



# The Effects of Artificial Lake Space on Satisfaction and Restorativeness of the Overall Environment and Soundscape in Urban Parks

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Several studies have proven that soundscape in blue space is conducive to human health and well-being, but few studies have explored which blue space characteristics would contribute to a better soundscape and visiting experience. Therefore, an on-site questionnaire investigation was conducted at two artificial lakes in Xi'an, China. The eight Perceived Sensory Dimensions (PSDs) as a landscape assessment tool were applied to identify the characteristics of artificial lake space in urban parks. The results showed that (1) In artificial lake space, overall environment and soundscape reached a very satisfactory level in general, while the respondents' perceived level of overall restorativeness and soundscape restorativeness as just medium, which indicated that the quality of artificial lake space needs to be improved. (2) According to people's perceptions, artificial lake spaces had the most obvious characteristics of *prospect*, *social* and *space*; *serene* and *nature* were medium; *refuge*, *rich in species*, and *culture* were the least. (3) The eight PSDs of artificial lake space, except for *social*, were positively correlated with soundscape satisfaction, overall satisfaction, soundscape restorativeness, and overall restorativeness. Moreover, among them, *serene* was the most significant characteristic in artificial lake space. These findings could be instructive to the design of urban parks with artificial lakes for improving users' visiting satisfaction and restorativeness.

**Keywords:** artificial lake space, perceived restorativeness, visiting satisfaction, perceived sensory dimensions (PSDs), soundscape

## INTRODUCTION

Blue space, as all visible surface waters in space, includes the marine environment and fresh water such as rivers, lakes, seas, and fountains (Völker and Kistemann, 2011; Foley and Kistemann, 2015; Grellier et al., 2017). There are significant differences in physical characteristics, ecological value, and experience between them. Although people living in inland areas have limited access to the ocean (Kummu et al., 2011), they have more access to freshwater space, which can be divided into natural water space and artificial water space, such as artificial lake space in parks. For inland areas with few natural freshwater resources, the urban blue space is mainly dominated by artificial lake space with certain greenery, which is of great importance for urban inhabitants (Jarvis et al., 2020).

Therefore, it is essential to focus on the construction of blue spaces, like artificial lake spaces, when planning and designing urban parks.

With the ever growing urbanization process, the psychological pressures of urban residents has been increasing sharply, which might lead to several types of physical and mental diseases (Glaser et al., 2000; Wilkins, 2008; Nilsson et al., 2017). Previous studies have claimed the importance of blue space, which is reflected not only in the ecological environment but also in people's physical (Gidlow et al., 2016; Memari et al., 2017) and psychological health (Pasanen et al., 2019; Pearson et al., 2019). Indeed, people that visit green and blue spaces feel happier than those in gray spaces (MacKerron and Mourato, 2013). Nutsford et al. (2016) showed that higher levels of blue space visibility were related to lower psychological stress (Nutsford et al., 2016). Moreover, artificial lakes, as an important type of blue space in urban parks, is closely related to people's life and health interests, but few studies have focused on lakes in urban parks in terms of its well-being aspect. Therefore, it is meaningful to study the artificial lake space, especially its health benefits in the overall environment.

Serenity and calm have been accepted as apparent features in blue space, especially in the open artificial lake space. Hence, as an essential aspect of building peace and serenity, the soundscape in artificial lake space is worth studying and has been proven to be positively related to people's visiting experience. Ma et al. (2021) found that an open artificial lake space provided the maximum soundscape satisfaction and pleasantness in their sample park (Ma et al., 2021). Fan et al. (2021) found that people in the proximity of an open artificial lake space had a relatively high soundscape satisfaction. Furthermore, the soundscape in the artificial lake space affects restorativeness, which contributes mostly to health and well-being (Fan et al., 2021). Patón et al. (2020) investigated 16 kinds of water relating sounds and found that natural water sounds like those from a small stream or pond, can produce relaxation in contrast to obvious artificial water sounds (Patón et al., 2020). As a main kind of blue space in urban parks, artificial lakes possess the potential for satisfaction and health benefits in terms of soundscape. Therefore, in the construction of urban blue spaces, it is necessary to strengthen the soundscape of artificial lake space, to explore the evaluated levels and ways to improve it.

However, mechanisms linked to restoration and the natural environment has often been overlooked (Dzhambov et al., 2018). Despite a few studies that have explored the mechanism of open artificial lake; like stress reduction, thermal comfort improvement, and the promotion of non-water sports activities (Steenefeld et al., 2014; Grassini et al., 2019; Vert et al., 2019), the specific level of satisfaction and restoration (e.g., medium, or better), and the characteristics of urban artificial lake space that can mostly promote human health remain absent. To guide the future planning and design of health-based urban blue spaces, like artificial lake spaces, the specific perceived characteristics related to well-being deserve further exploration. Therefore, a measurement system of perception attributes of an artificial lake space needs to be introduced. Eight perceived sensory dimensions (PSDs) were developed by researchers at the Swedish University of Agricultural Sciences as a classification

system that identified the most representative characteristics of nature. The classification system contained eight dimensions, as follows: "serene" (e.g., salient and calm), "nature" (e.g., wild and untouched), "rich in species" (e.g., many animals and plants), "space" (e.g., spacious and free), "prospect" (e.g., flat and well-cut lawns with scattered trees), "refuge" (e.g., an enclosed and safe place), "social" (e.g., entertainment and exhibitions), and "culture" (e.g., decorated with fountains and ornamental plants) (Grahn and Stigsdotter, 2010). The eight PSDs have been applied in many studies related to the relationship of urban park characteristics and stress recovery (Grahn and Stigsdotter, 2003; Peschardt and Stigsdotter, 2013; Memari et al., 2017). Considering its wide application in landscape studies, PSDs were used to measure the perceptions of artificial lake space in this study.

At present, there are many indicators to measure spatial restorativeness. Two prevailing theories of restorativeness in the natural environment are widely applied: attentional restoration theory (ART) (Kaplan and Kaplan, 1989; Kaplan, 1995) and stress recovery theory (SRT) (Ulrich et al., 1991). The perceived restorativeness scales (PRS) have been developed according to ART to evaluate people's recovery levels in different environments (Hartig et al., 1997; Fátima et al., 2017), which contains four main components with 16 items in total: Fascination (the attraction of involuntary, effortless attention); Being-Away (a shift away from the present daily routine to a different environment); Compatibility (fit to an individual's planned behavior and environmental demands); and Extent (it can be experienced through immersion in intellectual activities and in physical environments.) (Hartig et al., 1996, 1997). Then Payne (2013) developed an evaluation system for restorative soundscape, incorporating psychological and situational factors based on the PRS and attentional restoration theory (ART)—Perceived Restorativeness Soundscape Scale (PRSS), which can help us assess the restorative aspect of soundscapes (Payne, 2013). PRSS, with a total of 19 items, contains six parts, as follows: Fascination, Being-Away-To, Being-Away-From, Compatibility, Extent (Coherence), and Extent (Scope). At present, the PRSS system is gradually applied in soundscape research (Zhang et al., 2017; Li and Kang, 2019; Zhao et al., 2020). In particular, soundscape as an indispensable part of the overall environment contributes to the construction of PSDs. For example, *serene* in the eight dimensions of PSDs is inseparable from soundscape. The purpose of linking PSDs with PRSS is to explore which relatively important dimensions of PSDs will affect the soundscape restoration, so that designers can improve the design of soundscape recovery from the perspective of PSDs in the future.

Overall, this study explored the relationship between two aspects—PSDs and the restorative potential of artificial lake spaces in urban parks—and identified the specific mechanism of specific artificial lake spaces on rehabilitation potential. The study will help to reasonably evaluate and enhance the health benefits of artificial lake spaces in cities and ultimately contribute to healthy urban and sustainable development. This study's specific objectives were to investigate:

1. What is the perceived evaluation level of satisfaction and restoration of the overall environment and soundscape in artificial lake spaces of urban parks?
2. Representation of the eight PSDs in artificial lake spaces of urban parks.
3. Correlations between the eight PSDs and the satisfaction and restorativeness of the overall environment and soundscape in artificial lake spaces of urban parks.

## MATERIALS AND METHODS

### Ethics

The studies involving human participants were reviewed and approved by the Ethics Committee of the College of Landscape Architecture and Arts, Northwest A&F University. Written informed consent to participate in this study was provided by the participants.

### Study Area

Two typical public urban parks in Xi'an, China, were selected as the study area based on similar sound levels and environmental conditions in both. The field survey was conducted from September to October 2019. The two urban parks with open artificial lakes—Qujiang pond heritage park (opened in 2008) and the Yanming lake wetland park (opened in 2016) were selected as the representative urban artificial lake space. The two parks are freely accessible and popular, and the two lakes are similar in size, gentle in velocity of flow, and slightly eddy. Four sample points were chosen in the perimeter of the hard revetment in each park. The distance of four sample points between the lake edge lines is basically the same (Figure 1).

### Questionnaire Structure

The questionnaire survey was conducted on-site using an app called “Wen Juan Xing” with participants’ agreement. The questionnaire consisted of two sections. The first section of the questionnaire was designed to collect the respondents’ perceptions in artificial lake spaces using the eight PSDs, including *serene, nature, rich in species, space, prospect, refuge, social, and culture*. The Likert five-level scale was used with 0 (no feeling) to 5 (very strong feeling). The second section of the questionnaire focused on recovery potential in artificial lake spaces, respectively, soundscape satisfaction, overall satisfaction, soundscape restorativeness, and overall restorativeness. The soundscape satisfaction and overall satisfaction were measured with a five-level Likert scale from 0 (very poor) to 5 (very good). As to soundscape restorativeness, a simplified perceived restorativeness soundscape scale (PRSS) as a subjective questionnaire can comprehensively determine the restoration of soundscapes. Six landscape architecture experts were invited to participate in the research process of the simplified PRSS. Those experts selected two questions in each dimension of PRSS which were considered to be representative and easy to understand. Moreover, “Being-Away-To” and “Extent (Scope)” as two dimensions of PRSS were neglected in this study for

the following reasons. First, the “Being-Away-To” and “Being-Away-From” dimensions of the PRSS were developed from the “Being-Away” dimension of the ART theory (Kaplan and Kaplan, 1989; Hammitt, 2000), both of which measure recovery from fatigue due to environmental change. “Extent (Scope)” and “Extent (Coherence)” were developed from the “Extent” dimension according to the ART theory (Kaplan and Kaplan, 1989; Payne, 2013). The “Extent (Scope)” dimension has only one question regarding the scale of the environment (“The sonic environment suggests the size of this place is limitless”), which is not especially relevant to our objectives and was not easily understood by the general respondents in the pre-experiments. Second, the neglect of “Being-Away-To” and “Extent (Scope)” of PRSS caused a unification of dimensions with PRS, which was in favor of respondents understanding and to avoid confusion. That is because respondents should understand the meaning of dimensions for a better comprehension of questions before filling in the questionnaire. Finally, to shorten the investigation time, and to avoid the psychological interference of the long-term investigation on the respondent, a simplified PRSS could be used instead, with Cronbach’s alpha of 0.90. Therefore, four subscales, selected as the following metrics, were calculated as a simplified PRSS: Fascination (“I find this sonic environment appealing” and “My attention is drawn to many of the interesting sounds here”); Being-Away-From (“This sonic environment is a refuge from unwanted distractions” and “These voices relieve the pressure of my daily life”); Compatibility (“These sounds relate to activities I like to do” and “I rapidly get used to hearing this type of sonic environment”); Extent (Coherence) (“All the sounds merge to form a coherent sonic environment” and “The sounds I am hearing seem to fit together quite naturally with this place”). As to overall restorativeness, the PRS with 16 items as an instrument for measuring the restorative quality of environment was applied, with Cronbach’s alpha of 0.88. There are four parts of PRS according to ART, as follows: Fascination (e.g., It is a fascinating environment); Being-Away (e.g., This is a good experience away from the troubles of real life); Extent (e.g., It is a confusing place); and Compatibility (e.g., I feel I belong here). Both PRSS and PRS were provided in the Chinese version, and each question was answered on a Likert five-point scale in response to “how much do you agree with the statement?” Scores ranged from 1 (not at all) to 5 (completely agree). In particular, the Likert five-point scale represents an evaluation level in terms of both satisfaction and restorativeness, which can be divided into four levels to indicate the level of perception: poor level (1–2), medium to poor level (2–3), medium to good level (3–4), and very good level (4–5).

### Field Survey

All respondents were randomly selected among visitors in each park and approached visitors were consented and informed that all answers would be anonymous. The willing participants were then invited to fill the questionnaire in individually using a tablet. Each sampling site was conducted to do a field survey twice over different days to reduce deviation caused by participant selection. Meteorological factors were measured simultaneously from 9:00 a.m. to 5:00 p.m. via Kestrel 5500 weather station while



**FIGURE 1** | Study area and photographs: **(A)** Location of the Qujiang pond heritage park and the Yanming lake wetland park in Xi'an, China; **(B)** four sample points in the Qujiang pond heritage park; **(C)** four sample points in the Yanming lake wetland park; **(D,E)** two images of the two study sites.

the questionnaire survey was conducted, including temperature ( $15.45^{\circ}\text{C}$ ,  $SD = 2.58^{\circ}\text{C}$ ), relative humidity ( $63.35\%$ ,  $SD = 11.47\%$ ), and wind speed ( $0.75\text{ m/s}$ ,  $SD = 0.66\text{ m/s}$ ). In addition, types of sound sources and sound levels can affect the subjective attitude to soundscape (Völker et al., 2018). In the pre-experiment before the field survey, the sound sources in the two sample parks were similar according to the perceptions of the respondents, which indicated that the two parks have a similar soundscape. As to each site's sound levels, it was measured continuously for 8 h, from approximately 9:00 a.m. to 5:00 p.m. via Kjaer 2250 class 1 sound level meter (SLM; 1-s logging period). Stable sound conditions were guaranteed at a similar level in each site each day with an average sound level of 64.10 dBA.

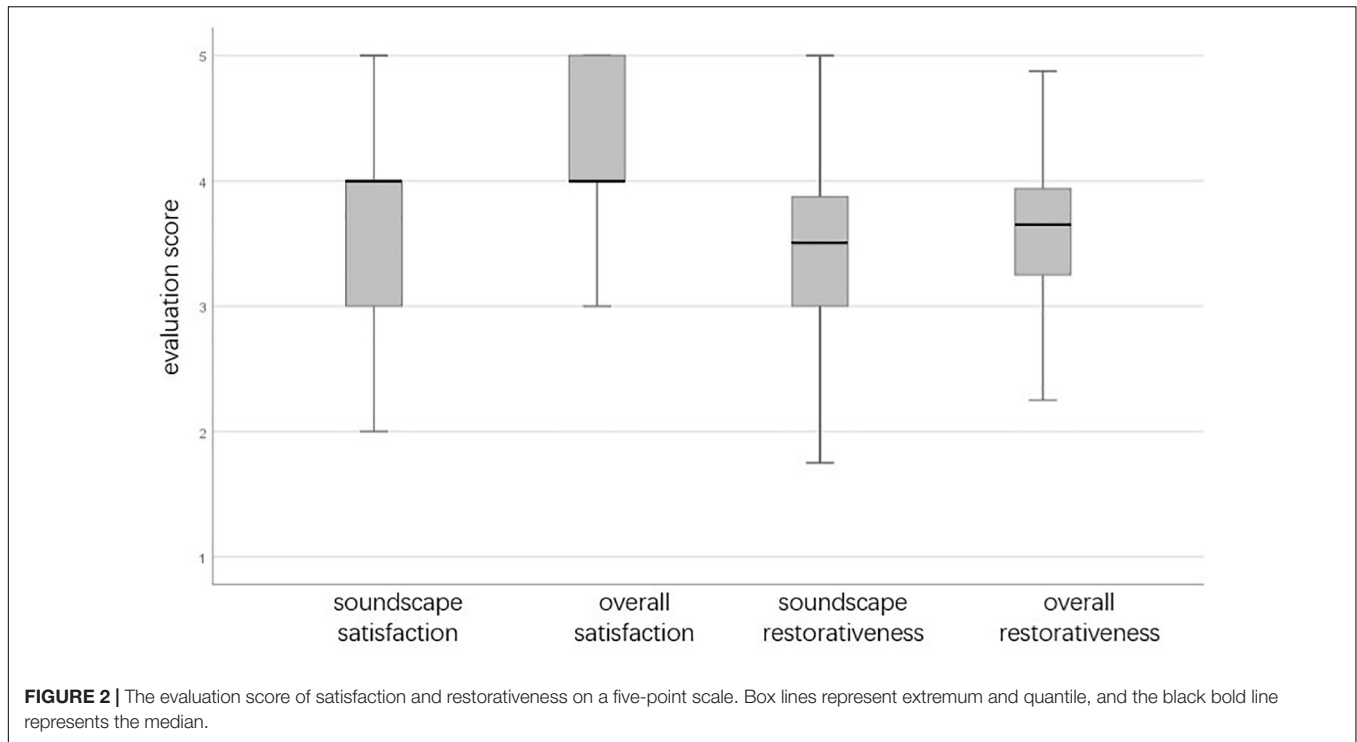
## Statistical Analysis

A total of 442 respondents (48.4% males) aged  $33.65 \pm 14.92$  completed the survey, and all those involved had self-reported

normal audition and vision with 272 in Qujiang Pond Heritage Park and 170 in The Yanming Lake Wetland Park, respectively. First, descriptive statistics (Box line diagram and Bar chart) were used to indicate respondents' visiting experience satisfaction and restorative potential for four variables: soundscape satisfaction, overall satisfaction, soundscape restorativeness, and overall restorativeness.

Secondly, to explore the representative characteristics in the artificial lake space within the eight PSDs, a one-Way ANOVA was conducted. The evaluation level of the eight PSDs served as the dependent variable, and the eight PSDs were used as factors. The SNK method was used to indicate the high or low level of the group according to the scores.

Finally, to examine the relationship between two sets of variables of eight PSDs and the satisfaction and restorativeness, a Canonical Correlation Analysis (CCA) was conducted, which can help in finding how independent variables can predict the



dependent variables by expressing the correlations between the two sets. In our study, the eight PSDs served as independent variables, while satisfaction and restorativeness of soundscape and overall environment were dependent variables. All statistical analyses were carried out using SPSS 25.0 software.

## RESULTS

### The Level of Potential Restorativeness in Blue Space

The distribution of soundscape satisfaction (median = 4.00) was relatively scattered, with a score range of 2–5 (Figure 2). In contrast, overall satisfaction (median = 4.00) had a more concentrated distribution. It can be concluded that soundscape satisfaction and overall satisfaction in an artificial lake space were relatively higher according to the approximate median score of 4. The score of soundscape restorativeness (median = 3.50) was scattered, with a range of 1.75–5. Overall restorativeness (median = 3.66) was more concentrated than soundscape restorativeness. Obviously, the median score of soundscape restorativeness and overall restorativeness were in the range of 3–4, indicating a medium to good level, which was lower than soundscape and overall satisfaction, with a median of 4, indicating a very good level. In particular, the mean level of overall satisfaction and overall restoration were both higher than those of soundscape.

### Perceived Characters in Blue Space

One-way ANOVA was used to analyze the characteristics of artificial lake spaces, suggesting that there were significant

differences among them. SNK (Student-Newman-Keuls) divided them into three groups ( $p < 0.05$ ), which showed that *prospect*, *social*, and *space* were the three most vital characteristics in artificial lake spaces, then *serene* and *nature* followed as a medium characteristics. *Refuge*, *rich in species* and *culture*, were the least vital characteristics. It can be concluded that people can look into the distance, carry out social activities, and feel a sense of space around artificial lakes, which are the perceptions of artificial lake spaces (Table 1).

### Correlations Between the Eight PSDs and Restorative Potential

A canonical correlation was performed to determine which PSDs in artificial lake spaces best predicted how people were satisfied

**TABLE 1 |** Perceived characteristics in blue spaces.

Eight sensory dimensions	Mean	SD	95% C.I.		Rank
			Upper limit	Lower limit	
Prospect	3.74 <sup>a</sup>	0.83	3.66	3.81	1
Social	3.72 <sup>a</sup>	0.86	3.64	3.80	
Space	3.66 <sup>a</sup>	0.85	3.58	3.74	
Nature	3.53 <sup>b</sup>	0.93	3.45	3.62	2
Serene	3.51 <sup>b</sup>	0.88	3.43	3.59	
Culture	3.37 <sup>c</sup>	1.06	3.27	3.47	3
Rich in species	3.34 <sup>c</sup>	0.95	3.25	3.43	
Refuge	3.23 <sup>c</sup>	0.91	3.14	3.31	

<sup>a,b,c</sup>Represents different groups.

and restored. The first ( $p < 0.001$ ) and second ( $p = 0.011$ ) canonical correlation pairs were statistically significant.

However, the degree of explanation of the change in two canonical correlation pairs is listed in **Table 2**, suggesting that the second canonical correlation pair's parameters were much lower since its explained proportion of variance were all lower than 0.1. In contrast, the first canonical correlation pair was more convincing since its explained proportion of variance were all more than 0.2, and the follow-up analysis mainly focused on the first pair canonical correlation pair. The correlation coefficient between two sets of factors obtained for the first pair of typical structures was 0.67 ( $p < 0.001$ ). As depicted in **Figure 3**, there were eight PSDs included in the final model, which contributed differentially (negatively and positively) to eight PSDs; *serene*, *culture*, *space*, *nature*, and *refuge* were the main determinants for the components due to high values of unstandardized coefficients ( $-0.47$ ,  $-0.28$ ,  $-0.21$ ,  $-0.19$ , and  $-0.19$ , respectively). Overall satisfaction, soundscape restorativeness, and overall restorativeness largely determined the canonical variate ( $-0.51$ ,  $-0.58$ , and  $-0.81$ , respectively) based on the dependent set of variables (satisfaction and restorativeness).

## DISCUSSION

### The Evaluated Level of Satisfaction and Restorativeness in Blue Space

There were more respondents who were very satisfied (scored 4–5 to soundscape satisfaction and overall satisfaction) with the soundscape and overall environment, than those who experienced an excellent restoration (scored 4–5 to soundscape restoration and overall restoration). To be specific, soundscape restorativeness and overall restorativeness had a medium to high score level rather than a very high level. It means that the soundscape restoration and overall restoration level requires the most improvement. The study further focused on improving visiting satisfaction, and restoration in particular, would contribute a lot to realizing the happiness and well-being of blue spaces as artificial lake spaces.

There are many reasons why people were satisfied and obtained health benefits from it. First, people's favoring of open water was one of the main reasons (Deng et al., 2020) because preference and perception evaluation (such as satisfaction evaluation) may be related to the landscape and this was inseparable from people's natural hydrophilicity (Foley, 2011). Some components of preferred landscapes are water, open

space, and trees (Kaplan and Kaplan, 1989; Adevi and Grahn, 2012). People consider the blue space as positive and attractive (Völker and Kistemann, 2011). Secondly, it is generally accepted that humans are multisensory (Schwarz, 2013; Nanay, 2018). Therefore, like soundscape, visual landscape is part of the overall environment, and it is also a direct indicator distinguishing between different landscapes. A visual landscape, for example, is one of the direct factors of the overall environmental evaluation, and the evaluation of soundscape will also be affected by the visual landscape. That is consistent with previous studies where Liu et al. (2014) found that overall soundscape evaluation can be affected by the esthetic quality of a visual landscape to a large extent (Liu et al., 2014). Pheasant et al. (2008) found that perceived tranquility linked to both the sound level and percentage of natural visual features including blue space (Pheasant et al., 2008).

The results support that artificial lake spaces can be a relatively good choice for humans' visiting experience and well-being. Previous studies have also shown that blue spaces like lakes were a preferred place for entertainment (Asakawa et al., 2004) and blue water features could provide a restorative landscape (White et al., 2010; Sonntag-Öström et al., 2015), though restoration still requires improvements. In future city constructions, landscape designers and other stakeholders should pay more attention to artificial lakes as one of the most critical public health resources.

### Representation of the Eight PSDs in Blue Space

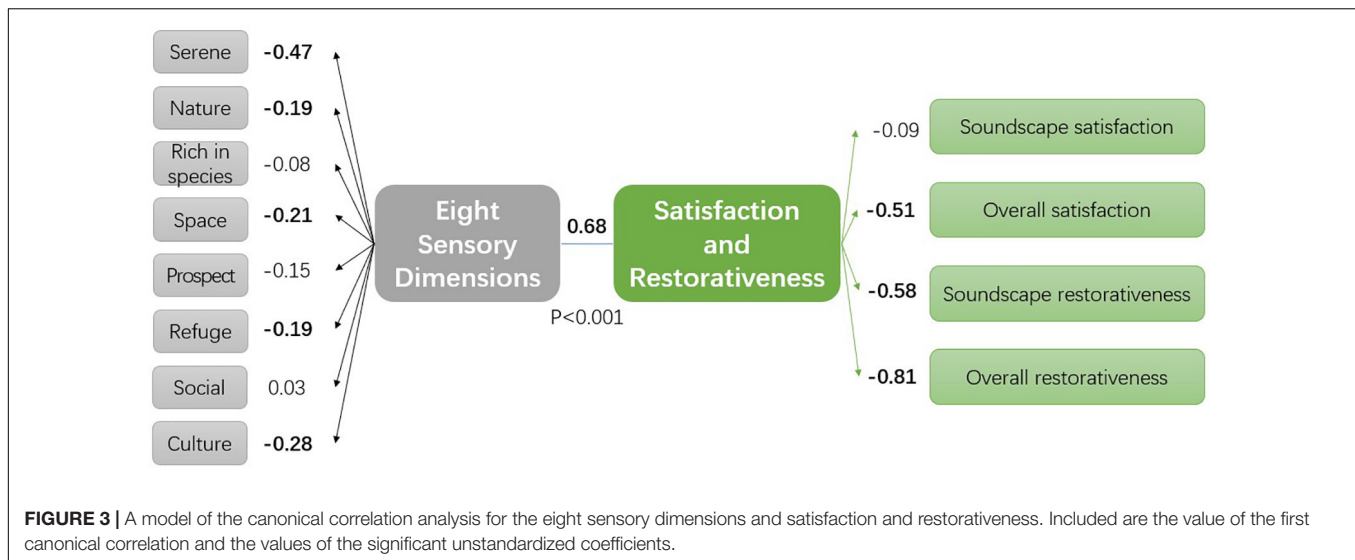
To explore people's perceived characteristics of artificial lake spaces, it is necessary to measure the perception characteristics using the eight PSDs. In the study, *prospect*, *social*, and *space* were important in artificial lake spaces. It means that, when people were on the water bank, they felt a broad vision, coherent and integrated expansive space, according to the meaning of *prospect* and *space*. Furthermore, people often gathered for chatting, sports, or other recreational activities according to the meaning of *social* from the eight PSDs. For the three most strongly perceived attributes, the selected sample site was artificial lake spaces in urban parks, with few aquatic plants on the lake surface and no aquatic trees and facilities to block the sight according to the actual construction of the lake space, as some respondents commented. People preferred to engage in a variety of social activities on the water bank, such as appreciation, being with kids, chatting, etc. (Dinda and Ghosh, 2021), so the PSD of *social* were obvious to be perceived.

*Refuge*, *rich in species*, and *culture* were less frequently perceived, indicating that artificial lake spaces lacked safety, privacy, diverse plants, and a sense of cultural and historical atmosphere according to the meaning of PSDs. According to the prospect-refuge theory, shelter and open vision are both indispensable as people would feel safe (Appleton, 1976). However, some respondents commented that "The artificial lake here is an open place, but the shore had fewer shelter facilities and plants that provided shade." Moreover, *serene* and *nature* were placed in the middle, indicating that artificial lake spaces were relatively calm, clean, and natural. This result was consistent

**TABLE 2** | Proportion of variance explained two pairs of canonical correlation.

Canonical variable	Set 1 by self	Set 1 by Set 2	Set 2 by self	Set 2 by Set 1
1	0.440	0.201	0.623	0.285
2	0.074	0.004	0.063	0.003

Set 1 and 2 mean the first and second canonical correlation pairs, respectively. The second canonical correlation pair was not analyzed in the study due to its very low proportion of explained variance.



with the previous study, which showed that blue spaces like open artificial lake spaces could provide tranquility to people (Gao et al., 2019; Qiu et al., 2021). On the one hand, water can absorb noise to create a better soundscape; further, human activity sounds were concentrated densely on the water bank, resulting in a decrease of tranquility (Dinda and Ghosh, 2021). Therefore, *serene* was perceived in the middle level. The reason for mid-level *nature*, the urban park lies between a natural environment (high natural environment) and an urban environment (low natural environment) in terms of soundscape (Payne, 2013). Hence, the *nature* level did neither score high nor low.

## Correlations Between the Eight PSDs and Restorative Potential

For eight PSDs, *serene*, *natural*, *rich in species*, *space*, *prospect*, *refuge*, and *cultural* except *social* were positively correlated with satisfaction and restorativeness. The first five most significant attributes were *serene*, *cultural*, *space*, *nature*, and *refuge*, which mostly acted on overall restorativeness. According to a previous study, *serene*, *nature*, and *refuge*, with the absence of *rich in species* and *social*, were considered the most representative characteristics of the restorative environment (Memari et al., 2017). *Serene* was the most frequent characteristic people preferred (Grahn and Stigsdotter, 2010). The eight PSDs had a weak relationship with soundscape satisfaction. Considering that the proportion of variance explained in the first pair of typical structures was approximately 20%, other factors may affect the satisfaction and restorativeness, especially the soundscape satisfaction. Given that eight PSDs describe the perception of the total environment, it might not be very proper for soundscape as only a sensory dimension of the overall environment.

To improve the environment of artificial lake spaces in urban parks, PSDs that were positively related to artificial lake space satisfaction and restorativeness should be compared with the currently existing PSDs. Specifically, *nature* and *serene* were in the medial level, and *cultural* and *refuge* were in the lower level,

while they were important in restorative potential. In the further landscape promotion of artificial lake spaces, *nature*, *serene*, *cultural*, and *refuge* perceived levels need to be increased. Due to people's hydrophilicity (Foley, 2011) and the importance of open water to well-being (Finlay et al., 2015), it is essential to find the breakthrough point of building artificial lake space.

To find out why *serene* was most effective in artificial lake space, the form of water (moving water or still water) and waterside bank deserves special attention. In a previous study, people felt harmonious and diverse in blue space because they were close to water and the water bank (Burmil et al., 1999). Steinwender et al. (2007) considered wide surfaces, as well as revetment plants, to make good contributions (Steinwender et al., 2007). First, the water itself can provide a high esthetic value component due to its winding revetment, peacefulness, and wide water surface. A wide field of vision is expected in blue spaces (McDougall et al., 2020). Broad vision wins people's favor (Van Berkel et al., 2018). Therefore, a vast and calm water surface can help create a perceived sense of *serenity* and *space*. Second, the waterside bank is also important. In urban parks, people come into contact water through the water bank, which plays a crucial role in the perception and construction of artificial lake spaces. Deng et al. (2020) found their sample lake was inferior to terrain and lawns because the bank had less shade (Deng et al., 2020). A high-quality pathway (Verbić et al., 2016) and an easily accessible closing-water space (McDougall et al., 2020) could improve the overall visiting experience around artificial lake spaces. It can be suggested to landscape planners and decision-makers in relevant departments that water banks should receive full attention when changing perceived attributes of artificial lake spaces.

Therefore, to achieve more *serene*, *nature*, *cultural*, and *refuge* characteristics, planning can include the following: Some rest and viewing facilities can be provided, so that people can stay for a long time to get the benefits of the lakes and create a serene soundscape for more calm. "The increase of cultural facilities will help create a sense of culture," as respondents

claimed. Adding well-maintained plants can enhance beauty (Chow, 2013), and plants can enhance *nature* and create *refuge* (Parsons and Daniel, 2002). Therefore, planting of plants should be increased on the lake banks.

## Limitations and Future Research

Although blue spaces are indeed beneficial to health, exploring the mechanism of the restorative potential in blue spaces remains significant. The artificial lake space combined with PSDs in this study was just a pilot study. There are still some limitations in the study. First some landscape features of artificial lakes such as the area of water, moving water or still water, people on the water bank or the island, water freezing in winter, etc., and other kinds of blue spaces such as rivers and natural wetlands, are worth further investigations in future studies. Second, demographic group differences, health status, and types of activities should be taken into consideration in future landscape evaluations (Arnberger and Eder, 2011; Lindholm et al., 2013; Carrus et al., 2015). Physiological restoration of artificial lake spaces is also worth further exploring.

## CONCLUSION

This study examined the levels of satisfaction and restorativeness of soundscape and overall environment, and the relationship between the PSDs and restorative potential in artificial lake spaces. The main results included that: First, artificial lake spaces had a high level of soundscape satisfaction and overall satisfaction, while restorativeness of soundscape and overall environment still need to be improved, due to limited positive responses; second, *prospect*, *social*, and *space* were the most three obvious PSDs in artificial lake spaces; third, *serene*, *cultural*, *space*, *nature*, and *refuge* primarily affected the restorative potential, especially the overall environment restorativeness. *Serene* was

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the critical factor for improving the quality of artificial lake spaces in urban parks.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of College of Landscape Architecture and Arts, Northwest A&F University. Written informed consent to participate in this study was provided by the participants.

## AUTHOR CONTRIBUTIONS

YQ and XF: methodology, validation, formal analysis, investigation, and visualization. YQ: writing—original draft. TG and LQ: conceptualization, methodology, validation, resources, writing—review and editing, supervision, project administration, and funding acquisition. LQ: formal analysis. All authors contributed to the article and approved the submitted version.

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**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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