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RESEARCH ARTICLE

Urban green parks as sociomental landscapes: Understandings from Iran's case study

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ABSTRACT

This paper aims to investigate the impact of complexity and mystery on the perceived legibility of citizens in urban parks. The theoretical framework is based on Rachel and Stephen Kaplan's theory (four cognitive states) and Lynch's legibility theory. The method is descriptive correlational. Data collection was done through a survey questionnaire and mental maps. The paper uses Lynch's mental maps and asks people to draw some aspects of the parks they remembered the most and compare the results with the surveys. The data analysis uses descriptive and inferential techniques as well as logical reasoning. The research claims a significant correlation with a higher-than-average coefficient between the legibility indicators (path, edge, node, district, landmark) and complexity and mystery in urban parks. The conclusion is that districts in urban parks have the most significant impact on the overlapping of citizens' collective mental maps. Landmarks, paths, edges, and entrances are almost equally and moderately fuzzy-scale on the legibility of citizens' mental maps in urban parks. Nodes play less of a role in citizens' collective mental maps than other park elements. Parks with too many entrances, non-linear paths, indistinguishable districts, and undefined edges are not perceptible to citizens, and citizens' perceptions of space differ significantly from the existing reality. The correlation between legibility dimensions, such as edges, nodes, landmarks, districts, paths, and entrances, is higher than the fuzzy scale average. Moreover, the legibility in each dimension will affect legibility dimensions a lot. Lynch's theory of legibility in the spatial perception of parks and Kaplan's theory of complexity and mystery criteria appear to be not fully responsive. It differs based on the features of each park, such as openness and closeness. For future research, it is better to comprehensively understand by using all dimensions of Kalpan's theory: complexity, mystery, refuge, and prospect.

Keywords: complexity; mystery; mental maps; urban parks; sustainability

1. Introduction

Involving people in urban projects and the use of citizen's views are critical factors for sustainable

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urban society development[1,2]. Considering people's perceptions and their cognition of the environment can play a crucial role in successful urban planning based on people's actual needs[3–6]. One of the most widely studied theories in environmental psychology is the mystery/complexity/legibility/coherence model of Rachel and Stephen Kaplan[7].

The labels used for the informational variables are coherence (immediate understanding), complexity (primary exploration), legibility (inferred knowledge), and mystery (inferred exploration). All four informational variables were suggested as predictors of environmental preferences. One of the critical distinctions between environments was natural scenes or built scenes[7–9].

Related studies showed a weak relationship between legibility and coherence with other preference components[10]. Other studies have also reported the limited impact and non-linear correlation of legibility and coherence with preferences[11–13]. Previous studies by researchers on the spatial qualities of urban parks in Iran show that citizens are compassionate about the mystery and complexity of parks and have considered the imbalance of these two issues as one of the most critical shortcomings of urban parks in Iran[14–17]. Thus, given the importance of mystery and complexity in the attractiveness of urban parks, this study focuses on these two aspects, examining their impact on the formation of socio-cognitive maps of citizens. Also, the two aspects of eligibility and coherence have been controlled, and their effect has been analyzed.

This paper aims to calculate how much complexity and mystery variables affect the perceived spatial cognition of citizens. The amount of perceived legibility by citizens interacts with how much they consider the space desirable. We seek to answer the following questions: What indicators lead to the establishment of complexity and mystery in urban parks? How do complex and mysterious environments influence the formation of socio-mental maps?

Relevant previous studies about this subject are investigated in the **Table 1**:

Table 1. Summary of the relevant studies related legibility and perception of urban parks landscape.

Authors (year)	Year	Discussion	Methodology	Results
Stamps[10]	2004	Mystery, complexity, legibility and coherence: A meta-analysis	Descriptive-analytical	There is a significant degree of heterogeneity in all data for all spaces, both natural and man-made.
Warren et al.[18]	2017	Wormholes in virtual space: From cognitive maps to cognitive graphs	Experimental	knowledge of navigation space is best characterized by a labelled graph, in which local metric information is approximate, geometrically inconsistent, and not embedded in a common coordinate system.
Topcu and Topcu[19]	2012	Visual Presentation of Mental Images in Urban Design Education: Cognitive Maps	Field study	True campus design can be achieved by analyzing the psychology of the space as it deals directly with sensed environment of the urban space. In this sense, it would be logical to assume that when a campus area has a good image, its users will feel more satisfied and prouder of being part of it and this, in turn, can boost its image.
Osóch and Czaplińska[20]	2019	City image based on mental maps	Field study and cognitive maps	The form of transportation around the city has a significant impact on the image of the city. This, within the studied group, is related to the wealth of pupils, and indirectly to the nationality of the respondents, because international students usually use private transport, and Polish students mostly take public transport with all its consequences.
Larsen et al.[21]	2016	Appropriate complexity landscape modeling	Development of mechanical simulation model	We emphasize that there is no single formula for the selection of the

Table 1. (*Continued*).

Authors (year)	Year	Discussion	Methodology	Results
Olazabal and Pascual[22]	2016	Use of fuzzy cognitive maps to study urban resilience and transformation	Social Survey—Fuzzy Cognitive Mapping Approach	optimal level of computational and representational detail that will
Doiran and Kariminejad[15]	2014	Identity and sense of place in new public spaces of urban development	Field study and survey	Identity and sense of spatial belonging are related to the method and manner of environmental design. By promoting the qualitative elements of the urban landscape, such as furniture, identity is strengthened in new spaces.
Sarmadi et al.[16]	2019	A comparative comparison of the components of sensory richness during the transition from garden to park in Tehran	Field study	Human cognition and experience of being in perspective is done through various sensory perceptions such as sight, hearing, smell, taste, touch and mind-dependent senses.
Turk et al.[23]	2015	Cognitive maps based on Lynch's model	Survey	According to Lynch's model: The path, node, edge, district, sign, or landmarks are elements that create spatial legibility and are reflected in cognitive maps of individuals
Zarghami et al.[14]	2018	The role of physical legibility on the security of urban parks	Survey	In the structure of urban parks, spatial legibility components can create different degrees of security in space.
Harris et al.[24]	2017	Green space context and vegetation complexity shape people's preferences	Survey	The development of a wider, more diverse range of urban green space landscapes would encourage a wider range of users, and therefore may increase recognition of the socio-economic value of these spaces and assist in their retention and protection from future urban development.
Ohly et al.[25]	2016	A systematic review of the attention restoration potential of exposure to natural environments	systematic review	-

In reviewing the background of the issue, we concluded that variables related to the parks are general and without considering the environmental factors' impact. This research seeks to fill this gap of the elements of the path, edge, node, district, and sign, and in addition, the entrance to urban parks can significantly impact the formation of mental and social maps. Identified landscape elements could help design the desired urban parks.

In this study, six parks in three cities of Tehran, Shiraz, and Bushehr were selected for the case study. Given that the paper's subject is to examine the relationship between complexity-mystery and socio-mental cognition in urban public parks, these two concepts are discussed as theoretical foundations of the article.

Architects, landscape architects, and urban planners have long advocated the desirability of complexity and mystery as natural and urban landscapes[26–30]. Substantial empirical evidence exists linking complexity and mystery to preferences for natural and urban landscapes[11,12,31,32]. However, within the context of behavior settings in urban parks, knowledge is limited regarding how these qualities are related to preferences and what physical design attributes are fundamental to their perception.

The perceptual and cognitional characteristics of a landscape help us perceive the nature of the landscape, either through our evolutionary history or by cultural experience[17,33–36]. Initially, they evaluated preference studies through empirical models[10,37–40]. we have studied the correlation between natural environmental preferences and the variables of Legibility, mystery, coherence, and complexity[41,42].

Kaplan and Kaplan[7] defined complexity as "the number of different visual elements in a scene: how intricate the scene is; its richness." Mystery relates to a scene's depth and the hidden qualities that may draw one closer to explore and gain more information[10,32,43,44]. Participants rate complexity for physically enclosed scenes lower than for physically open ones[45]. Imagine that being in the setting would result in more outstanding attention restoration[45,46]. Lynch[47] introduces the concept of Legibility in urban design, indicating that Legibility can be easily recognized and communicated in an interconnected format[47]. Complexity refers to the degree of diversity of environmental elements[13]. Space's extreme complexity or novelty makes the interior confusing and impossible to analyze. However, a low level of complexity creates a sense of worthlessness and typicality. By contrast, large and open expanses are low complexity[32]. Most people understand complexity as a disorganized variety. There are two distinct types of complexity: 'organized' versus 'disorganized'[48].

Plan legibility reduces ambiguity over possible goals that might be achieved. It is a well-structured space with distinctive elements, so finding one's way within the scene and finding one's way back to the starting point is easy. It is also essential that the objects be identifiable and that the scene is experienced as interpretable. Thus, Legibility entails a promise or prediction of the capacity to comprehend and function effectively[7]. Lynch, who pioneered image maps (in the 1960s), suggests that there are overlapping features among images that people perceive from a place, namely paths, edges, districts, nodes, and landmarks. It would be wrong to assume that every area should contain all these features.

Mystery means the amount of confidential information within the environment that one can discover[43]. It is one factor that leads to more environmental exploration[13]. That implies that entering the scene is possible and finding somewhere to go[7,32]. There are several ways for scenes or settings to suggest that there is more information available. Some classic examples include the bend in the path and a brightly lit area partially obscured by foreground vegetation[7]. Some claim that specific design elements can also convey this property[49].

Based on the theoretical foundations of urban parks' Legibility, studying the subject's evolution, and the critical analysis of theories explaining the topic, the theoretical research model is presented in the diagram below (**Figure 1**).

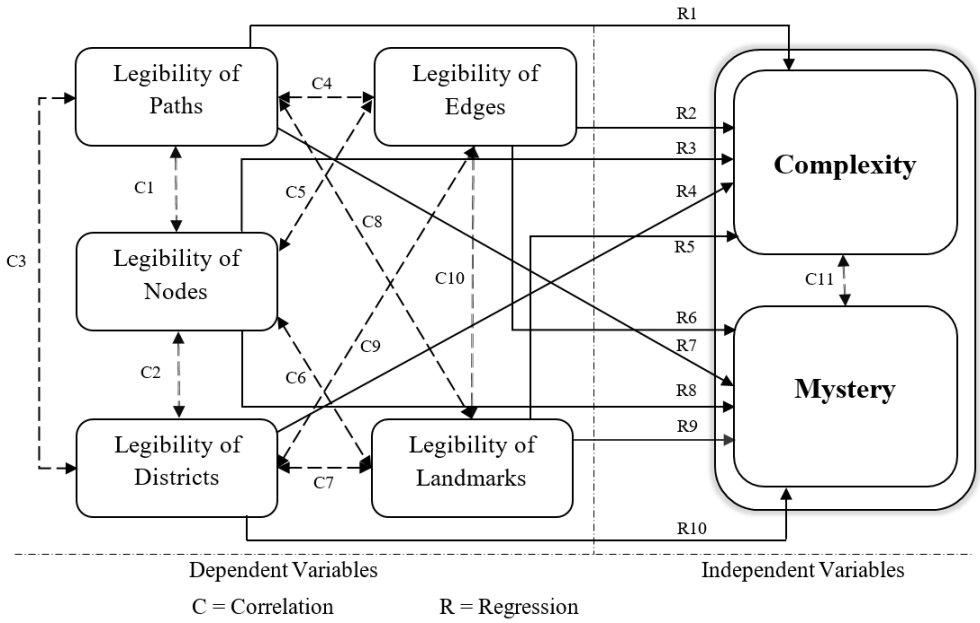


Figure 1. Theoretical model of research.

2. Methodology

The mental map is a concept that has been used and defined in numerous ways in this study[50,51]. It is more suitable for spatial structure understanding[52].

The present study is among descriptive-explanatory studies regarding its aims and methodological framework; it is fuzzy (Ragin). It is a piece of applied research from its results; it is qualitative-quantitative based on the research process[53]. The fuzzy degrees of the concept have been specified based on Ragin's fuzzy values. Since fuzzy logic has been mainly used for control and measurement in industry and environmental studies, this logic and method are used in this paper[54]. Fuzzy mathematical models represent a new and promising trend in applied mathematics and are increasingly being used in various applied fields in situations involving various kinds of uncertainties where the methods of probability theory and mathematical statistics cannot strictly formalize these[55]. A fuzzy evaluation of the effect that an implicit factor has on an organization's key performance indicators will be obtained using fuzzy logic rules, algorithms, and procedures.

On a macro level, data collection has been done by referring to scientific texts and documents. The primary data for this research was sourced from in-person surveys at six parks under study during the summer of 2019. These parks were meticulously chosen based on varying geographical, social, and cultural attributes to ensure a comprehensive understanding of the subject. Data has been collected based on experimental survey methods using a questionnaire and face-to-face interviews on the micro-level[52].

This study also examines the mapping technique used to determine legible urban elements categorized by Lynch and Ware[47,56]. The studied parks possess different geographical, social, and cultural characteristics. Interviewers were required to walk within the study area and asked respondents to cooperate in producing the mental maps. The respondents were asked to draw mental maps of items discussed by Lynch[47], including path, node, district, edge, and landmark. These items were customized based on each park. In analyzing the data, the frequently mentioned elements were listed and sorted. Then, all the elements mentioned and sketched by the respondents are filtered and placed into groups according to the categorization made by Lynch[47]. The legible elements are determined based on the frequency of mention and repeated sketching according to each category.

In addition to the above methodologies, a quantitative analysis was undertaken to understand the relationships between the variables under study. Using SPSS, a correlation analysis was conducted to statistically evaluate the strength and direction of linear relationships between pairs of continuous variables. This analytical procedure provided insights into the interdependencies among the various components of legibility, complexity, and mystery across the parks. It facilitated a deeper understanding of how specific variables influenced one another and contributed to shaping perceptions within the urban park settings. The results from this analysis were pivotal in interpreting the relationships between factors and informed subsequent stages of the research.

2.1. Operational definition of the variables

The operational definitions of the indicators of legibility are as described in **Table 2**[57–62]; and operational definitions of the indicators complexity and mystery are described in **Table 3**. Their credibility was provided by reference to the theoretical background, the scientific consensus of the experts, and authors' content knowledge.

Table 2. Indicators to measure urban legibility.

Dimensions	**Practical indicators of legibility**
Paths	1- Adequate path width
	2- Clear and predictable routes
	3- Effective path interconnectivity
	4- Balanced lanes and intersection points
Nodes	1- Clear and distinct entrances
	2- Strategically placed entrances
	3- Functional use of space (e.g., standing, sitting areas)
Ddistricts	1- Thoughtful placement of buildings and features (e.g., pavilions, play areas)
	2- Clearly defined areas (e.g., walking, sitting zones) with integrated design
Edges	1- Clear boundary demarcation (e.g., transparent fencing)
	2- Intuitive spatial understanding
	3- Pleasing visual perspectives and views
	4- Use of natural terrains (e.g., hills, valleys)
landmarks	1- Presence of significant monuments
	2- Adequate and aesthetically pleasing signs for navigation
	3- Symbolically vibrant elements

Table 3. Indicators to measure park complexity and mystery.

Dimensions	**Practical indicators of complexity and mystery**
Complexity	1- Avoiding centralized park designs
	2- Challenges in visualizing park's overall shape
	3- Varying terrain levels throughout the park
	4- Seasonal shading techniques and spatial highlights
	5- Harmony in plant choices (e.g., trees, shrubs, hedges)
	6- Rich element variety and diverse views
	7- Balanced complexity in paths and spaces
Mystery	1- Presence of aromatic features (e.g., flowers, trees)
	2- Audible elements (e.g., water sounds, birds)
	3- Tactile features, both natural and artificial
	4- Intricate geometric symbols and concepts
	5- Discovery of new areas as one explores further
	6- Elements of surprise and the unexpected
	7- Overarching sense of allure and enigma
complexity	1- Lack of emphasizing on centrality in shape of the park.
	2- difficulty of visualizing the shape of the park
	3- diversity of variation of levels in the park
	4- Focus on shading in different seasons and highlighting the spaces.
	5- Consistency between the plants of the park (trees, shrubs, hedges, ...)
	6- Wide variety of elements in the park and number of different things happening in every frame of view.
	7- The paths and spaces of this park have an appropriate amount of complexity.

Table 3. (*Continued*).

Dimensions	Practical indicators of complexity and mystery
mystery	1- indication of olfactory elements (aromas of flowers, trees, ...)
	2- Prominence of aural elements (water sounds, birds, foliage of trees, animals, etc.)
	3- Significance of natural and artificial touch elements.
	4- Usage of a intricate geometric shape to represent a symbolic concept.
	5- Discovering new features by going further in the space.
	6- Existence of a sense of surprise (meaning that one is confronted with something unexpected).
	7- Significance of enigma and attractiveness.

2.2. Fuzzy scale of the concepts

Fuzzy logic is a new technology that replaces the methods needed to design and model a system that requires sophisticated and advanced mathematics, using linguistic quantities and expert knowledge[63,64]. The fuzzy method is a control methodology and a way to process data based on allowing small group membership instead of categorized group membership[53]. The overall structure of the fuzzy set is based on three qualitative cutting points, namely, fully membered, transient, and fully non-membered[65] (**Table 4**). The membership function of classical and fuzzy sets can be represented as follows.

$$A = \left\{ X, \mu_A^{(X)} / X \in A, \mu_A^{(X)} \in \{0,1\} \right\} \ \bar{A} = \left\{ X, \mu_{\bar{A}}^{(X)} / X \in A, \mu_{\bar{A}}^{(X)} \in [0,1] \right\} \quad (1)$$

A fuzzy set A with a membership function $\mu_A^{(X)}$ allocate to each point in x an actual number in the range [0, 1] and amount of $\mu_A^{(X)}$ represents the membership degree in A[63,64].

Table 4. Fuzzy valuable labels (authors).

Fuzzy Degree	Fuzzy numbers
Essentially membership	[0.845, 1, 1]
Very high membership	[0.75, 0.875, 1]
High membership	[0.625, 0.75, 0.875]
Fairly membership	[0.5, 0.625, 0.75]
Membership/non membership	[0.375, 0.5, 0.625]
Fairly low non membership	[0.25, 0.375, 0.5]
low non Membership	[0.125, 0.25, 0.375]
Very high non membership	[0, 0.125, 0.25]
Completely non membership	[0,0, 0.125]

2.3. Mental/cognitive maps

One of the most common ways of examining the perception of space in geographic research is through cognitive maps. This practice is derived from the assumption that cognitive maps influence spatial behavior[66]. Residents or visitors actively create their space through spatial behavioral patterns. Thus, an ongoing dynamic relationship exists between their conception of the space, behavior, and construction. Examining spatial activity and movement enables us to see the construction process of social space and the relationship between perception and space[67].

Cognitive mapping is a method developed and employed by behaviorists and cognitive scientists. The term mental map refers to a map of a place or a specific area (neighborhood, city, world, etc.), drawn by freehand[68]. They are externalizations of the mind onto paper in a complete and observable form[69].

The image of a city is an outcome of individuals' knowledge, experience, emotions, and external stimuli that determine the process occurring between the city and the observer[20]. Mental imagery is a cognitive process necessary for constructing and adapting models seeking complex solutions[70]. The picture formed in such a process is called a cognitive map. Mental/cognitive maps encompass all the internal processes that enable a person to acquire and manipulate information about the nature of his or her spatial environments[71]. They are incomplete, segmented, and mentally distorted internal representations of the environment. They are also constantly updated; they thus offer a snapshot of an individual's physical knowledge at any one instance. These cognitive processes are part of the unique design process[70].

The analysis of mental maps and actual spatial patterns of behavior-setting activities challenges prevailing notions about the spatial structure of urban park spaces and the internal power relations between their users[67]. As the literature shows, factors such as age, gender, family status, education, socioeconomic status, and knowledge regarding the specific environment being researched all influence mental maps[71–73]. Mental maps provide the external borders of an individual's potential activity space, which can be defined as the area that contains most of the individual's destinations[74–77].

2.4. The studied areas

This study was conducted in six parks in three Iranian cities (**Table 5**). 1- Tehran: Laleh Park (Case 1), Saei Park (Case 2), Jamshidieh Park (Case 3). 2- Shiraz: Ghori Park (Case 4), Kholdebarin Park (Case 5). 3- Bushehr: Sadaf Park (Case 6).

Table 5. Introduction of studied parks.

city	**Tehran**			**Shiraz**		**Bushehr**
park	laleh	Saei	Jamshidie	Ghouri	Kholdebarin	Sadaf
Area	35 hectares	12 hectares	10 hectares	1.2 hectares	3.2 hectares	3 hectares
map						

Participants consist of people who use the parks regularly and have been to the park only once. That helped to explore the range of user opinions. The sample size is 265 respondents who visited the studied parks, and the sampling method is purposive. The survey was studied in the summer of 2022.

3. Results

The results and their analysis include describing the background variables and analyzing the role of independent variables and the degree of correlation of the variables.

3.1. Background variables

The statistical output in **Table 6** indicates that 52.5% of the participants were female and 47.5% were males. The output illustrates that on the 15–80 age range of the respondents. Around 29.8% had primary education, junior high school degree, and high school diplomas, 33.5% had Bachelor's degrees, and 36.66% held a Masters' degree and Ph.D.

Table 6. Background variables of respondents.

case	No.	sex		Average age	education		
		Male	female		High school	Bachelor's	Master's & PH.D.
Case1	45	21	24	39.87	13	11	21
Case2	46	22	24	36.4.2	17	15	14
Case3	45	19	26	33.4	10	18	17
Case4	41	23	18	39.8	9	19	13
Case5	45	19	26	29.8	14	21	10
Case6	43	22	21	43.2	16	13	14
-	265	126	139	37.21	79	97	89

The data shows that 52.01% percent of respondents stay in the park for only half an hour. Statistical Output for residence duration shows that 36.9% of the respondents have lived in the neighborhood for 5 to 10 years, and the average occupancy is between 1 and 5 years.

Case studies have been introduced based on the following indicators and components with the place-based approach. These components are Physical—spatial quality, Socio- activity quality, Symbolical quality, Comfort, and ecology (**Table 7**).

Table 7. Current status of studied parks.

		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Physical—spatial quality	Integration of elements (Plants, Furniture, materials if park floor and buildings, etc.)	3	3	2	2	3	1
	Harmony in colors	4	3	3	1	2	2
	Proportions of buildings and elements	3	4	3	2	3	2
	Continuity in pedestrian spaces	3	4	1	3	4	3
	Physical enclosure	4	3	4	2	2	1
	Transparency of facades	1	1	1	3	3	4
	Physical safety in spaces	2	2	2	4	4	2
	Varity of spaces	3	3	2	1	2	3
	Mixed used	2	4	1	2	3	3
	Flexibility in physical and spatial elements	2	2	1	1	2	4
	Compatibility of uses with park character	2	1	3	1	3	2
	Absence of physical and movement barriers	3	3	2	4	1	3
	Physical eligibility	2	1	1	3	4	4
	Harmony in styles	3	2	3	2	3	2
	Easy access	3	3	1	4	4	3
Socio-activity quality	Hierarchy in spaces	3	3	4	1	2	1
	Safety against vehicles	4	4	4	2	1	3
	Varity of social groups	4	3	2	3	2	3
	Lighting	1	2	2	2	2	2
	Security in night and day	2	2	1	4	1	2
	Flexibility for activities	2	2	2	3	2	3
	Possibility for participatory activities	3	2	2	2	3	2

Table 7. (*Continued*).

		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
	The comfort of disabled and disadvantaged	3	1	1	1	2	3
	Historical events and memories in spaces	2	2	1	1	1	1
	Old and valuable buildings near the park	4	3	1	4	2	2
Symbolical quality	Urban decorations and pop arts	2	3	3	1	2	1
	Symbolical elements	2	3	4	3	1	1
	guiding signs	1	2	2	1	1	1
	Uniqueness	2	3	4	1	1	1
	Natural symbols	1	4	4	4	2	3
	Thermal comfort	2	3	3	3	3	3
	Vernacular materials and plants	4	3	3	3	2	3
	Comfort in hot and cold conditions	2	3	2	2	2	2
Comfort and ecology	Comfort in Wind and humidity	3	2	3	1	2	2
	Absence of air pollution	3	3	4	2	2	3
	Shadow and day light	3	3	4	3	4	1
	Surface water and waste	3	3	2	3	2	1
	Green spaces	4	4	4	4	3	2

3.2. Regression between eligibility of entrances, nodes, districts, landmarks, and paths on complexity and mystery

According to the research logic, which is fuzzy, the independent fuzzy set (complexity-mystery) and dependent fuzzy set (Spatial legibility) of all six parks and their comprehensive descriptive analysis have been discussed in this paper. Drawing insights from the descriptive analysis of complexity mystery and legibility, we see varied regression values across different park cases concerning complexity and mystery against spatial legibility factors. The variance across these parks is a testament to each park's unique spatial attributes and design elements, impacting visitors' perceived complexity and mystery. In Laleh Park, the legibility of nodes has the most impact on perceived complexity by citizens. At the same time, the legibility of districts results in a decreased perception of complexity. As for the perception of mystery, all items of legibility have an incremental impact except for the nodes, which is significantly less than others.

In understanding the parks' qualitative characteristics, which could indirectly influence legibility perceptions, we analyzed the attributes listed in **Table 7**. This table provides a breakdown of the case studies based on components like Physical–spatial quality, Socio-activity quality, Symbolic quality, Comfort, and ecology. For instance, features such as 'integration of elements', 'compatibility of uses with park character', and 'easy access' within the 'Physical—spatial quality' dimension can be linked to park design attributes affecting legibility. Similarly, 'hierarchy in spaces' and 'safety against vehicles' from the 'Socio-activity quality' dimension are also factors that could influence visitors' spatial perceptions. Combined with our main regression analysis, these qualitative attributes provide a comprehensive understanding of how park design and functionality impact the perceived complexity and mystery in the different parks studied.

In Saei Park, the legibility of nodes, districts, and landmarks results in a decreased perception of complexity. While the other two items have an incremental impact, the amount is tiny. However, the legibility of paths, edges, and landmarks decreases the perception of mystery. In contrast, the legibility of nodes and districts has a negligible impact on the increase of perceived mystery by citizens. In Jamshidieh

Park, all items of legibility have an incremental impact on perceived complexity except for districts and landmarks.

Furthermore, in the case of perceived mystery, the legibility of edges, nodes, and landmarks decreases, while the other two increase perception. In Ghouri Park, the legibility of edges and nodes has a negligible impact on the perception of complexity. However, it looks like the other items of legibility have a noticeable incremental impact. Also, all items of legibility have a Signiant enormous impact on the perceived mystery by citizens. In Kholdebarin Park, most items of legibility increase complexity, while the legibility of districts has the most impact. All items of legibility have an incremental impact on the mystery, whereas the impact of legibility of landmarks is significantly more than others. In Sadaf Park, the legibility of paths, districts, and landmarks decreases perceived complexity, while the other two result in a slight increase. As for the mystery, all items have an incremental effect, while the legibility of landmarks ranks on top and the legibility of nodes on the bottom.

3.3. Correlation analysis of complexity and mystery

Laleh Park's legibility of paths and landmarks has the highest degree of correlation. The legibility of edges and landmarks and the legibility of paths and districts are also highly correlated. At the lower level of correlation, there is the legibility of paths and nodes, the legibility of nodes and landmarks, and the legibility of districts and edges. After that, the legibility of districts and landmarks and the legibility of nodes and edges. Overall correlation relationships between different items of legibility in this park are significantly high. However, the correlation between our independent items (complexity-mystery) is very low.

In Saei Park, the legibility of districts and landmarks and the legibility of nodes and paths are highly correlated. There is a correlation between the legibility of landmarks and edges in lower levels and the legibility of nodes and landmarks. Other correlations between legibility items were not that Signiant. However, the correlation between complexity and mystery is relatively low.

In Jamshidieh Park, the legibility of edges and landmarks has the highest correlation. In the following levels, we correlate the legibility of nodes and landmarks and the legibility of districts and landmarks. The rest of the correlations did not have a noticeable amount, and some of them, like the legibility of districts and paths, had a negative correlation. The independent variables (complexity-mystery) had an average amount of correlation.

In Ghouri Park, the legibility of paths and districts is highly correlated. In total, correlations between legibility items in this park were insignificant, except between paths and nodes, which were very small. However, our independent variables were highly correlated.

In Kholdebarin Park, edges and landmarks were the most correlated items. After that, there is the legibility of nodes and districts. The other items had an average correlation, except for the legibility of paths and landmarks, which was pretty low. The correlation between complexity and mystery was slightly lower than the average amount.

In Sadaf Park, the legibility of paths and districts and the legibility of paths and edges in the next level correlate most. The legibility of paths and nodes also has an average correlation, while the rest of the items were not worth mentioning. The correlation between complexity and mystery was lower than the average amount in this case.

The experimental data obtained from the model test shows that, on average, all the studied parks had a high level of correlations and regression between their variables (**Figure 2**). The legibility of landmarks has the most, and the legibility of nodes has the most negligible impact on perceived complexity. In the case of

mystery, the legibility of districts has the most impact on its perception, and the legibility of paths has the most negligible impact. The most correlation is between the legibility of paths and districts and edges and landmarks. There is an average correlation between the legibility of paths and nodes, nodes and districts, and the legibility of paths and edges. The amount of correlation between other variables of legibility is less than average, whereas the correlation between independent variables (complexity-mystery) is very low.

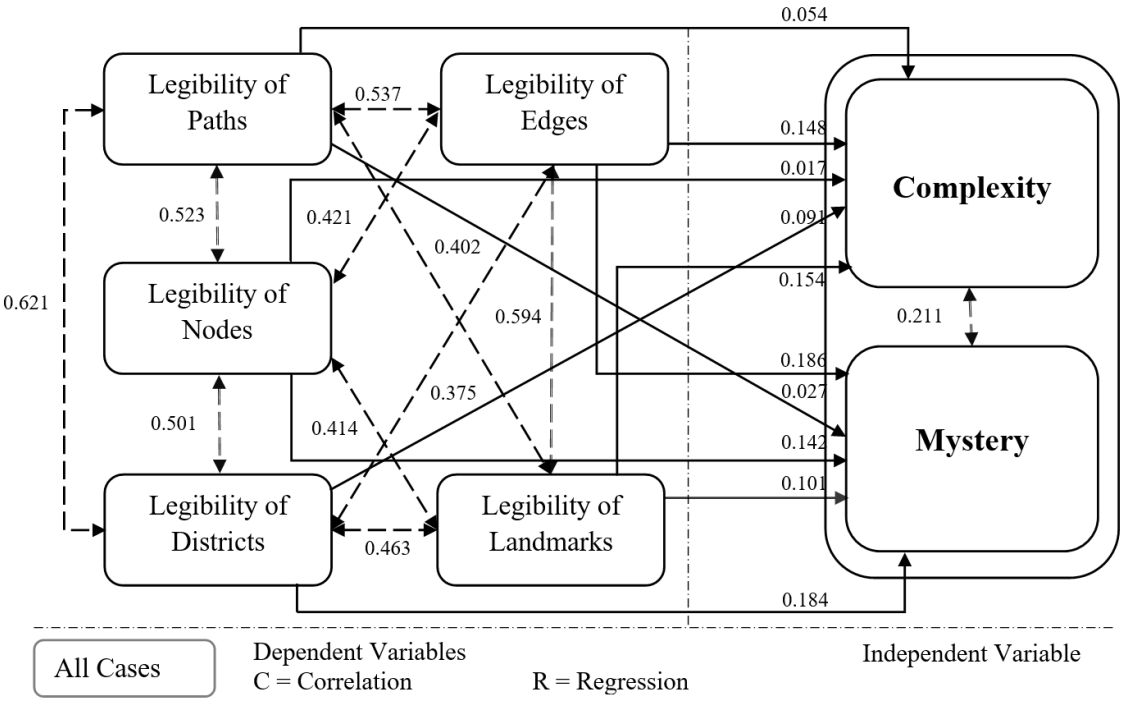


Figure 2. Theoretical model test in the studied parks.

As it is clear from the graph related to the correlation, the highest correlation between the variables is related to the legibility of paths and districts, with a coefficient of 0.62. The correlation between edges' legibility and districts is also at 0.59, above average. Also, the correlation between paths and edges is 0.537, and the correlation between nodes and districts is 0.51, and these coefficients are also higher than the average in the fuzzy scale. The correlation between complexity and mystery is positive and equal to 0.211, lower than the average level. Generally, the component regression related to legibility on complexity and mystery is around 0.12.

3.4. Analyzing the mental maps

This paper focuses on the prevailing view of learning in navigation space, where places are viewed individually. A cognitive map is constructed by path integration from one place to another. We categorized our requisitions into five types: paths, edges, districts, nodes, and landmarks[47]. We also added a factor: entrances, which we thought hold great importance. These factors were differentiated for each park since they had different characteristics (fountains, playgrounds, parking lots, etc.). We asked the participants to draw these items into a map we gave them to remember. The maps were given by face-to-face survey in each park, and 45 maps were drawn for each park. The legible elements are determined based on the frequency of mention and repeated sketching according to each category.

According to **Table 8**, the order of the parks based on the amount of legibility is as follows: 1- Kholdebarin (69.58%) 2- Sadaf (59.89%) 3- Ghouri (49.84%) 4- Laleh (44.23%) 5- Jamshidieh (38.1%) 6- Saei (33.5%). Kholdebarin is a plane park with straight pathways and direct vistas. Placements of important

buildings inside and near it also help to indicate this park. On the other hand, Saei Park is located a few meters lower than the street level. That makes it impossible to see the street from the inside. Pathways consist of straight and curved lines and many prospect barriers. However, the area of the parks should also be considered since Kholdebarin is much smaller than Saei Park.

The categories that people remember the most are districts and, after that, landmarks. Moreover, the minor rememberable category is nodes.

Table 8. Mental maps analysis.

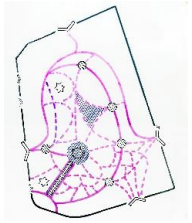
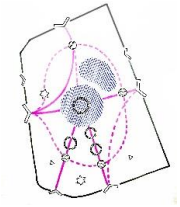
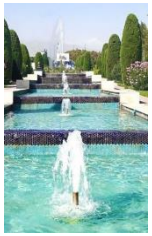
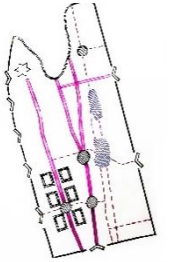
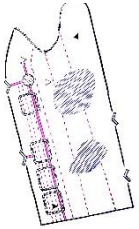
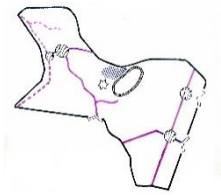
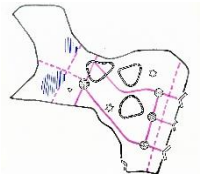
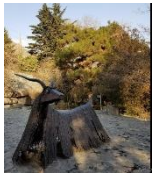
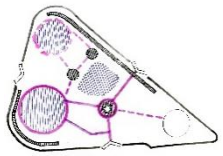
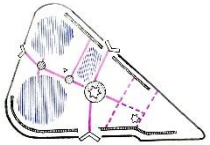
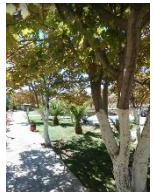
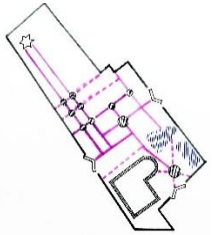
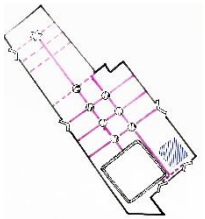
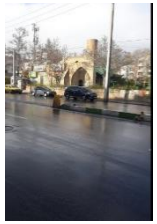
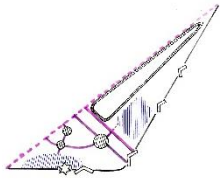
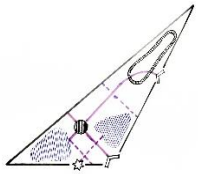
park	Original map	Mental maps based on interviews	Current status images					
			entrances	edges	districts	landmarks	paths	nodes
Laleh								
		44.23%	52.3%	61.1%	52.2%	21.8%	40.87%	15.15%
Saie								
		33.5%	21.92%	45.9%	38.1%	23%	43.85%	24.38%
Jamshidieh								
		38.1%	34.5%	26.2%	63.4%	23.95%	39.05%	31.43%

Table 8. (*Continued*).

park	Original map	Mental maps based on interviews	Current status images					
			entrances	**edges**	**districts**	**landmarks**	**paths**	**nodes**
Ghouri								
		49.84%	69.89%	14.10%	33.89%	81.31%	31.57%	47.95%
Kholdebarin								
		69.58%	40.89%	73.12%	87%	97.89%	70%	26%
sadaf								
		59.89%	32.15%	62.12%	67.1%	68.12%	60.23%	48.65%
All parks		49.19%	36.58%	47.09%	54.6%	49.6%	47.59%	32%

As the chart of **Figure 3** implies, the impact of the nodes in all parks is in close range. The scope of the impact of the landmarks in different parks is very different due to the form, size, and attractiveness of the Landmarks. Routes, areas, and edges are also somewhat different.

The degree of overlap of each element, including the entrance, edge, path, node, landmark, and district in the cognitive maps, shows that the landmark and district align with the existing reality regarding recognizability, legibility, and overlap (**Figure 3**). The edges and paths also correspond more than average to the existing reality. Nodes and entrances have generally not received much attention in cognitive and social maps and have less impact on the formation of maps. Nodes are generally less effective than other elements, but inputs can be essential and effective if unique and indexed. Also, in different parks, the effectiveness of each component is very different. The diagram above shows that time entrance can be influential in correctly forming mind maps corresponding to both indicative and symbolic reality. The entrance is not a number.

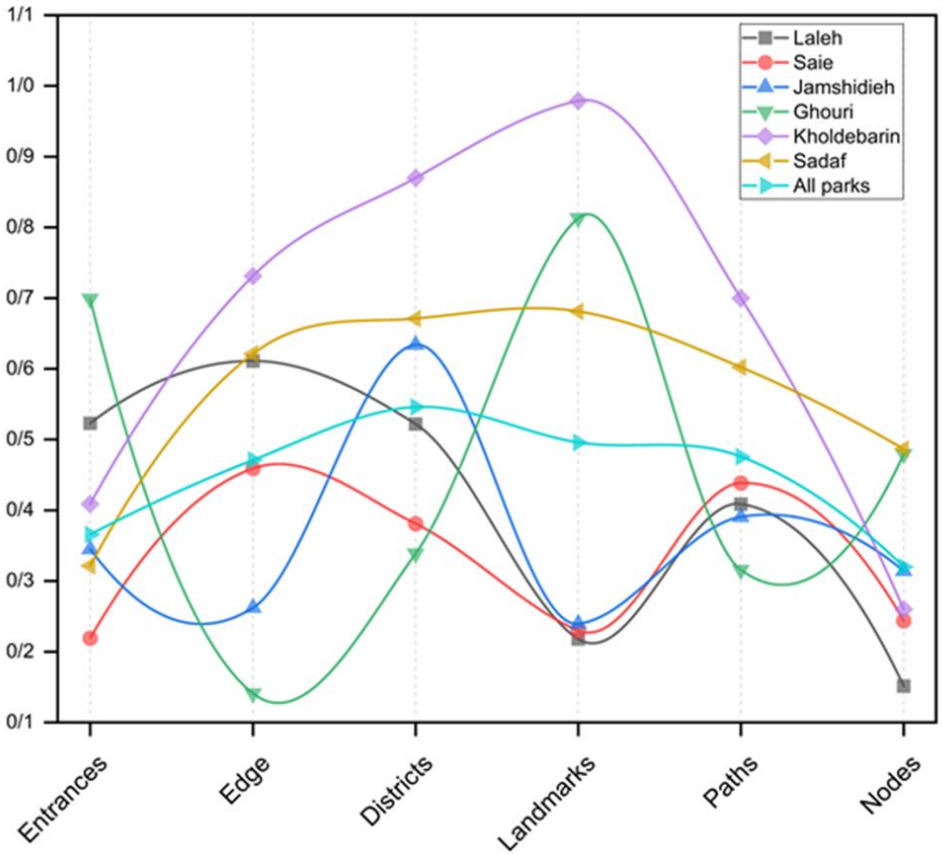


Figure 3. Amount of overlapping of elements in mental and social maps.

The correlation diagrams of **Figure 4** show that complexity through the district, landmark, and edge can have the most significant increase. The slope of the changes is high with the mentioned elements. Nodes have the most negligible correlation with complexity. Complexity through nodes increases when the number of nodes increases and the nodes are illegible. When the entrances are more, whether they are indexed or not, they do not correspond as much to reality in mental maps.

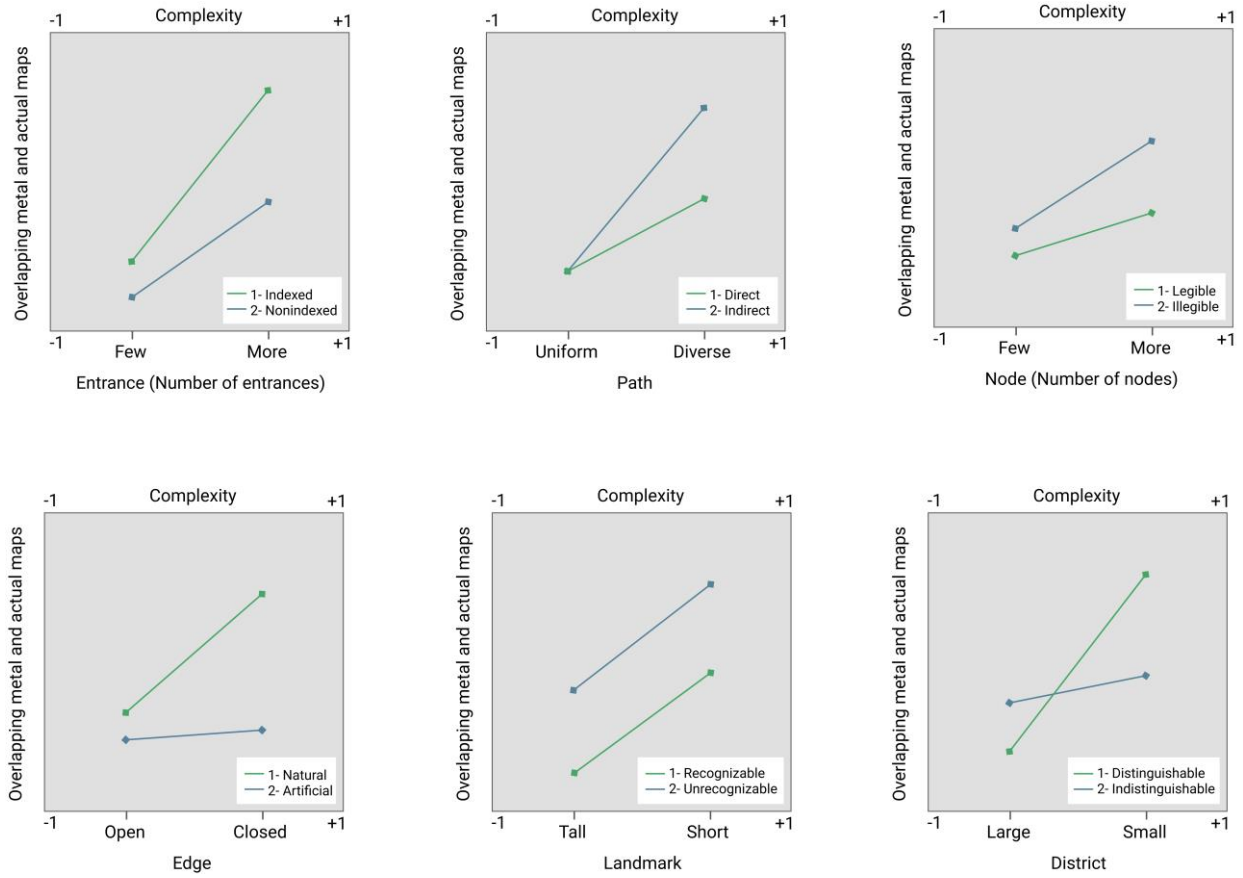


Figure 4. Correlation between complexity and environmental elements.

Nevertheless, when the number of entrances is few and indexed, the complexity of the space is significantly reduced. When uniform and direct or indirect, Paths do not affect complexity production. However, when the paths are varied and indirect, they significantly add to the complexity of the space. Edges generally produce less open and natural complexity, but the complexity increases as closeness and naturalness increase. If short and recognizable, landmarks are as complex as long, less recognizable landmarks. Districts produce more complexity on small scales but are still more complicated if large-scale and indistinguishable. Even if they are large in scale, they must be distinguishable. Only large, distinguishable districts reduce the complexity of the space.

Paths, nodes, and districts are very effective in mystery space. Entrances and landmarks have minimal effect in this regard. Edges, on average, the mystery of parks. When indirect and varied, paths cause more mystery than any other items, and districts are strangely mistrial when they are too narrow and less distinct. Nodes significantly affect space mystery when large, varied, and illegible. The edges naturally enclose, causing more mystery (**Figure 5**).

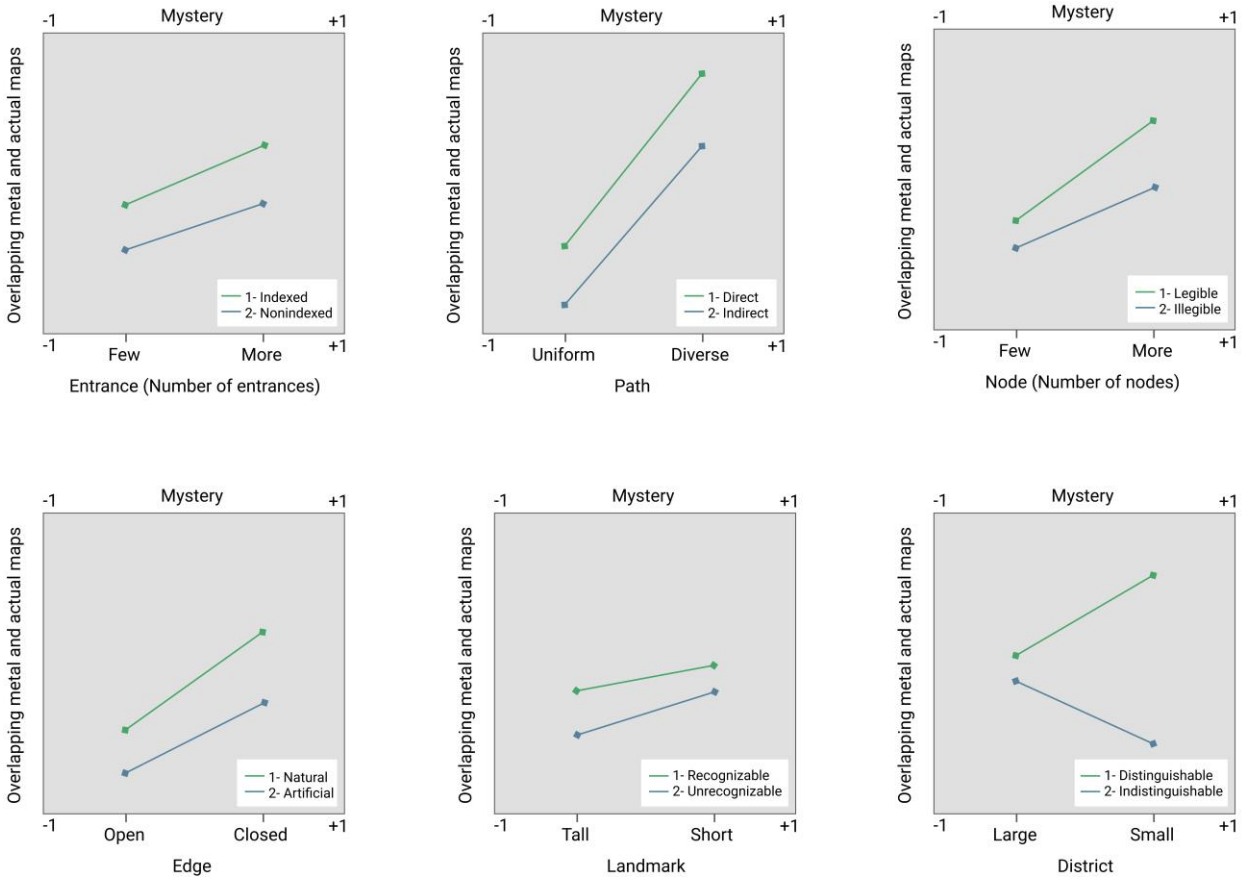


Figure 5. Correlation between mystery and environmental elements.

Considering that the subject of the study is the adjustment of the levels of mystery and legibility in all parks, these two components are generally in conflict with each other. Naturally, most results are related to the transitory or practical impact of these two components on each other. These can include both positive and negative. Therefore, we see more negative results than other research results and the numerical data in the sections related to the discussion and conclusions. This research aims to find the optimal conditions between these positive and negative results.

4. Discussion and conclusion

In this paper, two of the four components of Kaplan's theory (complexity- mystery) were investigated, and the effect of each component on the perceived legibility in urban parks was analyzed. Results confirm the hypothesis of this study: There is a reverse relationship between the components of complexity mystery and the development of spatial legibility. However, the regression between legibility components and complexity- the mystery was not wholly negative, and most of the regressions were between 0 and 0.1.

In urban parks, districts have the most significant impact on the overlap of citizens' collective mental maps. Landmarks, paths, edges, and entrances are almost equally and moderately fuzzy-scale on the legibility of citizens' mental maps in urban parks. Nodes play less of a role in citizens' collective mental maps than other park elements.

In response to the first question, he said that landmarks and areas significantly impact the complexity and mystery of parks. Edges and paths also have a significant impact in this regard. However, nodes and nodes have a much smaller effect on the complexity and mystery of urban parks than other factors. In landmarks, their height is more effective than their recognizability. In districts, it is much more effective than

being distinguishable. The degree of naturalness is much more effective at the edges than the closed edge. Nodes are almost equally effective in both number and eligibility. Entrances are much more effective when they are fewer than when the entrances are more. In answer to the second question, complexity, and mystery reduce the overlap of a person's mind maps with real space. Mind maps vary significantly as the complexity and mystery of space increase or decrease.

Furthermore, this issue, on the one hand, reduces legibility and the ability to understand the space easily. On the other hand, it causes non-uniformity, the tendency to re-presence in space and repeat the experience of space. Complexity and mystery significantly impact the non-overlap of district landmarks and edges in mind maps.

Regarding the degree of overlap of citizens' mental maps with the existing reality, the highest overlap is achieved in parks with a regular grid network with the slightest difference in height and direct paths and the least number of entrances. The most negligible overlap is when there are large topographies with varying surfaces and straight paths, and the ability to perceive the park as a whole would be challenging. Parks with too many entrances, non-linear paths, indistinguishable districts, and undefined edges are not perceptible to citizens, and citizens' perceptions of space differ significantly from the existing reality. Edges of trees with regular rows or linear streams are much more legible.

The park's scale and extent are crucial for its legibility and spatial perception. Extensive parks lead to mental disturbance. The shape of the parks is also an essential factor. Regular and geometric shapes are, in fact, much more legible than non-geometric and irregular shapes. The correlation between legibility dimensions, such as edges, nodes, landmarks, districts, paths, and entrances, is higher than the fuzzy scale average. Moreover, the legibility in each dimension will affect legibility dimensions a lot.

Lynch's theory of legibility in explaining the factors affecting the spatial perception of parks, as well as Kaplan's theory of complexity and mystery criteria, appear to be not fully responsive and proportional to the number of entrances, path shapes, and type of edges (hard or soft), the topography of the park and the number of landmarks and types of landmarks indicating of the city, the scale of the parks and the number of citizens, and the shape of the plan of the park in terms of regularity and irregularity. Contrary to Kaplan's theory, the degree of correlation between the two components of complexity and mystery is not high, and complexity does not necessarily lead to the perception of mystery, or the sense of mystery does not lead to an understanding of complexity.

Examination of the results of this research with the subject literature shows that the elements of the path, edge, node, road, landmark, and area act very differently depending on the parks' physical, spatial, activity, semantic, and ecological characteristics. For limited spaces with definite boundaries, it is necessary to add an input element. Elements of Lynch's theory with parameters such as number, position, and size influence the formation of mind maps. The participation of all aspects of Lynch's theory in a balanced way leads to more legible and realistic mind maps. The location and size of the domains, the number of entrances, the number of nodes, the size and shape of the routes, the size and number of landmarks, and the continuity and naturalness of the edges are essential in matching social and mental maps with real space.

In drawing and analyzing mind maps, the position of the elements of space alone is not enough. Still, the size, number, and position of the elements compared to each other are very effective and should be seriously considered in studies. Also, for collections such as parks and gardens, etc., the input element should be drawn and examined to increase the accuracy of people's perception of space.

Compared to related research, the innovation aspects of this research are reviewed Case examples with distinctive features of the process. It demonstrated the production of cognitive maps. Also, conceptual

modeling and concepts of legibility mechanisms and processes (factors on components) in the environment of urban parks are other specific aspects of this research. At the same time, determining the role of each park element, including entrances, paths, edges, areas, and nodes separately, is also a new aspect of this research. That confirms the results of related research in this regard to a large extent. Considering the low significance level of most of the findings, another research on A larger scale with more samples is suggested to investigate and analyze this issue.

The claim of the research based on the obtained results is that the presence of the appropriate width of the paths is an indicator. Entrances, separable areas, and easy understanding of the space are desirable and necessary for creating spatial legibility from the citizens' point of view. Also, the possibility of different classes in a park, the provision of peace of mind, and its flexibility are the most critical factors for increasing the sense of ownership and defensibleness of a place from the citizens' point of view. According to the degree of private and public and the possibility of monitoring and defending the territory, different thinkers divided the territory into different types. They have been categorized as primary (private), secondary (semi-private-semi-public), and public. The critical issue is that the territories are designed so that people can recognize their primary, secondary, or public status, and the users can dominate the place as appropriate.

Author contributions

Conceptualization, MY; methodology, MY; software, ND; validation, MY; formal analysis, ND and ZZ; investigation, ND; resources, ZZ; data curation, ZZ; writing—original draft preparation, ND; writing—review and editing, MY; visualization, ZZ; supervision, MY; project administration, MY; funding acquisition, YY. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest

The authors declare no conflict of interest.

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