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RESEARCH PAPER

Investigating Visual Aesthetic Fatigue in Urban Green Spaces

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Abstract

Life experience suggests that visual aesthetic fatigue (VAF) is quite common. However, few academic works have focussed on VAF in landscapes, thus our understanding of this issue is very poor, not to mention what measures can be taken to mitigate it. To address these gaps, this study investigated VAF using 16 photographs taken in urban green spaces in Xuzhou (local landscapes) and Hong Kong (non-local landscapes) as stimuli. The visual aesthetic quality (VAQ) of 16 photographs was evaluated four times by the same college students at an interval of one week. Statistical analysis demonstrated that VAF occurred in urban green spaces. Male respondents had a higher VAF than females. There were no significant differences in VAQ and VAF between local and non-local landscapes. No landscape characteristic significantly correlated to or predicted VAF, implying that it is very difficult to mitigate VAF through designing and managing static landscapes.

Article Highlights

- **Effects of repeated occurrence of same stimuli on aesthetic quality were measured**
- **Visual aesthetic fatigue occurred in urban green spaces**
- **Male respondents' visual aesthetic fatigue is higher than that of females**
- **Similar impact of local and non-local landscapes on visual aesthetic fatigue**
- **No landscape characteristic significantly correlated to visual aesthetic fatigue**

Keywords Aesthetic fatigue · Repeated exposures · Landscape preference · Urban green space · Landscape design

Introduction

Visual aesthetic quality (VAQ) is not only related to observers' satisfaction and psychological well-being (Tyrväinen et al. 2017; Wang and Zhao 2020), but also closely linked to other functions of a landscape, including ecological quality (Junker and Buchecker 2008; Zhao et al. 2017a), mental stress relief (Ratcliffe and Korpela 2016; Wang and Zhao 2020), physical activity (Tyrväinen, et al. 2017), the image of a place (Ewald 2001) and the development of local economy (Chen and Wang 2013). For example, a beautiful image can make the city very famous and increase its tourism potential (Ewald 2001; Sayadi et al. 2009), benefiting the economic development, in turn providing potential funds for caring for and improving the beautiful landscapes in the city (Zhu and Zhang 2008), forming a virtuous circle between economic development and the improvement of landscape quality. Therefore, Wang et al. (2016) claimed that protection and improvement of VAQ were the central issue for sustainable development.

The landscape in our daily life is relatively fixed. The most noticeable landscape changes are those that occur with different seasons (Xu et al. 2022). However, these changes are always very slow, which means that in a short time, such as a month, we see almost the same landscape every day. The theory of aesthetic fatigue suggests that when a stimulus continuously acts on the receptor of human, sensory adaptation will appear, and with the prolongation of the action time of the stimulus, the intensity of the sensory response to the stimulus will be lower and lower (Lin et al. 2003), implying that when the stimulus becomes more and more familiar after again and again exposure, individuals

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gradually habituate to the pleasurable properties of the stimulus, finding it less attractive with each exposure (Leventhal et al. 2007). The theory is mainly applied in the field of museum and art (Bitgood 2015; Mikuni et al. 2022). To the authors' knowledge, only a case study has explored this issue in landscapes (Li et al. 2018), which concluded that participants' preference ratings for the photographs taken in four Chinese traditional gardens were the highest when they saw the photographs for the first time, and the lowest in the third view. This study only demonstrated the occurrence of visual aesthetic fatigue (VAF), but did not explore the driving factors of VAF. Furthermore, it is impossible to get the general conclusion from a case study. Therefore, the published research leaves us with a critical knowledge gap in our understanding of VAF in urban green spaces which provide people with many benefits, including relatively low-cost opportunities to connect with nature (Kaplan et al. 2006), benefiting people's health physically and psychologically (Gascon et al. 2016; Zhu et al. 2021; Zhang, et al. 2022), cushioning the effect of urban heat islands (An et al. 2022), and acting as noise screens (Wang et al. 2022). The aesthetic quality plays a vital role in giving full play to the functions of urban green spaces due to the fact that an ugly place can discourage people access to it (Gobster et al. 2007). Therefore, the question arises: what design and management measures should be taken to relieve or even eliminate the negative effects of VAF on aesthetic quality of urban green spaces? To the best of the author's knowledge, no clue can be found in existing literature.

Gobster et al. (2007) suggested that we desired to see, live in and visit places perceived to be beautiful. However, the landscape is possibly perceived to be lower and lower in preference rating when an observer sees it again and again within a short time, and even perceived ugly due to VAF. Thus, if we ignore the problem of VAF when conducting landscape design and management, it may cause the serious degradation of perceived beauty of existing landscapes. It likely loses the attraction to people, thereby reducing the functionality of landscapes. The present study tries to investigate the VAF in urban green spaces and find out its driving factors, expecting to provide some cohesive evidence to guide landscape design and management to mitigate VAF, in turn, increasing the attraction of urban green spaces. Specifically, the following four questions guided this study.

(1) Does VAF occur in landscapes?
(2) What are the differences in VAF between male and female respondents?
(3) Is there any difference between respondents' VAF of local landscape and that of non-local landscape?
(4) What are the essential landscape characteristics that influence VAF?

Materials and Methods

Study Area

Xuzhou is a medium-sized city in the northwest of Jiangsu province, eastern China, with a typical warm monsoon climate which determines that the local natural vegetation is deciduous broad-leaved plants. This city has experienced rapid expansion of urban green spaces in the past three decades. By 2018, the urban green spaces in Xuzhou include 74 parks with various types such as urban park, forest park, wetland, botanical garden, etc. The per-capita urban green space is 17 m^2 (Zhao and Huang 2021).

Hong Kong is a big dense city in southern China. More than 80% of its total area is hilly terrain which is unfavourable for urban development, thus, Hong Kong is one of the most densely populated cities in the world (Wan and Shen 2015). Although the government has recognized the positive aspects of urban green spaces for sustainable development and resident's health, and put great efforts to provide green spaces, open spaces accounts for only 9% of the developed land area of the city, and, compared with cities of similar size, Hong Kong's proportional provision of urban green spaces is among the lowest in the world (Tan et al. 2013). The local natural vegetation in Hong Kong is tropical or subtropical evergreen broad-leaved plants under the subtropical monsoon climate. Obviously, Xuzhou and Hong Kong have significant differences in terms of urban green spaces, which is conducive to the comparison in VAQ between the two cities and VAF between local and non-local landscapes.

Photographs

This study used photographs as surrogates of real landscapes. This method has been widely used in landscape preference assessment by previous research (e.g. Yao et al. 2012; Zhao et al. 2013a,b; Xu et al. 2022) and its reliability has been evidenced by early research (Nassauer 1983; Herzog and Chernick 2000; Palmer and Hoffman 2001). This method has the advantages of fast progression, low cost and comparing multiple landscapes simultaneously (Zhao et al. 2013b).

A total of 16 photographs were selected using stratified random sampling from a pool with more than 200 photographs to represent the various visual landscapes in urban green spaces (see Appendix). These photographs were taken in Xuzhou (ten photographs) and Hong Kong (six photographs) using the same digital camera (NIKON D3400) with a focal length of 35 mm and an aspect ratio 16: 9 on clear or less cloudy days from 9 a.m. to 16 p.m.

at eye level (about 152 cm above the ground). The ten photographs in Xuzhou were taken in summer 2017, and the six photographs in Hong Kong were taken in summer 2021, which can reduce seasonality bias.

Respondents and VAQ Evaluations

Although some experts thought college students were less representative of the general public, they had several advantages in landscape assessment, such as high efficiency, low cost and easy to organize (Wang et al. 2016). In the present study the same respondents should regularly evaluate the VAQ of photographs four times, it is extremely difficult to recruit the respondents from social groups, particularly in this period of COVID-19 pandemic and the Chinese government has implemented strict epidemic control measures. Thus college students were employed as respondents in this study. Lothian (1999) indicated that the minimum number of respondents was 30 for perception assessment. Therefore, a total of 36 college students from China University of Mining and Technology (CUMT) were invited to rate the VAQ of 16 photographs through the snowball sampling method initiated by five college students, and all students were voluntary and signed a consent before the surveys. The students were similar in ages (20–22 years old), educational level (junior students) and cultural background (Han nationality living in China), including 21 females and 15 males. Although these students' hometown is in different regions, CUMT is located in Xuzhou. The students have lived in Xuzhou for almost three years (they were admitted to CUMT in early September 2019). Therefore, the photographs taken in Xuzhou were treated as local landscapes, and the photographs taken in Hong Kong as non-local landscapes because no student comes from Hong Kong or ever visited the city. This study received an ethical approval from a university.

All photographs were evaluated four times at an interval of one week from May 5 to June 2 2022 by the same group of students in a classroom, and the specific time to conduct the survey is strictly limited to 3:00 p.m. to 4:00 p.m. Referring to the scale used in previous literature (Xu et al. 2018; Mangone et al. 2021), a seven-point scale ranging from 1 (not at all) to 7 (very beautiful) was used to assess the VAQ of 16 photographs. The photographs were shown on a 1.6×1.2 m white screen in a random order by a projector in a classroom and played one by one. After a photograph was played, the respondents were requested to complete the VAQ judgement. All respondents attended the four evaluations. To avoid the accidental interactions between the first evaluation and next three evaluations as far as possible the played order of photographs was changed in each evaluation. To eliminate the impact of indoor environment on the evaluations, the layout inside the classroom remains unchanged and the temperature (26℃) and humidity (48%) are controlled by an air conditioner.

Landscape Characteristics Judgement

Landscape assessment is context dependent (Gobster et al. 2007). Therefore, establishing the quantifiable dependence relationships between the subject's judgments and specific objective attributes of a landscape can guide landscape architects to improve subjects' perceptions through manipulating the landscape attributes (Arriaza et al. 2004; Zhao et al. 2021; Zhao and Huang 2021). To find which landscape characteristics constituted important drivers of VAF in urban green spaces, 20 landscape characteristics representing the main features of the landscapes studied in this paper were picked out by referring to previous literature (Arriaza et al. 2004; Zhao et al. 2013a; Zhao and Huang 2021; Hu and Zhao 2022), in which nine characteristics were calculated objectively (Table 1) and 11 other ones were judged subjectively by four experts majoring in landscape architecture (Table 2).

Objective Measurement

The first eight characteristics listed in Table 1, including ratio of building, ratio of paved area, ratio of sky, ratio of woody plants, ratio of grass, ratio of water body, ratio of topographical variation and ratio of aquatic plants were calculated by placing

Table 1 Objective measurement of landscape characteristics (Zhao et al. 2013a; Konopinski 2020)

Landscape characteristics	Calculation
Ratio of building	$P_i = M_i/M$, where P_i = ratio of *i*th characteristic; M_i = the number of squares covered by *i*th characteristic; M = the total number of squares on a photograph
Ratio of paved area	
Ratio of sky	
Ratio of woody plants	
Ratio of grass	
Ratio of water body	
Ratio of topographical variation	
Ratio of aquatic plants	
Landscape diversity	Using the formula of Shannon–Wiener index

Table 2 Subjective judgement of landscape characteristics (Arriaza et al. 2004; Zhao and Huang 2021)

Landscape characteristics	Scores			
	0.00	0.33	0.67	1.00
View scale	Closed	Slightly open	Semi-open	Open
Vegetation density	Very low	Low	Moderate	High
Type of land vegetation	Grass	Only shrubs or shrubs with grass	Only trees or trees with grasses	Mixed vegetation
Configuration of land vegetation	Completely regular	Regular configuration dominated	Semi-natural	Natural
Perceived diversity of vegetation	Single	Low	Moderate	High
Maintenance of vegetation	No maintenance	Poor	Moderate	Good
Visual naturalness of water	No water	Orderly form	Semi-natural form	Natural form
Accessibility of water	No water	Difficult to access	Neutral to access	Easy to access
Quality of water	No water	Bad	Moderate	Good
Type of topography	Almost flat	Slightly undulating	Moderately undulating	Highly undulating
Number of colours	1	2–4	5–7	More

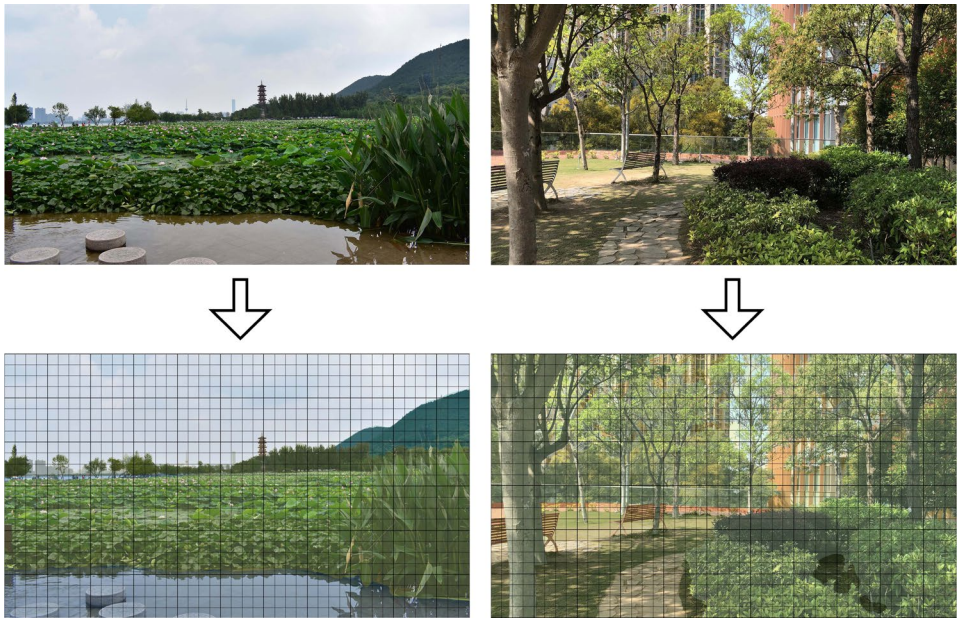

Fig. 1 Two sample photographs (top row) and the method to calculating the objective characteristics (bottom row)

a grid (24 × 43 = 1032 squares) over the whole photograph (Fig. 1), and each square covered by more than 50% of a given variable was marked and counted (Zhao et al. 2013a). Then the number of squares covered by a given variable was divided by the total number of squares on the whole photograph. Therefore, the score of each characteristic ranged from 0 to 1.

Landscape diversity was calculated by Shannon–Wiener index (formula (1)) which can describe the variation at multiple levels of genetic organisation, through whole species or larger taxonomic units to ecosystems (Konopinski 2020).

$$\mathrm{LD} = -\sum_{i=1}^{s} \frac{N_i}{N} \log_2 \frac{N_i}{N} \tag{1}$$

where LD: value of landscape diversity; S: number of landscape characteristics, N_i: value of the *i*th characteristic, N: sum values of all characteristic.

To unify the scale of landscape diversity to other characteristics, landscape diversity score was normalized by formula (2) (Ding et al. 2016).

$$\mathrm{LD}_{iN} = \frac{LD_i - \min(\mathrm{LD})}{\max(\mathrm{LD}) - \min(\mathrm{LD})} \tag{2}$$

where LD_{iN}: the normalized value of landscape diversity of the *i*th photograph; LD_i: the landscape diversity score of the *i*th photograph; min(LD) and max(LD): the minimum and maximum score of landscape diversity among the 16 photographs, respectively. The normalized value of

landscape diversity ranges from 0 to 1, being in line with other characteristics.

Subjective Judgement

In an office room 16 photographs were projected on a white wall individually in a random order. The four experts were asked to judge 11 landscape characteristics of each photograph according to the scales shown in Table 2 which indicated that the scale ranged from 0 to 1 to be consistent with the scales of the nine characteristics calculated objectively. To relieve possibly fatigue, a fifteen-minute break was given after completing eight photographs. The interclass reliabilities of landscape characteristic scores across the four experts ranged from 0.724 to 0.907 (Cronbach's Alpha). Landis and Koch (1977) claimed that if the Cronbach's Alpha was more than 0.701, it meant good internal reliability, implying that the characteristics scores judged by the four experts can be used with confidence. Therefore, the average score of the four experts was used as the values for a particular characteristic of each photograph. The average score could synthesize the four experts' judgments and gave a more accurate description of a characteristic.

Data Analysis

SPSS 25.0 was employed to analyse the data. At first, the interclass reliabilities of VAQ scores of four evaluations were tested to prove the reliability of the data and confidence of their use. The one-way ANOVA which is widely used in practice to compare statistical differences existing two or more data sets, was employed to explore the differences in VAQ and Standard Deviation (SD) of VAQ between four evaluations because, followed by Shapiro Wilk's and Levene's test, the data of VAQ and SD of VAQ are normally distributed (the first evaluation, $p=0.709$ (VAQ), $p=0.707$ (SD); the second evaluation, $p=0.742$ (VAQ), $p=0.114$ (SD); the third evaluation, $p=0.880$ (VAQ), $p=0.652$ (SD); the fourth evaluation, $p=0.922$ (VAQ), $p=0.306$ (SD)) and homogenous ($p=0.487$ (VAQ), $p=0.522$ (SD)). And Post hoc test (LSD) was used to examine pairwise comparisons among the four evaluations. The Mann–Whitney U test, a kind of non-parametric method for checking the two sets of data, was used to examine the differences in VAQ and VAF between male and female respondents, and between local and non-local landscapes. It is equivalent to the one-way ANOVA, but does not apply the normality assumption (Zhao et al. 2017b). At last, the correlation analysis and stepwise multiple linear regression analysis were used to explore the driving factors of VAF, because the later can build quantitative relationships between VAF and multiple landscape characteristics after excluding the non-significant characteristics.

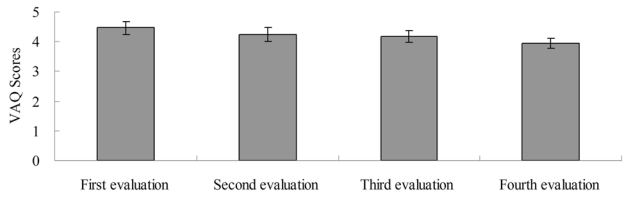

Fig. 3 Mean VAQ scores (±standard error) within photographs in four evaluations

Results

Reliability

The interclass reliabilities of VAQ scores of four evaluations were calculated. Cronbach's Alpha was 0.834 (first evaluation), 0.768 (second evaluation), 0.852 (third evaluation), and 0.790 (fourth evaluation), which showed good internal reliabilities of VAQ evaluations.

Overall Evaluation of VAQ and VAF

The mean VAQ scores of 16 photographs within respondents in the four evaluations are presented in Fig. 2 which showed that the aesthetic scores of most photographs (9 of 16) successively decreased over repeated exposures. Based on the average score of 16 photographs, VAQ scores also

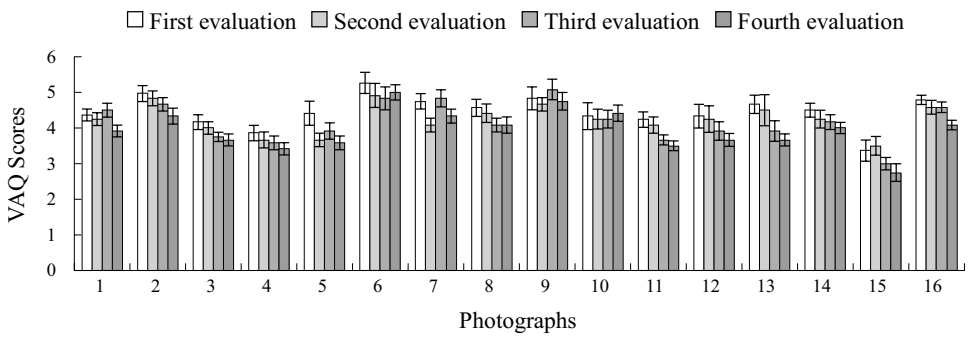

Fig. 2 Mean VAQ scores (±standard error) within respondents of 16 photographs in four evaluations

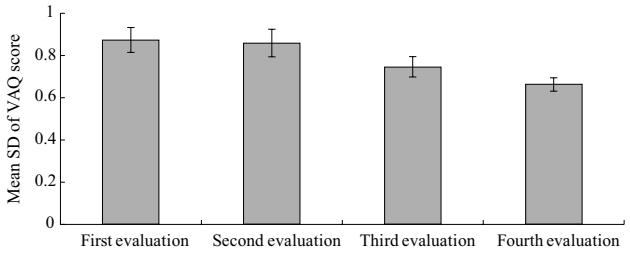

Fig. 4 Mean SD of VAQ scores (±standard error) within photographs in four evaluations

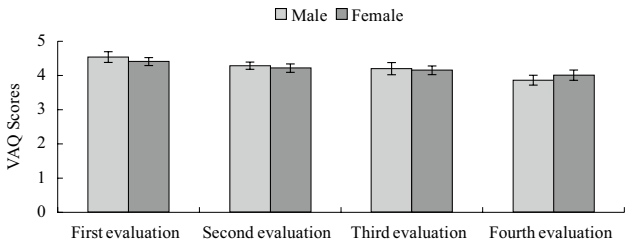

Fig. 5 Mean VAQ scores (±standard error) of male and female respondents within photographs in four evaluations

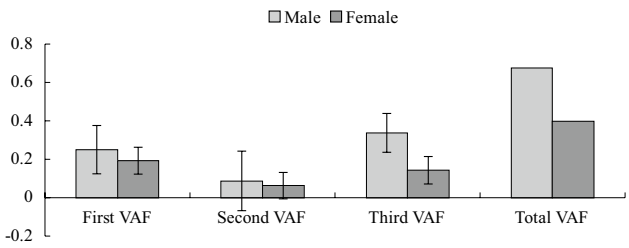

Fig. 6 Mean VAF (±standard error) of male and female respondents within photographs

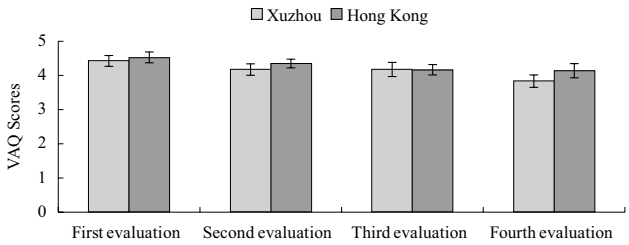

Fig. 7 Mean VAQ scores (±standard error) of local (Xuzhou) and non-local landscapes (Hong Kong) within respondents in four evaluations

successively decreased over repeated exposures (Fig. 3). The one-way ANOVA showed that there was a significant difference in VAQ scores between the four evaluations ($F=2.946$; $p=0.040$). Results of post hoc test (LSD) showed that the VAQ score of the first evaluation vs. that of the fourth evaluation was significantly different ($p=0.005$). Generally, VAF occurred in urban green spaces and resulted in an average loss of 11.4% of the aesthetic value when the same landscape was repeated four times at an interval of one week.

We also found a very interesting result that the mean Standard Deviation (SD) of VAQ scores of 16 photographs within the respondents was smaller and smaller over repeated exposures (Fig. 4). The one-way ANOVA claimed that there was a close significant difference in SD of VAQ between the our evaluations ($F=2.279$; $p=0.079$), which implies that with the repeated occurrence of the same landscape, respondents' aesthetic preference for it tended to be consistent due to the fact that there is a negative relationship between SD and consensus.

Differences in VAQ and VAF Between Male and Female Respondents

Because the respondents were similar in age, educational level and cultural background, the respondents were divided into two groups by gender to explore the gender's effect on VAQ and VAF. The mean VAQ scores of 16 photographs assessed by the two groups in four evaluations are shown in Fig. 5. The Mann–Whitney U test claimed that there were no significant differences in VAQ between males and females (Mann–Whitney $U=1995.000$; $p=0.800$). The mean VAF of males and females are presented in Fig. 6 in which the first VAF is determined by the VAQ score of the first evaluation minus that of the second evaluation, the second VAF is determined by the VAQ score of the second evaluation minus that of the third evaluation, and so on, and the total VAF is the sum of the first, second and third VAF. The result demonstrated that VAF of males was higher than that of females. The Mann–Whitney U test indicated that there was a significant difference in VAF between males and females (Mann–Whitney $U=1596.500$; $p=0.031$), which implies that men's preference for a recurring landscape declines much faster than women's.

Difference in VAQ and VAF Between Local and Non-local Landscapes

Sixteen photographs used in this study were divided into two groups according to the cities where the photographs were taken (ten photographs were taken in Xuzhou, and six photographs in Hong Kong). The mean VAQ and VAF scores of the two groups of photographs in four evaluations are shown in Fig. 7 and Fig. 8, respectively. The Mann–Whitney U test suggested that there were no significant differences in VAQ and VAF between the two cities (for VAQ, Mann–Whitney $U=427.000$; $p=0.462$; for VAF, Mann–Whitney $U=362.000$; $p=0.101$), which implies that the familiarity

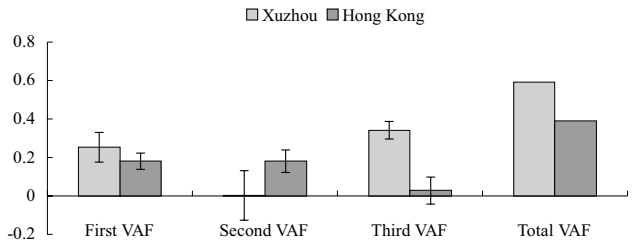

Fig. 8 Mean VAF (±standard error) of local (Xuzhou) and non-local landscapes (Hong Kong) within respondents

with the landscape seems to have a weak influence on the occurrence of VAF because the respondents have lived in Xuzhou for a few years, their familiarity with the local landscapes is higher than that with the Hong Kong landscapes which they have never visited.

Driving Factors of VAF

The correlation analysis claimed that no significant correlations between VAF and landscape characteristics were found. The stepwise multiple linear regression analysis, using VAF as dependent variables and 20 landscape characteristics as independent variables, indicated that no characteristic entered the models, suggesting that no characteristic can predict VAF. Curve estimation regression analysis was employed to examine possible non-linear relationships between VAF and landscape characteristics. However, still no significant relationships were found.

Discussion

Reasons for no Driving Factors of VAF

The present study demonstrates that, after four repetitions at an interval of one week, VAF occurs in almost all landscapes (Fig. 3), which poses a big challenge to landscape designers and managers, because the landscape in real world keeps a relatively fixed appearance in a specific period of time, and the traditional landscape design has not taken VAF into account yet. Unfortunately, the present study does not establish reliable relationships between landscape characteristics and VAF, failing to provide valuable clues to guide landscape design and management to mitigate VAF. This seems that VAF is less related to the permanent landscape features, implying that regardless of the pleasurable properties of the landscape, if they remain unchanged for a long time, the beauty will gradually decreases in the eyes of visitors after again and again exposures to it. Mikuni et al. (2022) also found a similar result, which suggested that viewing time and appraisals decreased over repeated exposures regardless of the participants' cultural backgrounds and the categories and styles of artworks, reflecting a universal reaction in art appreciation. The mechanism may be that VAF is a widespread phenomenon rooted in our natural perception system which was built during the long evolutionary history (Darwin 1859) and remains relatively unchanged. Therefore, it is very difficult to mitigate VAF through designing and managing static landscapes, inspiring that to fight against VAF, it is necessary to find other methods, such as building an emotional bond to a place, and highlighting the dynamic design of the landscape.

Mitigation of VAF in Urban Green Spaces

The concept of place attachment may be used to fight against VAF. Place attachment is broadly defined as an emotional or affective bond developed towards a specific place (Manzo and Devine-Wright 2014), which derives from the concept of topophilia developed by Tuan (1977). Although no research has checked the association between place attachment and VAF, previous literature demonstrated that place attachment was positively related to tourists' loyalty to a specific destination (Jian et al. 2021; Zou et al. 2022) and positively associated with residents' well-being (Han et al. 2021) which has been evidenced to be closely related to landscape preference (Wang and Zhao 2020). To the authors' knowledge, no literature has paid efforts on how to help residents building place attachment to a definite environment. However, Low and Altman (1992) claimed that the origin of place attachment was mainly biological, environmental, psychological, and sociocultural, as well as their interrelation, and Loukaitou-Sideris et al. (2014) stated that the natural environment could create a place attachment. These findings provide some clues to guide landscape design to mitigate VAF through building the sense of place attachment.

In addition, the time-dimension should be considered carefully to fight against VAF because VAF is just caused by the repeated occurrence of the stimuli over a period of time. Landscape continues both in space and time, consisting of permanent features as well as ephemera (Jones 2003). Ephemeral quality can be conveyed by vegetables, flowers, and seasonal colour of trees as well as stars and the moon. Therefore, intensifying the seasonal changes of the landscape and maintaining the landscape following the circadian rhythms can improve ephemeral quality, in turn mitigating VAF in urban green spaces. Correspondingly these features with obvious seasonality are encouraged to be used in landscapes, including deciduous plants, water and the vegetation with bright flowers and colourful fruits in different seasons. Meanwhile, elements reflecting differences between nightscape and daytime landscape are also welcome, such as starry sky and moonlight in different moon phases.

Men's and Women's VAF

This study suggests that when the same landscape reappears four times, the aesthetic value evaluated by men declines significantly faster than women (Fig. 6). The reason is not clear due to the fact that only one literature has involved in VAF in landscapes and no work explores the difference in VAF between men and women. However, based on evolutionary theory, we tentatively infer the possible three reasons. First, in primitive society, men and women have a clear division of labour, in which men mainly conduct hunting (Locay 1997). Animals do not always appear in the same environment due to the fact that they wander around for food and courtship. Thus men always hunt the animals in different environments. To hunt more animals and provide meat food for themselves and their families, men build an aesthetic preference for the changed environments, in turn, their aesthetic appreciation for the same landscape losing quickly. On the contrary, women are mainly engaged in collecting and provide plant food to feed themselves and their offspring (Locay 1997). Plants grow in a fixed place, to gather the fruits and (or) seeds of plants, women possess a high aesthetic tolerance for recurring landscapes, thus, their VAF is much lower than that of men. Second, existing literature has evidenced that men preferred adventures to women (Holland-Smith 2016). This implies that new things which usually include unknown information are preferred by men, logically, compared with women, familiar objects arouse less aesthetic appreciation of men. Third, early literature suggested that aesthetic preference was determined by genes (Bourassa 1990; Hartig 1993). We reasonably presume that VAF is also built during the long evolutionary history and rooted in our genes according to the basic principle of evolutionary theory that the fittest survives and the unfit is eliminated (Darwin 1859). Obviously, a man's reproductive potential is much greater than that of a woman. A man with less VAF means that he falls in love with only a woman for a long time. He certainly passed fewer genes to subsequent generations than those who enjoy mating with more women. Therefore, men's genes of VAF are much stronger than women's, and these genes also affect people's aesthetic preference for the landscape. Of course, the hypothetical mechanisms mentioned above are lack of robust evidence, which calls for a future study to test them.

Variation of Consensus of VAQ Evaluation with Landscape Repetitions

Wang et al. (2016) demonstrated that VAQ score had a significantly positive linear relationship with judgement consensus, meaning that a landscape with high VAQ score usually induces a higher consensus among respondents' evaluations. The authors also explained that during the long evolutionary history, people have formed a relatively similar assessment for a landscape that supports their survival and reproduction, and this landscape always was rated a high rating of preference. Our results suggest that the consensus of VAQ score within respondents increases, while VAQ score decreases over the repeated exposures to the landscape (Figs. 3 and 4), which implies that the lower the VAQ, the higher the consensus, conflicting the findings of Wang et al. (2016). This conflict can be possibly explained by the fact that, in the experiment of Wang et al. (2016), the respondent judged the VAQ only one time. While, when the landscape repeated occurrence, more information was received by respondents, and the comprehensive information that respondents get from the landscape tends to be similar, inducing a similar assessment of aesthetic quality.

Limitations and Further Research

First, sample size of photographs and number of respondents are small, especially when the photographs are divided into two groups according to the cities where they are taken (ten in Xuzhou and six in Hong Kong), and the respondents were divided by gender (15 males and 21 females). Small sample size increases the occasionality and reduces the reliability of general conclusions drawn from this study. Second, we conducted the four evaluations at a constant interval of one week. Therefore, the findings just say that the repeated occurrence of a landscape at an interval of one week can induce VAF. We assume that if the interval changes, VAF likely changes, inspiring a future study to explore the threshold of interval, i.e. finding the optimal interval of landscape repetitions that do not induce or only cause a very small VAF. Defining the threshold can help us to manipulate the intensity of landscape changes according to the threshold to mitigate VAF, which has significantly practical values to guide landscape design and management. Third, understanding the mechanism of VAF is encouraged in the future study, which can make landscape design and management targeted to mitigate or even eliminate VAF in our daily landscapes.

Conclusions

This study investigates the phenomenon of VAF in urban green spaces and tries to explore the driving factors of VAF. The four questions proposed by this study are answered. For the first question "does VAF occur in landscapes?" Yes, VAF occurs in landscapes, and VAF significantly decreases the aesthetic values of urban green spaces after four repetitions of the same stimuli at an interval of one week. For the second question "what are the differences in VAF between male and female respondents?" Males' VAF is significantly higher than females', that is to say, with the repetitions of the

same landscape, males' aesthetic preference declines faster than females'. For the third question "is there any difference between respondents' VAF of local landscape and that of non-local landscape?" No, the respondents' VAF for local and non-local landscapes has no significant difference. For the fourth question "what are the essential landscape characteristics that influence VAF?" No significant characteristic which can drive VAF is identified, meaning that the present study cannot provide credible measures to fight against VAF. However, based on the existing theories such as place attachment and ephemeral quality, possible methods to mitigate VAF are discussed.

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Data availability The authors confirm that the data supporting the findings of this study are available in the article.

Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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