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Bridging landscape preference and landscape design: A study on the preference and optimal combination of landscape elements based on conjoint analysis

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ABSTRACT

Landscape preference is the focus of landscape research, in which the relationship between landscape elements and landscape preference is an important issue. Most previous studies have analysed correlation between the landscape preference scored by the public and scores on the quality of landscape elements by experts; some have compared the effects of individual landscape elements on landscape preference by photo simulation. In this study, landscape preference is regarded as the selection preference of landscape element combination. The conjoint analysis method is used to further explore the ranking and optimal combination of the significant degrees of impact of landscape elements on landscape preference when multiple landscape element combinations are used. The results show that the influence degrees of landscape elements on landscape preference in urban parks followed the order water, square, openness of the landscape, vegetation, road and seats. The optimal combination of landscape elements is the open landscape with flowing water, a shaded square, rich vegetation, a road and seats. This study demonstrates the advantages of the conjoint analysis method over the univariate method in controlling multiple variables, improving experimental efficiency and obtaining more meaningful results. A combination of urban park landscape elements based on landscape preference is helpful to inspire landscape architects to make choices among multiple landscape elements, provides evidence-based design methods for landscape design and offers basic parameters for the wide application of the parametric design or computational design of landscape architecture.

1. Introduction

Landscape perception plays an important part in landscape field. Hunziker et al. proposed two modes of landscape perception, one as space and one as place. The two modes have received widely differing weights depending on our biological inheritance and our psycho-social cultural background (Hunzikerm et al., 2007). About biological inheritance, the "prospect-refuge" theory shows the innate preference of humans for savannas composed of shrubs, trees and open spaces, which has been generally confirmed in the studies of scholars from various countries (Orians and Heerwagen, 1992; Townsend and Barton, 2018). In terms of the psycho-social cultural context, it was found that the meanings of landscape elements determine to a large extent how they are perceived. This is the case, for example, with renewable energy infrastructure, which gets a higher preference ratings if people associate "sustainability" with it (Salakb et al., 2021), or with Persian Gardens, where certain elements have little meaning for Afghan immigrants (Bazrafshanm et al., 2021), and thus are perceived less positively than by locals.

Landscape preference is a part of landscape perception, and it reflects the comprehensive results of a series of perceptual activities, such as emotional cognition, when the public faces the landscape. Understanding landscape preference helps to explore what kind of landscape is most favoured based on the comprehensive evaluation results of users on the landscape (Gonzalo et al., 2014; Junge et al., 2015). Some studies have also found that landscape preference reflects the effect of landscape on human attention recovery to some extent (van den Berg et al., 2003). Improving landscape preference can promote the public’s physical and

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mental health in various ways.

Previous studies on landscape preference have mainly focused on the relationship between landscape preference and landscape elements. Of these, the latter refer to the physical elements that constitute a landscape, among which plants and water are significantly related to landscape preference (Santosa et al., 2018; Wang and Rodiek, 2019). The increase in plant species and plant density can significantly promote the landscape preferences of respondents (Gonzalo et al., 2014; Sharafatmandrad and Mashizi, 2020; Li et al., 2020; Polat and Akay, 2015). Studies on water and visual landscape preference have been performed for a long time, and the general conclusion is that interviewees have a significant preference for water. This preference is that strong that it is largely unaffected by other landscape assessment measures and respondents' assessment measures (Petrova et al., 2015; Kaplan and Herbert, 1987; Yu, 1994). The scale of open space also has a significant effect on landscape preference (Dramstad et al., 2006; Ode et al., 2010), which may be related to the "prospect-refuge" theory, i.e., the innate human preference for savannas composed of shrubs, trees and open spaces (Appleton, 1975; Orians and Heerwagen, 1992).

Relating to the methods, Most landscape preference studies were performed with photos by asking interviewees to rate the beauty degree or preference degree of photos with different landscape elements. At the same time, experts were asked to score or objectively quantify landscape elements, carrying out correlation analysis, etc. The relationship between landscape elements and landscape preference could be determined through the results (Sharafatmandrad and Mashizi, 2020; Li et al., 2020). However, this approach fails to scientifically control the variables of landscape elements and does not take into account the influence of different forms of landscape elements in different photos on landscape preference, resulting in a low credibility of the research results.

In addition, in recent years, the photo simulation method is used to modify a single landscape element in the picture to effectively control the variables of landscape elements, with the aim to compare the presence or absence of landscape elements and the influences of their different forms on landscape preference (Wang and Rodiek, 2019; Deng et al., 2020). However, few people have applied the photo simulation method to study the permutation and combination of landscape elements. In most previous studies, only one single variable was modified for each group of control photos, making it difficult to study the changes in landscape preference in the case of multiple landscape preference variables. This is also not consistent with the public's preference for landscape in reality.

Under actual circumstances, the public does not separately evaluate each landscape element but carries out an overall evaluation on the combination of multiple landscape elements to generate preferences. The public's preference for landscapes with multiple elements can be analogous to the preference for commodities with multiple attributes. Like choosing products, the public choose the most preferred landscape by perceiving the existence or absence of multiple landscape elements and their forms of expression.While in this case, what combination of landscape elements are most preferred by public?

In this context, this study adopted the conjoint analysis method, a multivariate statistical analysis method to predict and evaluate the behaviour of choice preference (Green and Srinivasan, 1990), which is commonly used in the selection of goods. The implementation steps of the conjoint analysis method are to first decompose several important attributes in the commodity, then decompose the expression forms of attributes into multiple levels, and obtain a series of combinations by arranging multiple levels of multiple attributes and finally collect and evaluate the public's preference for the selection of different combinations. According to the preference results, the relative importance of each attribute, the influence of each level of the same attribute on the selection preference and the optimal combination of attribute levels are estimated (Bridges et al., 2011). Compared with the univariate research method, this method can combine multiple key landscape elements and their different manifestations in the same scene and conduct integrated evaluation, which not only ensures the scientific nature of the control variables but also simulates the landscape combined by multiple elements.

At present, the conjoint analysis method is gradually being used in the field of landscape architecture. It has already been used to explore the relative importance of park features that influence youth visitors of parks (Veitch et al., 2017), explore travel environment preferences of different age groups (Van Cauwenberg et al., 2016; Ariane et al., 2015; Mertens, 2015), collect the preference degree of tourists to agricultural landscape elements (Sayadi et al., 2005, 2009), determine landscape quality parameters for recreational activities in rural areas (Goossen and Langers, 2000), among others.

Although these studies have adopted the conjoint analysis method to study preferences and obtained the influence degree of different elements on preferences, they did not further deduce the combination of the most favoured landscape elements. In another case, researchers not only used the conjoint analysis method to quantitatively analyse the influence of design elements on the thermal environment of gardens but also further analysed the optimal layout mode of spatial elements of Lingnan gardens under the synergistic effect of landscape elements (Xue, 2016).

To create an urban landscape that is more preferred by the public and transform the perception of landscape preference into a quantitative and operable optimisation model of landscape element combination and configuration, this study focuses on the landscape elements of urban parks. Based on the conjoint analysis method, the study has the following objectives: (1) to determine the degree of influence of different landscape elements on landscape preference, that is, public preference and choice of landscape elements when multiple landscape elements appear conjointly.

(2) to determine the best combination of landscape elements and their manifestations in the case of the maximum landscape preference.

This research aims to provide a perspective and research method to study landscape preference through landscape element combination, and to provide some guidance for landscape architects to choose the best combination of various landscape elements in the design.

2. Methods and materials

2.1. Study area

We focus our case study in Zhujiang Park, an urban park in Guangzhou, China.

Guangzhou Zhujiang Park is located around the Pearl River New Town in the CBD of Tianhe District, Guangzhou City, Guangdong Province (Fig. 1). It is a comprehensive urban park integrating outlooks, recreation, culture and leisure, covering an area of 28.13 hm^2. It is widely used for daily activities of residents near the Pearl River New Town in Tianhe District. The landscape of Zhujiang Park is shown in Fig. 2a and b.

2.2. Research process

In this study, the conjoint analysis were used to analyse landscape preference. In order to conduct it, we used orthogonal experimental design to analyse landscape preference. The orthogonal experimental design (OED) is a mathematical method created by Taguchi, a Japanese statistician in 1950 s. OED is one way to qualitatively analyze the correlations among the relevant variables at different levels through designing orthogonal table and statistical analysis. It offers an ability to discover the best combination levels for different factors with a reasonably small number of experimental samples. This method has been widely accepted by engineers, technicians, researchers, entrepreneurs, and managers (Zhu et al., 2013).

The outline of the research design is as follows:

(1) Literature coding and content analysis of the English literature of

Fig. 1. Location of Zhujiang Park in Guangzhou City, China.

Fig. 2. a. Lake area in Zhujiang Park in Guangzhou City, China. 2b. Lawn area in Zhujiang Park in Guangzhou City, China.

visual landscape preference in the past 10 years and determination of the landscape elements adopted in this study and their forms of expression.

(2) Combination of multiple landscape elements and their different manifestations into multiple test groups by the conjoint analysis method.

(3) Few representative sample groups were selected by the orthogonal experimental design (OED). The photo simulation method was used to present each sample group through the photo media.

(4) Users of Zhujiang Park were interviewed and the preferences of the interviewees on the landscape shown in these pictures were collected through questionnaires.

(5) The SPSS 26.0 software was used to verify the reliability and validity of the qualified questionnaires, and Kendall's correlation analysis was conducted on the respondents' characteristics, recreational

Table 1
Landscape elements and forms used in the study.

Landscape element (attribute)	Form (level)
Water	Non-existing
	Moving water
	Still water
Vegetation	Vegetation without abundant species
	Vegetation with abundant species
Seats	Non-existing
	Existing
Road	Non-existing
	Existing
Square	Non-existing
	Shaded square
	Unshaded square
Openness of the landscape	Closed
	Open

Table 2
Orthogonal fractional factorial design.

Pair	1	2	3	4	5	6
Water	Non-existing	Non-existing	Moving water	Moving water	Still water	Still water
Vegetation	Vegetation without abundant species	Vegetation with abundant species	Vegetation with abundant species	Vegetation without abundant species	Vegetation without abundant species	Vegetation with abundant species
Seat	Non-existing	Existing	Non-existing	Existing	Non-existing	Existing
Road	Non-existing	Existing	Existing	Non-existing	Existing	Non-existing
Square	Non-existing	Shaded square	Non-existing	Shaded square	Unshaded square	Unshaded square
Spatial scale	Closed	Open	Closed	Open	Open	Closed
Photo						

frequency and landscape preference. Then we used range analysis and variance analysis to calculate the relative influence degrees and select the optimal combination of the orthogonal test results. A further ANOVA test was performed on the score of landscape elements and visual landscape preference, and the significance and F values.

2.3. Selection of landscape elements

The literature was searched from relevant English journals from 2011 to 2020, and literature coding and content analysis were carried out on the landscape element evaluation indices using in the retrieved publications. To fully cover the literature on landscape preference, the title was restricted as follows: (landscape quality) OR (landscape value) OR (landscape evaluation) OR (landscape perception) OR (landscape preference). The selected publications were screened again with the following criteria: (1) landscape elements are used as evaluation indices; (2) there is a detailed research process and specific research results. In total, 34 English publications met the screening criteria.

The evaluation indices of landscape elements selected from the 34 publications were recorded and classified as second-level indexes, and the second-level indexes with similar contents were classified as first-level indexes. Then literature analysis was carried out to select the landscape elements in urban parks. It was concluded that water, vegetation, seats, road, square and openness of the landscape were important landscape elements of landscape preference in urban parks (Wang and Rodiek, 2019; Petrova et al., 2015; Wang et al., 2020). The corresponding expression forms of these landscape elements were determined as follows:

The manifestation forms of water were classified according to the static and still state of water (Arriaza et al., 2004; Bulut and Yilmaz, 2008) and then divided into "no", "moving water" and "still water". The corresponding expression forms of these landscape elements were determined.

(2) According to the classification of vegetation, vegetation generally has two expressions, namely vegetation without abundant species and vegetation with abundant species (Arriaza et al., 2004; Yao et al., 2012). Vegetation is reflected by herbs and trees, herbs, shrubs and trees.

(3) Openness of the landscape is considered in numerous publications and is a suitable index for the evaluation of landscape preference (Wang et al., 2020; Tveit, 2009). In this study, two forms of expression were selected, "closed" and "open". A small ratio of visual distance to boundary height was used to create a closed space scale. A large ratio of visual distance to boundary height is used to create an open space scale.

(4) According to the literature, seats are important recreational facilities, and urban park landscapes with seats are preferred (Wang and Rodiek, 2019). This paper used the two expression forms "existing" or "non-existing".

(5) For roads, the expressions “existing” on “non-existing” were used (Wang and Rodiek, 2019).

(6) The square is an important recreational space for activities. Guangzhou has a south-Asian tropical monsoon climate, and shading is therefore an important aspect. Therefore, the manifestation forms of the square were divided into "non-existing", "shaded square" and "unshaded square".

2.4. Experimental design

According to the above selection of landscape elements, the attributes and levels of landscape elements selected in this study are shown in Table 1.

According to the Conjoint Analysis Method, these landscape elements and expression forms are represented in a combined way, which requires a total of 3^2 x 2^4 times, that is, 144 times of comprehensive tests. Because of the high workload and low practicability, we used the orthogonal experimental design method to assist the conjoint analysis method. According to the orthogonality of mathematics, a few representative sample groups were selected from a large number of comprehensive combinations to carry out the test, with the aim to obtain the results of the comprehensive test through the analysis of part of the test results. The combinations were reduced to 12 pairs by Allpairs, an orthogonal table generation tool designed by the statistician Genichi Taguchi.

The experiment used the picture simulation method to display the combination of landscape elements (Daniel and Boster, 1976; Hull and Stewart, 1992; Daniel, 2001). Previous studies have shown that pictures can accurately reproduce the landscape, and the assessment results based on pictures are highly similar to those based on field investigations (Iii, 1990; Schroeder and Daniel, 1980). The authors took photos from Zhujiang Park in Guangzhou, extracted landscape elements and then edited the pictures.

The photos of Zhujiang Park were taken from 2 to 5 PM on December 27, 2020, when the weather was clear and sunny. We selected the viewing platform and resting square, which are frequently used by the public for photographs. The relevant landscape elements were extracted and edited by Adobe Photoshop CC 2018, and 12 groups of landscape pictures were simulated (Table 2).

2.5. Questionnaire survey

Questionnaires were distributed and collected in Zhujiang Park on the afternoons of January 10–16, 2021. The respondents were tourists of Zhujiang Park.

The questionnaire was divided into three parts: (1) demographic characteristics of interviewees, including age, educational background and professional background; (2) frequency of using urban parks; (3) respondents’ preference for 12 landscape pictures. Respondents’ preference for landscape pictures was assessed by a Likert scale of 1–7, with

Table 2 (*continued*)

7	8	9	10	11	12
Non-existing	Non-existing	Moving water	Still water	Still water	Non-existing
Vegetation without abundant species	Vegetation with abundant species	Vegetation without abundant species	Vegetation with abundant species	Vegetation without abundant species	Vegetation with abundant species
Existing	Non-existing	Non-existing	Existing	Non-existing	Existing
Existing	Non-existing	Non-existing	Non-existing	Existing	Existing
Non-existing	Shaded square	Unshaded square	Non-existing	Shaded square	Unshaded square
Open	Closed	Open	Open	Closed	Closed
					

1 indicating “dislike very much” and 7 indicating “like very much”. Prior to the experiment, the participants were asked to imagine how much they would like the landscape shown in the picture.

2.6. Data processing

We first used the SPSS 26.0 software to verify the reliability and validity of the qualified questionnaires.

Then, The relative influence degree of orthogonal test results was calculated by range analysis and variance analysis. The range was calculated as follows:

on any column, R = max { k1, k2, k3 } - min { k1, k2, k3 } , $R' = R \times d \times \sqrt{n}$.

In the formula, $k_i : K_i/s$, where S is the number of occurrences of each level on any column.

K_i : When the horizontal sign on any column is I, $K_i$is the sum of the corresponding test results.

The number of expression forms of water and square was 3, d = 0.52, and the number of expression forms of other landscape elements was 2, d = 0.71.

Based on range analysis, we used the variance analysis method to test the significance of the interaction effect of factor effects to clarify the stability of factors and the specific influence degree of factors at a given level.

The general formula of ANOVA is as follows: $S_j = \frac{b}{a}\sum_{k=1}^{b} y_{jk}^2 - \frac{1}{a}\left(\sum_{i=1}^{a} y_i\right)^2$,

where S_j is the sum of squares of column deviations, that is, the sum of squares of deviations between the mean values of test indicators and the total mean values of each level in column j, indicating the fluctuation of test data in this column; b is the number of levels in column j; y is the result of the test index; i is test number (row number); j is the number of columns; a is the number of tests; n is the total number of columns.

The optimal combination of landscape elements and their expression forms is further selected. The largest values of k_1,k_2,k_3 of the same landscape element are the best expression forms of the landscape element. The combination of the best expression forms of each landscape element is the optimal combination of landscape elements and their expression forms.

3. Results

A total of 131 questionnaires were collected at the park and screened according to the sample of respondents who rated all 12 pictures for "“recreation” in the same way or who scored only two points in total, of which one score was consecutive (e.g., 665555555555 for each picture). In this way, we screened out the questionnaires that were not answered carefully, which led to the excessively homogeneous landscape preference of each picture. Overall, 26 samples were screened out of 131 questionnaires, and the qualified rate of samples was 80.15%.

3.1. Reliability

We used the SPSS 26.0 software to verify the reliability and validity of the 131 qualified questionnaires. Cronbach’s α coefficient of the landscape preference scoring questionnaire was 0.862, indicating good reliability of the questionnaire.It is confirmed that a Cronbach’s α greater than0.801 indicated excellent internal consistency (Landis and Koch, 1977). Therefore, the overall validity of the questionnaire was good. We then measured the structural validity of the questions in the questionnaire by KMO (Kaiser Meyer Olkin) and Bartlett test of spericity. The KMO coefficient of the questionnaire was 0.816, and the significance probability value of Bartlett’s spherical test was 0.000.

3.2. Sociodemographic characteristics and recreational frequency of the respondents

The sociodemographic characteristics and recreational conditions of the respondents are shown in Table 3. Overall, the interviewees are 18–44 years old and mainly hold a junior college or bachelor’s degree. The frequency of recreation is relatively high, with interviewees vising the park once a week or more accounting for 40%, indicating that the

Table 3
Sociodemographic characteristics and recreational situation of the respondents.

Sociodemographic characteristics		**Number**	**%**
Age	< 17	4	3.81%
	18–44	81	77.14%
	45–59	12	11.43%
	> 60	8	7.62%
Educational background	High school and below	19	18.10%
	Junior college or undergraduate	66	62.86%
	Graduate student or above	20	19.05%
Design background	Yes	6	5.71%
	No	99	94.29%
Recreational situation		number	%
Recreational frequency	Once a week or more	43	40.95%
	1–3 times a month	41	39.05%
	Once half a year	19	18.10%
	Less than once half a year	2	1.90%
Recreational activity (multiplechoice)	Walking	92	87.62%
	Sitting and resting	74	70.48%
	Photographing and bird watching	28	26.67%
	play with kids	25	23.81%
	exercise	7	6.67%
	playing Chess and Cards	5	4.76%
	practice tai Chi	3	2.86%
	dance	3	2.86%
	drawing and practice calligraphy	2	1.90%
	sing	2	1.90%

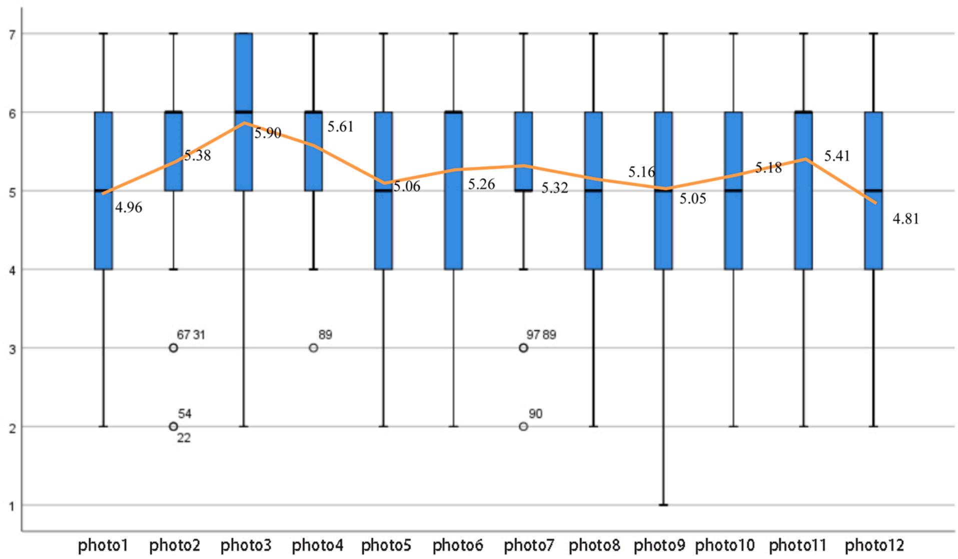

Fig. 3. Average scores obtained by the 12 photos.

interviewees frequently use the park and are familiar with it. Recreational activities include walking, sitting and resting, photography, bird watching and playing with children.

Kendalľs correlation analysis was conducted on the respondents' characteristics, recreational frequency and landscape preference (Appendix 1). The age of the interviewers is positively correlated with picture 12, whereas education background was negatively correlated with pictures 5 and 9. Frequency of use was positively correlated with pictures 3, 4, 7, 9, 11 and 12. There was no consistent expression form of landscape elements in these pictures, and it can therefore be considered that education background has no significant influence on the preferences for water, vegetation, seats, road, square and openness of the landscape.

3.3. Landscape preference score

The scores of preferences for the 12 photos in the qualified samples are shown in Fig. 3; photo 3 scored the highest(5.90). This photo is characterised by moving water, rich vegetation, a road, a square and a relatively closed space. Photo 12 rank the last (4.81), with rich vegetation, seats, a road and an unshaded square, but without water and a relatively closed space.

3.4. Preference for landscape elements

We calculated the relative influence degrees and select the optimal combination of the orthogonal test results with range analysis and variance analysis (Table 4). According to the values of R' and S_j, the landscape elements that have an impact on the landscape preference followed the order water, square, openness of the landscape, vegetation, road and seats.

A further ANOVA test is performed on the score of landscape elements and visual landscape preference, and the significance and F values are shown in Table 5. Water and square have three manifestation forms, which needed to be tested by homogeneity of variance. The ANOVA of water body and square yield a $p > 0.05$, indicating that different groups of samples have homogeneity of variance for different satisfaction levels. Further analysis of variance shows that the significance levels for water and square are 0.000, and there are significant differences among the three classifications of water and square.

When the significance levels for vegetation, seats, road and openness of the landscape are less than 0.05, the expression forms of these factors

Table 4
ANOVA results for square representation and visual landscape preference scores.

	Score					
		Quadratic sum	Degrees of freedom	Mean square	F	Significance
Water	Interblock	198.352	2	99.176	71.422	0.000
	intra-class	7677.485	5529	1.389		
	sum	7875.837	5531			
Square	Interblock	257.448	2	128.724	93.421	0.000
	intra-class	7618.389	5529	1.378		
	sum	7875.837	5531			
Vegetationr	Interblock	4.628	1	4.628	3.251	0.071
	intra-class	7871.210	5530	1.423		
	sum	7875.837	5531			
Seats	Interblock	.695	1	.695	0.488	0.485
	intra-class	7875.142	5530	1.424		
	sum	7875.837	5531			
Road	Interblock	1.337	1	1.337	0.939	0.333
	intra-class	7875.500	5530	1.424		
	sum	7875.837	5531			
Openness of the landscape	Interblock	9.397	1	9.397	6.606	0.010
	intra-class	7866.440	5530	1.423		
	sum	7875.837	5531			

Table 5
Test results of landscape orthogonality.

Number	Water	Vegetation	Seats	Road	Square	Spatial scale	Mean score
1	1	1	1	1	1	1	4.96
2	1	2	2	2	2	2	5.38
3	2	2	1	2	1	1	5.90
4	2	1	2	1	2	2	5.61
5	3	1	1	2	3	2	5.06
6	3	2	2	1	3	1	5.26
7	1	1	2	2	1	2	5.32
8	1	2	1	1	2	1	5.16
9	2	1	1	1	3	2	5.05
10	3	2	2	1	1	2	5.18
11	3	1	1	2	2	1	5.41
12	1	2	2	2	3	1	4.81
k_1	5.1260	5.2350	5.2567	5.2033	5.3400	5.2500	
k_2	5.5200	5.2817	5.2600	5.3133	5.3900	5.2667	
k_3	5.2275				5.0450		
R	0.39	0.05	0.00	0.11	0.35	0.02	
R'	0.71	0.11	0.01	0.27	0.62	0.04	
S_j	10.2888	0.0065	0.0000	0.0363	0.2781	0.0008	
Importance ranking	1	4	6	3	2	5	

have a significant correlation with the score of visual landscape preference, and the value of F indicates the significance degree of the influence. As seen in Table 5, water, square and openness of the landscape significantly influenced the visual landscape preference, following the order square > water > openness of the landscape; vegetation, seats and road had no significant effect on the visual landscape preference.

3.5. Optimal combination of landscape elements

The sum of squares of the column deviations of water was the largest one, indicating that compared with other landscape elements, water had the most significant influence on landscape preference. Pictures with moving water and will still water were preferred, and moving water was preferred over still water. A high plant diversity had a positive effect on landscape preference, whereas the presence of seats and garden paths had a slightly negative effect on landscape preference. Compared with the absence of squares, shaded squares had a positive effect on visual landscape preference, whereas unshaded squares had a negative effect on visual landscape preference.

Based on the ranking of the importance degree of influence and the size of k_i, the optimal combination of landscape elements is as follows: flowing water, shaded square, rich vegetation, open landscape with road and seats. This combination is beyond the range of 12 trials and was the optimum combination in 144 comprehensive trials. Scenarios of the optimum combination display are shown in Appendix 2.

4. Discussion

4.1. Influences of landscape elements on landscape preference

In this study, the sum of squares of the column deviations of water was considerably higher than that of other landscape elements, indicating that water had the highest positive effect on landscape preference. Previous studies have also found a significant preference for water (Petrova et al., 2015; Kaplan and Herbert, 1987; Yu, 1994), and it was the most highly rated landscape element in one study (López-Martínez, 2017). Most likely, this is because water is an evolutionary necessity for survival, according to Wilson's biophilia theory (Kuper, 2018; Wilson, 1984). We only investigated the existence of water and the flow and static state of water, but not the specific water quantity and quality, which should be the topic of future studies.

The preference for a diverse vegetation was high, which has also been widely demonstrated in previous studies. For example, interviewees preferred landscapes with a high vegetation richness (Wang and Rodiek, 2019). A high variety of vegetation helps reduce stress and restore attention, thus improving landscape preference (Deng et al., 2020; Kuper, 2018). Furthermore, the average score and the sum of the square of the series deviation ($k_2 = 5.28, S_j = 8.25$) of the preferences of the landscape with moving water were higher than that of the landscape with rich vegetation ($k_2 = 5.00, S_j = 0.61$), indicating that the influence of vegetation on landscape preference was considerably smaller than that of moving water. In other words, when given a choice between flowing water and a high vegetation diversity, water is generally preferred.

The presence of seats only slightly positively affected. In contrast, in previous studies on urban green space, respondents preferred places with seats, especially those with backrests and armrests (Wang and Rodiek, 2019; Zhang et al., 2013). The differences between the results of this paper and those of previous studies are mainly caused by the research methods. The landscape preference obtained by the conjoint analysis method in this study reflected the preference for seats and other landscape elements. The slightly positive influence of seats on landscape preference can be interpreted as those of with water, vegetation and shaded squares; seats themselves are less favoured and can easily be omitted.

This study also found that the shaded square had a positive effect on visual landscape preference, whereas the unshaded square had a negative effect on visual landscape preference.

This shows the importance of the regulatory ecosystem services within the landscape preference, given that urban heat island is a worldwide problem. In China, shading greatly affects the usage of a square, which is especially obvious in Guangzhou, since Guangzhou is located in the south Asian tropical monsoon climate zone and the highest temperature reaches 37 °C. This is mainly because Chinese people generally do not like to be exposed to the sun over long periods, and if shading is provided on a square, the general public are more inclined to use it. Apart from it, squares have been playing an important role in Chinese culture and were once public spaces for political gatherings. Today, citizens still prefer squares for social activities.

4.2. Optimal combination of landscape elements

This study found that the optimum combination of landscape elements is an open landscape with flowing water, a shaded square, rich vegetation, a road and seats. This depicts a landscape that is naturally open and suitable for passage and activity, which is in agreement with the theory of restoration of perception in landscape. A previous study has found that the general public prefers large spaces with a natural "feeling" and a diverse vegetation (Grahn and Stigsdotter, 2010). At the same time, this type of landscape ensures accessibility and recreational activities, which helps to enhance site dependence (Lin et al., 2019) and thus the public's preference for the landscape. According to the results of this study, landscape architects should pay attention to the combination and balance of natural landscape elements and recreational facilities when designing urban parks.

4.3. Limitations

Photo editing may have led to biased results, and the selected landscape elements of the material may have a certain degree of influence on the results of landscape preference.

As mentioned in the Introduction, preference ratings for certain elements in the urban green space can be universal (e.g., water is perceived positively in virtually all cultural backgrounds) but also very culture-specific depending on the meaning (Bazrafshanm et al., 2021) and the symbolic contents (Hunzikerm et al., 2007). We attempted to keep the symbolic content consistent in our photo editing by only exhibiting images from a few sites that are all concerned with urban park contents. As a result, we are convinced that we did not mix symbolic components in our experiment. However, the influence of meanings could not be fully controlled in our rather simple experiment. The fact that all of the respondents were raised in a Chinese cultural environment ensures that their interpretations are similar. Nevertheless, even these may vary inter-culturally and would need to be assessed with in-depth interviews or questionnaires with the respondents.

4.4. Suggestions

Studies on landscape preferences facilitate the screening out of the factors influencing landscape preference, allowing the construction of a typed design model and paving the way for parametric design or computational design (Wang, 2019). The present research is based on previous studies on the degree of preference for landscape elements, that is, the optimal combination of landscape elements. Further studies should be based on specific design goals in a specific spatial environment to measure and simulate the effects of the components of each element and its spatial layout on landscape preference.

Besides, there are more symbolic contents involved in the 12 images, for example coherence, legibility, complexity and mystery, which may also effect landscape preference. The relationship of landscape preference and symbolic contents need to be further studied.

5. Conclusions

Through conjoint analysis and quantitative analysis, this study found that the significant effects of landscape elements on landscape preference followed the order water, square, openness of the landscape, vegetation, road and seats. Furthermore, under the condition of the maximum landscape preference, that is, the public consider the landscape with the highest aesthetic value and the one most suitable for recreation. The optimal combination of landscape elements is the open landscape with flowing water, a shaded square, rich vegetation, a road and seats.

This study demonstrates the advantages of the conjoint analysis method over the univariate method in controlling variables, improving experimental efficiency and optimising the research results. At the same time, taking landscape preference as a combination of landscape elements is helpful to clarify the relationship between landscape elements and landscape preference in urban parks, determining which landscape elements should be given priority in park design. In addition, it is helpful to build a bridge between landscape preference and landscape design, and inspire landscape architects to make choices among multiple landscape elements. At the same time, this study is helpful to provide evidence-based design methods for landscape design and basic parameters for the wide application of parametric or computational design in landscape architecture.

This study combines scientific and rational parametric design with artistic and perceptual design thinking, facilitating landscape architecture projects with the support of scientific models.

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CRediT authorship contribution statement

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix 1. Correlation coefficients between frequency of use of demographic characteristics and landscape preference

		photo1	photo2	photo3	photo4	photo5	photo6	photo7	photo8	photo9	photo10	photo11	photo12
Age	Correlation index	0.045	0.024	0.016	0.1	0.144	0.039	0.066	-0.076	0.127	0.08	0.096	.202*
	Sig.	0.604	0.78	0.854	0.249	0.095	0.651	0.444	0.379	0.139	0.349	0.265	0.021
	N	105	105	105	105	105	105	105	105	105	105	105	105
Educational background	Correlation index	-0.002	-0.085	-0.117	-0.056	-.209*	-0.107	-0.065	0.024	-.182*	-0.132	-0.066	-0.141
	Sig.	0.984	0.323	0.18	0.511	0.015	0.212	0.448	0.777	0.033	0.122	0.436	0.104
	N	105	105	105	105	105	105	105	105	105	105	105	105
Non-design background	Correlation index	-0.001	-0.165	0.095	-0.019	-0.086	0.022	0.046	-0.033	0.055	0.111	-0.001	0.04
	Sig.	0.988	0.065	0.294	0.83	0.336	0.807	0.609	0.713	0.534	0.212	0.989	0.654
	N	105	105	105	105	105	105	105	105	105	105	105	105
		-0.082	-0.159	-.209*	-.200*	-0.114	-0.131	-.359**	-0.158	-.250**	-0.047	-.175*	-.193*

(*continued on next page*)

(*continued*)

		photo1	photo2	photo3	photo4	photo5	photo6	photo7	photo8	photo9	photo10	photo11	photo12
Recreational frequency	Correlation index												
	Sig.	0.333	0.06	0.015	0.018	0.179	0.12	0	0.062	0.003	0.577	0.037	0.023
	N	105	105	105	105	105	105	105	105	105	105	105	105

** At level 0.01 (double tail), the correlation is significant.

* At level 0.05 (double tail), the correlation is significant.

Appendix 2. Simulation picture of the optimal combination of landscape elements

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