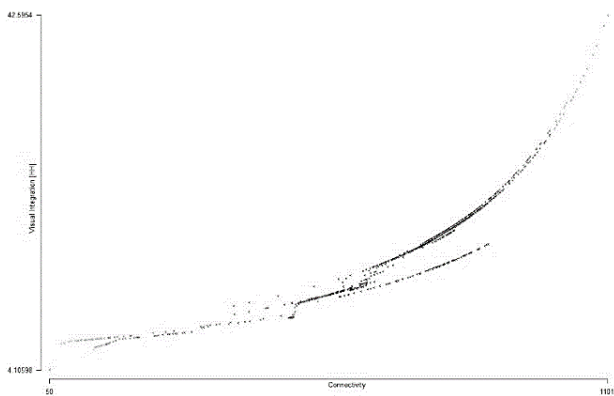


Fig. 13. The relationship between integration and connectivity in Jannat house. Source: Authors.



Fig. 14. Kharand House architectural plans. Source: www.caoi.ir

Table 5. Integration and connectivity figures obtained from DepthMap software in Kharand House. Source: Authors.

Connectivity	Integration	
Ground floor		
1479	21.91	Max
53	6.2	Min
First floor		
938	19.03	Max
49	3.77	Min
Second floor		
860	12.24	Max
85	3.44	Min

physical or intellectual components in the space such as its openings or furniture rather than view and movement –as observed in Eyvan and Jannat House projects. On the contrary, dispersion in the integration-connectivity diagram caused a more significant relationship between space syntax and behavioral patterns in the remaining three cases.

Table 7 demonstrates how consistent space syntax analyses were revealed to be with the dwellers' activity and behavioral patterns in the studied cases. The table

suggests that space syntax yielded satisfying results in terms of setting boundaries between private and public spaces and the integration or separation of the components of space in all studied cases. However, a closer look reveals conflicts which will be discussed further as follows.

Each of the space syntax components revealed details of the potential in the space to withhold interactive events. Results of analyses reported in Table 8 indicate which of these components have managed to connect with



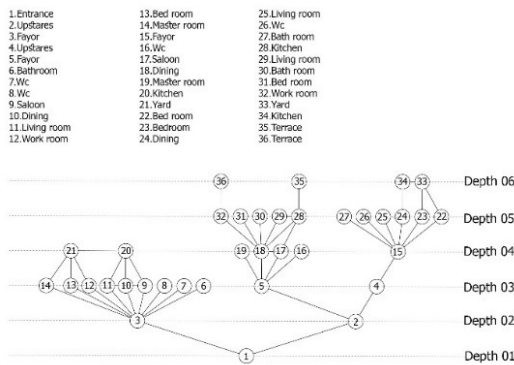


Fig. 15. Justified graph of Kharand House.  
Source: Authors.

the behavioral patterns of the dwellers in each house in terms of the factor influencing social interaction and to what extent. Results indicated that space syntax criteria managed to perform better in House No. 7, Bahar House, and Kharand House compared to Jannat and Eyvan Houses.

## Conclusion

Among the achievements of the present study, one could point to the spatial-social structure analysis at an architectural scale based on VGA analyses and its comparison to behavioral patterns in contemporary housing. Moreover, the present study developed space syntax maps and analyses of contemporary housing genotypes in Isfahan, which could prove beneficial in the process of housing design and planning carried out by other designers.

Results of the present study regarding research literature suggest that the space syntax parameters used in the present study —i.e., integration, connectivity, and depth—have managed to reveal a significant portion of the relationship between the structure of space and the behavioral patterns it contains. However, other suitable tools such as integration-connectivity diagrams and justified graphs were also examined in line with the present work's subject. Our results confirm that the social interaction of individuals in built environments such as housing is not a mere topological issue but is rather affected by environmental and metric components, as the proposed theoretical framework indicates. The capabilities of space syntax were revealed to vary depending on the environment,

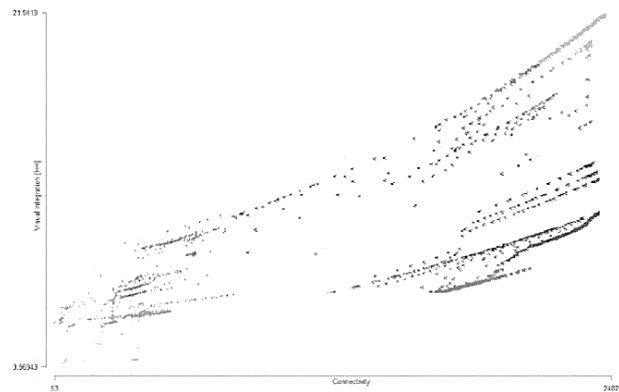


Fig. 16. The relationship between integration and connectivity in Jannat house. Source: Authors.

indicating inconsistencies in some cases. Our results also confirm the results of previous research suggesting that the expanse and complexion of the relationships between space components increase their functional efficiency, although previous research has not considered the expanse of space as a factor leading to stronger environmental and intellectual components, only holding a topological study of space as the criterion for the conclusion.

Space syntax is a methodological system making it possible to discover and justify the spatial-social current in the environment through the quantification of its qualities. The study of contemporary housing spatial patterns in the present work revealed that the socio-spatial system of contemporary housing is less dependent on the spatial configuration found in traditional examples. Although the formation of interpersonal interactions and activities is still under the influence of integration, connectivity, and depth, the relations between individuals are not regulated merely through physical and visual separation or integration of spaces. Rather, the architect takes stimulants such as texture, light, navigation, view, landscape, and furniture in designing a space seeking to distinguish it as a space with unique features rather than a mere space in a general configuration, which is the starting point of reregulating relations in the spatial-social system of a house.

Although space syntax is largely reliable when it comes to understanding general current such as determining the public and private areas of the house and recognizing the spatial patterns in contemporary housing, a closer

Table 6. Comparison of integration analysis and behavior pattern maps of the dwellers. Source: Authors.

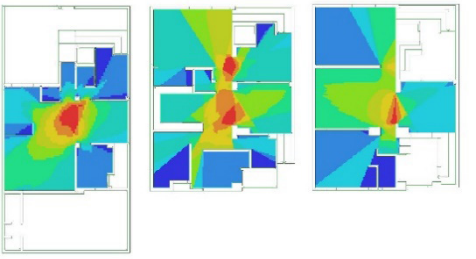

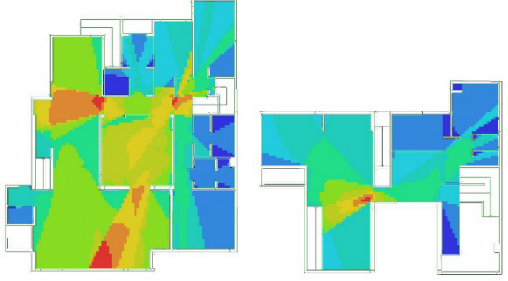

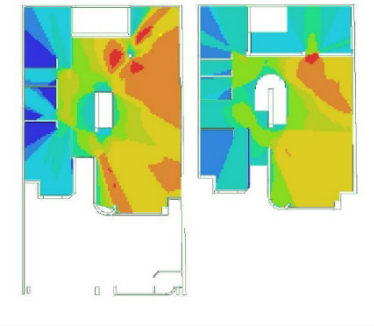

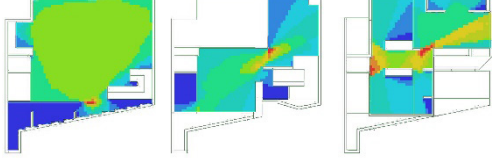

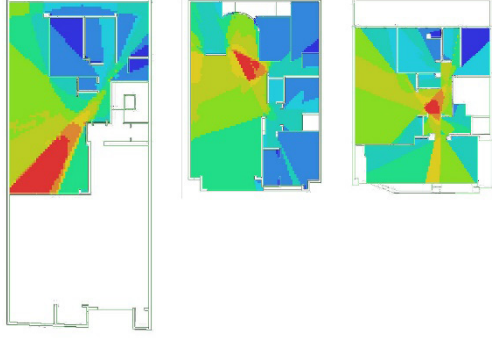

Studied case	Integration map	Behavioral pattern map
Eyvan House		
House No. 7		
Bahar House		
Jannat House		
Kharand House		

Table 7. Consistency level between space syntax analyses and dwellers' behavioral patterns. Source: Authors.

Studied case	Consistency between space syntax and behavioral patterns	Inconsistency between space syntax and behavioral patterns
Eyvan House	Specifications of private and public areas in the house were consistent with justified graphs. Most (ST) and (AT) group activities occurred in highly integrated spaces.	The (SP) pattern was situated in a highly integrated space while (ST) was situated in a less integrated space on the third floor. Greater spatial integration is observed in the guest space compared to the living room and kitchen in the public area of the ground floor, whereas most of the movement and functional diversity of the residents occurs in the kitchen and living room.
House No. 7	Specifications of private and public areas in the house were consistent with justified graphs on the ground floor. The justified graph confirmed the placement of private areas at greater depths.	The kitchen area on the ground floor with a relatively high integration was specified as a private area (P) by users. The hallway and kitchen had the same depth upstairs and downstairs, but users deemed the spaces upstairs to be more private. (SP) and (ST) spaces had the same depth upstairs but contained different behavioral patterns.
Bahar House	Specifications of private and public areas in the house were consistent with justified graphs on each floor. (ST) and (A) group activities occurred in highly integrated spaces.	The space around the void upstairs had the greatest integration but was revealed to be of not much significance in terms of movement and activity. The space specified by users as a movement space (W) on the ground floor had a moderate level of integration and connectivity compared to the whole structure.
Jannat House	The private and public areas of the house were consistent with the integration map and justified graph in the case of the ground floor. (ST) and (A) behaviors occurred in more integrated spaces.	The basement included a set of behavioral patterns associated with interaction, conversation, and privacy including (G), (SP), (A), (ST), and (AT) alongside each other in a space with a low depth and high integration. The justified graph indicated the private and public arenas of the house to have the same depth.
Kharand House	The justified graph and integration map determined the accessibility and isolation of private and public spaces on all floors. The intersection between the private and public spaces on the first and second floors was revealed to be highly integrated as they played an adjoining part between these arenas.	The greatest integration was observed in the living room on the ground floor although this space was revealed to have an insignificant role in the movement and behavior pattern of the dwellers and was more of a guest-specific space (G). As a dominant movement space (W), the joint between the private and public areas had a low integration on the ground floor.

Table 8. Comparison of the relationship between social behavior components and space syntax in studied cases. Source: Authors.

Studied case	Interaction component	Consistency between interaction components and space syntax analysis		
		Integration	Connectivity	Depth
Eyvan House	Privacy	●	●	●●
	Personal space	●●	●●	●●
	Territory	●●	●●	●●●
	Crowding	●●●	●●	●●
House No. 7	Privacy	●●	●●	●●
	Personal space	●●	●●	●●
	Territory	●●●	●●●	●●●
	Crowding	●●	●●●	●●
Bahar House	Privacy	●●	●●	●●
	Personal space	●●●	●●	●●●
	Territory	●●	●	●●●
	Crowding	●●	●●	●●●
Jannat House	Privacy	●	●	●●
	Personal space	●	●	●
	Territory	●●	●●	●
	Crowding	●●●	●●●	●●
Kharand House	Privacy	●●	●	●●
	Personal space	●●	●●	●●●
	Territory	●●●	●●●	al●
	Crowding	●●	●●	●●

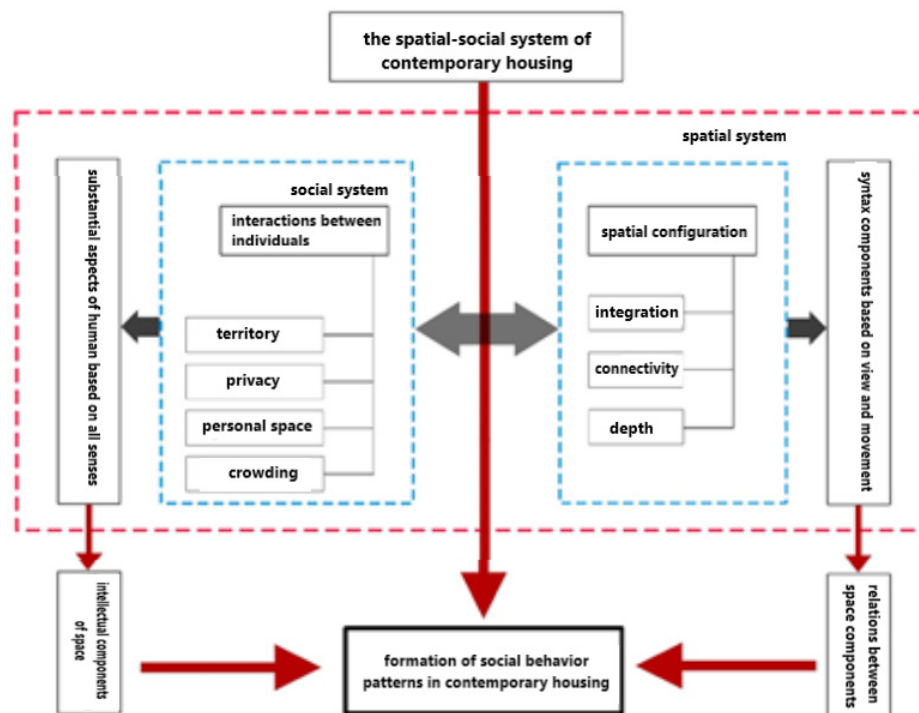


Fig. 17. The relationship between configuration and intellectual components of space in the formation of the spatial-social system in contemporary housing. Source: Authors.

look into it at a finer scale where the details of space are more noted by the users reveals the defects of this analysis. Convex space is held as the criterion for investigation as long as a social interaction analysis is desired. Results of the present study indicate that as the convex space expands and becomes more connected, the integration of the overall spatial structure becomes more coherent, allowing for the emergence of activities and a wide range of interactions in a convex space. Here, the individual features of space are the elements that determine how space impacts behavioral patterns. Individual attributes of space perceived by all human senses and forming his mental model of the space shape the social structure of contemporary housing alongside configuration (Fig. 17).

The audience perceives the relationship between the components of space after being present in the built environment, seeing it, and moving through it. Although a huge part of human perception is formed by his sense of vision, he is also considered to be regulating his actions and reactions to the environment. This whole being engages in behaviors and activities based on his sensory and mental experiences of space,

while movement and vision have the most significant impact on the establishment of the dual space-human relationship. This is why configuration plays a significant role in the definition and formation of this relationship. However, the deeper and more tangible relationship between the audience and the environment –be it due to strong sensory stimulants or personal experiences with the environment—adds something to the space that cannot be identified by space syntax analyses and indicates a need for further environmental research.

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