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Studying the Cognitive Specifications of Perceiving Environment in Older Adults and Their Behavior Using Cognitive Maps, Case Study: Kahrizak Nursing House

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Abstract

Cognitive aspects in different fields of older adults' perception of architecture were discussed to determine cognitive specifications of the older adults living in Kahrizak Nursing Home (Tehran) using cognitive maps. The association between older adults' cognitive maps and spatial structure of the nursing home was also examined. In terms of nature, this study is an applied-theoretical work. The study was carried out in two phases namely, qualitative and quantitative; and as to the objective, the study was an applied work. Data gathering was done through a library-document method and the status quo of the nursing house was examined through field observations. In addition, interviews were conducted for data gathering. The space syntax approach was used for analyzing the spatial structure of the nursing home. Simulations were carried out in Depth Map and as the results indicated the highest integration was equal to 7.3 and the mean value was equal to 3.5. The maximum and mean values of connectivity were 20 and 8.6 respectively; these figures for choice were 67 and 11.06 respectively. Maximum and mean values of total depth were 257 and 138.7 respectively. The results indicated a significant relationship between the cognitive maps of the older adults and the analyses based on the space syntax method. This can be attributed to the physical structure of architecture in Kahrizak Nursing Home.

Keywords:*-Space perception, cognitive maps, older adults, space structure, space syntax*

Introduction

Population aging is a major problem of the current century. Changes in the traditional structure of families, lower income, losing spouse, lack of sense of security in single older adults, and lack of social security are all obstacles in the way of having an independent life in older adults. Therefore, it is imperative to study and examine older adults nursing homes. Older adults' perception and cognition of their environment and architectural spaces affect fulfillment of their physical, mental, and social needs and expectations regarding cognitive perceptions. The perceptual and cognitive specifications of older adults living in nursing homes were examined using cognitive maps. To this end, Kahrizak Nursing Home was selected as a case study. To determine countermeasures to deal with the multi-aspect social problems caused by aging, there is a need to conduct projects to improve spatial cognitive capabilities in older adults who might suffer relatively declining capabilities. The present study is concentrated on the perception of physical spaces with an emphasis on some mental processes (feeling, perception, diverse aspects of memory, organization of purposeful and adaptive behaviors regarding the environment) in older adults living in nursing homes. To this end, cognitive maps were used. Therefore, the objective of the study is to provide a definition of objective space specifications using the living spaces of a nursing home. To define perceptual spaces in older adults, cognitive maps were used. Through comparing the cognitive maps and analytical diagrams and tables generated in Deep Map, the relationship between space physics and cognitive maps was examined. It is our intention to place physical, mental, and behavioral aspects in older adults within one psychological framework. The framework is based on information obtained through examining cognitive and behavioral patterns of older adults. The objective is to achieve an understanding of the elements of mental aspects of senescence. Specifically, our focus is on nursing homes and given the current policies regarding senescence, this study can be considered as an ongoing study with an emphasis on the importance of physical and social infrastructures of nursing homes to improve quality of life of older adults. The study tries to extract users' perception and experience of their environment. Therefore, the actual specifications of the spaces under the study were identified and evidence of the users' demands were collected. Space syntax theory tries to create a causal relationship between physics of architecture and human society (Bafna, 2003). According to the theory, along with physical aspects, the configuration of space also has a notable effect on human activities (Vaughan, 2005). Space syntax method enables designers to predict users' behaviors in the environment. Thus, this model can be used in the designing process to create an interactive relationship between the physics of space and behavior of users. The concept of space syntax was first introduced by Prof. Bill Hillier in the UK in 1970. He believed that, to some extent, space can affect man's behavior (Chen, Junzhang, & Liang, 2022). Stedman, Hillier, and Hanson conducted studies in this field, and in his book "architecture morphology" Stedman tried to introduce the theory (Stedman, 1989) by covering mostly the theoretical aspects of architecture morphology. He also covered different probabilities in architectural space combinations. Bill Hillier and Hanson explained this theory in their book "Logic of social space" and offered justification diagrams to simulate spatial patterns (Hillier and Hanson, 1984).

Dawes et al. (2021) introduced space syntax as an efficient method to analyze the specifications of spatial structure and used axial analysis and the parameters for their spatial analysis. Space syntax theory seeks a way to describe and analyze urban and/or architectural configured space. The description can uncover the social logic deep inside the lower layers and guides us toward further theories to elaborate social and cultural behaviors (Groat & Wang, 2013).

Developing cognitive maps is a process in which an individual gleans, encodes, memorizes, remembers, and decodes information regarding their position relative to the physical environment. The term cognitive map is widely used in many fields of science like environment psychology, social psychology, anthropology, geography, cognitive studies, urban planning, and architecture. Cognitive maps are mental constructs that encompass all the internal processes that enable an individual to collect and manipulate information about the nature of the spatial environment (Long, 2008). Cognitive maps are formed relative to man's mental processes. They are more flexible compared to other types of mental expressions and help an individual to navigate and form routes inside familiar spaces (Jacobs & Schenk, 2003). Analysis of cognitive maps highlights problems and issues and each cognitive map is abnormal to some extent so that it is an individual's attempt to represent a cognitive imagination (Downs & Stea, 1973). Lynch's map image typology (1960) is the most commonly used technique for analyzing cognitive maps. This approach filters specific elements through concentrating on the main recorded elements; afterwards, the maps are analyzed to extract the quantity of the recorded elements. Loyd & Steinke (1985) showed that cognitive maps and images are the same between individuals with identical knowledge, beliefs, and experiences. According to Freundschuh & Kitchin (1999) cognitive maps are a developed multidisciplinary field with a wide spectrum of local benefits in which geography is a key element. Kitchin argued that studying cognitive maps has theoretical benefits for our perception of spatial decision making, particularly when it is about the ability to find routes, migration options, consumer behavior, and decisions and behaviors of leisure time (Kitchin, 1997).

The importance of this study lies with three aspects. Aspect one is a theoretical aspect, so it enables us to collect experimental evidence that supports the key role of spatial syntax of the environment in forming cognitive maps. Aspect two is a psychological aspect so that it enables us to test the efficiency of a cognitive approach to spatial perception and intelligibility of the environment. Aspect three is an applied aspect so that using the space syntax method, we can discover the relationship between older adults' perception and cognition of the physical specifications of architecture. By representing the relationships between spatial syntax as measured using cognitive maps in a readable and easy to understand manner, designers can use this method to perceive and evaluate the quality of their design and spatial syntax. There is a paucity of studies on the dominant role of spatial syntax in man's spatial experience. Cognitive map processing is considered a tool to measure how cognition and perception of the user regarding an environment affect their performance in using the environment. One aspect of the importance of this paper is reporting data about different ways older adults recognize their environment. Subjective representation of spatial syntax has been neglected in many cognitive studies. To have an efficient approach to the multi-aspect social problems of aging, we need to conduct projects to improve cognitive capabilities of living spaces in older adults, with degraded cognitive capabilities, in the modern age.

The main objective of this study was to identify the elements affecting space perception and recognition in older adults using cognitive maps. In addition, this study tries to give a picture of older adults' awareness of architectural spaces and their environment.

Methods

The study was carried out as a theoretical-applied work through a combined method. In terms of nature, the study is a combination of simulation and descriptive-analytical methods. Data gathering was done through the library method and when needed, field observation was also used.

Cognitive maps

The older adults living in Kahrizak Nursing Home were asked to draw their living space, including indoor and outdoor spaces. They were asked to picture all elements they can draw using shape or writing. There was no limitation in the type of drawing or the time. Cognitive maps were examined and the elements and spaces were compared to the plan of the compound.

Simulation and analysis

After completion of maps, the compound plan was analyzed in Depth Map and the output maps and tables were used for logical reasoning analysis. Given the cognitive maps, axial analysis was conducted using integration, connectivity, choice, and total depth parameters. The hypothesis of the study states that there is a relationship between space syntax and cognitive maps of older adults.

Eventually, space syntax analyses were compared to the cognitive maps drawn by the participants and the relationship between cognitive maps and space syntax was examined.

The study site

Kahrizak Nursing Home is located on Dr. Hakimzade Blvd., further up Kahrizak Town, Qom Old Rd., Tehran (Fig.1). The nursing home was established in 1973 as the second nursing home in Iran after Rasht nursing home. Kahrizak compound is built on a plot of land with an area of 420000m2 and a roofed area of 180000m2 as the largest nursing home in Iran. Figure 2 illustrates an aerial view of the compound. It is notable that the compound also hosts disabled and MS patients. The disabled and MS patients have separate dormitories, while they share the workshops and medical areas. Currently, 1680 older adults live in Kahrizak Nursing Home. The nursing home is a charity organization and the users are mostly from low and middle economic classes. In addition, most of the residents choose life in the compound as their last option.

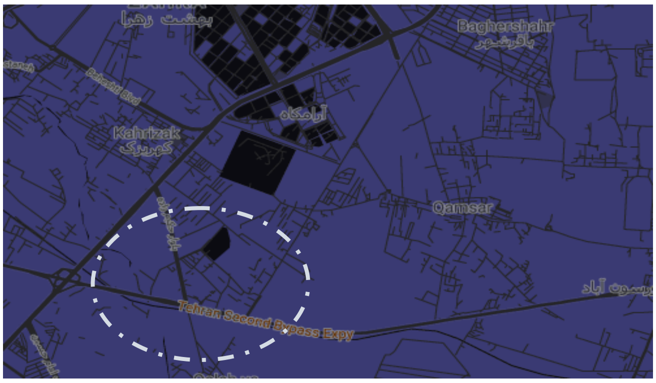

Figure 1- Stud site (www.googleearth.com, 2022)

Figure 2- An aerial view of Kahrizak Compound (Kahirzak Charity, 2022)

Figure 3- Plan site of Kahrizak Compound (authors)

The GIS maps of the compound were provided by Tehran Municipality and modified based on available maps and the current status of the compound.

Study population

The participants were 40 older adults in the age range of 60-80 years old. All the participants had general consciousness and were able to walk with good cognitive and perceptual performance. The participants all expressed their desire to participate in the study.

Cognitive maps

The participants were asked to sketch their environment including spaces outside the compound along with all the elements in their minds. There was no limitation in terms of drawing the maps. The maps were examined and the spaces mentioned or missed by the participants were highlighted. Figure 4 illustrates some of the maps drawn by the participants.

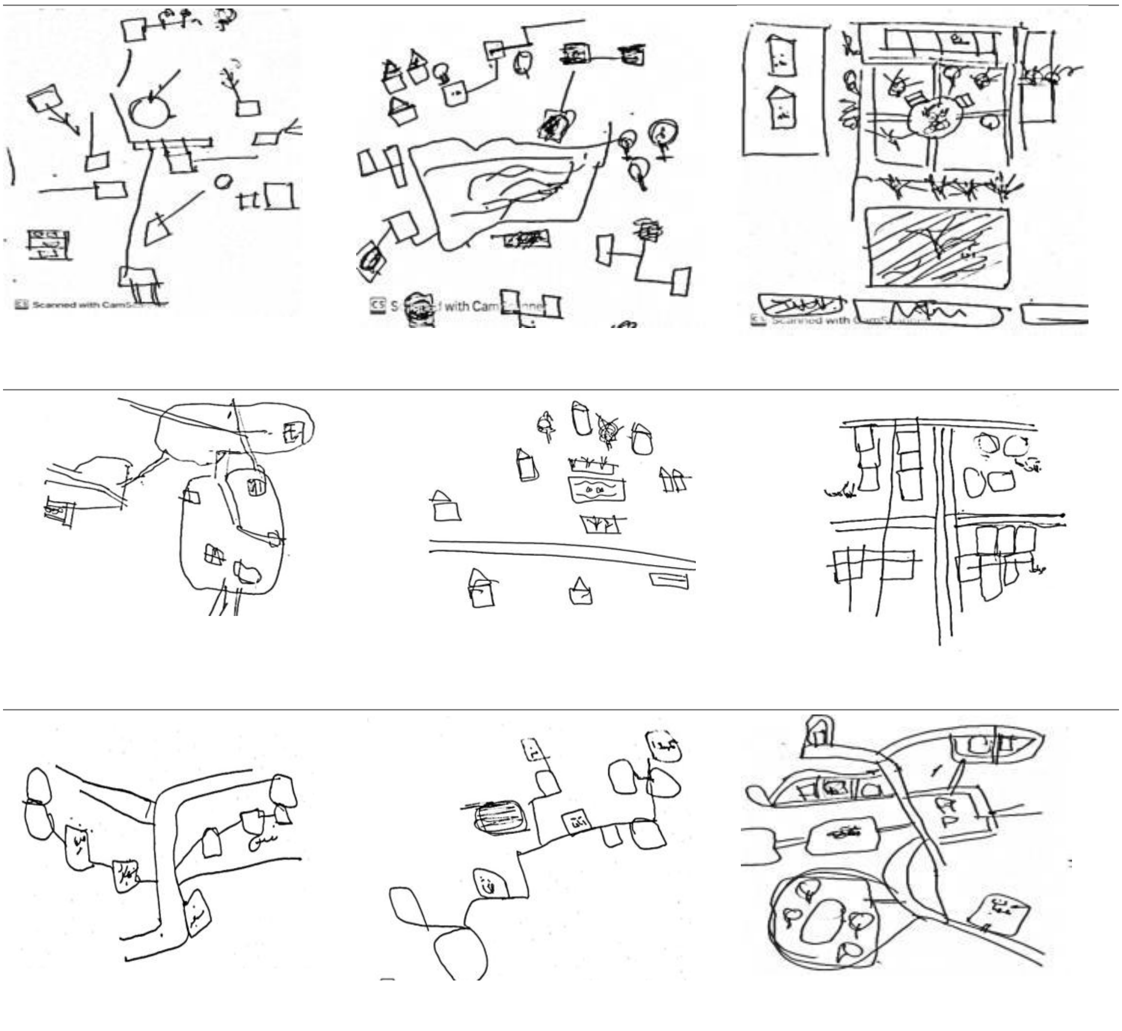

Table 1- Examples of cognitive maps by the participants

Results

Four parameters were used in axial analysis:

1. Integration

2. Connectivity
3. Choice
4. Total depth

Integration

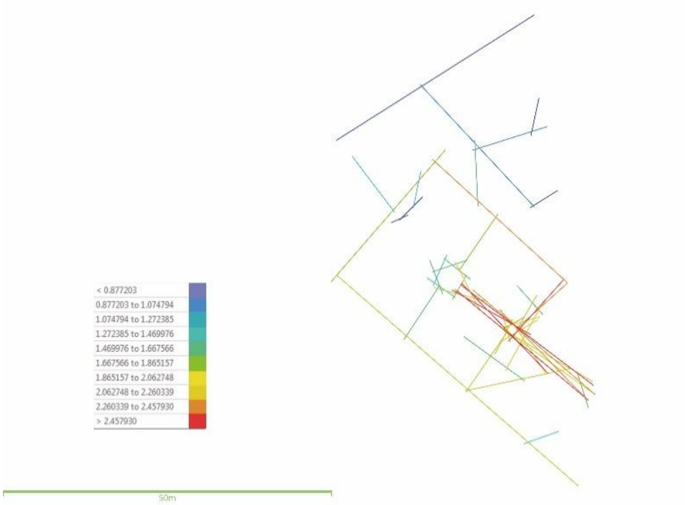

Figure 5- Analysis of integration in the area under study

Figure 5 illustrates the analysis of integration in the compound. The parameter indicates integration in the area under study. Warmer colors indicate routes with higher integration (access and presence in the space are defined by integration). Integration was examined at integration HH and integration R2 levels.

Table 1- Routes analysis based on integration index

Integration	Routes
0.210897	Min
7.33489	Max
3.5722	Mid
7.33	Route 1
5.65	Route 2
5.34	Route 3
4.32	Route 4

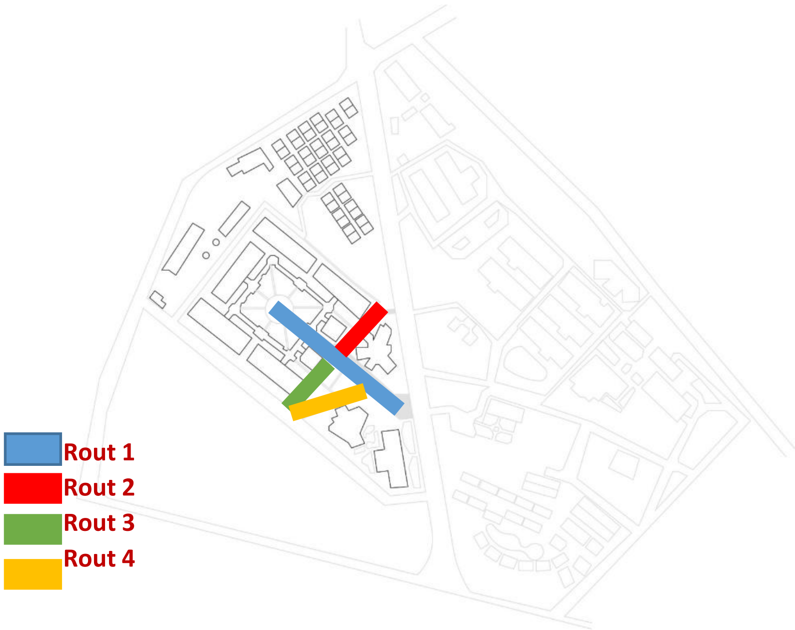

Figure 6- Routes listed in the Table above are highlighted

Given the integration analyses and Table 1, the routes leading to the part of the dormitory space that surrounds the water display (route 1) are mentioned in the majority of cognitive maps (integration = 7.3). Route 4 leading to the workshop area, despite its unique external architecture features, is not mentioned in the cognitive maps and has a low attendance (based on field observations). Therefore, to make sure of older adults' attendance, the integration level must be at least 7.3. Figure 6 highlights the information in Table 1 on the map of compound.

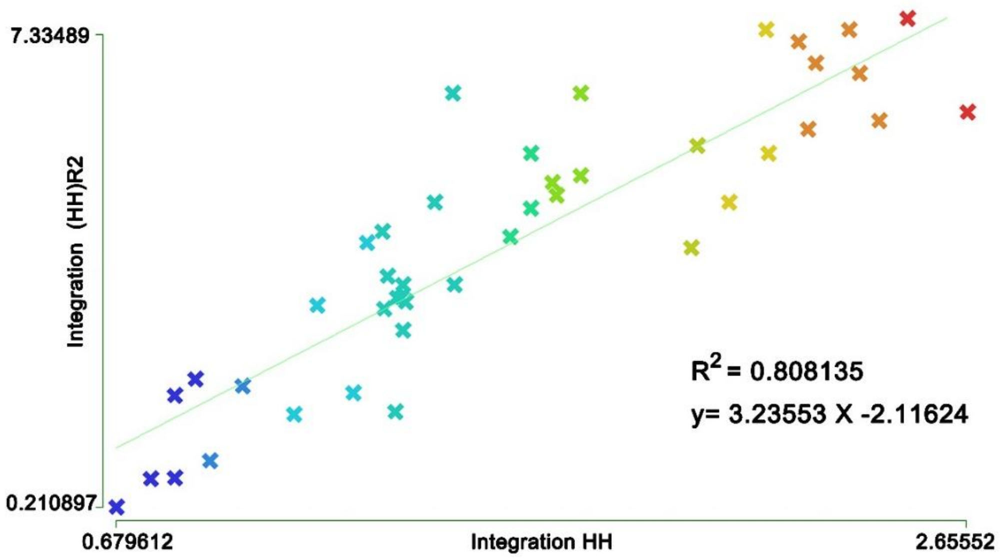

Diagram 1- The correlation of integration at integration HH and integration R2 level

Diagram 1 illustrates that the integration of the compound is high. Spots with warmer colors highlight routes with a higher integrity and a higher attendance in the space. The value of R2 is almost close to 1. The area marked in blue in Fig. 6 has the highest integration of the compound.

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Connectivity

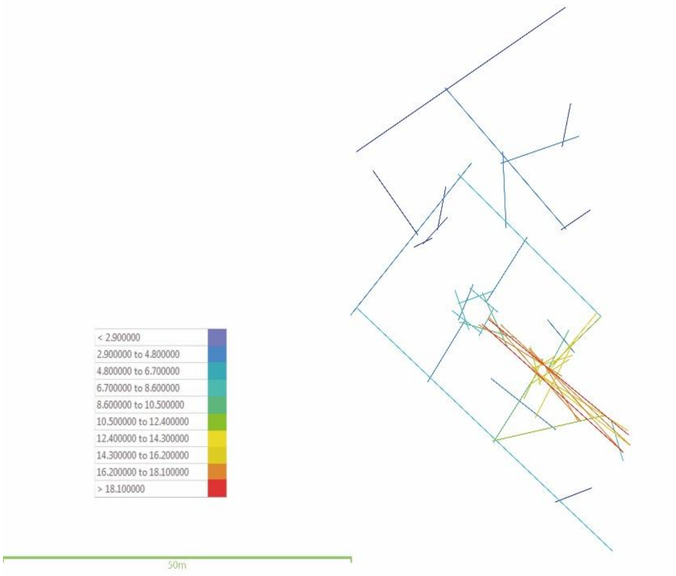


Table 7- Analysis of connectivity in the area under study

Figure 7 illustrates connectivity in the area under study. The warmer colors illustrate routes with a higher connectivity. Table 2 lists the data of connectivity in the area under study. Clearly, the minimum and maximum connectivity in the compound are equal to 1 and 20 respectively.

Table 2- Routes analyses based on connectivity

Routes	Connectivity
Min	1
Max	20
Mid	8.6
Route 1	20
Route 2	16
Route 3	14
Route 4	11

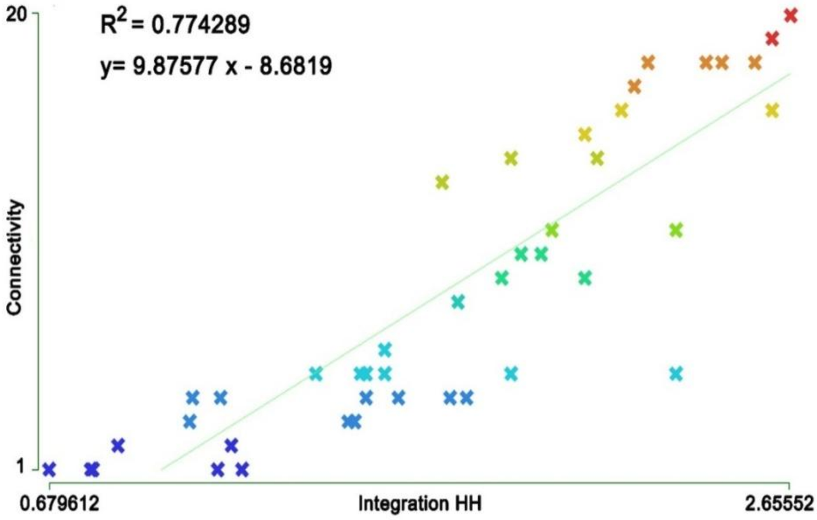


Diagram 2- Legibility correlation

Diagram 2 illustrates correlation coefficient (R2) of the connectivity diagram of the perception of movement spaces (space intelligibility is important in terms of the relationship between connectivity and integrity). Perception level in these spaces is at a moderate level with a relatively low intelligibility so that the users do no comprehend the general structure of the compound.

Distribution of the points with warm colors indicate routes with good legibility in the compound.

Given the above findings and the cognitive maps, a minimum legibility of 20 is needed in the space to make it comprehendible for older adults.

Choice

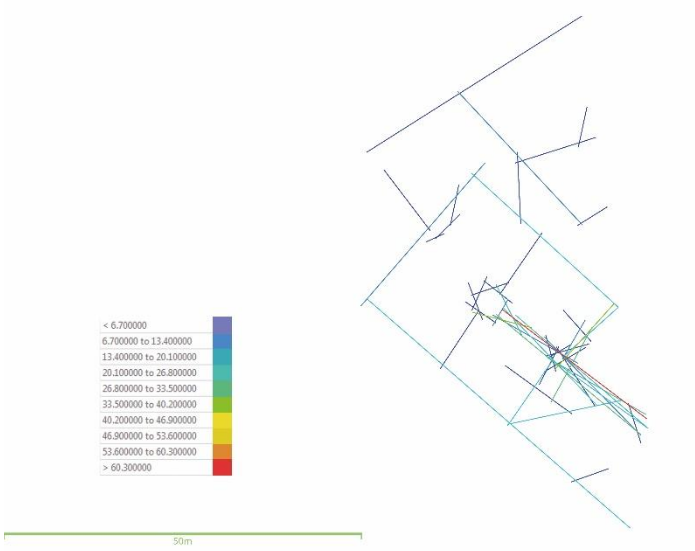


Figure 8- Analysis of choice in the area under study

Given the analyses of choice illustrated in Figure 8, the main axis (route 1) has a high choice. As highlighted in the map, routes with warmer colors have a higher choice score and routes with colder colors have a lower choice score.

Table 3- Routes in the area under study based on choice

Routes	Choice
Min	0
Max	67
Min	11.06
Route 1	67
Route 2	38
Route 3	20
Route 4	16

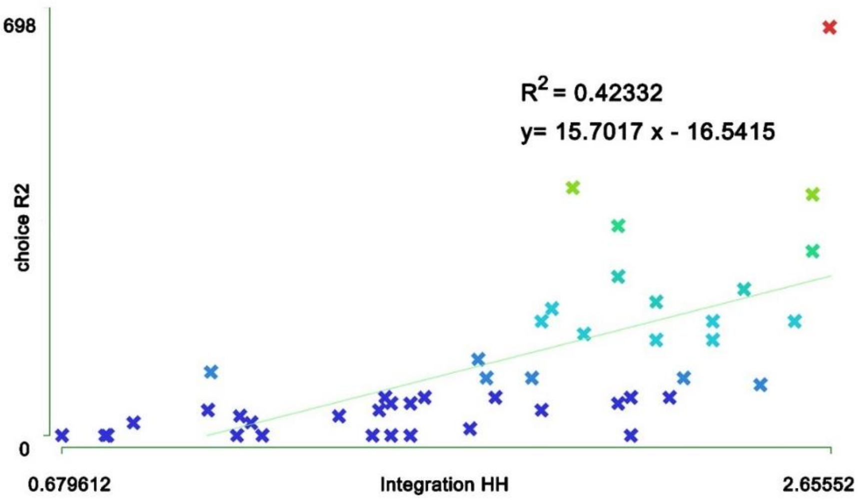


Diagram 3- Correlation of choice and attendance

Diagram 3 shows the correlation between choice and integration, which highlightschoice of the space. As illustrated, the spaces in the area under study have a low value for gathering. A few spots with warmer color at the top of the diagram indicate people have an easier attendance at those spots.

Given the analyses (Table 2), the minimum value for 67 is needed for selection parameters to make sure of attendance of older adults. Thus, route 1 has a higher choice score (the route leading to the center of the yard and water display).

Total depth

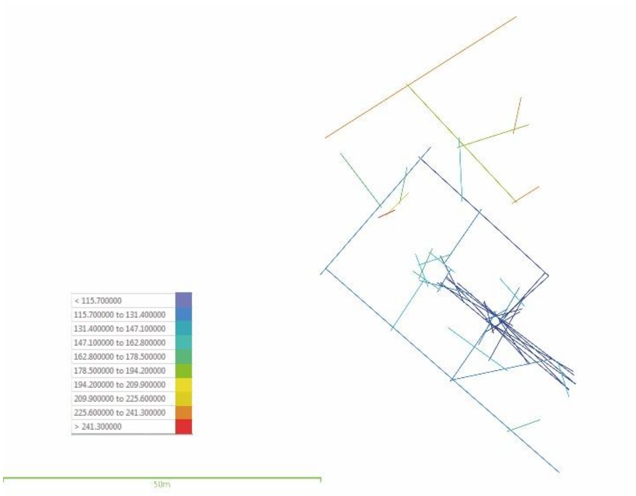


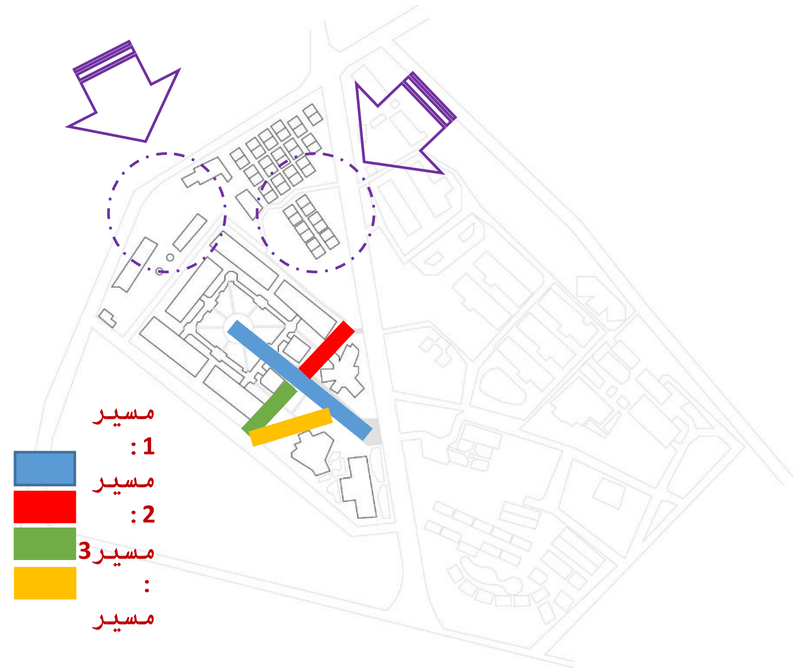
Figure 9- Total depth in the area under study

Total depth indicates accessibility depth of the space. The warmer colors have a higher total depth and attract a lower level of traffic. These spaces are far from the gathering spaces. Figure 9 illustrates total depth in the area under study.

Table 4- Analysis of routes based on total depth

Routes	Total depth
Min	100
Max	257
Mid	138.7
Route 1	100
Route 2	101
Route 3	120
Route 4	117

Based on total depth analysis, it is clear that the sections with high total depth have a less chance to be used. This means that allocating rarely used sections of the plan to group activities can improve the choicescore and



use of such spaces.

Image 10- Analysis of the area under study based on total depth

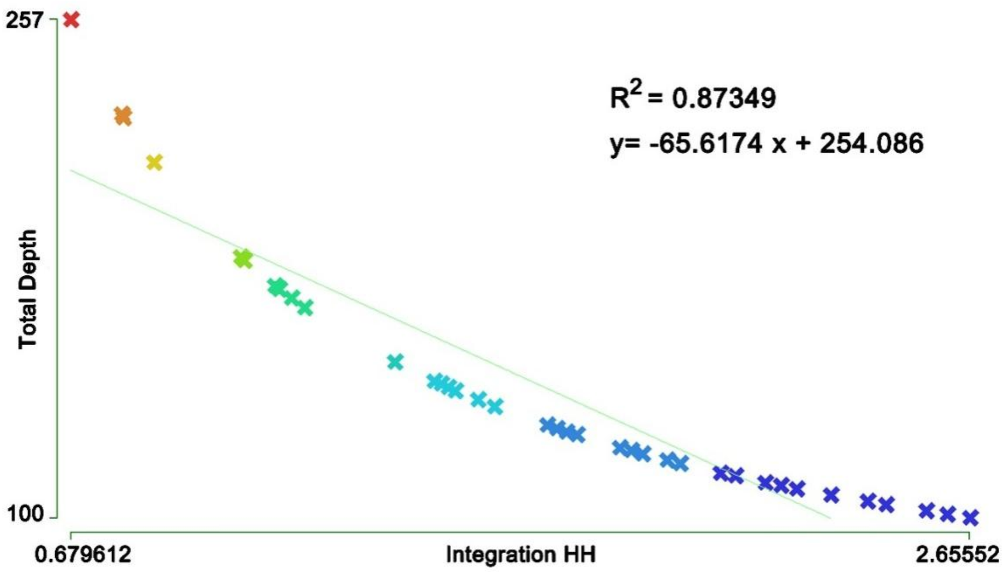


Diagram 4- Correlation between total depth in movement space

Diagram 4 illustrates the correlation of total depth in the movement space, which indicates ease of access. Correlation coefficient (R2) based on the diagram shows that most of the spaces of the compound have an easy access.

The spots marked by warmer colors indicate the routes with easier access. Routes with blue color lead to the central yard and water display, and based on the cognitive maps,are highlighted by all participants.

Discussion

Cognitive maps technique was used to examine older adults' awareness of their living space. The importance of physical spaces used for everyday activities and the effect of such spaces on human behavior are undeniable. The environments with inefficient design or environments with inefficient adaptability have a negative effect on users' awareness and cognition. This was the issue examined using space syntax analyses and the parameters. The results showed that the physical specifications of the compound had a role in the wrong perception of the space. Through modifications in the architectural spaces of the nursing home, it is possible to improve attendance of older adults in common spaces. It is notable that the aging process affects physiological and mental capabilities of older adults so that senior citizens are more prone to depression. Such changes are evident in lower desire and energy to undertake everyday activities. The cognitive maps showed that many of the available spaces in the nursing home were neglected in the mental image of the participants and such spaces were rarely used by them. This indicated a low level of cognition and awareness of living space in the participants. We cannot attribute this finding to the aging process of the participants as Depth Map plan analyses supported the drawbacks of the architecture of Kahrizak Nursing Home. In addition to the architectural features, evidence showed the strict safety and health standards of the environments under study had had a negative effect on independence of older adults. There are novel tools to examine the physical environment of houses and nursing homes which merit further studies and practical uses. Apparently, there is a need to introduce fundamental changes in the way of controlling older adults using new and indirect approaches. Our findings highlighted the importance of the physical environment in older adults' recognition of their space. Older adults living in nursing homes mostly spend most of their time inside the facilities. Therefore, designers and providers of care services must pay more attention to the improvement of the living space quality in terms of design features of the environment.

The analyses showed that the workshop spaces (route 4, leading to the workshop space) were not attractive for the participants. While the officials insisted that older adults used the workshops, our observations did not support their claim that the majority of the users of workshop areas were disabled. Even the chance of earning revenue was not enough to motivate the older adults to use workshop spaces. In addition to space syntax analyses that showed the route leading to the workshops (route 4) had a low score in terms of choice, integration, and total depth, a comparison with the cognitive maps indicated the minimum integration level to make sure of users' attendance and access was equal to 7.3. Connectivity was high in some sections of the compound such as the main route at the center of yard; however, intelligibility of the space was low in general and the older adults were not able to comprehend the structure of the compound. As the results showed, the minimum intelligibility of the space must be equal to 20, to make a space understandable and intelligible for older adults. Based on choice and attendance analyses, the minimum choice score to make sure of attendance and choice of older adults was equal to 67. Total depth parameters represented spaces with less traffic and far away from gathering points. Such spaces were mostly neglected in the cognitive maps and were not memorized by the participants (mostly the spaces at the end of the compound and densely populated dormitories).

The future works on older adults' cognition of their environment and environment design for older adults needs to take into account perceptual cognitive differences caused by aging. In addition, there is a need to pay more attention to urban design and planning to facilitate location orientation in older adults. Historic sites, natural landscaping, buildings with higher usability, and more direct access can improve urban intelligibility in older adults. The experimental technique of cognitive maps introduced by Lynch, which was further developed by

Epliard, tries to extract user's perception of the environment they experience. Therefore, the technique identifies the actual specifications of space and provides evidence of expectations.

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