The Study of Spatial Evolution in the Traditional Houses of Iran with Emphasis on the Aspects of Physical and Spatial Relationship using the Space Syntax (Case study: Qajar and Pahlavi houses in Tabriz)

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Abstract

Iranian houses have changed physically and communicatively over the years. The turning point of these changes can be seen in the architecture of houses of the Qajar and Pahlavi periods. In order to examine these changes, eight houses of Tabriz were selected in this study. Four of them belong to the Qajar period and the other four to the Pahlavi period. One of the houses, which belong to the transitional period between these two eras, was analyzed due to its noticeable changes. The purpose of this article is to compare and evaluate the spatial structures of Iranian houses in the two periods of Qajar and Pahlavi by studying and analyzing the selected houses in Tabriz from the aspects of physical layout and spatial relationships. To serve this purpose, a mixed research method is used based on historical approach and interpretive and comparative strategy. Desk studies and filed studies were both used for data collection. Since the results of the research are qualitatively based on having a quantitative analysis of data, analysis has been done in the qualitative part by comparing ground floor plans and extracting effective spaces from the quantitative analysis of the spaces by the method of space syntax and with the help of Auto Cad, A-Graph and Depth Map software. After that, the obtained data was compared, and aspects of physical layout and spatial relationship were described based on the process of changes made in the selected houses. The results of the study showed that the entrance, *Hashti* (vestibule), outer courtyard, *Tanabi* (a type of hall) and inner courtyard are the influential factors of physical changes in the Qajar and Pahlavi periods, evident in the plan of the selected houses. Some of the main spatial elements, form, shape and elongation of houses, spatial hierarchy, constructed facades, building orientation, neighborhoods, the place of the entrance and its multiplicity, and the place of spatial elements have the greatest impact on spatial relationship and human behaviors in comparison with the main and secondary axes in the selected houses from the Qajar and Pahlavi periods.

Keywords: Spatial structure, traditional houses of Iran, physical and connectivity aspects, space syntax, Qajar and Pahlavi periods.

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Introduction

In the old architecture of Iran, residential spaces were considered as the main spaces of human life in the general state of the house that were affected by various factors. In the last decade, the study of spatial structure and connectivity and the manner of its analysis have received the attention of researchers in the field of architecture and urban design (Memarian, 2002; Dursun, 2007; Karlen, 2009; Mustafa, 2010; Edja, 2015; Saatci, 2015). According to them, the physical elements of the building, spatial structure, relationship of the buildings, and the location and function of the spaces are important and influential factors in the formation of architectural spaces (Hillier, Hanson, 1989; Hanson, 2001). A precise examination of the plan of houses in different areas shows that there are significant differences in the design of these houses despite some similarities in their spatial configuration (Eldem, 1984; Kuban, 1995). The theory of space syntax was proposed about spatial structure in "The Social Logic of Space", a book written by Bill Hillier and Julien Hanson (Hillier, Hanson, 1984). In this book, it is considered that "space is the machine" (Hillier, 1996). The purpose of space syntax is to study the human relationship with space and to find how ideas are configured in space systems in different societies –spatial properties that cause the formation of behavior in the forms (Dursun, Saglamer, 2003; Dursun, 2007). In this study, the spatial structure of old houses of the Qajar and Pahlavi periods of Tabriz was studied using the space syntax, and the extent of changes was examined in the physical elements of the houses, their structure and spatial relationships. Therefore, the following main question has been raised:

What is the process of formation of the spatial structure of Iranian houses in the Qajar and Pahlavi periods?

The following sub-questions are also raised:

1- How have the houses of Qajar and Pahlavi periods in Tabriz changed in terms of plan and spatial structure? (Qualitative question)

2- How have the houses of the Qajar and Pahlavi periods in the city of Tabriz changed in terms of behavior and connectivity? (Quantitative question)

Theoretical Foundations

Spatial structure of houses

Every house has a dynamic structure that affects the emotional and spiritual needs of individuals according to spatial changes in different periods and is organized according to a specific order of social and cultural principles. In addition to the activities performed in a house, an important point about a house in historical periods is its spatial pattern and configuration –a point accompanied by complex rules about how activities are connected and how they are sequenced (Hanson, 1998: 2; Reis, 2003; Saruwono, 2012; Alitajern, Molavi Nojoum, 2016).

Various factors such as performance, the culture of residents, lifestyle, climatic characteristics, behavioral and social patterns and organization of spaces, have given a special meaning and concept to the formation of the spatial structure of houses (Rapaport, 2010; Rapaport, 2013; Hillier, Hanson, 1984; Lawrence, 1987; Hillier, 2007).

In this study, according to the division of the general structure of traditional houses into interior and exterior, the principle of hierarchy and spatial continuity from the entrance to the main part of the house and the combination of different spaces in the structure of traditional houses are investigated.

Space syntax

The space syntax is a theory that can be used to transfer science-based knowledge to the design process, creating a connection between science and design. In this theory, several tools are produced for analytical, quantitative, descriptive and graphical data that are increasingly in use today. Accordingly, space analysis is performed in architectural projects, detailed designs, and design proposals (Hillier, Hanson, 1984; Hillier, 1996; Sisman, Dursun cebi, 2017).

The purpose of space syntax is to describe and analyze how to combine the model and spatial arrangement in a structure and format of graphic shapes and thus facilitate scientific interpretations of the desired spaces (Barani et al., 2012; Mustafa & Hassan, 2013: 445). In this technique, by converting the spatial

structure of the built environment into graphic patterns, the relationships between its various spaces are presented in mathematical data. An analysis of this data can explain the interrelationships between the body of the environment and the behavior of its users (Hillier & Hanson, 1984: 294).

In order to analyze the spatial structure, with the help of some parameters, the space syntax provides the following spatial properties:

Integration: It refers to the degree to which a point relates to the overall structure of its set or subset. A space that can be reached by passing fewer spaces is more integrated and vice versa (Jiangl et al., 2000). The index of integration is directly and linearly related to the index of connectivity –the more connections a space has and the more nodes it connects, the greater the degree of integration (Heidari et al., 2017).

Connectivity: It refers to the connection or the degree of the number of lines that reach a node. A node that has more connectivity is connected to more nodes and benefits from more support (Oftadeh, 2016). The connectivity of spaces is a good indicator for recognizing communal spaces and facilitating the circulation between spaces (Young & et al, 2015: 16-2).

Depth: It is divided into two parts in the method of space syntax: (1). Metric depth or the very distance between two nodes (2). The number of nodes that are to be passed to go from node A to node B (Memarian, 2002).

In order to analyze the spatial structure by the method of space syntax, using Depth Map software, data can be obtained in the form of graphs, charts and tables. The following are some of the practical concepts and terms used to describe this data.

Visual step depth: It refers to the number of changes in direction that can be reached from one point to another. The number of dots is indicated by the color spectrum. This color spectrum and the number of dots indicate a change of direction in a plan.

Isovist Analysis: It refers to the view from a certain point that is shown with estimation. In fact, visibility can be considered as a cone of the user's view of the surrounding space from the point in question (Benedikt, 1979: 47).

Convex Map Analysis: Depth Map shows a depth numerically for each space. For spaces that have different levels of connectivity, interconnection will change. The connectivity between convex spaces forms a graph that represents the internal relations of the spaces.

Linear map (integration): In converting a convex space into linear maps, some consecutive convex spaces that have a more complete angle of view are combined and thus form a single space (single line).

Research Background

In the last decade, the use of space syntax in the field of architecture has increased in various studies. A review of these studies may help to understand how they have used the space syntax. In general, studies that are related to the space syntax can be categorized in terms of application into distinct spectra, each with different ways and methods in using the space syntax.

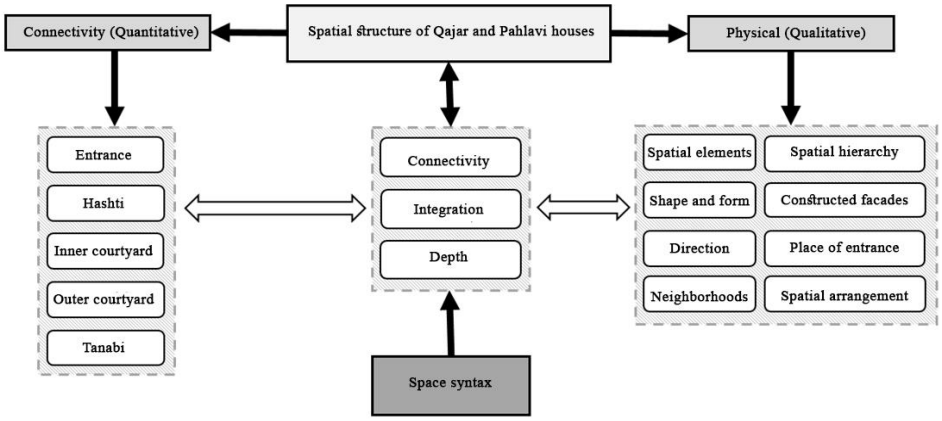
The conceptual model of the relationship between the spatial structure of the house and the space syntax

The theoretical framework of this research is based on the model presented in Figure 1. It is based on the relationship between the spatial structure of traditional houses of the Qajar and Pahlavi periods in the city of Tabriz using the method of space syntax. In this model, the spatial structure of houses is divided into two general parts: (A). Physical (qualitative) dimension that is based on the characteristics of spatial elements, form and shape, spatial hierarchy, constructed facades, building orientation, neighborhoods, the place of the entrance, and the place of spaces, and (B). Connective (quantitative) dimension that is studied using the parameters of connectivity, integration and depth in the space syntax based on the selected spaces of the main elements: entrance, Hashti, outer courtyard, inner courtyard and Tanabi.

A part of the space syntax studies puts emphasis on the way houses are configured, the hierarchy of spaces and the importance of house areas in terms of privacy. This can be effective in the type of structure and organization of space (Sheikh Bahaei, 2019; Monteiro, 1997; Bellal & Brown, 2003). Some other researchers in this field, based on the concepts and tools of the space syntax, are concerned with the systematization of

indigenous and traditional houses regarding the cultural concepts and patterns, recognition of the ideas and lives of the predecessors, connections of different spaces of houses, and the configuration of space with lifestyle and social and family beliefs. In these studies, each of the factors has played an important role in the formation of patterns, the type of organization of houses and the function of spaces (Kamalipour et al., 2012; Hamedani Golshan, 2015; Madahi and Memarian, 2016; Seo, 2003; Bellal, 2013). A number of space syntax studies have identified a key element of the space, such as the yard, to study the extent of its capabilities and the manner of its configuration for different applications (Hajian et al., 2020; Latifi and Diba, 2020; Mustafa & Hassan, 2013). A group of studies used the parameters of space syntax to study the amount of seclusion and space privacy with the help of the comparison of spatial arrangement in traditional and contemporary houses (Okhovat, 2013; Habibi et al., 2019; Mustafa & et al, 2010). In other studies that are concerned with space syntax, the focus is more on the differences between the behavioral patterns of houses in a country. In these studies, researchers emphasize the role of behavioral and comprehensive patterns in the spatial structure (Adeokun, 2013; Ding & Ma, 2020).

According to Table 1, it can be concluded from the study of research methods in the category of housing applications that the simultaneous study of changes, spatial analysis and spatial patterns and the comparison of their impact has been less considered. Therefore, in the present study, the houses of the Qajar and Pahlavi periods have been studied from a quantitative and qualitative point of view.



F1. Conceptual model of research.

Category	Categorization of space syntax studies based on research field	Researchers
First	- Spatial layout of traditional houses to adapt the needs of users to spatial organization - Spatial hierarchy and importance of home areas - Home spaces in a family based on the gender of its users	- Sheikh Bahei, 2019 - Monteiro, 1997 - Bellal & Brown, 2003
Second	- Comparison of traditional houses based on the type of formal classification and spatial layout - Recognizing the ideas of the past from a spatial dimension by studying the traditional housing - Configuration of traditional spaces according to indigenous culture and identity - How to change traditional houses according to lifestyle and family beliefs - The role of culture and beliefs of people in the structure and configuration of rural houses	- Kamalipour et al., 2012 - Hamedani Golshan, 2015 - Madahi & Memarian, 2016 - Seo, 2003 - Bellal, 2013
Third	- Identify a key element in the spatial configuration of the house - The degree of permeability and flexibility of traditional houses - The effect of spatial adaptation on the changes of mosques and the differentiation of their performance	- Hajian et al., 2020 - Latifi and Diba, 2020 - Mostafa & Hassan, 2013
Fourth	- Adapting the space of traditional and modern housing - Responding to the spatial arrangement in influencing the sense of spatial belonging of traditional and modern houses - The relationship between home morphology and residents' privacy	- Okhovat, 2013 - Habibi et al., 2019 - Mostafa et al, 2010
Fifth	- Typology of indigenous houses based on comprehensive patterns - The relationship between the spatial structures of houses and the behavioral patterns of its inhabitants	- Adeokun, 2013 - Ding & Ma, 2020

T1. Categorization of space syntax studies based on the research field of some researchers.

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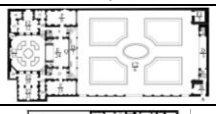
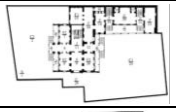
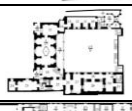
Research Methods

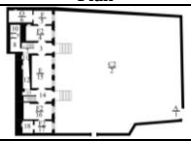
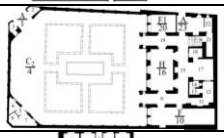
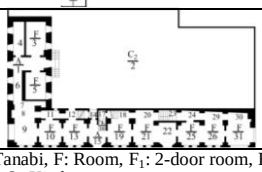
This research is about evaluating and comparing the changes in the spatial structure of eight historical houses in Tabriz in the Qajar and Pahlavi periods. To do so, we used a mixed (quantitative and qualitative) research method based on historical-interpretive strategy. Moreover, we used the simulation and comparative methods of case studies. The data required for this study was collected with desk studies and field survey, which has been done by studying the available documents and maps and using the tools of observation, drawing and simulation of case studies. The analysis and comparison of the houses in the initial stage has been done qualitatively and through the comparison of the plan spaces in the historical periods. In the final stage, the houses were analyzed by the quantitative method of space syntax using justified samples with the help of specialized software, including Auto Cad, A-Graph and Ucl Depth Map. According to this theory, with the help of Depth Map software, simulations of spaces (qualitative data) can establish the relationships between variables in micro-spaces with different components, and finally achieve the quantitative or graphical analysis of data, examination of patterns, and the spatial relationships and concepts between them. The qualitative results of the research are based on the logical reasoning of the extracted items, the quantitative analysis of the data, their comparison and the description of the physical and connectivity dimensions based on the performance of the effect of house changes.

Introduction of the Study Samples

Most of the old houses of Tabriz have remained from the Qajar and Pahlavi periods. The reason of choosing these two historical periods is that the old houses of Tabriz were mostly constructed in that time. Moreover, in these periods, there is a shift in the style of housing from the introvert architecture of the Qajar period to the extrovert architecture of the Pahlavi period. Among other reasons that make these periods suitable for this study are the variety of plans, the diversity of interior spaces, the accessibility of documents and historical background of houses, and the fact that the houses of these periods are easy for field observation and interpretation. According to the aforementioned reasons, in this study, 16 houses in the Qajar and Pahlavi periods were eligible for study in terms of spatial structure from which 8 houses were selected for the study of plan, space, behavior and connection. Moreover, since the main spaces of a house are located on the ground floor and most of the human activities and behaviors occurs there, and because this floor has access to the open spaces inside (yards) and outside (passages) a house, this research is concerned with the spatial structure of this floor. In Table 2, four houses that belong to the Qajar period, and in Table 3, four houses that belong to the Pahlavi period are shown.

Name	Period	Picture	Plan
Behnam House	Early Qajar Period		
Ganjeizadeh House	Early Qajar Period and First Pahlavi King		
Qadaki House	Late Qajar Period		
Amirnezam Garousi House	Late Qajar Period		
Plan guidance		A: Entrance, B: Hashti, C: Yard, C_1: Interior courtyard, C_2: Exterior courtyard, C_3: Backyard, D: Balcony, E: Tanabi, F: Room, F_1: 2-door room, F_2: 3-door room, I: *Hozkhaneh* (a roofed space with a basin), J: Staircase, Q: *Orsi* (Sash window)	

T2. Introduction of the selected houses from the Qajar period.

Name	Period	Picture	Plan
Parvin Etesami House	First Pahlavi		
Lalehei House	Early Pahlavi Period		
Neishabouri House	First Pahlavi		
Rastegar House	Early Pahlavi		
Plan guidance		A: Entrance, B: Hashti, C: Yard, C_2: Exterior courtyard, E: Tanabi, F: Room, F_1: 2-door room, F_2: 3-door room, H: Hall, J: Staircase, O: Kitchen	

T3. Introduction of the selected houses from the Pahlavi period.

Analysis of Findings

The effect of changes in the spatial structure of houses in the Qajar and Pahlavi periods on the spatial connections and human behaviors

In order to analyze the spaces of the study samples according to Tables 2 and 3, the plans of the selected houses were prepared in Auto Cad and the justified graph of each plan was made in A-Graph to make it easy to analyze the pans in Depth Map. Each of the study samples was studied and analyzed spatially in both qualitative and quantitative methods. In the first (qualitative) part, the physical changes of the plans were examined. After that, the results of comparing the plans were presented graphically based on Table 4 for quantitative analysis in specialized software. In the second (quantitative) part, the study samples were analyzed in specialized software and the results were extracted as graph, chart and numerical data that are shown in Tables 5 and 6.

Qualitative analysis of Qajar and Pahlavi houses

Qualitative analysis of Behnam and Ganjeizadeh (Sharghi) houses

Behnam house was constructed northward and southward, while Ganjeizadeh (Sharghi) house was constructed northward. The orientation of both buildings is to the south. Behnam and Ganjeizadeh (Sharghi) houses had neighbors on three sides and had a passage and entrance to the house from one side only. In Behnam house, there is a balcony, but Ganjeizadeh house does not have a balcony. In both houses, Tanabi is located along the main axis and on the ground floor. The outer courtyards are rectangular, located on the main axis with north-south elongation on the southern parts of the plans. The inner courtyard of Behnam house is located on the north behind Tanabi. According to the qualitative analysis of these two houses, it can be concluded that the spatial relationship and human behaviors are in a good condition because in the early Qajar period, most of the main spatial elements were existed in houses with a correct hierarchical order.

Qualitative analysis of Qadaki and Amir Nezam Grossi houses:

The construction of the building in Qadaki House is on the northern, western and eastern sides, but in Amir Nezam House, it is on the southern and western sides. The main building is located between the outer and inner courtyards. The orientation of houses in Qadaki house is to the south, but in Amir Nezam house, in addition to the south, it is

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also oriented to the north. The reason of having this two-side orientation was to bring more natural light to the house from both sides. Moreover, since privacy was not an issue any more, this two-side orientation was suitable to remove the main hall and move the women's place to the north Tanabi. The porch in Amir Nezam's house has been removed. At the entrance, after entering the house, the main facade of the building can be seen. Hashti in Qadaki house is octagonal. Tanabi is on the ground floor in Amir Nezam's house, but it is on the first floor in Qadaki's house, and Hozkhaneh is on the ground floor. The outer courtyard in both houses is located to the south of the house. The inner courtyard of Amir Nezam house is located in the north of the house. Due to the low level of the courtyards from the general level, the steps between the courtyards of the houses can be seen in the side facades and in the main (southern) façade of Amir Nezam house. Based on the qualitative analysis of these two houses, we find that although some spaces (halls, porches) were removed in the late Qajar period, and some other elements were added and changed (e.g., changes made in the direction, construction of stairs in the facades and the increase of entrances), in this period, like the early Qajar period, spatial relationship and human behaviors are still important.

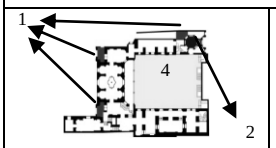
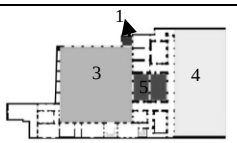
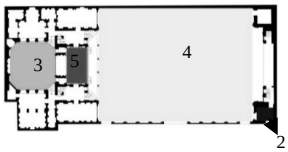
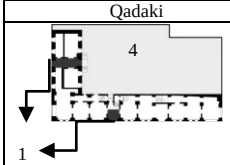
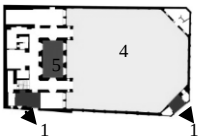
Qualitative analysis of Ganjeizadeh (Sharghi), Parvin Etesami, Lalehei, Neishabouri and Rastegar houses

The western side of Ganjeizadeh house was constructed in the first Pahlavi period. Here, by examining this house and comparing it with Parvin Etesami, Lalehei, Neishabouri and Rastegar houses, it can be seen to what extent the construction period can affect the way of spatial relationship and human behaviors. Parvin Etesami and Lalehai houses were constructed northward, Neishabouri house was constructed northward and eastward, and Rastegar house was constructed northward and westward. During this period, Hashti is totally removed and except for Neishabouri house, the entrance in other examples reached the inside of the house without any intermediate space. Parvin Etesami, Laleh and Neishabouri houses have an extrovert architecture. The architecture of Rastegar house, in which the entrance is located on the exterior part of the façade, is even more extrovert. As a result, the courtyard is rarely used and the spatial connections and human behaviors are reduced. In Ganjeizadeh (Sharghi) and Lalehei houses, Tanabi has been moved from the ground floor to the first floor, and in Rastegar and Neishabouri houses, it is totally removed. However, in Parvin Etesami house, Tanabi is located on the ground floor. The sash windows have also been removed from Tanabi during this period and they have separate windows. Hozkhaneh in Parvin Etesami and Neishabouri houses is located in the basement, while there is no Hozkhaneh in Lalehei and Rastegar houses. Instead of one large balcony, single protruded balconies, which are open on three sides, have been used in Ganjeizadeh and Lalehei houses. Neishabouri house is the only house with a Hashti. Modifications and removal of some spatial elements (front hall, Hashti, Tanabi, large balconies) and extensions (change of construction facades, stairs in facades, multiple entrances and single balconies) as well as observation of extrovert architecture in Ganjeizadeh house have affected the human behaviors and spatial connection of this house. In Parvin Etesami, Lalehei and Neishabouri houses, the level of spatial connection and human behaviors has decreased. In Rastegar House, this shortcoming is more serious, and the extrovert architecture of this house has a greater impact in reducing the level of spatial connection and human behaviors.

Conclusion of the qualitative analysis of Qajar and Pahlavi houses

The qualitative comparison of the ground floor plans in the selected houses revealed that some elements and physical spaces have an effective role in the spatial relationship and human behaviors of these houses. These elements and spaces were analyzed according to the spatial hierarchies prioritized in traditional houses. The results are presented at the end of this section, and the evaluation and analysis of ground floor plans in the second (quantitative) part is based on these results. According to the results of the

qualitative study, it was found that five spaces (including the entrance, Hashti, outer courtyard, Tanabi and inner courtyard) play an effective role in changing the plans and spatial connections. The second section is concerned with the quantitative analysis of these spaces with the help of Depth Map software.

Designated spaces: Entrance 1 Hashti 2 Inner courtyard 3 Outer courtyard 4 Tanabi 5				Period
				Qajar
Qadaki	Amirnezam Garousi	Ganjeizadeh	Behnam	House
				Pahlavi
Rastegar	Lalehei	Neishabouri	Parvin Etesami	House

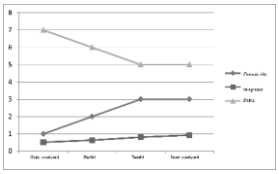
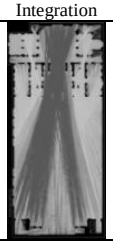
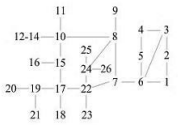
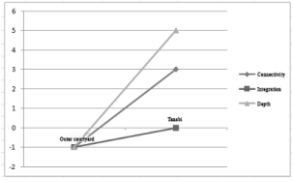
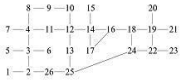
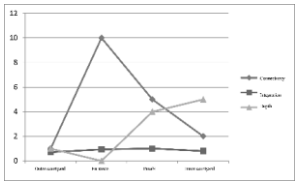
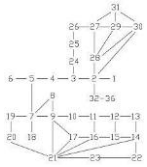
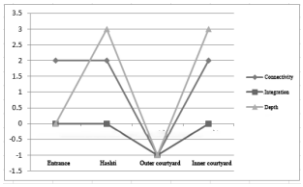
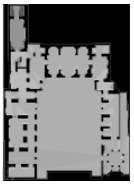
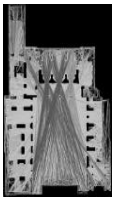
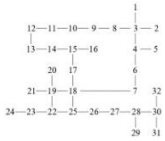
T4. Quantitative analysis of changes in the spatial structure of Qajar and Pahlavi houses

The quantitative analysis of the selected houses shows that spatial elements (entrance, Hashti, outer courtyard, Tanabi, and inner courtyard), form, shape and elongation of houses, spatial hierarchy, constructed facades, building orientation, neighborhoods, the place of the entrance and its multiplicity, and the place of spatial elements with regard to the main and secondary axes in the Qajar and Pahlavi periods is influential in the way of spatial connection and human behavior. Based on the analysis of ground floor plans, the existence and elimination of some main spaces in the Qajar and Pahlavi periods have had beneficial effects on spatial connection and human behaviors in old houses. The analysis of these selected spaces in the form of graphs, charts and numerical data can be found in Tables 5 to 10.

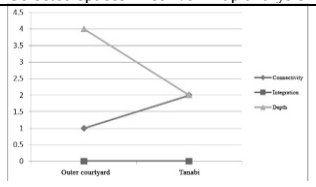
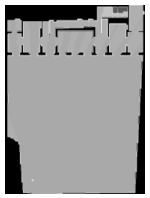
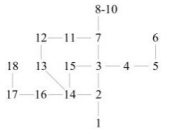
Quantitative analysis based on graphs and charts

Using specialized software designed for the quantitative analysis of space syntax, it was revealed that changes or removal of some main spaces affect the spatial connection and human behaviors in old houses. The level of effectiveness is determined by the intensity of hot and cold spots and color spectra in graphs, and the lines and numerical data of charts in Tables 5 and 6. This data was obtained from the analysis of justified graph, integration, visual step depth, isovist analysis and convex map analysis. At the beginning, since the analysis of space syntax parameters is done according to and with the help justified graphs, they were drawn to better show the relationships of interior spaces. These graphs show the continuity limit of nodes and the shortest distances between them. According to the justified graphs, in the Qajar period, the continuity of spaces was greater and the distances between them were less. As we approach the end of the Pahlavi period, the continuity of spaces decreases and their distances increase. Based on the comparison of integration graphs, the intensity of hot spots to cold spots in the Qajar period is higher than the Pahlavi period, which shows the great depth of spaces and spatial connections in the Qajar period. In analyzing the graphs of visual step depth, the entrance was considered as the base and starting space. In this graph, the change of directions from one point to another is shown by color spectra. The larger the color spectra, the greater the change of direction, and vice versa. According to the obtained graphs, the change of direction in Amir Nezam and Qadaki houses, which are related to the Qajar period, is greater than other houses including those belong to the Pahlavi period. In the graphs of isiovist analysis, as we move from the Qajar period to the Pahlavi period, the number of

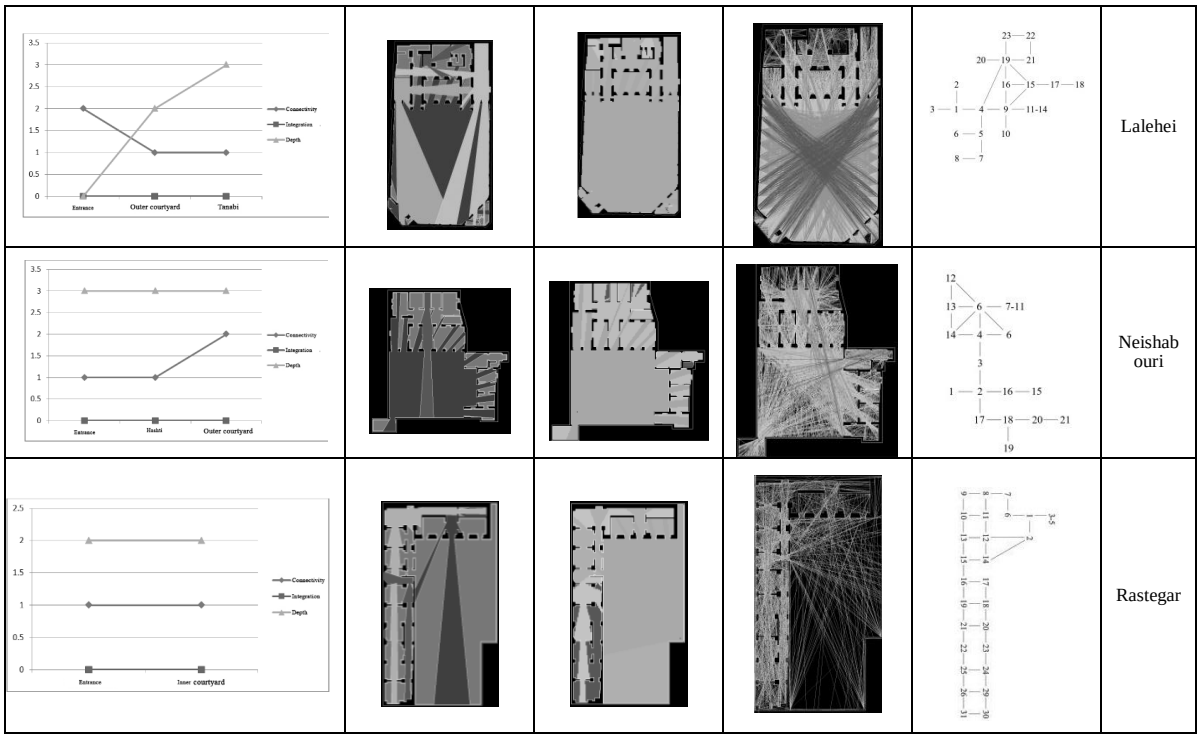
specific points for visual access increases, which indicates the weakness of physical spaces in terms of human communication in the houses of Pahlavi period. In the graphs of convex map analysis, which was obtained according to the selected spaces in the study samples of houses of both periods, the numerical values of the parameters of spatial relationship, integration and depth are shown in linear groups. The analysis of these parameters is described in the next section.

Selected spaces in convex map analysis	Isovist analysis	Visual step depth	Integration	Justified graph	Name
					Behnam
					Ganjeiz adeh
					Amirnez am Garousi
					Qadaki

T5. Quantitative analysis of changes in the spatial structure of houses of the Qajar period.

Selected spaces in convex map analysis	Isovist analysis	Visual step depth	Integration	Justified graph	Name
					Parvin Etesami

T6. Numerical analysis of changes in the spatial structure of Pahlavi houses



T6. Numerical analysis of changes in the spatial structure of Pahlavi houses.

Quantitative analysis of selected spaces based on numerical data

By comparing the ground floor plans of selected houses of Qajar and Pahlavi periods concerning spatial connectivity, integration and depth, we can qualify the effect of existence, removal and absence of some main spatial elements (entrance, Hashti, inner courtyard, outer courtyard and Tanabi) on the spatial connection and human behaviors. According to Tables 7 and 8, the results of the numerical data are obtained and presented in Table 9. According to Table 9, with regard to the parameter of connectivity in the selected houses, it is determined that the connection of spaces in the houses of the Qajar period (with the numerical value of 2.62) is more than the houses of the Pahlavi period (with the numerical value of 1.29). This high level of connection is a sign of privacy in the houses of the Qajar period. In addition to this, it indicates the activity of space areas, ease of circulation in spaces, and the strong connection of spatial structure which have created public, semi-public, semi-private and private spaces in the houses of this period.

The parameter of integration is also higher in the houses of the Qajar period (with the numerical value of 0.78) than the houses of the Pahlavi period (with the numerical value of 0.67). This difference is due to the existence of a spatial hierarchy that has caused the multiplicity of spaces with spatial classifications and arrangements in the structure of houses. Therefore, it was necessary to walk a long distance from the entrance before reaching the private spaces. As a result, the higher integration of the Qajar houses increases the level of their privacy and introversion.

The parameter of depth in the houses of the Qajar period (with the numerical value of 7.76) is more than the houses of the Pahlavi period (with the numerical value of 2.45). This has enriched the physical spaces and created spatial diversity in the spatial structure of the houses of the Qajar period. In addition, the separation of public spaces from private spaces increases the spatial hierarchy, reduces the amount of access and permeability to private spaces, and ultimately increases the privacy of homes in

this historical period. Low numerical values in the Pahlavi period indicate a decrease in the degree of privacy and a tendency to extrovert architecture in this period. Although in both historical periods, the numerical values of the connectivity and integration are greater than the numerical value of the depth, as we approach the Pahlavi period, there is a decrease in the depth of the spaces that increases the necessity of public spaces. This is due to the changes that are made in the physical plans and spaces of Pahlavi houses where public spaces replace the private spaces. Therefore, the elimination of some public spaces that act as intermediate spaces to reach private spaces has disrupted the spatial hierarchy and reduced the depth, which has resulted in a decrease in the degree of privacy and introversion in Pahlavi houses.

		Entrance				Hashti				Inner courtyard			
Period	Name	No.	Connectivity	Integration	Depth	No.	Connectivity	Integration	Depth	No.	Connectivity	Integration	Depth
Qajar	Amirnezam	1	10	0.932743	0	-	-	-	-	0	1	0.708643	1
	Behnam	-	-	-	-	1	2	0.634049	6	5	3	0.923506	5
	Qadaki	3	3	0.645746	1	2	2	0.540252	3	0	-1	-1	-1
		4	1	0.529762	2								
		8	2	0.436524	4								
	Ganjeizadeh	-	-	-	-	-	-	-	-	-	-	-	-
Pahlavi	Parvin	-	-	-	-	-	-	3-	-	-	-	-	-
	Lalehei	1	3	1.004511	1	-	-	-	-	-	-	-	-
		3	1	0.726949	2								
	Neishabouri	2 & 3	1	0.851237	3	1	1	0.851237	3	-	-	-	-
	Rastegar	1 & 3	1	0.516354	2	-	-	-	-	0	1	0.516354	2

T7. Numerical data obtained from the selected spatial elements in the plans of Pahlavi and Qajar houses.

		Outer courtyard				Tanabi			
Period	Name	No.	Connectivity	Integration	Depth	No.	Connectivity	Integration	Depth
Qajar	Amirnezam	0	2	0.802434	5	6	5	1.010472	4
	Behnam	0	1	0.514925	7	3	3	0.809168	5
	Qadaki	2	2	0.540250	3	-	-	-	-
	Ganjeizadeh	0	-1	-1	-1	3	3	1.009661	5
Pahlavi	Parvin	0	1	0.458958	4	2	2	0.785328	2
	Lalehei	0	1	0.708309	2	2	1	0.708309	2
	Neishabouri	0	2	0.868971	3	-	-	-	-
	Rastegar	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-

T8. Numerical data obtained from the selected spatial elements in the plans of Pahlavi and Qajar houses.

Period	Name	Connectivity	Integration	Depth
Qajar	Amirnezam	4.5	0.85	2.5
	Behnam	2.25	0.7	5.75
	Qadaki	1.75	0.6	1.83
	Ganjeizadeh	2	1	2
	Total average	2.62	0.78	7.76
Pahlavi	Parvin	1.5	0.6	3
	Lalehei	1.33	0.75	1.83
	Neishabouri	1.33	0.85	3
	Rastegar	1	0.5	2
	Total average	1.29	0.67	2.45

T9. Total average of the numerical data obtained from the Pahlavi and Qajar houses.

Conclusion

Since almost all of the main spaces of Tabriz old houses are located on the ground floor, the below results, which were obtained from the study of this floor in the houses of the Qajar and Pahlavi periods, can be generalized to most of the houses in this period. Based on

the findings of the present study, spatial hierarchies and their physical changes in the houses of the Qajar and Pahlavi periods have played a significant role in human communication. In addition to the change in the placement of spaces, the removal and relocation of some important influential elements in the plan of the studied houses, has had a tremendous impact on human communication. According to the numerical results obtained from the quantitative analyzes of Table 9, the following spaces were respectively the most influential factors to establish human communication in the Qajar period compared to the Pahlavi period: entrance, Hashti, outer courtyard, Tanabi and inner courtyard. Moreover, based on Table 10, it can be concluded that houses in the Qajar period were built based on the regular and traditional spatial hierarchy of their time. Although the spatial depths of the houses were high based on the indigenous culture of the time, the level of relationship between the spaces was also observed. Although, it is rare to see the signs of modern architecture in the late Qajar period, in, this type of architecture, which was an imitation of the methods used by Western architecture, is quite evident the late Pahlavi period. In addition to this, while the decrease in the depth of spaces has led to an increase in spatial relationships and human behavior, the removal of some of the main elements has led to the loss of privacy. As a result, in the Pahlavi period, the Iranian architecture has started to fade, and the emergence of extrovert architecture has diminished the privacy of Iranian houses. It can be even said that the architectural style of the houses of the first Pahlavi period has started the imitation of Western architecture and the absence of identity in the architecture of the houses of the present era. According to the results obtained from the analysis of the studied houses, it seems that the structure of space and its configuration played a significant role in increasing the level of privacy and maintaining extroversion. This was made possible by factors such as the observation of the spatial hierarchy, the existence of intermediate spaces as public areas to reach the private areas, the existence of public areas, the strong connection in the structure of houses, the valuation and prioritization of spaces, and the observation of the level of accessibility and permeability. The observance of these factors, which are rooted in the past culture, beliefs and lifestyles of the Iranian people, can increase the satisfaction of the residents.

	Parameter						Conclusion
Period	Connectivity		Integration		Depth		
Qajar	Distance of spaces	Lower	Continuity of spaces	Higher	Spatial depth	High	Due to the multiplicity of physical spaces and the creation of spatial hierarchy and introversion in the houses of this period, spaces are deeper. As a result, the visual access of the spaces decreases and the privacy increases.
	Human relationships	High	Spatial relationships	High			
	Spatial connections	Higher	Integration	Higher			
Pahlavi	Distance of spaces	High	Continuity of spaces	Lower	Spatial depth	Lower	By removing the main physical spaces, the spatial hierarchy has been weakened, reducing spatial privacy and promoting extroversion in the houses of this period. As a result, spatial depth is reduced and visual access is increased, which reduces privacy and increases public spaces.
	Human relationships	Lower	Spatial relationships	Lower			
	Spatial connections	Lower	Integration	Lower			

T10. Comparing the physical characteristics and relationships of Qajar and Pahlavi houses.

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