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Exploring the Influence of the Visual Attributes of Kaplan's Preference Matrix in the Assessment of Urban Parks: A Discrete Choice Analysis

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Abstract: A significant majority of the literature on natural environments and urban green spaces justifies the preferences that people have for natural environments using four predictors defined by Kaplan's preference matrix theory, namely coherence, legibility, complexity, and mystery. However, there are no studies implicitly focusing on the visual attributes assigned to each of these four predictors. Thus, the aim of this study was to explore the influence of nine visual attributes derived from the four predictors of Kaplan's matrix on people's preferences in the context of urban parks. A discrete choice experiment was used to obtain responses from a sample of 396 students of Golestan University. Students randomly evaluated their preferences towards a set of potential scenarios with urban park images. The results of a random parameter logit analysis showed that all of the attributes of complexity (variety of elements, number of colors, and organization of elements) and one attribute each of coherence (uniformity), mystery (visual access), and legibility (distinctive elements) affect students' choices for urban parks, while one attribute each of mystery (physical access) and legibility (wayfinding) did not affect the choices. Furthermore, the results indicated a preference for heterogeneity of the attributes. The findings of this study can provide instructions for designing parks.

Keywords: information processing theory; landscape design; multinomial logit model; predictors of preference

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1. Introduction

Today, the growth of urbanization and city development have reduced green spaces in cities, and the surrounding of cityscapes with buildings have separated individuals from contact with nature and natural environments. Therefore, the existence of urban green spaces, including parks, as structures affected by nature is considered one of the main needs in citizens' lives, and due to their significant position, can enhance people's well-being and provide a place full of tranquility and vitality for residents [1,2]. What makes urban parks important today and makes people choose to use them for their leisure time, in addition to their principled design and desired vegetation quality, is their visual quality [3–5]. The visual expression of the landscape can be considered the main component for determining the identity of the environment and is a means of communication between the environment and its users. The relationship between the landscape and its perception and interpretation by users is very important, so this perception of the landscape is directly related to recognizing the landscape's aesthetic characteristics [6–8]. Therefore, the investigation and study of individuals' landscape preferences can be considered an effective and vital way to identify the landscapes with different visual value in order to organize, design, and manage these landscapes. Kaplan worked during the end of the 20th century to develop knowledge about the connections between preferences for parks and natural environments and their aesthetic attributes, with the aim that the knowledge could be used in practice. The result became one of the most referenced theories in environmental psychology, Kaplan's preference matrix, which is based on an information processing model [9]. This theory shows that individuals have two types of basic needs in relation to the environment: a need to understand and a desire to explore [10]. Together, understanding and exploration form the framework of the informational preference matrix, which has four key information variables: "coherence", "complexity", "mystery", and "legibility" [11]. Several studies of natural environments and urban green spaces have justified the preference choices that people have for such environments using the four predictors [10,12,13]. The four predictors provide information to understand why people prefer and choose such environments. However, the visual attributes of these predictors that play an important role in people's preferences are not known yet.

Aim

According to Kaplan's perceptual model, people like and prefer landscapes based on four predictors: coherence, legibility, complexity, and mystery. As far as we know, there is no study that implicitly focuses on the visual attributes assigned to each of these four predictors. The purpose of this study is to first find specific visual attributes derived from the four predictors in Kaplan's preference matrix and to divide them into different levels of hypothetical influence, then to explore the influence of these visual attributes on people's preferences for urban park environments using discrete selection methods. The aim is to investigate to what extent the different visual attributes affect people's preferences, as measured by choice behavior.

2. Materials and Methods

2.1. Literature Review

This article focuses on the aesthetic predictors in physical environments that lead to high preference in humans. This is a classic question in aesthetics, which has engaged researchers in experimental Psychology since Gustav Fechner's studies in the 19th century [14]. Over the years, many studies have been devoted to finding out which specific design attributes define these predictors and how the acquired knowledge can be used in practice, for example in architecture and landscape architecture. Through an extensive literature review, we will establish visual attributes related to Kaplan's preference matrix for further studies.

2.1.1. Mystery

One of the most important predictors of preference is mystery [15]. Kaplan defined it as hiding part of the landscape to recognize it. The mystery results from a lack of complete perception, due to the inability to see part of the landscape. This provides an opportunity to learn something that is not quite apparent from the present vantage point [16]. Mystery (inferred exploration) arouses one's curiosity and encourages people to go deeper into the scene to explore and learn more about the content. Mystery does not mean the presence of new information, but the promise that new information exists. In fact, mystery means the promise of more information, and in particular the opportunity to gather new information in a landscape [17]. According to Kaplan's theory, curvature paths and visual elements that partially obscure visual accessibility are the most important mystery attributes.

Physical Access (Shape of Paths)

Physical access refers to the defined paths in a landscape through which the observer can discover this landscape [18]. Based on Kaplan's definition of mystery, curved paths have more mystery than straight ones, so this study will investigate the paths in two forms, straight and curved, as most studies of environmental preferences suggest that curved paths are the most important visual attribute of mystery.

According to Kaplan's concept of mystery, Gimblett et al. [18] introduced five physical attributes of mystery, including screening, distance of view, spatial definition, physical access, and background radiance. The results of their study revealed that physical access was the factor of discovery and involvement with the environment that had the strongest effect on mystery. A study by Herzog and Miller [19] suggested that environments with high levels of mystery must have curved paths with a high degree of visual access around the boundaries. The results of their study showed a significant positive relationship between mystery and the perceptual component of path curvature. A study by Eriksson and Nordlund [20] found that predictors of mystery, such as curved paths, encourage individuals into walking in and exploring the environment. Similarly, Kuper [21] evaluated mystery via physical access and visual access with other factors at three different sites (park, village, and art center). In a study of urban woodlands [22], the results showed that curved paths increase aesthetic and recreational preferences, because curved paths provide more opportunities for exploration and recreation and increase physical access in these environments. Studies on urban streets [23] have also reported that people prefer curved paths over straight ones, as defined by the mystery element; these paths firstly arouse curiosity and secondly seem to reach destinations more quickly.

Visual Access

Visual access is a combination of the ability to see and influence vision [24]. Kaplan defines visual access as the amount of the view of a landscape that is constrained by visual barriers such as vegetation [11]. There are several ways to block or obstruct a view.

Mystery refers to hidden elements [8]. Gimblett et al. [18] showed that mystery is affected by visual access, especially regarding vegetation. Similarly, the presence of factors in the scene that create a sense of concealment and refuge, such as the presence of dense vegetation, restricts visual access, which is an attribute of mystery [25]. The researchers also claim that visual access affects the degree of mystery of the environment. Landscapes with low visual access have high levels of mystery because these landscapes actually promise more information [16,24]. In a study by Herzog and Miller [19], mystery was related to visual access or openness. The results showed that if fewer hidden elements were observed, the visual access increased, which led to the factor of mystery decreasing. In a study on stone carvings and urban scenes, the results showed that occlusion views influence mystery [26]. After several experiments, Stamps [27] stated that occlusion is an attribute of mystery, believing that mystery is a visual function. One of the elements that can obstruct one's view and movement in the landscape is vegetation, a high density of which increases the mystery of a landscape [11]. Many studies have shown that the presence of vegetation partially obstructs one's view and encourages one to explore the environment [20,21]. Studies on building facades have also shown that one's visual perception and mystery is influenced by vegetation density [28,29]. Because part of the facade is hidden and there is the promise of more information, this increases one's motivation to explore.

2.1.2. Legibility

Legibility is an important indicator of urban perception that was examined by Lynch [30] in the context of the visual quality of urban environments. This factor in Kaplan's environmental preference studies points to the possibility of an inferred understanding. According to Kaplan's definition of legibility [17], this is an area that is easy to view and form a mental map of, which increases the possibility of wayfinding. In addition, the area should have an appropriate spatial structure with distinct, identifiable elements and landmarks that increase readability [10].

Wayfinding

Kaplan states that finding a way through the landscape influences one's perception of legibility in an environment [10]. Additionally, in a study of neighborhood parks, the entrance is an important factor influencing accessibility, which is one of the visual attributes of legibility [31]. In recreational landscapes, finding a path through the presence of signage is one attribute of legibility because it helps to create a positive mood towards service providers [32].

Distinctive Elements

Scholars have stated that the presence of distinct elements such as landmarks makes it easy to make a legible mental map [30,33]. Subsequently, many studies have been conducted on the perceptions of cities, with the results showing that the presence of distinct elements has a great impact on environmental legibility [34]. For example, tall buildings as landmarks greatly impact the perceptions of legibility for commuters, conveying a sense of direction to the destination [35]. The results of studies have shown that one of the visual attributes of legibility in a landscape is the presence of salient elements. These elements are effective in human perceptions of a landscape and are easily memorized [36].

2.1.3. Coherence

In 1998, Kaplan stated that a coherent environment means that there is an organized order in specific regions. This allows people to identify specific areas and make them easier to understand. Coherence is also enhanced by repetition and texture uniformity [11]. A cohesive and orderly environment is easier for people to understand directly, as these elements contribute to their ability to create meaning [10].

Uniformity (Texture)

Material or texture changes are attributes of the coherence in a scene. Texture changes can define different areas, as each area can be identified by a similar material; therefore, coherence is reduced if one of them has multiple materials [11]. In a study by Ode et al. [7], the results showed that the unity of a scene, texture repetition, and color are correlated with coherence. Subsequently, Huang [37] investigated the characteristics of rural landscapes and their impacts on visitor preferences. Coherence in that study implied the organization of elements and unity in the scene, which are features of rural landscapes.

Organization of Components—Order (Areas)

Kaplan et al. [11] compared the features of two nature scenes. The type and number of elements in both scenes were the same. In high coherence areas, the same species of trees came together to form distinct areas. In low coherence areas, trees from different species were scattered in the area. Studies have also shown that organization and order have a significant impact on coherence in natural environments [7,38]. Kuper [39] examined people's preferences of landscapes with three levels of coherence (high, medium, and low) based on how plants were organized in the landscape (formal, clustered, or scattered) in urban, residential, and field environments. The result showed that people had the highest preference for environments where plants were organized in clustered units.

2.1.4. Complexity

The research on complexity includes a series of studies focusing on several areas in addition to natural and urban environments. Among other things, one of the most important predictors of interior design [40], along with logos [41], websites [42], and photos [43] was considered. Recent studies have shown that the complexity of the environment can have a major impact on people's mental health, attractiveness, and learning [44,45].

Complexity was first studied in aesthetic studies, and in general this component was recognized as the principal factor determining aesthetic responses. Berlyne [46] suggested that environments with intermediate levels of complexity would be judged as being the most beautiful; that is, humans would prefer medium complexity more than both low and high complexity. In 2016, a study by Alpak et al. [47] found that people's preferences indeed were the highest for urban landscapes of intermediate complexity. This study also showed that important predictors of complexity were the experience of coherence and the organization of the components of the urban landscape. Fechner [14], in his pioneering aesthetic studies, argued that beauty is the result of something conveying an expression containing two factors, complexity and order, where order, as stated above, is a significant part of coherence. Later studies suggested that beauty is the balance between these two factors [30]. Complexity and coherence thereby seem to be related. However, this negative correlation does not simply mean that more of one will automatically lead to less of the other. Something that is experienced as disordered is not necessarily a result of too much complexity, but could instead be a result of low coherence (Kaplan and Kaplan, 1989 [10]). In addition, a high amount of complexity will not necessarily lead to low preference, as long as there is also high coherence. Information on the spatial organization of landscape patterns can, therefore, be seen as an important component for describing perceived complexity [48].

Berlyne [49] explored why organisms have different levels of arousal when exposed to stimuli with different characteristics of novelty, complexity, surprise, and so on. In 1971, he introduced three sets of variables that had the potential for arousal through the amount of information transmitted to an organism. One of them included complexity, and he suggested that the perception of complexity was related to factors such as order, the amount of elements in a scene, and asymmetry [30]. In studies on environmental preferences, Kaplan [9] considered complexity as being an immediate exploration component. He introduced the features of complexity, namely diversity, the number of different visual elements in a landscape, and organization. Additionally, when complexity is high in a scene, that scene offers more different things to increase the sense of exploration [10].

Variety of Elements

Complexity in a scene involves the number of elements present in the scene [50]. Additionally, the variety of places is an attribute of complexity [51]. In general, the presence of different elements with different shapes that have different functions represents the presence of complexity in a scene [52]. In studies of visual indicators predicting landscape preferences, the results showed that the number and variety of landscape elements that represent diverse features are strong predictors of complexity [53–55]. Kuper [38] considers vegetation diversity as a visual attribute of complexity. He states that a high number of different plant species give more landscape information for exploration [48]. Visual complexity in urban landscapes depends on the amount of information one receives from the environment. This information includes the number of visual elements and their variety [56–58]. Studies of the number of elements in facades also show that the number affects the experience of complexity [59]. The design characteristics for the perception of complexity in interior design are the number and variety of elements. In environments with low complexity, there is very little furniture or accessories [60].

Number of Colors

Weil [61] considered complexity as the diversity of five attributes, and in a study of natural environments and artworks to measure complexity, color was one of the factors found to influence diversity. Many studies have suggested that the color diversity of plants affects individuals' aesthetic preferences [62–64] and that plants covered with colorful flowers are attractive and stimulating for most people and provide high levels of aesthetic preference [65]. In a study of regenerated industrial landscapes, the results showed that color diversity is an important factor in people's preferences [66]. Subsequently, another study was carried out on urban roof landscapes that showed that plant characteristics such as color increase landscape diversity, meaning they are most preferred and restorative [67]. One of the visual attributes of complexity in urban streets is the number of colors that significantly impact one's perception of complexity in an urban setting [68]. Kuper [69] used the color changes of plants in 4 different visual modes at several different sites to predict the level of complexity. The results showed that the scene's complexity was low when the numbers of flowers and colors were fewer. In his second study on the complexity of plant diversity (flowering, leafy, or autumn-colored plants), the results showed that flowering plants (yellow and purple) and autumn colors (yellow and red), through their color, provide more environmental information than leafy greenery. This information can also provide an incentive to explore the environment [39]. Color also plays an important role in determining the level of visual complexity in abstract images.

Organization (Symmetry–Asymmetry)

Many studies have suggested that the organizational level is one of the attributes of complexity (e.g., [7,55]). How complexity relates to symmetry has been shown to be one of the most important factors influencing aesthetic judgment and preference [49,70]. The organization of a setting can be symmetrical or asymmetrical. In studies of tourist destinations, the results showed that symmetry is an important factor in aesthetic judgment [71,72]. Many studies have addressed the impacts of this component on complexity. For example, in a study of nature images, the results showed that complexity is affected by symmetry [73]. In another study on product packaging, symmetrical information items had a significant impact on the complexity of the packaging [74].

Studies have also examined the three attributes of complexity simultaneously [75,76]. For example, in a study of natural landscape preferences and restoration in these environments, the predictors of complexity were defined as the number of elements, the level of organization, and the number of colors [75].

2.2. Discrete Choice Experiment

Choice modeling is a method for modeling stated preferences, which are generally elicited as DCEs. DCEs are now commonly used in transportation research, health economics, energy research, and environmental economics, and recently in landscape architecture. The DCE approach is based on Lancastrian consumer theory [77] and random utility models and allows the analysis of the stated choices under utility maximization [78]. Lancaster [77] stated that individual utility levels for goods do not relate to the goods themselves but to attributes of the goods. The basic idea of a DCE is to choose the most preferred alternative from a number of alternatives, whereby each alternative contains the same attributes differentiated by attribute level. The indirect utility function formally is representing as:

$$\mathrm{U}_{ni} = \mathrm{V}_{ni} + \varepsilon_{ni}\ \forall j.$$

Here, U_{nm} refers to the true utility of the alternative i to the respondent n. V_{ni} is the deterministic or observable portion of the utility and is calculated by multiplying the parameters βm (1, $\cdots$, m) of the variables (observable and important visual attributes) that are presented to respondents in the DCEs and x_{nji} (levels of visual attributes).

$$V_{ni} = \beta_{nm}\, x_{nmi}.$$

Here, ε_{ni} is the error or the portion of the utility that is unknown and that represents the random components of the utility, also called the error term. Error terms are unobserved and unmeasured. A wide range of distributions can be used to represent the error terms over individuals and alternatives. Considering a specific parametric distribution of the observed component, a probabilistic analysis of individuals' choices is possible. Random utility ε_{ni} has a probability distribution. In the framework of the DCE approach, it is assumed that if alternative (i) is preferred to alternative (j), the utility of alternative (i) is greater than the utility of alternative (j).

$$P_{ni} = Prob\ (u_{ni} > u_{nj}\ \forall j \neq i),$$
$$= Prob\ (V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}) = Prob\ (V_{ni} - V_{nj} > \varepsilon_{nj} - \varepsilon_{ni}\ \forall\ j \neq i).$$

The type of DCE determines the probability distribution. There are several different probability distributions in the various models, namely standard conditional, logit, multinomial probit, nested logit, and mixed logit models or random parameter logit models. If the error term is an identically and independently distributed type I extreme value (Gumbell distribution) with scale parameter (μ), the probability of individual *n* choosing an alternative (*i*) over another (*j*) takes the well-known form of the multinomial logit:

$$P_{ni} = \frac{e^{\mu\beta xni}}{\sum_{j=1}^{j} e^{\mu\beta xnj}}$$

Constant (homogeneous) parameters were assumed for each attribute over all respondents. According to the current literature on DCE, the conditional logit model, often called the multinomial logit (MNL) model, has been widely used when research samples have mean preferences. It is well-known that the standard MNL model has the limitation of providing a point estimate for each coefficient, which is equivalent to assuming preference homogeneity for the entire sample. This condition does not likely hold in all scenarios; therefore, analysists are often concerned with estimating more flexible models that account for taste heterogeneity. Among the various options is the random parameter logit (RPL) model. The RPL model assumes that coefficients are individual-specific and follow a random distribution, for which a location and a scale parameter are estimated. Thus, the probability that a given individual chooses any alternative becomes:

$$P_{ni} = \frac{e^{\mu\beta xni}}{\sum_{j=1}^{j} e^{\mu\beta xnj}} \mathrm{f}(\beta)\mathrm{d}\beta$$

F(β) shows a distribution density that can include any continuous probability, and the model can be estimated using the maximum simulated likelihood method.

2.3. Study Erea

The study was conducted within Gorgan city. This city is the capital of Golestan Province, which is located in the north of Iran, and is a large city bordering (approximately 30 km) the Caspian Sea (Figure 1). Golestan University is a major institute of higher education in Gorgan with about 4000 students.

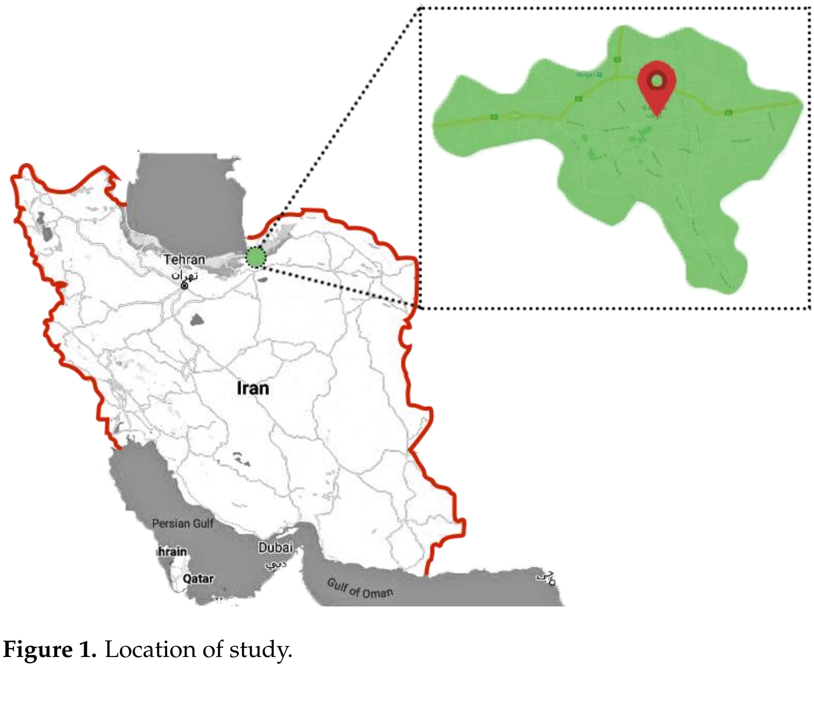

Figure 1. Location of study.

2.4. Participants

Participants for this study consisted of 396 students from Golestan University. According to Table 1, the age group under 25 years old accounted for 82% of the sample, while more than 70% of the sample were undergraduate students. Furthermore, 55% of the respondents were female.

Table 1. Demographic profile of the participants (n = 396).

Age	**<25 Years 82%**	**25–30 Years 14.5%**	**>30 Years 3.5%**
Gender	male 45%	female 55%	
Occupation	Undergraduate 70.5	Graduate 19.5	

2.5. Questionnaire

The questionnaire consisted of two parts. The first part was related to the demographic information of the participants (gender, age, field of study, and level of education), while in the second DCE part of the questionnaire a digital questionnaire was shown to the participants. These images were modeled based on experimental design to create different scenarios. Each participant was shown 6 sets of choices with 2 choice options each (2 images representing different scenarios) and had to choose the urban park that represented their preferences. Each participant evaluated 12 urban park images.

2.6. Experimental Design

Visual Attributes and Levels

Based on the literature review, a total of nine visual attributes derived from the four predictors of the preference matrix and their levels were considered. Table 2 shows an overview of the attributes and their levels.

Table 2. Description of research variables.

Mystery	
Physical access	[20–23]
Visual access	[20,21,29]
Complexity	
Variety of elements	[38,47,48,51,53,54,56,75,76,79]
Number of colors	[39,62,63,65,67,75,76]
Organization	[71,72,74–76,80]
Coherence	
Uniformity	[7,37]
Organization	[38,47,81]
Legibility	
Wayfinding	[31,32]
Distinctive elements	

Mystery can take on two attributes—visual access and physical access. The aspects of physical access were straight and curved paths. Visual access in an urban park is highly affected by dense vegetation at eye level; therefore, full visibility is provided by tall trees and visual obstructions are created by short trees.

Complexity can take on three attributes—the variety of elements, number of colors, and organization of elements. The attribute variety of elements included the number of elements in the scene. For example, the presence of 3 types of elements shows low diversity and 9 types of elements show high diversity. The number of colors equaled 2 or 4 colors in the flowers. The organization of elements was designed symmetrically and asymmetrically.

Coherence can take on two attributes—uniformity and organization of elements. Uniformity consisted of two levels, a single material and 3 materials, and there were three ways of organizing natural elements, namely scattered, clustered, and formal.

Legibility can take on two attributes—distinctive elements and wayfinding. Distinctive elements such as landmarks include two levels, presence and absence, while wayfinding through signs also has the same levels. It should be noted that the amount of trees and vegetation in all scenes was equal to avoid the influence of greenery in the images. Table 3 shows the attribute levels used in the DCE on urban parks.

Table 3. Attribute levels used in the DCE on urban parks.

Predictors	Visual Attributes	Levels	
Mystery	Physical access	Curved	Straight
	Visual access	None	Full
Complexity	Variety of elements	3	9
	Number of colors	2	4
	Organization	Asymmetry	Symmetry
Coherence	Uniformity	1	3
	Organization	Scattered	Clustered Formal
Legibility	Distinctive elements	Included	Excluded
	Wayfinding	Included	Excluded

The full factorial design included all possible combinations ($2^8 \times 3 = 768$); thus, a D-optimal orthogonal design was employed and evaluated using the program SAS Version 9.2 to reduce the number of combinations to 72. The created design consisted of a final set of 72 choice profiles, presented in 12 choice sets with 2 choice sets in 6 blocks to which participants were randomly assigned. 'No choice' was not a realistic option in the context [82,83] and the participants selected one of the urban parks. For each choice option, the images were constructed using Sketchup and Photoshop software programs. All renderings were taken from the observer's point of view. This allowed the participants to evaluate the simulation from one point as if they were standing on the pathway. Figure 2 presents an example of a choice task in the choice experiment. The list of the 9 attributes was also shown.

Figure 2. Overview of the different levels for 2 stimuli images: (**left**) high visual access, straight path, high variety of elements, high number of colors, symmetrical, high uniformity, organization scattered, and without signage and distinctive elements; (**right**) low visual access, straight path, low variety of elements, low number of colors, symmetrical, low uniformity, organization clustered, with signage, and without distinctive elements.

In the discrete choice experiment, an alternative from the choice set represents the alternative with the highest level of preference. In the stated preferences approach, individuals choose an alternative from various alternatives, and choosing one alternative over the other alternatives indicates that the chosen alternative has the highest utility [84]. In this study, utility refers to the scene inside the image, not the image itself, and participants are asked to choose the environment inside the image. The utility derived from the environment is the only difference between the two alternatives [38,82,85].

2.7. Data Collection

Data were collected from students at Golestan University. First, aim and a short description of the survey procedure were presented. Then, participants were required to give their informed consent, and were informed that they were free to leave at any time. Subsequently, participants completed the first part of the questionnaire, which included demographic details. Next, participants were randomly assigned to a block. In this study, each participant was shown only one block. Each block contained 6 choice sets, and each set contained 2 alternatives. The block was selected randomly to be displayed to individuals to avoid the effect of any order in the experiment. These random numbers are given at www.random.org, for free. In selecting blocks to be displayed to participants, it was always important that the number of times each block was displayed to participants was approximately the same to avoid the potential impact of each block's chances of being displayed. The data collection process took approximately 4 min per person. This questionnaire was shown to the students using Java software on a laptop (Figure 3). This software was designed for collecting data using a jar format. By selecting blocks from the menu and then selecting 'start survey', binary images are shown. Each participant chooses one of the images. In the end, data are placed in an excel file related to the same block. Each respondent was randomly assigned 6 choice sets with two varying alternatives, leading to a total of 2376 observed choices (396 × 6 = 2376). The advantage of this data collection method is that the number of unusable and discarded answers is reduced.

Figure 3. Screen shots of the software and a choice task.

3. Results

3.1. Random Parameter Logit Model

Here, the observations from 396 students were obtained for data analysis, which was a sufficient sample size for this type of experiment. A RPL model was used to estimate the main effects model with visual attributes and to investigate the extent of the response heterogeneity using Panda Biogem software [86].

First, the randomness of the corresponding parameters was measured to consider the main effect of visual attributes as random ($p < 0.1$). An attribute of mystery (physical access) and an attribute of the level of coherence (clustered) with non-significant. RPL model had an acceptable fit (McFadden pseudo-R^2 = 0.202, n = 2358, panel effects, 235 uniform draws, 10 attributes, normal distribution).

3.2. Parameter Value

The RPL model probes the mean sample estimates and the presence of preference heterogeneity among respondents. The levels of visual attributes were dummy-coded in the utility function based on whether they were present (value 2) or not present (value 1). Dummy coding makes it relatively easy to interpret the modeling results for part-worth effects. The parameter value for each dummy-coded attribute level is by definition the part-worth value of that attribute. Utility is added compared to the base alternative if the value = 2 (present). Thus, the parameter value indicates the part-worth utility for that visual attribute (βa). Table 4 shows the model parameters.

Table 4. Parameter estimates of the RPL model.

Attributes	Reference Levels		PV [a]	SE	*p*	St.dv	SE	*p*-Value
Mystery								
Visual access (**high**)	Medium	β1	0.226	0.091	**<0.01**	1.49	0.549	**<0.001**
Physical access (**curve**)	Straight		−0.009	0.058	0.875	-	-	-
Complexity								
Variety of elements (**9-high**)	3-low	β2	0.559	0.089	**<0.0001**	1.7	0.442	**<0.0001**
Number of colors (**4-high**)	2-low	β3	0.29	0.086	**<0.0001**	0.635	0.175	**<0.0001**
Organization (**symmetry**)	Asymmetry	β4	0.208	0.080	**<0.001**	-	-	-
Coherence								
Uniformity (**3-high**)	1-low	β5	0.474	0.103	**<0.0001**	**0.975**	0.185	**<0.0001**
Organization (**formal**)	Scattershot		−0.003	0.087	0.969	**−1.17**	**0.573**	**<0.05**
Organization (**clustered**)	Scattershot		−0.060	0.085	0.484	-	-	-
Legibility								
Wayfinding (**included**)	Excluded	β6	0.168	0.094	**<0.1**	1.41	0.669	**<0.05**
Distinctive elements (**included**)	Excluded		0.094	0.1	0.348	0.878	**0.189**	**<0.0001**

Number of observations = 2358; log likelihood = 2606.5937; LR chi2(10) = 197.46; pseudo R^2 = 0.0365; [a]: parameter value.

Figure 4 shows a graph of the parameter value related to each visual attribute on which it was significantly based on regarding the results in Table 4. The variety of elements (*complexity* attribute, β2 = 0.559, <0.0001) had the most positive influence on preference, followed by uniformity (*coherence* attribute, β5 = 0.474, <0.0001. Next was the number of colors (*complexity* attribute, β3 = 0.290, <0.0001) followed by visual access (*mystery* attribute, β1 = 0.226, <0.01). Organization (*complexity* attribute, β2 = 0.208, <0.001) and wayfinding (*legibility* attribute, β2 = 0.168, <0.1) had the lowest values. Two attributes, organization (*coherence* attribute) and distinctive elements (*legibility* attribute), did not significantly influence preferences.

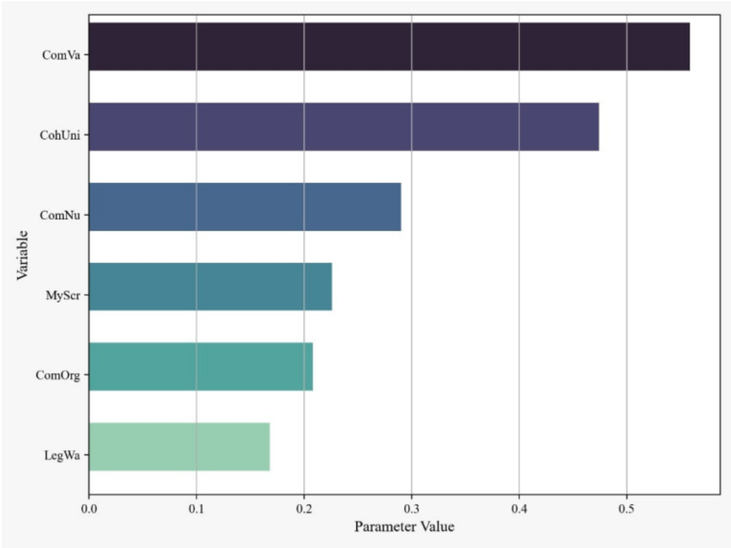

Figure 4. Part-worth utility for visual attributes.

3.3. Evaluation of Attribute Levels

A positive sign of the coefficients throughout the model means that a higher value of the variable increases the probability to choose a visual attribute compared to the reference level. Based on the results in Table 4 regarding *complexity* attributes, the respondents preferred 9 types of elements (high diversity) over the presence of 3 types of elements (low diversity). They also clearly preferred environments with a high number of colors over those with a low number of colors. Another property of complexity was the organization, where respondents preferred symmetry over asymmetry. In terms of *coherence* attributes, participants preferred environments with 3 materials over those with single materials. Regarding the organization of natural elements, formal coherence attributes were found to be significant at $p < 0.05$. Furthermore, the results regarding *mystery* attributes showed that visual access was a significant visual attribute, with respondents preferring full visual access over medium visual access. The second attribute of mystery, physical access, was not found to be significant at $p < 0.05$. Finally, for the results regarding *legibility* attributes, respondents preferred environments where distinctive elements were included over environments where they were excluded. The result for the wayfinding attribute was not found to be significant at $p < 0.05$.

3.4. Random Parameter

The results in Table 4 show that the standard deviations of the visual access (1.49, <0.001), visual elements (1.7, <0.0001), number of colors (0.635, <0.0001), uniformity (0.975, <0.0001), and distinctive elements (1.41, <0.05) were significant. Although the means for organization as a *coherence* attribute and wayfinding as a *legibility* attribute were not significant, the standard deviations were significant (−1.17, <0.05, 0.878, <0.0001). A significant standard deviation indicates preference heterogeneities for these attributes and different choices of visual attributes from one individual to another. Although the mean value for organization as a *complexity* attribute was significant at $p < 0.05$, standard deviations of organization were not found to be significant.

3.5. Interactions

Interactions between levels of visual attributes were investigated. Among all interactions, only one significant relationship found, between organization (an attribute of *complexity*) and visual access (an attribute of *mystery*). However, this interaction was not significant in ML.

Although the sample included students at Golestan University, the interactions between each of the demographic variables including age, gender, and education were estimated in ML. Their effect were not found be significant at $p < 0.05$.

4. Discussion

In this study, the effects of attributes derived from the four predictors of Kaplan's preference matrix on individuals' preferences for urban parks were examined. As stated in our review, complexity emerged early on as an important factor in people's preferences, followed by coherence. Kaplan's work led to the development of a preference matrix, where complexity and coherence were supplemented with the legibility and mystery factors. Our comprehensive review led to three specific visual attributes being linked to complexity, as well as two visual attributes each being linked to coherence, legibility, and mystery. Since these visual attributes had clear levels, a preference study via DCE would increase knowledge of these attributes, and using this knowledge urban parks should be designed to increase people's preferences for these areas.

Many studies have shown the relationships between the four predictors (complexity, coherence, mystery, and legibility) and preferences [10,13,58]. However, this study also showed the roles of certain visual attributes associated with these predictors, and how these attributes increased people's preferences for urban parks. People had high preferences for urban parks with a high variety of elements. Furthermore, the parks should be colorful, have a symmetrical organization of elements (complexity attributes), have high uniformity (coherence attributes), a high level of visual access (an attribute of mystery), and should facilitate wayfinding (an attribute of legibility). However, physical access (an attribute of mystery) and distinctive elements (an attribute of legibility) did not contribute to people's decisions when choosing urban parks.

The present study investigated the complexity based on three visual attributes: a variety of elements, the number of colors, and organization. The most important attribute of complexity that predicted preference was the variety of elements in the environment, which is consistent with the results of most studies that have measured complexity based on the number and variety of elements [38,48,51,53,55,57,60,79,87]. A greater variety of elements means that there is more to explore and that the viewer has a lot to discover, which leads to people staying longer in the environment [38]. The second attribute of complexity is color diversity. Color diversity in vegetation and flowers is an important factor that affects the complexity of parks. Previous studies have shown that color diversity has significant relationships with preferences and aesthetic preferences [21,39,63,65], and the greater the color diversity the greater the preference [57,58]. Furthermore, researchers have stated that scenes with more color diversity improve psychological well-being and have restorative potential [39,64]. The third attribute regarding complexity is the organization of components. In this study, the symmetrical organization of components was highly preferred. Studies have shown that an area can have high complexity and high preference if there is order, whereby the symmetry of the area is an important visual attribute that reduces the feeling of chaos, increases understanding, and increases one's ability to interpret the content [47,55]. The study by Chen et al. [73], among others, showed that people prefer symmetrical scenes to asymmetrical ones, and that the results are interpreted on the basis that symmetrical environments are less complex. Complex and difficult-to-interpret environments are tiring, and the symmetrical images contain fewer unique elements and are less complex than asymmetrical images, making it easier for individuals to process the scene.

The second most important characteristic that affects people's preferences for urban parks is the uniformity of the material, which is related to coherence. Researchers have investigated and demonstrated the positive effects of coherence on preferences and aesthetics [37,88,89]. In this study, one chosen visual attribute was material, with one or three materials in the image. According to the definition of coherence, immediate understanding easily arises in scenes with less information (one material), so people may prefer these scenes. However, the results of this study suggest that scenes with one material are perceived as boring, so the respondents prefer, perhaps due to the recreational intention, several different materials (up to three types of material). Again, there is a link between complexity and coherence that has been investigated in many studies [38,54,90]. There seems to be a golden mean in both cases. The second visual attribute of coherence was organization at three different levels, and this attribute showed no significance in terms of preference expect in terms of formality. Formal organization was possibly perceived as boring, while clustered organization possibly followed the golden mean.

Visual access is an important attribute of mystery. People seem to prefer moderate visual access in such settings because the promise of hidden information is more prevalent in scenes with a partial view [24]. The promise of further information also encourages one to explore and stay in the environment [20], and this exploratory behavior helps individuals to build a mental map in the park [91]. In this study, we found that a large number of elements in the park could partially block the participant's view, while a high level of visual access to vegetation modulates their view, which is related to the "partial hiding of the scene" effect and the definition of mystery. Scenes with a medium level of dense vegetation provide a medium level visual access. In this regard, many studies have indicated that medium-density scenes have high preference [92]. Furthermore, according to Appleton's landscape theory, people's chances of survival increase in landscapes where they are able to see without being seen [93]. As such, high-density scenes that block people's vision reduce the person's sense of security. Therefore, the presence of dense trees that block the entire view of the person in parks is less preferred.

This study shows that people's choices of urban parks relate to their ability to understand and find signs in the environment. Therefore, such signs should be included in urban parks. There are various visual attributes that increase legibility, such as the presence of various odd elements, which help the visitor in the absence of artificial signs [11]. The forms and materials used in artificial signs are important and influential factors. For example, wooden materials often create more coherence between artificial elements and the natural environment [82]. The entrance to the urban park in this study was designed in such a way that the viewer's vision was partially blocked at first, reducing the visual access and feeling of security. However, on the other hand, blocking part of the vision can cause exploratory behavior in individuals.

In addition to the above results, this study also shows preferences for heterogeneous attributes. This showed that individual preferences are different. However, the factors and personal characteristics can influence preference need to be studied more.

Method Discussion

The study was based on a literature review that included both classic studies by Fechner [14] and Berlyne [49] and the research by Kaplan [10], as well as more current studies. Unfortunately, literature reviews are often limited to recent years, which means that important results from classical studies can be distorted or completely forgotten over time. The review showed that there was good support in the research for the selection of the nine visual attributes that could be linked to Kaplan's preference matrix. It was also possible to specify strength levels for these nine visual attributes, which made it possible to use them in discrete choice experiments. These nine attributes could of course have been expressed in different ways by manipulating the images, and could have been combined in other ways. In addition, we may have missed some important visual attributes related to the preference matrix.

In this study, we used images as the visual aspects of environments to examine in this study. We used screen shots for several reasons. First, people must, within a reasonable period of time, make a choice based on selected possibilities in the discrete choice experiment. Hence, it was not possible to use more advanced equipment such as immersive virtual environments. Second, image-based studies of preferences (e.g., on screens) have been shown to be valid and reliable [94]. In a potential follow-up study, we could conduct the research in fields where multisensory aspects are included, based on embodied, situated cognition [95–97].

An innovation in this study is the choice to study manipulated images through a discrete choice experiment. The results show that the DCE resulted in clear and significant results, which showed that visual attributes related to complexity above all are of great importance in the choice of park to visit.

The participants selected in this study are not representative of the population. However, a relatively homogeneous group is often preferred in experiments so that any differences found can be attributed to the chosen experimental situation rather than to differences in the respondents. Hence, we used homogenous convenience sampling [98]. This kind of relatively small experimental study with a homogeneous sample of respondents should be followed by a more comprehensive study with a randomized sample of respondents. Since university students were the sample in this study, it would be worthwhile conducting follow-up studies with other samples more representative of the general population, reflecting the influence of the respondents' sociodemographic or situational characteristics. In addition, comparative studies are needed regarding the effects of visual attributes on environmental preferences in different countries and cultures.

Some of the results found here stood out. The visual attributes that most influenced the respondents' choices were related to complexity and coherence. Kaplan argues that these predictors are perceived two-dimensionally, while legibility and mystery are perceived three-dimensionally; that is, when moving in the environment. This could be an explanation for the result found here.

Another result that stood out was that our respondents had strong preference for environments with many and strong colors. Completely different results have been reported from therapeutic environments, where depressed and exhausted people cannot cope with such environments at all but completely avoid them [99]. Probably the result from the present study has to do with the fact that the respondents in this case were young, healthy students, who had no problems with environments containing many strong stimuli.

5. Conclusions

With reference to the importance of urban parks in urban life and the effects on people's health and well-being, this study focused on recognizing the visual characteristics that influence people's choices and preferences for urban parks.

The main result was that people's preferences are high for environments that are perceived to have high complexity. However, there must be organization and order in this complexity, for example through symmetry. Several results support our findings that there is a fine balance between complexity, coherence, mystery, and legibility, not least in terms of the high or low levels of attributes associated with these predictors. The area should be perceived as interesting and easy to find without being perceived as boring, chaotic, or even unsafe. The results of this study can be interpreted as meaning that there is a golden mean. More research is needed to specify the design attributes that can reveal this golden mean. Our study shows that image studies combined with DCE can be used to develop and validate design attributes to be used in machine learning and AI, where many developments now occur [100], or to validate design attributes in models used in the practical design of urban parks [97,101].

This study can also provide knowledge for designing parks, which would help landscape architects, architects, urban planners, and other professional designers to increase use and user satisfaction among citizens when visiting urban parks. The overall result of improving the structure of urban green spaces is to attract people to spend more time in urban parks and to reap the benefits of such spaces. This study points to the significant impacts of diversity, especially the diversity of elements in the park, and suggests that designers should use different elements to create spaces that are more attractive and multifunctional. This can be done by adding various types of equipment and facilities, including sports equipment, as well as a variety of plant species, flowers, and vegetation. In addition, spatial diversity should be incorporated (spaces for exercise, games for children, etc.) and different types of materials should be used. This study also shows the importance of seeking a balance between order and ease of finding in a green area in order to increase the feelings of trust and security, but at the same time to create interest in exploring the area. This involves finding the balance between visual accessibility and the feeling of mystery in the environment.

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