A Study of Mental Restoration and Preferences for Specific Urban Blue and Green Spaces

特定の都市の青と緑の空間に対する精神的回復と好みの研究

2022 年 7 月

千葉大学大学院園芸学研究科

環境園芸学専攻　緑地環境学コース

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（千葉大学審査学位論文）

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Content

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Abstract

Urban green and blue spaces have many health and aesthetic benefits that have been highlighted in previous studies. However, most of the current research is general and there is still relatively little research addressing specific blue (e.g., urban park blue spaces) and green spaces (e.g., specific green environmental settings in urban parks) in cities. Therefore, this thesis makes efforts in these research gaps.

This thesis discusses the mental recovery and preference of specific green and blue spaces in urban environments through five experiments: The first study used virtual reality to create a simulation of people sitting in a pavilion, to evaluate the preferences and mental restoration of nine pavilions in Tokyo. The results showed that VR viewing effectively promoted mental restoration. The enclosure of the pavilion did not significantly affect people's preferences and perceived mental restoration in the environment setting. Moreover, the regression analysis revealed that the prospect and serene dimensions significantly influenced preferences; for restoration, the dimensions of “richness in species” and “serene” were significant predictors. The second study used the Du Fu Thatched Cottage Museum as the subject region and employed a convenience sampling method to analyze the preference and mental restoration of different road settings of Chinese classical gardens. According to the findings, the majority of visitors

felt that the road settings in these classical gardens provided psychological recovery, and half of the roads received a preference score of five or above. The regression results indicated that nature, culture, space, refuge, and serene were found to be important predictive dimensions for both mental restoration and preference. The third experiment involving 10 different urban park blue spaces in Huanhuaxi park was conducted to assess urban park blue spaces' aesthetic preference and restorative potential. The results indicated that (1) a water body with good water quality and natural visual form may be more attractive and have restorative potential; (2) blue spaces with high vegetation diversity are preferred, and artificial elements should be evaluated more carefully when added to the scene to avoid disharmony and conflict with the surrounding environment; (3) in practical design, the proportions of plants, buildings, topographical changes, and water should be coordinated to maintain the blue space's landscape heterogeneity; (4) more leisure activities and interactions should be considered for better recovery; and (5) designers need to emphasize the balance of natural and man-made elements to enhance the visual quality of the water feature. The fourth study involved a field survey of blue spaces in three cities. In this survey, users' perceptions of the environmental quality (physical and aesthetic quality) of each blue space were assessed using a questionnaire. Afterwards, a regression model between the environmental quality of the blue spaces and the users' preferences was developed. The last study empirically investigated the restorative benefits of "viewing" behaviors in urban blue spaces and urban green spaces and compared the features of the two restorative environments using the Improved Restorative Components Scale. The results showed that: 1) 15 min

viewing in UGS significantly enhanced subjective vitality, while the improved results in UBS were not significant; 2) UGS exhibited higher Fascination and Compatibility attributes; 3) the restorative experience in UGS was multisensory, leading to a stronger restorative effect; and 4) the results of the analysis revealed that the restorative experience of UBS could be enhanced.

These findings increase understanding of how specific blue and green spaces in urban environments provide direct health benefits, and have theoretical and practical value for the future design and planning of "healthy cities".

Keywords: Specific blue and green spaces, Urban environment, health benefits, aesthetic benefits, Management and planning

Chapter 1 Introduction

1.1 Background

1.1.1 Urbanization and Health

An increasing number of people live in cities because of urbanization. Approximately 70% of the population is expected to live in urban areas by 2050 (Figure 1-1) and with nearly 90% of the growth occurring in Asia and Africa, particularly China, India, and Nigeria (United Nations, 2018). The development of dense (Ng et al., 2012) and compact cities (Lin & Yang, 2006) has accelerated due to this evolving urbanization process, resulting in significant constraints on the natural environment and green space in cities. Rapid urbanization and unhealthy lifestyles are threatening human health and quality of life (Song et al., 2020). In addition, city densification has had several negative consequences for humans, including increased congestion and reduced quality of life as well as negative psychological and physical health repercussions (Xie et al., 2022).

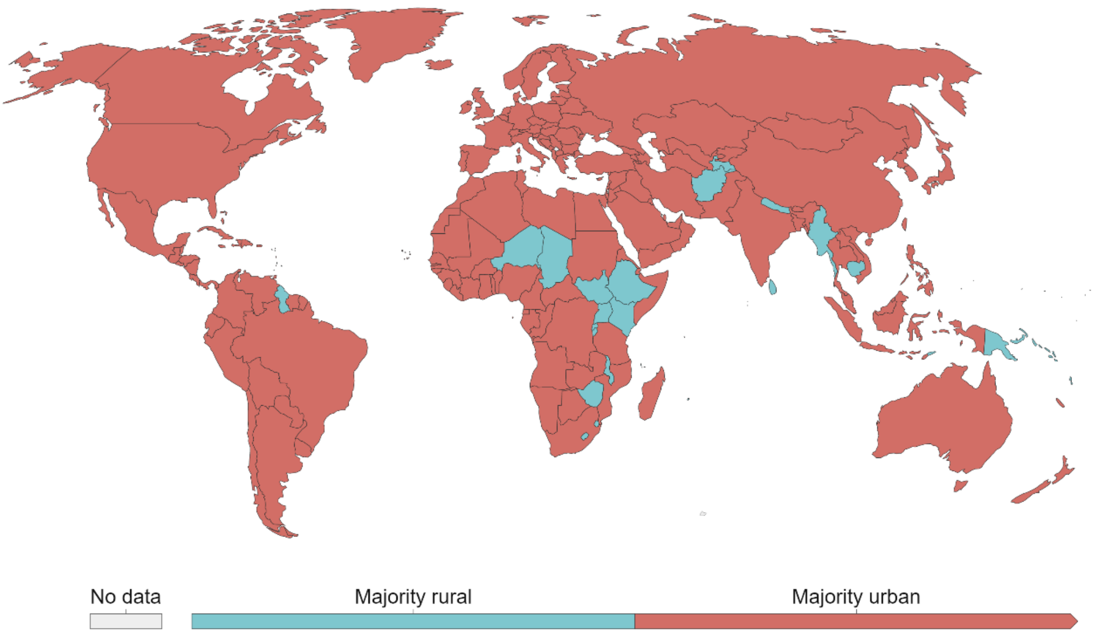


Figure 1-1 World population in 2050

(Resource: https://ourworldindata.org/grapher/population-density)

Although urbanization can improve population health to some extent, such as through access to quality health care and infrastructure, (Gong et al., 2012), urban dwellers face many health risk issues, such as poor mental health (McKenzie et al., 2013), increased suicide rates (Mok et al., 2013), chemical, biological, and physical hazards (Gong et al., 2012), obesity (Monda et al., 2007), increased cancer rates (Haynes, 1986), hypertension (Hu et al., 2011), decrease in social interaction (Krieger & Higgins, 2002), depression (Helbich, 2019), and anxiety (Walters et al., 2004). In addition, health problems have significant social and economic impacts and increase healthcare costs (McKenzie et al., 2013). Therefore, the control and reduction of health risks associated with urbanization has become an important issue and is included in the agenda of creating "healthy cities" and "sustainable cities" (von Schirnding, 2002).

1.1.2 Promoting healthy urban natural environment

Presently, more than half of the world's population lives in cities, and this number will continue to increase (United Nations Population Fund, 2015). With the influx of migrants into cities, various natural environments in cities are becoming increasingly important for promoting human health (Luo et al., 2022).

According to reports, there is a link between the environment built and health problems. For example, densely developed man-made urban environments reduce the health of residents (Tanaka et al., 1996); urban residents are at a significantly increased risk of anxiety and mood disorders (Peen et al., 2010); more urban living environments are associated with higher rates of prescription for psychotropic medication for anxiety, depression, and psychosis (McKenzie et al., 2013); spending time in urban environments significantly reduces positive emotions and increases stress and fatigue (Song et al., 2020). Accordingly, there is a growing recognition that the urban environment is critical to public health and well-being. Mitigating the negative effects of the modern urban environment and controlling stress-related mental health problems are topics of increasing interest to urban planners and managers (Elsadek et al., 2019).

In this systematic study, the natural environments in cities are currently divided into two main categories: green spaces, such as urban forests, parks, and green roofs (Subiza-Pérez et al., 2019), and blue spaces, such as rivers, streams, and ponds (McDougall et al., 2020) (Fig. 1-2). These blue-green spaces, as an extension of nature in the city, improve the urban living environment and positively influence the health of citizens (Subiza-Pérez et al., 2019).

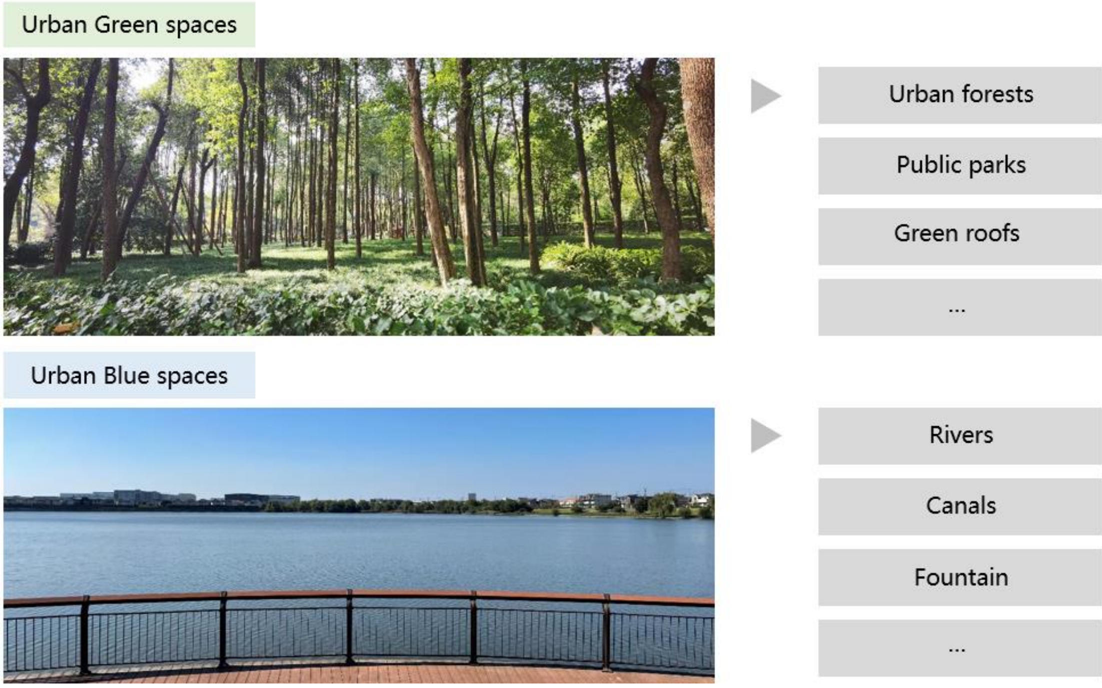


Figure 1-2 Urban natural environment.

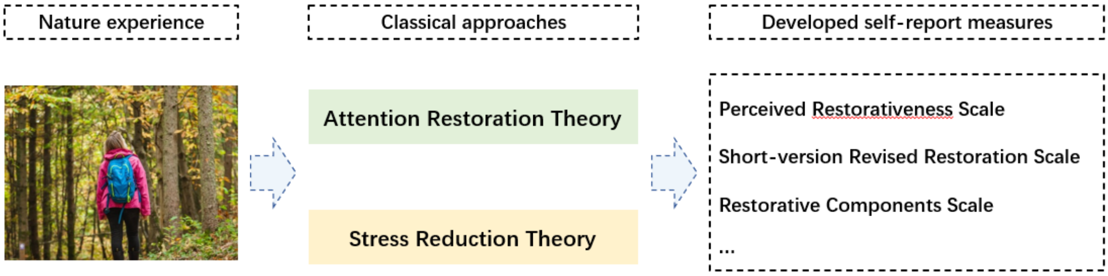


Figure 1-3 Nature experience and restorative measurement.

1.1.3 Nature experience and restorative measurement

Urbanization increases the importance of natural experiences in cities (e.g., in urban parks or forests; Jeon, Jo, & Lee, 2021). Research has proved that experiences in nature (i.e., observing nature, interacting with natural resources, and activities in the natural environment) positively affect health outcomes. For instance, Shanahan et al. (2016) used a nature-dose framework to study the relationship between urban population health and the duration, frequency, and intensity of exposure to nature. The results showed that long-term visits to green spaces significantly lower incidences of depression and high blood pressure. Another study involving 30 gardeners, who performed a 30-minute gardening and reading task, discovered that outdoor gardening activities could promote the recovery of positive mood (Van Den Berg & Custers, 2011). Urban green spaces are also considered suitable places for residents to encounter biodiversity. Although the population may not be able to accurately identify the actual species richness, well-being is positively correlated with the perceived diversity and richness of species (Dallimer et al., 2012). A Swedish study showed that rehabilitation gardens relieve acute stress and serve as a social space to improve self-esteem (Adevi & Mårtensson, 2013). This evidence points to the health benefits of natural experience.

Among such studies, attention restoration theory (ART; Kaplan, 1995) and stress reduction theory (SRT; Ulrich et al., 1991) have been the main approaches to explain the restorative benefits of natural experiences. ART has emphasized the importance of restoration from attentional fatigue based on cognitive functioning and proposed four components: fascination, being-away, extent, and compatibility. From Kaplan's perspective, the depletion of directed attention can be restored by rest; moreover, the state of reduced fatigue of directed attention is the restorative experience (Kaplan, 1995). SRT is a psycho-evolutionary model that emphasizes the importance of recovering from psychological and physiological stress related to threats or challenges based on affective functioning. Ulrich et al. (1991) theory focuses on physical environments and considers these physical environments as sources of stress or relief.

Based on these two theories, various self-report measures have been developed to assess the degree of perceived restoration in different environments, such as the Perceived Restorativeness Scale (Hartig, Korpela, Evans, & Gärling, 1997), Restorative Components Scale (Laumann, Gärling, & Stormark, 2001), Short-version Revised Restoration Scale (Han, 2003), and Short-version Revised Restoration and Preference Scale (Deng et al., 2020). Therefore, it is feasible to measure the restorative influence of natural experiences using self-report scales (Fig. 1-3).

1.1.4 Restorative environmental feature measurements

Exploring the ability of different environmental features to provide restoration is important for evidence-based health design (Memari, Pazhouhanfar, & Grahn, 2021). These qualities can be characterized based on people's experience and perceptions of these features (Chen, Qiu, & Gao, 2019). Expert judgment is a widely used technique for assessing natural environments based on vision. Studies have often used landscape features, such as the number of elements, shapes, colors, topography, scale, and visual focus (see Arriaza et al., 2004, Deng et al., 2020, Wang et al., 2016, Wang et al., 2019b, Yao et al., 2012). However, the use of this technology has been criticized for ignoring the user's perspective (Penning-Rowsell & Hardy, 1973). Consequently, a completely bottom-up approach called Perceived Sensory Dimensions (PSD) is widely used to evaluate environmental qualities (Memari et al., 2021). Moreover, Grahn and Stigsdotter (2010) identified eight different PSDs from a representative sample of the Swedish population: 1) social (suitable for social activities and entertainment), 2) prospect (preference for vistas over the surroundings), 3) rich in species (consisting of many animals and plants), 4) serene (an undisturbed, silent, and calm environment); 5) culture (artificial elements and decorations); 6) space (a spacious and free setting); 7) nature (feeling and experience of being in the natural environment); and 8) refuge (sense of safety). These eight qualities are experiential and based on multiple theories, including ART, SRT, biodiversity theories, and social quality theories. Thus, they are widely applicable across landscapes (Memari et al., 2021), such as urban parks (Qiu & Nielsen, 2015), small public urban green spaces (Peschardt & Stigsdotter, 2013), urban forests (Chen et al., 2019), and natural forests (Stigsdotter, Corazon, Sidenius, Refshauge, & Grahn, 2017).

In addition, environmental psychology uses Attention Recovery Theory (ART) to explain perceptual restorative features; thus, the reasons why an environment is restorative (Kaplan, 2001). The ART concept emphasizes the importance of recovery from attentional fatigue based on cognitive functioning and proposes four components: Fascination, effortless attention and interest in the scene; Being Away, enabling people to free their attention from directed attention and daily stress; Extent, engaging the mind and supporting extended exploration; and Compatibility, engaging in activities that are "compatible" with our internal motivation (Herzog et al., 2003). However, a recent study suggested that it is more reasonable to use physical components (novelty) and psychological components (Escape) instead of the single factor of Being Away (Pals et al., 2009). Thus, the Improved Restorative Components Scale (IRCS) can be used to measurement restorative environmental feature, which consists of five factors: Fascination, Novelty, Escape, Extent, and Compatibility.

1.1.5 Benefits of specific urban green spaces

A variety of specific green spaces in cities have health benefits that are worth discussing. In densely populated and congested cities, urban parks (as part of urban nature; Razak, Othman, & Nazir, 2016) are valuable to citizens and visitors because they provide a space for physical activity (Mak and Jim, 2019, McCormack et al., 2010, Ou et al., 2016), natural experiences (Kabisch et al., 2021), mental and physical recovery (Rahnema et al., 2019, Masullo et al., 2021a), and social interaction (Guan et al., 2021, Peters et al., 2010). However, most of these studies have focused on exploring general aspects of urban parks (i.e., in parks) and not on specific resting environment settings.

Resting environments (also known as restorative environments) provide resting activities, relaxation, and recovery (Wang, et al., 2019a). Many studies have attempted to discover the benefits of different resting environments. For instance, Wang et al., (2019b) considered forests as a type of resting environment and stated that forest rest often includes physical relaxation, body scanning, and meditation. Herzog, Ouellette, Rolens, and Koenigs (2010) argued that worship houses as resting environments enable the occurrence of psychologically meaningful activities (e.g., reflection, quiet prayer, socializing). Pals, Steg, Siero, and Van der Zee (2009) measured the perceived restorative characteristics of two zoo attractions (i.e., butterfly garden and baboon attraction). Thus, studying various specific resting environment settings (e.g., lawns, pavilions, ponds, understory spaces, and trails) in urban parks is significant.

Among them, pavilions are common facilities in urban parks and attract visitors and tourists to rest and relax (Mu et al., 2021). Pavilions have a long history within the field of architecture. In ancient

China, many garden designers used this traditional building as a space for resting and viewing landscapes. Some garden owners gave pavilions specific names to express their emotions and ambitions (Yinong, 1999, Xie, 2016). Similarly, in early Europe, the term "Pavilion" was derived from the Old French language, and initially referred to a square tent that was often used as a pleasure-house or summerhouse in a garden (Drew, 2006). The forms of pavilions and materials used to create them have diversified over time, and some variations include the timber pavilion (Aras, 2013), the glass pavilion (Schneider & Nordenson, 2008), and the steel pavilion (Gutschow, 2006). Apart from providing rest and decoration, the pavilion can also be used to hold an exhibition (Schneider & Nordenson, 2008) and for commemorative events (Ryoo, 2018). In addition, Xu, Hong, Mi, and Yan (2018) found that pavilions are wind-proof measures in urban parks that help slow wind speed and improve thermal comfort. Meggers et al. (2017) designed an experimental pavilion to explore indirect evaporative cooling usage and radiant cooling geometric reflection. The study used thermal imaging cameras and a novel scanning MRT sensor and found that the mean radiant temperature inside the pavilion was significantly lower. However, despite their importance as a place to rest and take in the view of urban parks, few studies have directly measured the restorative influence of pavilions.

Moreover, although it is an important part of green spaces and urban cultural heritage, classical gardens have received scant attention in environmental perception and restoration. Studies on classical gardens have mostly focused on historical features (Kuitert, 2002), design aims and art (Slawson, 1991), and aesthetic value (Zhao et al., 2017, Chen et al., 2009). According to Pajin (1997), classical gardens are places where people can retreat from the busy world and seek solace, relaxation, and wisdom through quiet walks and meditation. However, research on the relationship between their environmental elements and restorative qualities is still lacking. Thus, rather than being limited to the original design objectives of the garden makers, the focus of this study is on the experience of each genuine site in these classical gardens (Lu, 2011). Walking spaces (roads or trails) are vital in classical gardens because they connect different sites of interest in the green space and are important places for leisure activities, such as walking, dog walking, and so on. Walking in urban green spaces has been shown to lower the heart rate (Aspinall et al., 2015), increase positive emotions and reduce anger (Hartig et al., 2003), increase meditation and reduce stress (Lin et al., 2020), and even provide increased safety and fewer barriers (Lin et al., 2019). Thus, road settings are important for the study of restorative urban green areas, such as classical gardens.

1.1.6 Benefits of specific urban blue spaces

Drawing an analogy with the related term greenspace, the term “blue space” summarizes all visible surface waters in space (Völker & Kistemann, 2011), which provides the regulation or provision of cultural ecosystem services (e.g., improving living environments and affecting the health and wellbeing of citizens) (Subiza-Pérez et al., 2019). Blue space is defined as "health-enabling places and spaces, where water is at the center of a range of environments with identifiable potential for the promotion of human wellbeing" (Foley & Kistemann, 2015, p. 158). Additionally, Urban Blue Space (UBS) is often considered an important component of urban development because it contributes to sustainability, landscape setting, environmental quality, quality of life, and human health (Völker et al., 2016). These urban blue elements can be permanent or non-permanent, natural or man-made (Völker et al., 2016).

The health benefits of blue spaces as restorative environments have been found. In previous studies, subjects were asked to observe photos of different landscapes to explore the association between green space and wellbeing, in which blue space (i.e., water body) is regarded as a part of green space (Han, 2003, Ulrich et al., 1991). An Irish study on “hydro-therapeutics” showed that holy wells and curative waters provide a form of “mind healing”. All visitors regard these sites as a retreat/restful asylum since one’s connections with nature are enhanced sensually (Foley, 2011). Moreover, Karmanov and Hamel (2008) reported the direct health benefits of urban blue spaces. They asked the participants to watch the nature and the city (a former eastern dock with a small canal in Amsterdam) for 10 min and found that both natural and urban environments used for the research were equal in terms of affective restoration potential. The research results indicate that adding some natural elements (e.g., water and greenery) to the city can effectively promote residents' health and is visually attractive. In recent research, blue space has been considered as a health resource to promote environmental health. Based on the therapeutic landscapes, Foley and Kistemann proposed the conception of "healthy blue space" defined as "health-enabling places and spaces, where water is at the centre of a range of environments with identifiable potential for the promotion of human wellbeing" (Foley & Kistemann, 2015). Depledge and Bird (2009) state that "Blue Gyms" (i.e., coastal areas) have always attracted residents and visitors and motivate outdoor activities, enhancing wellbeing of humans. Moreover, an empirical study showed that increasing the proportion of water in the natural and built environment would significantly increase restorativeness. This study suggests that certain visual properties (e.g., water reflecting light, lines, and patterns of light) of aquatic environments are potentially restorative (White et al., 2010). Furthermore, other studies emphasized the psychological and mental health benefits of visiting the beach (Ashbullby et al., 2013), that blue spaces restore mental wellbeing for women in Copenhagen (Thomas, 2015), and urban waterways as positive amenities for neighborhood quality of life (Haeffner et al., 2017). In sum, many studies have begun to highlight the various benefits of blue spaces, such as higher life satisfaction (van den Bogerd et al., 2021), better self-reported general and mental health (Pasanen et al., 2019), higher physical activity (Dzhambov et al., 2018), self-reported recreational visits (Elliott et al., 2020), and increased aesthetic experience and positive emotions (Völker et al., 2016). However, most of the current research on blue space focuses on city/regional level population survey data (e.g.: Poulsen et al., 2022; van den Bogerd et al., 2021; Pasanen et al., 2019; Dzhambov et al., 2018; Elliott et al., 2020). There is still a lack of studies on the health outcomes of specific blue spaces in urban environments (like urban park blue spaces).

1.1.7 Study of aesthetic preferences and restoration

Landscape preference studies started in the 1960s (Ivarsson & Hagerhall, 2008). The work of Kaplan and Kaplan (Kaplan & Kaplan, 1983) and Ulrich (Ulrich, 1981) proved that the landscape experience is related directly to a psychological model, describing an approach to understanding restorative environments based on cognitive functioning. Some environmental theories have shown that people's preference for a particular environment is related to restoration, since environmental preference depends on environmental attributes that have potential functional significance for the perceiver (Kaplan & Kaplan, 1989, Ulrich, 1983). Such perceptual mechanisms could allow the individual to rapidly and automatically assess whether a particular environment should be approached or avoided (Van den Berg et al., 2003). For example, urban green spaces that combine natural water, dense vegetation, and a large well-kept lawn are considered to bring better restoration because urban green spaces with high biodiversity are an important preference indicator. The generation of this restorative environment is believed to be derived from the integration of preferences formed by human evolution (Deng et al., 2020). However, empirical evidence indicates that people who are stressed or fatigued are most likely to recover from their preferred landscape (Van den Berg et al., 2003, Deng et al., 2020, Wang et al., 2019a). Thus, the above reasoning may explain why one's preference for an environment could be concerned with restoration brought by this environment.

Two influential accounts have been mainly concerned with research on the restorative environment in recent years, that is, attention restoration theory (ART) (Kaplan & Kaplan, 1983, Kaplan & Kaplan, 1989) and stress reduction theory (SRT) (Ulrich, 1981, Ulrich, 1983). ART has emphasized the importance of restoration from attentional fatigue based on cognitive functioning and proposes four components: fascination (an effortless attention and interest to a scene), being away (enabling people to free their minds from directed attention and everyday stress), extent (the potential of an environment to allow the user to explore with scope and coherence), and compatibility (engaging in activities that are "compatible" with our intrinsic motivations). These four components depend on the interaction between the scene and the observer (Ivarsson & Hagerhall, 2008) and are measured by improving attention and affective recovery (Van den Berg et al., 2014). SRT is a psycho-evolutionary model that emphasizes the importance of recovering from psychological and physiological stress related to threats or challenges based on affective functioning. SRT mainly supports the affective and physiological recovery from acute "stress" or depletion of emotional resources, which is measured by physiological indicators, such as lowering blood pressure and stress hormone levels (Van den Berg et al., 2014).

Additionally, landscape preference is a hotly debated and researched topic in the fields of environmental psychology and landscape architecture. Kaplan and Kaplan (1989) used "Evolutionary theories" to explain visual landscape preferences and claimed that it was a beneficial human reaction that aids survival and well-being. They discovered that people's preferences for specific environments were linked to restoration because environmental preferences were based on environmental features that the perceiver may find functionally important. Many experts have since conducted studies on landscape preference and restoration, finding a favorable association between the two (Van Den Berg & Custers, 2011, Han, 2010, Menatti et al., 2019, Jahani & Saffariha, 2020, Wu et al., 2021). Furthermore, many studies have discovered that the different landscape elements of green spaces can have varying degrees of influence on aesthetic preference and restoration. For example, natural landscape elements such as water, trees, flowers, and lawns can positively influence aesthetic preferences and psychological recovery (Jahani & Saffariha, 2020, Kaltenborn & Bjerke, 2002, Howley, 2011, Dutton, 2009), whereas artificial landscape elements such as buildings and roads tend to degrade aesthetic preferences and psychological recovery (Acar et al., 2006). However, studies have indicated that artificial features (decoration cover, statues) related to culture (poetry walls, cultural architecture) and art have a high landscape preference and restoration value (Packer & Bond, 2010, Deng et al., 2020). These studies showed the importance of landscape elements for green space preferences and restoration, but in cases where artificial elements can adequately display cultural meanings, the relationship between natural and artificial landscape elements and preference and restoration has not been fully investigated.

1.1.8 Lack of research on comparing blue space and green space

The health benefits of various green spaces in cities have been reported, such as decreased salivary cortisol concentrations and stress relief after short-term exposure (15–30 min) to urban parks and woodlands (Tyrväinen et al., 2014). After 15 min of walking along a path surrounded by vegetation, visitors' negative psychological states (tension, fatigue, confusion, and anxiety) were significantly reduced and vitality increased (Elsadek et al., 2019). Viewers observing a nearby green space through a high-rise window showed a significant increase in frontal and occipital alpha power and a significant improvement in mood state (Elsadek et al., 2020). Walking in a green space with a high per capita area (PCA) and sitting in a green space with a low PCA were most beneficial in reducing stress and improving mood (Lin et al., 2019). Moreover, street greenery in cities significantly promotes physical activity among older adults (He et al., 2020), and workplace greenery (physical and visual access) is significantly associated with lower levels of perceived stress (Lottrup et al., 2013). This evidence suggests that interactions with green spaces and exposure to green environments can be physiologically and psychologically restorative.

Although still limited compared to green space studies, evidence for the importance of blue spaces for human health is growing (Völker et al., 2018). A study of the North American Great Lakes region showed that living close to the Great Lake was associated with lower rates of anxiety and mood disorder-associated hospitalization (Pearson et al., 2019). A study in Portugal suggested that urban blue spaces could mitigate outdoor equivalent temperatures and reduce heat-related mortality in the elderly population (Burkart et al., 2016). Another study in England used geo-narrative interviews to reveal how the diverse coastal experiences of residents contribute to individual health and well-being (Bell et al., 2015). However, most current research on blue spaces focuses on population survey data at the city and regional levels (Pearson et al., 2019; Burkart et al., 2016; Poulsen et al., 2022), theoretical studies in laboratory settings (White et al., 2010; Bulut & Yilmaz, 2009), and interview-based qualitative analyses (Vaeztavakoli et al., 2018; Völker et al., 2016; Bell et al., 2015). There is still a lack of empirical research on blue-space health outcomes in urban settings.

Furthermore, although studies have begun to link green and blue spaces, these studies are still discussed in the context of macro-based perspectives such as distance (Boers et al., 2018), residential blue and green accessibility (De Vries et al., 2016), perceived neighborhood blue and green (Dzhambov et al., 2018), and the Blue-Green Space Landscape Pattern Index (Wu et al., 2020). There is still a lack of empirical evidence from field experiments (Fig. 1-4), which is necessary to increase our understanding of how blue and green spaces in real urban environments provide direct health benefits. It is important to note that although one empirical study (Gidlow et al., 2016) used green and blue spaces as survey sites, both spaces were still discussed as equivalent settings (that is, natural environments), and their restorative differences were not discussed. Moreover, in the environmental setting of the study (Gidlow et al., 2016), the blue space is a trail next to a canal with extensive natural vegetation, and the presence of this vegetation (green) might lead to some bias, as the restorative effect might be a joint effect of blue and green. However, our study is not intended to negate this contribution, but rather to build upon the study by Gidlow et al. (2016) by setting the blue space as a more pure "blue," that is, a large body of water without vegetation, which allows participants to fully immerse themselves in the blue environment.

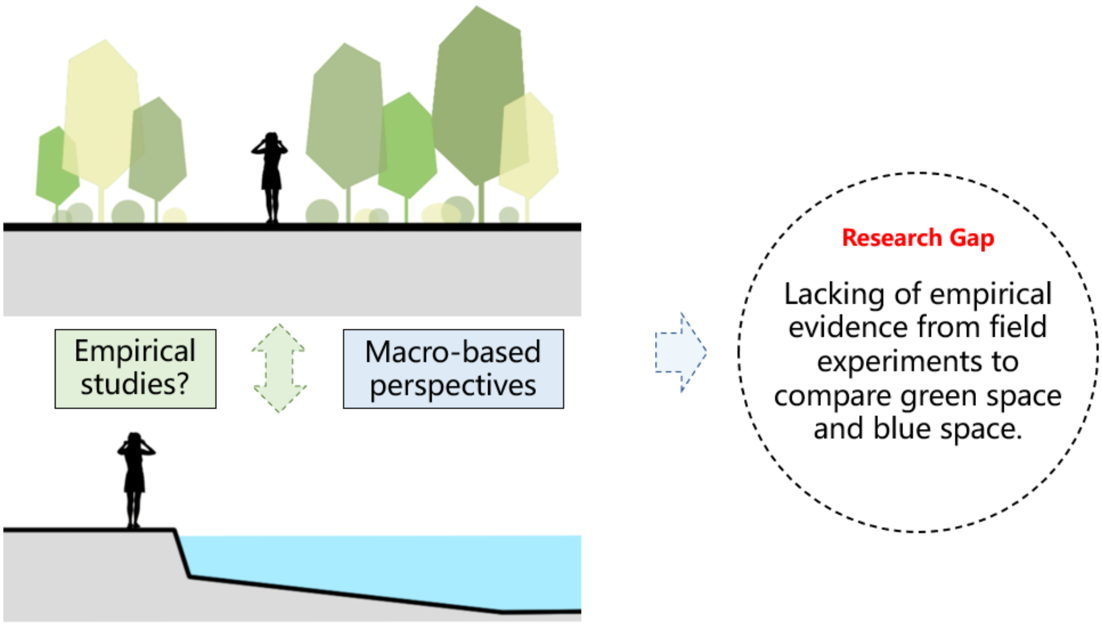


Figure 1-4 Lack of research on comparing blue space and green space

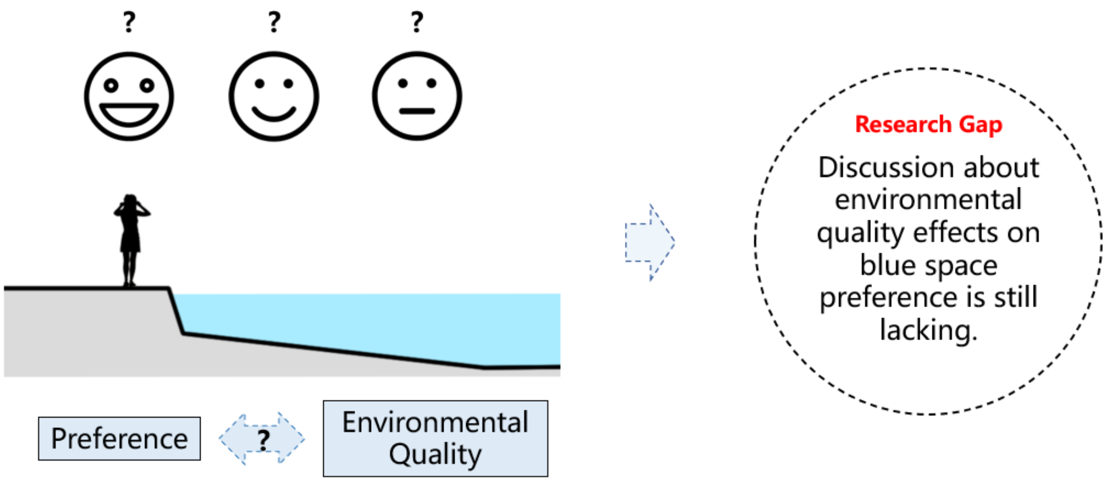


Figure 1-5 Lack of research on the environmental quality and preferences of blue spaces

1.1.9 Lack of research on the environmental quality and preferences of blue spaces

Cities are important living spaces for the global population, and citizens experience different urban environments in their daily lives. Among these environments, urban blue space (UBS), a natural or man-made outdoor environment that is primarily characterized by water and allows human access from the near end (in the water, on the water, near) or from the far end (seen, heard), plays an important role in improving the urban environment (Mishra et al., 2020). Similar to green spaces, blue spaces provide many cultural ecosystem services for cities, such as reducing the heat island effect (Xie & Li, 2021), urban water management (Wendel et al., 2011), promoting socialization (De Bell et al., 2017), promoting the well-being of the elderly population (Brückner et al., 2021), lower antidepressant prevalence (McDougall et al., 2021), promoting mental health (Boers et al., 2018), attracting recreational and travel behavior (Börger et al., 2021), enhance residents' life satisfaction (van den Bogerd et al., 2021), contribute to urban sustainability (Völker et al., 2016), environmental education (May, 2006), and reinforce urban waterfront aesthetics (Gabr, 2004). These studies have highlighted the positive effects of blue spaces, showing that they are associated with psychological benefits and aesthetic values, and provide places for recreational and physical activities (De Bell et al., 2017). Furthermore, the various benefits of blue space are centered on natural capital, which relies on environmental entities that connect ecosystems and social systems (Costanza et al., 2017). Therefore, understanding and effectively using these natural capitals (e.g., blue spaces) in cities has become a top concern for urban environmental policies (Zhang et al., 2022).

The field of urban planning has long been interested in the association between the urban environment and human behavior as it affects social well-being (Handy et al., 2002), and the findings can guide environmental design (Hao et al., 2021). The environmental quality of blue spaces has been discussed in previous studies, for example Luo et al. (2021) discussed the aesthetic and health benefits that blue spaces provide to people by assessing landscape characteristics (e.g., water quality, aquatic plant population, water accessibility) of 10 blue spaces in urban park. Völker et al. (2016) conducted qualitative interviews with 211 visitors to blue spaces and assessed the different experiences and aesthetic implications of seven blue space features and structures. Mishra et al. (2020) developed The Blue Health Environmental Assessment Tool to assess the health impacts of blue space environments based on a review of existing place assessment tools. Brückner et al. (2021) investigated the connection between users' environmental perceptions and experiences of blue spaces through photovoice. After investigating northern Utah residents' access to local waterways, Haeffner et al. (2017) found that blue space characteristics, as well as accessibility, significantly influence households' interactions with local urban waterways. Pitt (2018) found that qualities associated with blue spaces, such as freshness, fluidity, and luminescence, were beneficial to visitor health through an interview about urban waterway perception and use, while opaque and smelly water bodies had more negative health effects. Bozkurt & Woolley (2020) first publicly documented the difference in attractiveness of artificial versus natural water features for children's water play, and suggested that opportunities and features provide for active play are important for promoting children's activities. The study of Vaeztavakoli et al. (2018) revealed the important therapeutic effect of the canals of Isfahan as a blue corridor on the physical, psychological and social health conditions of the local population. van den Bogerd et al. (2021) used a cross-sectional study to investigate an intervention called "urban blue acupuncture" and showed that improvements in blue space quality were associated with higher well-being and life satisfaction of local residents. In summary, different blue space features and qualities appear to provide different benefits, and environmental qualities are significantly associated with interactive outcomes, such as aesthetic benefits, experiential qualities, and restorative outcomes. Therefore, environmental quality investigations and studies to these blue spaces are important because they can reveal which qualities (or to which degree of quality) are associated with these benefits and thus provide insights into environmental planning and management.

Research on preferences dates back to the 1960s and has evolved since then (Ivarsson & Hagerhall, 2008). Environmental preference is often defined as 'liking' (Peschardt & Stigsdotter, 2013) or finding locations aesthetically pleasing (Hartig & Staats, 2006). Environmental preference is considered to be a preference for a location (Peschardt & Stigsdotter, 2013), which is a complex concept. Users may have different aesthetic preferences for environments due to human-environment interactions, perceptions, and information biases (Ulrich, 1977, Zheng et al., 2011). Kaltenborn & Bjerke (2002) suggest that although landscape preferences are influenced by age (Balling & Falk, 1982), culture (Hartig, 1993), education level (Yu, 1995), and living environment (Van den Berg & Coeterier, 1998), in general, humans prefer natural scenes due to evolutionary theory.

Although many factors influence environmental preferences, the relationship between environmental quality and preferences has been highlighted (Hagerhall, 2001, Wang et al., 2016). Environmental psychologists have noted that physical qualities play a key role in the prediction of environmental preferences, such as topographic variation (Herzog, 1987), scene scale (Herzog, 1985), openness (Shulin et al., 2014), number of elements (Luo et al., 2021), naturalness (Kaplan et al, 1972). Moreover, the aesthetic quality of some environments is also correlated with preference, as it is a typical aesthetic experience (Stecker, 2006). Generally speaking, physical quality is a measure of the physical attributes/characteristics of an environment, while the aesthetic quality of an environment derives from the cognitive and aesthetic responses of the user after multisensory interaction with the environment (Subiza-Pérez et al., 2019). Most previous research on the aesthetic quality of environments has focused on visuals, such as visual complexity (Van den Berg et al., 2016), visual focus (Arriaza et al., 2004), visual coherence (Tveit et al., 2006), and color contrast (Luo et al., 2021). Although these direct visual experiences are important, they do not reflect the results of experiencing the environment through multiple senses (Subiza-Pérez et al., 2019), such as the multisensory stimulation of smell and sound (Chen et al., 2009), and the mystery that encourages continued exploration (Herzog & Bryce, 2007). Therefore, other aesthetic experiences besides visual aesthetics need to be considered when establishing the correlation between preferences and the aesthetic quality of the environment.

Factors influencing users' attitudes towards parks have been categorized into psychological and physiological factors in the study by Wan et al. (2020). However, previous studies on preferences for blue spaces have tended to discuss either physical features or aesthetic perceptions in isolation (Bulut & Yilmaz, 2009, Luo et al., 2021, Subiza-Pérez et al., 2019, Zhao et al., 2013a, Gabr, 2004), rarely considering both aspects together. The human aesthetic evaluation of a landscape is not an isolated mental process; it must be associated with the physical environment and the related emotional and cognitive structures (Kaltenborn & Bjerke, 2002). For example, a visitor can perceive the high level of maintenance of the area in which he or she is located (physical quality) as well as the diversity of the landscape (aesthetic quality), which are not two contradictory aspects, but can be perceived simultaneously. In summary, this study suggests that predicting preferred environmental quality can be measured simultaneously in terms of both physical and aesthetic quality.

Despite the increasing number of relevant papers, however, most of the current studies focus on the association between blue space environmental quality and health (Vaeztavakoli et al., 2018, Pitt, 2018, Mishra et al., 2020, Brückner et al., 2021, van den Bogerd et al., 2021), and there is still a lack of studies assessing the environmental quality and user preferences of urban blue spaces (Fig. 1-5). This research is necessary because it can reveal why and to what extent users prefer such blue spaces. In addition, many studies have shown that this positive attitude towards the environment also influences users' willingness to revisit and use these places, which is valuable in promoting the use of urban natural spaces (Chen et al., 2020a). More, the Nature-deficit disorder associated with urbanization has developed into a major social issue (Song et al., 2020), and UBS should be encouraged as a natural resource. Although "blue gyms" (White et al., 2016) have been highlighted as a health intervention, how to attract more use by residents by improving environmental quality is still a topic.

1.2 Overall study aims

Urban green and blue spaces have many health and aesthetic benefits that have been highlighted in previous studies. However, most of the current research is general and there is still relatively little research addressing specific blue (e.g., urban park blue spaces) and green spaces (e.g., specific green environmental settings in urban parks) in cities.

Therefore, this doctoral thesis hopes to discuss these topics through several experiments. The overall research objectives of this thesis are:

1) (Study 1 and Study 2) To study the preference and mental restoration of specific urban green space settings, and the factors that influence them.
2) (Study 3) To study the preference and mental restoration of specific urban blue space settings, and the factors that influence them.
3) (Study 4) To identify the physical and aesthetic environmental components that significantly influence the perceived preference for urban blue space.
4) (Study 5) Compare the difference in mental restoration between urban blue space and urban green space, and the difference in restorative environmental features.

The specific problem settings for each study will be presented in the corresponding chapter.

1.3 Structure of the thesis

Figure 1-6 shows the structure of the thesis. The first chapter is the introduction, which contains the background and objectives of the study, and the structure of the thesis. The second chapter introduces the methodology and procedures of the five studies. The results and discussion of the five studies will be placed in chapter 3 to 7. The last chapter will summarize the full text and present the limitations of the study and future work.

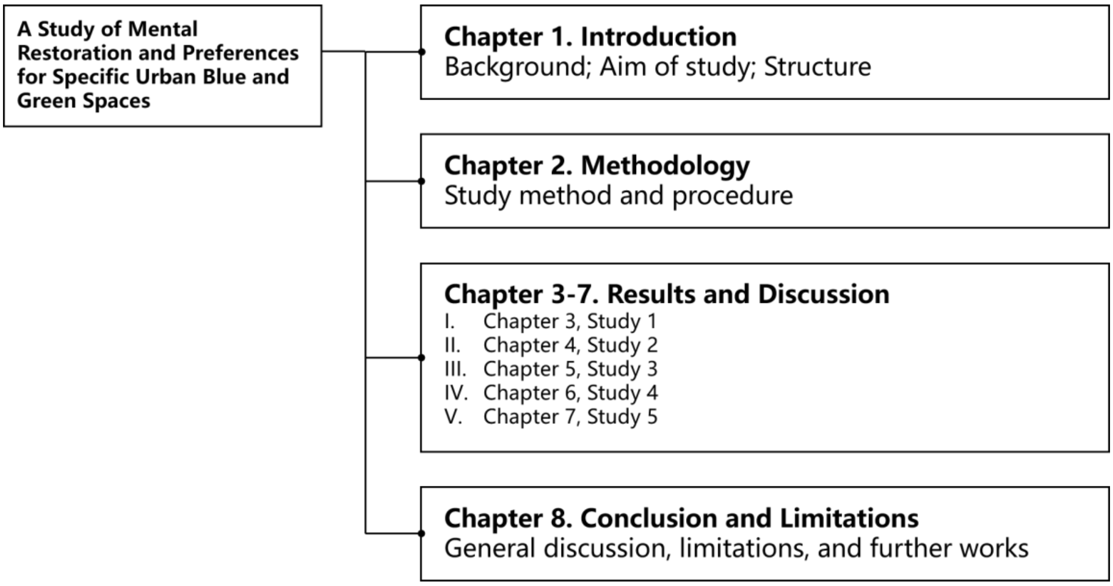


Figure 1-6 Structure of the thesis

Chapter 2 Study Framework

2.1 The framework and procedures of each study

Natural experiences in urban parks have a positive impact on the well-being and quality of life of people living in urban settings. Thus far, studies focused on urban parks have primarily surveyed general urban park spaces. There is a lack of research on specific rest environment settings, especially for leisure facilities such as pavilions. The first study used Virtual Reality to create a simulation of people sitting in a pavilion, to evaluate the preferences and mental restoration of nine pavilions in Tokyo (N=61) (Fig. 2-1).

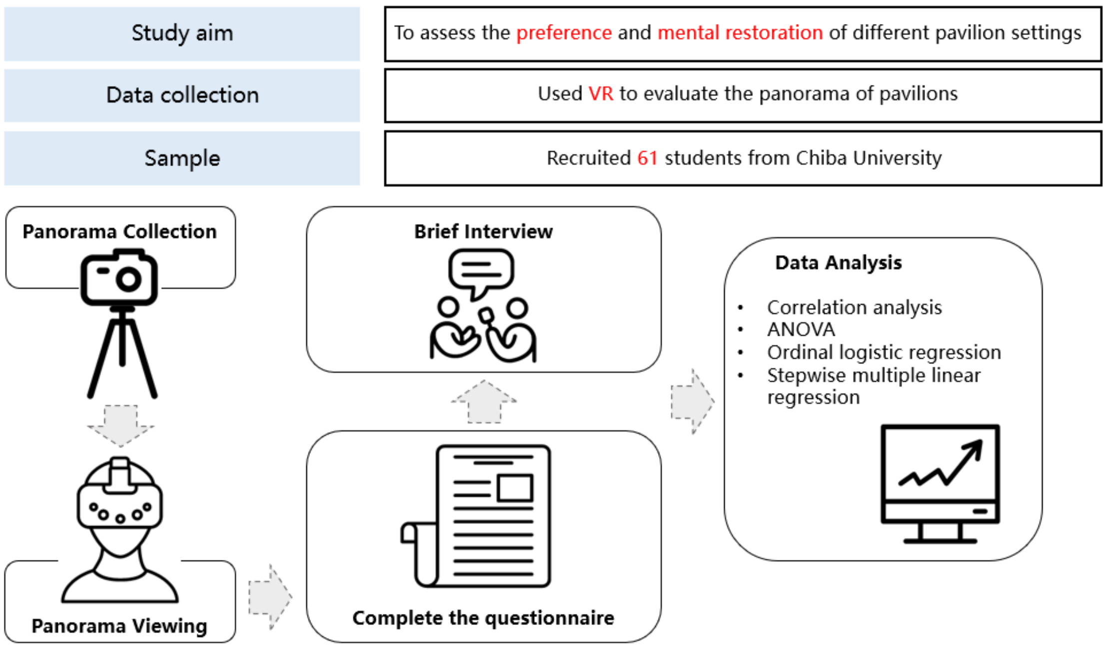


Figure 2-1 Framework of the first study

The impact that classical gardens have on the well-being and quality of life of visitors, especially city dwellers, is an important topic. Scholars have previously focused on landscape aspects, such as water bodies, plants, rocks, chairs, pavilions, and public squares, in various green spaces but have overlooked the road settings that visitors walk on. This study used the Du Fu Thatched Cottage Museum as the subject region and employed a convenience sampling method (n = 730) to analyze the preference and mental restoration of different road settings of Chinese classical gardens (Fig. 2-2).

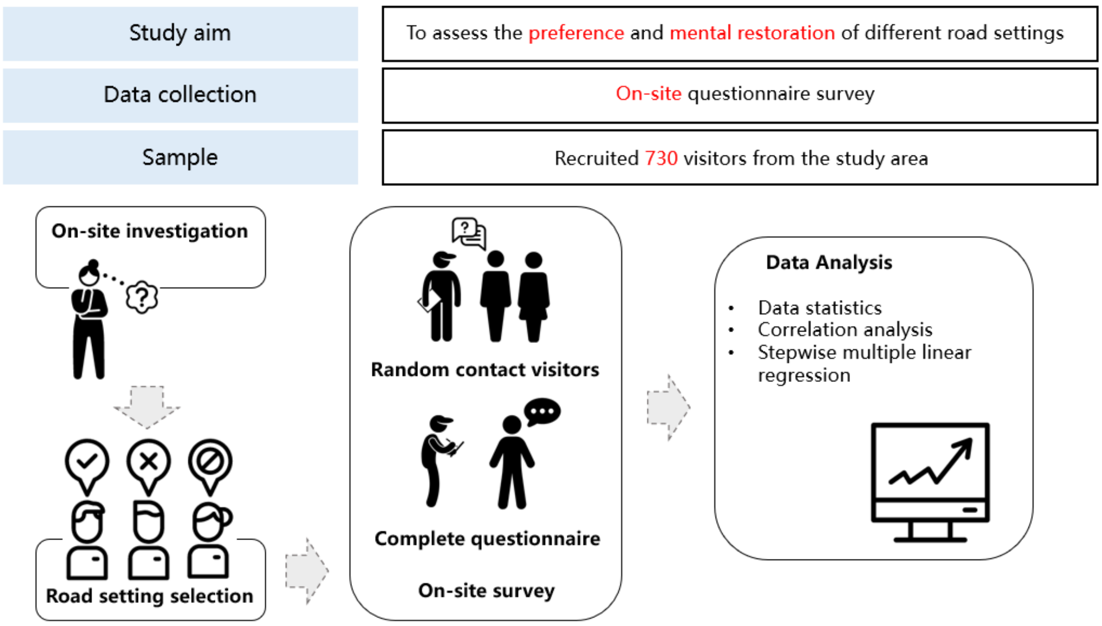


Figure 2-2 Framework of the second study

Urban parks are essential parts of a city's natural environment, and blue spaces of urban parks bring aesthetic and health benefits to people. However, the current blue spaces mainly focus on the marine environment or a giant water body scale at the urban or regional level. The urban park blue spaces (e.g., rivers, creeks, ponds) are relatively neglected. This experiment involving 10 different urban park blue spaces in Huanhuaxi park was conducted to assess urban park blue spaces' aesthetic preference and restorative potential (Fig. 2-3).

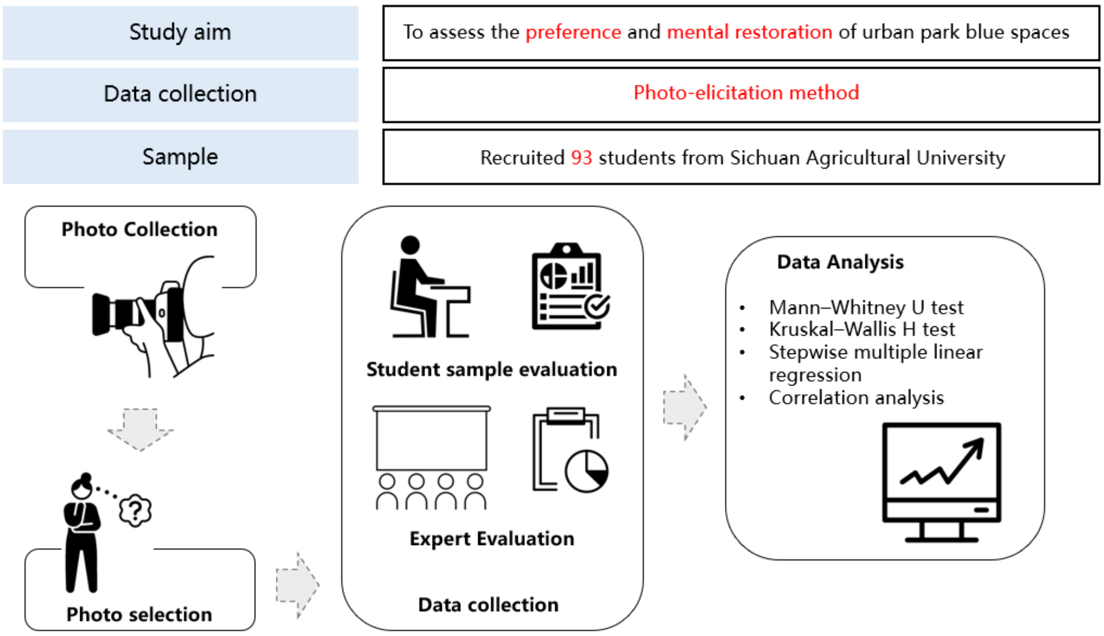


Figure 2-3 Framework of the third study.

Blue spaces, especially as important natural environments, provide various benefits. This study establishes a relationship between preference and environmental quality by investigating visitors' perception of the environmental quality of blue spaces (physical and aesthetic). For this purpose, 296 questionnaires were collected from three blue spaces and a multiple linear regression analysis was executed (Fig. 2-4).

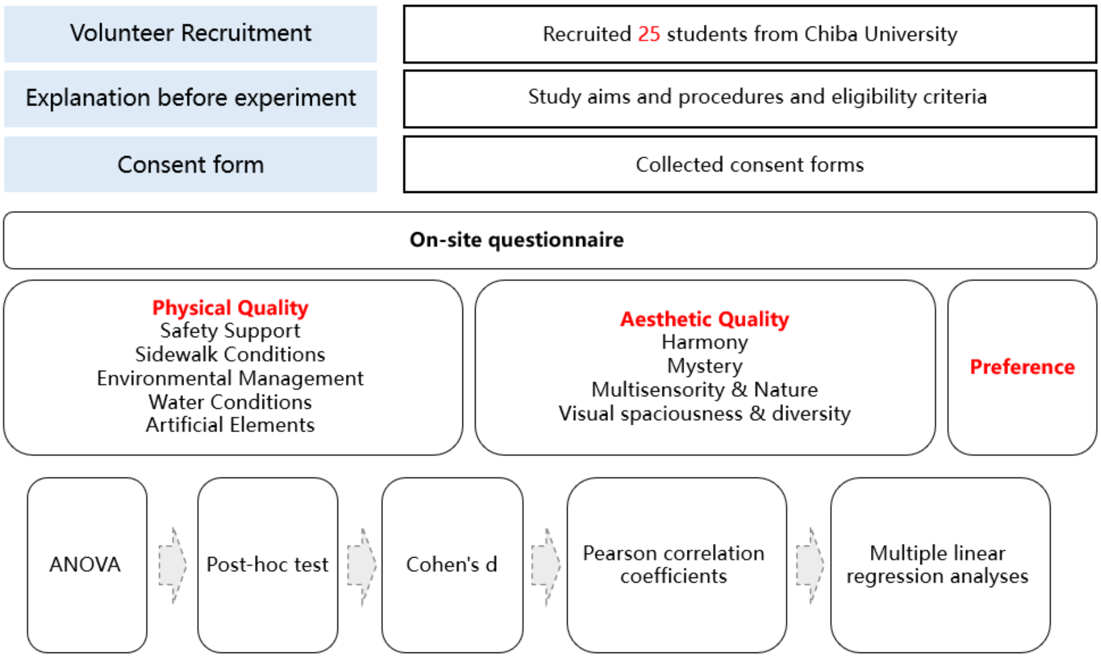


Figure 2-4 Framework of the fourth study

Blue and green spaces are of great value for promoting public health in cities. Although studies have begun to link green and blue spaces, these studies are still discussed from a macro-based perspective and lack empirical evidence from field experiments. This study empirically investigated the restorative benefits of "viewing" behaviors in urban blue spaces (UBS) and urban green spaces (UGS) and compared the features of the two restorative environments using the Improved Restorative Components Scale (IRCS) (Fig. 2-5). These findings increase understanding of how blue and green spaces in real urban environments provide direct health benefits and have theoretical and practical value for the future design and planning of "healthy cities".

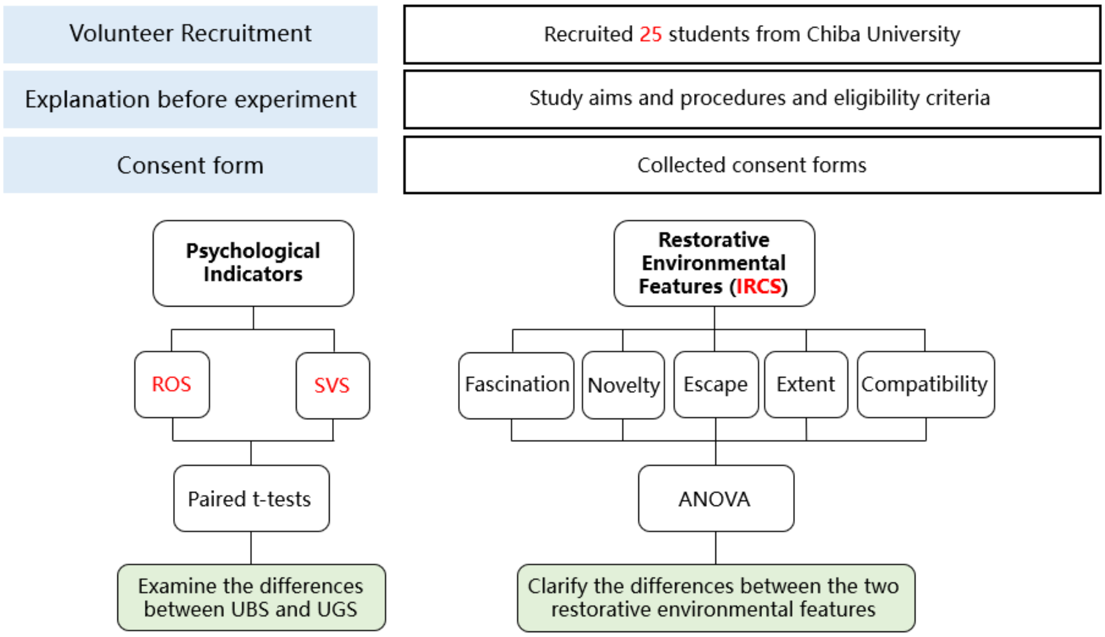


Figure 2-5 Framework of the fifth study

2.2 The profile of the five studies

The Table 2-1 shows the profile of the five studies.

Table 2-1. The profile of the five studies.

Item	**Study 1**	**Study 2**	**Study 3**	**Study 4**	**Study 5**
Aim	To assess the preference and mental restoration of different pavilion settings	To assess the preference and mental restoration of different road settings	To assess the preference and mental restoration of urban park blue spaces	To identify the physical and aesthetic environmental components that significantly influence the perceived preference for urban blue space	Compare the difference in mental restoration between urban blue space and urban green space
Data Collection	Used VR to evaluate the panorama of pavilions	On-site questionnaire survey	Photo-elicitation method	On-site questionnaire survey	On-site survey
Sample	61 students from Chiba University	730 visitors from the study area	93 students from Sichuan Agricultural University	Recruited 25 students from Chiba University	Recruited 25 students from Chiba University
Data Analysis	◆ Correlation analysis ◆ ANOVA ◆ Ordinal logistic regression ◆ Stepwise multiple linear regression	◆ Data statistics ◆ Correlation analysis ◆ Stepwise multiple linear regression	◆ Mann–Whitney U test ◆ Kruskal–Wallis H test ◆ Stepwise multiple linear regression ◆ Correlation analysis	◆ ANOVA ◆ Cohen's d ◆ Pearson correlation ◆ Multiple linear regression analyses	◆ Shapiro-Wilk test ◆ Paired t-test ◆ Pearson correlations ◆ ANOVA

Chapter 3 Use of virtual reality to evaluate preferences and mental restoration in urban park pavilions

3.1 Methodology

3.1.1 Restorative evaluations using virtual reality

Not everyone has access to the natural environment (Browning et al., 2020). As time constraints due to long work hours may hinder opportunities for natural experiences, alternatives to recovery need to be explored (Reese et al., 2021). Virtual reality (VR) is an effective medium for inducing emotions (Moura et al., 2021) and can simulate highly realistic environments (Mattila et al., 2020). Furthermore, Reese et al. (2021) indicated that images, videos, and VR can elicit psychological effects, which indicates that visual stimuli are sufficient to elicit recovery. VR emphasizes "immersive experiences" rather than just "viewing" (Portman et al., 2015). Thus, VR experiences are considered highly similar to the physical experience of nature (Reese et al., 2021), as VR can trigger restorative experiences comparable to real environments (Yin et al., 2018), regardless of whether the experience is active or passive (Reese et al., 2021).

VR technology can provide more environmental information and create a more realistic environmental experience than traditional two-dimensional media (such as photos). Thus, there is an increasing use of VR for restorative evaluation, particularly in urban parks (Jeon et al., 2021, Yu et al., 2020, Masullo et al., 2021a). For example, in previous studies, the use of a VR representation of nature reduced the pain experienced and recalled by patients (Tanja-Dijkstra et al., 2018) and six minutes of exposure to VR improved mood (Browning et al., 2020). Moreover, natural scenes presented through VR were able to provide objective and subjective relaxation and recovery after stressful experiences (Anderson et al., 2017). VR has also been widely used in the health and medical fields for numerous purposes and impacts, including motor rehabilitation (Sveistrup, 2004), functional recovery after stroke (Merians et al., 2006), stress relief (Wang et al., 2019), psychological restorative efforts for middle-aged and older adults (Yu et al., 2020), and reduced negative emotions by viewing forest environments (Yu et al., 2018). More importantly, combining nature (e.g., forest, botanical garden) and VR, and introducing it into healthcare settings can be an effective alternative to analgesics, thus reducing additional medical applications (Tanja-Dijkstra et al., 2018). In summary, experiencing nature through VR is effective for improving mental health, reducing pain, and relieving stress. This fact substantiates the use of VR simulations of pavilion settings in different urban parks to evaluate mental restoration in this study.

3.1.2 Participants

Participants were recruited using a social networking platform (Line). The inclusion criteria were normal vision and no cognitive or mental disorders. The volunteers included 61 students from the Faculty of Horticulture, Chiba University: 32 women (52.4%), 29 men (47.6%); average age 25.5 (±1.53). The participants were predominantly from the following departments: Landscape Planning, Garden Design, and Greenspace Environment. All participants voluntarily participated in the study and provided verbal consent. Each person was presented with a small gift as a token of appreciation upon experiment completion.

3.1.3 Study site and stimuli

During the desk research, the authors compiled information on all pavilions in Tokyo. Open traditional gardens and semi-open traditional gardens within urban parks were selected as the study area. To avoid repeated investigation of pavilions in similar environments during the field investigation (September 1–20, 2020), the three researchers investigated 24 pavilions across 14 urban parks in Tokyo (Fig. 3-1). A GoPro Fusion 360 (with 9 megapixels and a sensor size of 6.17 × 4.55 mm) was used to capture the panorama. To ensure consistency, we chose similar weather and light conditions for photography (Fig. 3-2). While shooting, the GoPro was placed on the seat in the pavilion, and the lens was in line with the sitting height of the human eye (1.2 m). In addition, to avoid distortion of the stitched panorama, the closest object surface (such as walls and pillars) to the lens exceeded the minimum stitching distance (20 cm). A total of 37 panoramas were taken (1–3 per pavilion). However, viewing all panoramas could be difficult for the participants. Therefore, after discussion, nine pavilions from seven urban parks were selected for the study (i.e., Rikugien Garden, Shinjuku Gyoen National Garden, Edogawa Heisei Garden, Mejiro Garden, Hibiya Park, Kyu-Furukawa Garden, and Kyu-shiba-rikyu Garden; Fig. 3-3, 3-4).

The criteria were as follows:

1) unique environmental settings,

2) sufficient natural environment outside the pavilion,

3) different pavilion shapes and enclosure levels,

and 4) no magnificent landscape outside the pavilion.

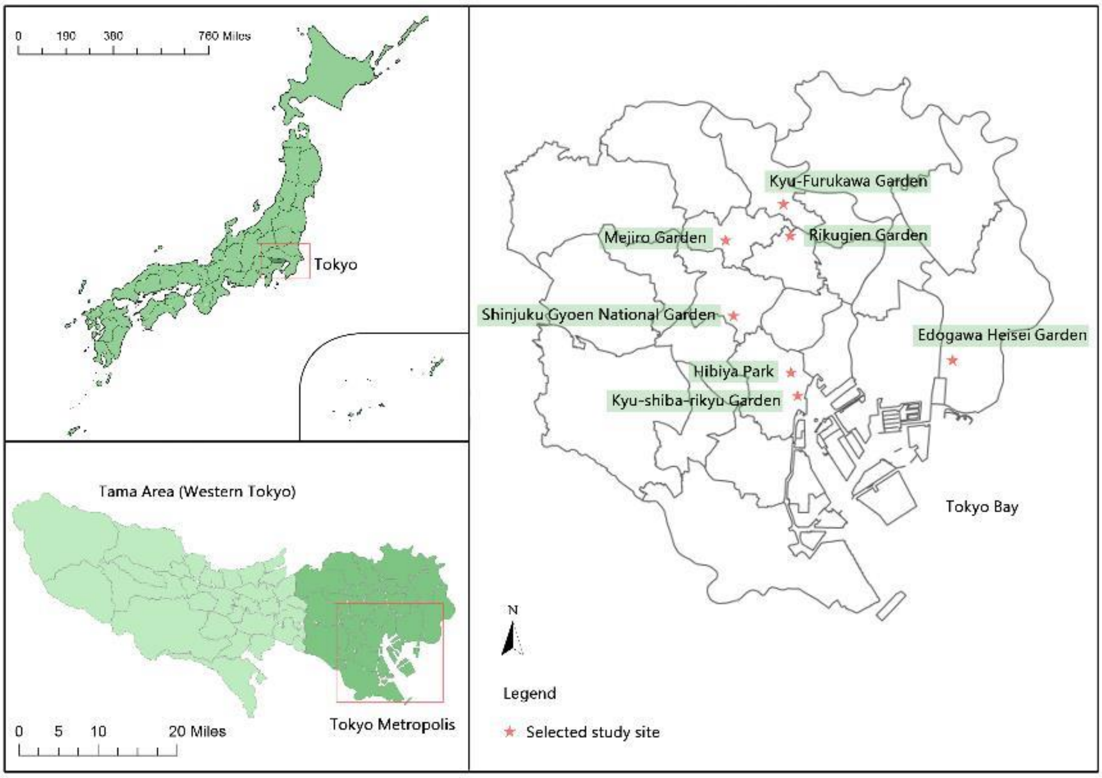


Fig. 3-1. The location of the study site.

Fig. 3-2. Collected panorama in Rikugien Garden.

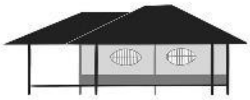
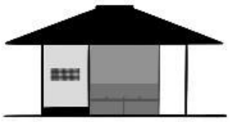
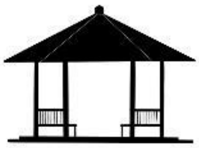
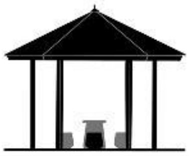
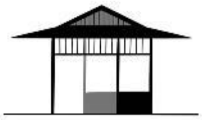
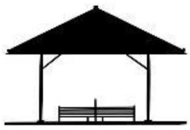
Code	Image	Sketch	Panorama	Description
1				Category: irregular Enclosure: semi-open Location: Rikugien Garden
2				Category: irregular Enclosure: semi-open Location: Shinjuku Gyoen National Garden
3				Category: square Enclosure: semi-open Location: Edogawa Heisei Garden
4				Category: hexagonal Enclosure: open Location: Mejiro Garden
5				Category: hexagonal Enclosure: open Location: Shinjuku Gyoen National Garden
6				Category: hexagonal Enclosure: open Location: Hibiya Park
7				Category: square Enclosure: open Location: Kyu-Furukawa Garden
8				Category: square Enclosure: open Location: Shinjuku Gyoen National Garden
9				Category: square Enclosure: open Location: Kyu-shiba-rikyu Garden

Fig. 3-3. Image, sketch, panorama, and description of the nine selected research pavilions.

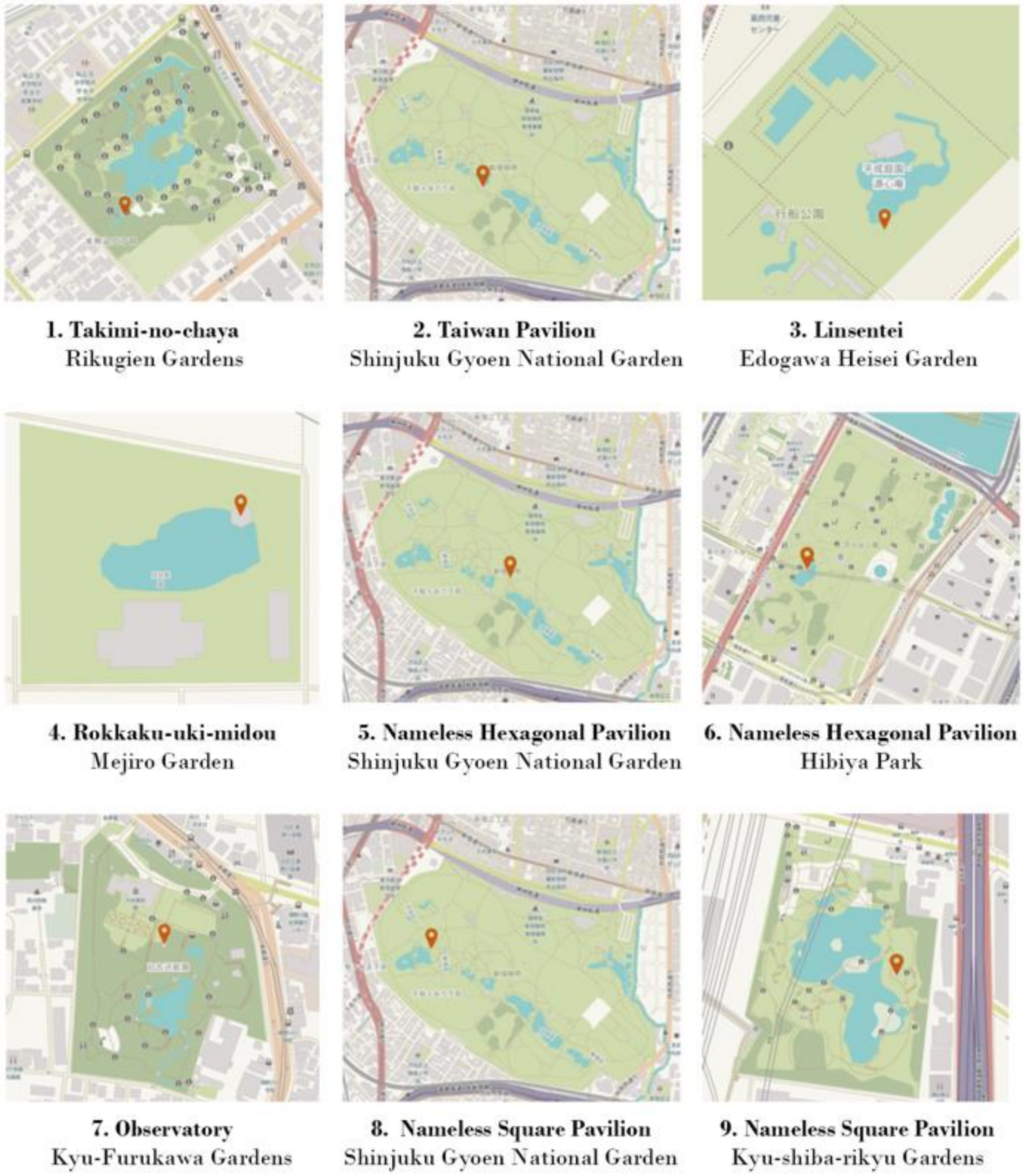


Fig. 3-4. The specific location of the selected nine pavilions.

3.1.4 Measures

Self-report scales were used to measure restorative experiences. Mental restoration can be measured in three dimensions: restorative experiences, positive emotions, and stress reduction (Wan et al., 2020, Hartig et al., 1997, Korpela et al., 2008, Pasanen et al., 2018). All descriptions were adapted to meet the purposes of this study. Restorative experiences, positive emotions, and stress reduction were measured using three, two, and three items, respectively. All items were rated on a 5-point Likert scale, ranging from 1 (completely disagree) to 5 (completely agree; Table 3-1). The mental restoration score of each pavilion is the mean value of these three dimensions.

Table 3-1. Mental restoration measure.

Dimension	Item	Scale
Restorative experiences	I feel restored after sitting here.	1 2 3 4 5
	I forget everyday worries after sitting here.	1 2 3 4 5
	Sitting here gives me a break from my day-to-day routine.	1 2 3 4 5
Positive emotions	Sitting here makes me happy.	1 2 3 4 5
	I feel energized after sitting here for a while.	1 2 3 4 5
Stress reduction	I feel relaxed after sitting here.	1 2 3 4 5
	Sitting here makes me feel calm.	1 2 3 4 5
	Sitting here helps me reduce stress.	1 2 3 4 5

In addition, an item measured the participants' preference for different pavilion settings: “Here the landscape is attractive to me” (1 = completely disagree, 5 = completely agree). The participants were told to focus on the natural environment outside the pavilion rather than on the architectural space.

Chen et al., 2019, Peschardt and Stigsdotter, 2013 used the PSD scale to explore how participants perceive varied natural environment settings (1 = completely disagree, 5 = completely agree; Table

2-2). This scale is composed of eight different dimensions, has proven reliability, and is often used to describe the characteristics of various natural environments (Chen et al., 2019, Peschardt and Stigsdotter, 2013, Stigsdotter et al., 2017, Qiu and Nielsen, 2015). A description was added after each dimension to enable the participants to understand these dimensions. All measurement tools were translated into Japanese, English, and Chinese versions for participants from different countries.

Table 3-2. Perceived Sensory Dimension scale.

Dimension	Description	Scale
Social	Here is an environment suitable for social activities.	1 2 3 4 5
Space	This is a spacious and undisturbed environment.	1 2 3 4 5
Nature	Sensation of wilderness and nature.	1 2 3 4 5
Refuge	Here is an enclosed and safe environment.	1 2 3 4 5
Prospect	Here is an open space with a wide view.	1 2 3 4 5
Serene	Here is a silent and peaceful environment.	1 2 3 4 5
Culture	There are many artificial elements decorating here.	1 2 3 4 5
Rich in species	Many animals and plants around here.	1 2 3 4 5

3.1.5 The generalized preference and restorative environment setting

The participants were requested to complete an additional questionnaire after viewing each pavilion to find a generalized preference and restorative environment setting (Deng et al., 2020). The questionnaire contains two items (both multiple choice, Fig. 3-5):

(1) "What do you want to do in this scene?"

(2) and "Which elements are your favorite in this scene?"

What would you like to do in this scene?	Yes/No	What elements of the scene do you like best?	Yes/No
Sitting		Lush plants	
Reading		Colorful vegetation	
Chatting		Water body	
Drinking tea		Animals (fish, birds, etc.)	
Meditation		Rockery	
Picnic		Buildings	
Viewing scenery		Natural pavement	
Painting		Road	
Photography		Meadow	
Sleeping			

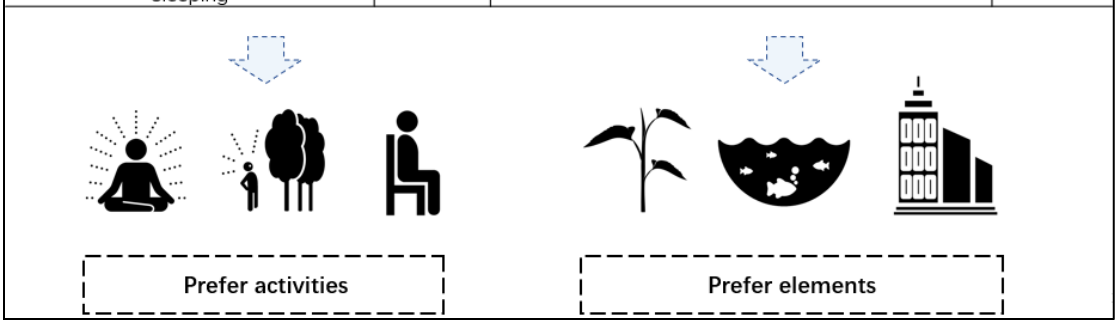


Fig. 3-5. The questionnaire about their prefer activities and elements.

3.1.6 VR viewing experience

Inspired by previous research (Yu et al., 2020), after each participant viewed all the pavilion settings, we conducted a simple semi-structured interview (approximately 5–10 min) to evaluate the VR viewing experience. It comprised three questions: “Did you experience physical symptoms, such as cyber sickness or dizziness?” “How did you feel when viewing these pavilion settings?” and “Does VR viewing make you want to visit these pavilions on-site?”

3.1.7 Procedure

The VR viewing experiment was carried out in the Landscape Planning Research Room from April 20-May 20, 2021. Each participant was instructed not to drink any alcoholic beverages for 12 h before the experiment onset. A freely rotatable chair was provided after the participants arrived in the research room. Meanwhile, a researcher explained the procedure and purpose of the investigation to all participants, following which their verbal consent was obtained. The participants were told that they were free to withdraw at any point, should they face any discomfort during the experiment. The head-mounted display (Oculus Go) was placed for the participants and adjusted to ensure comfortable viewing of the panorama (Fig. 3-6b). Next, they were permitted to freely view each panorama of the pavilion setting without a time limit and were requested to complete the questionnaire. Only once the current pavilion questionnaire had been completed could the next pavilion be viewed. During this phase, the participants were informed that they were in this environment. They were asked not to stand up or slide the chair; only a slight swing of the chair was allowed, but the head could be freely turned to watch (as if sitting on a pavilion seat) (Fig. 3-6c).

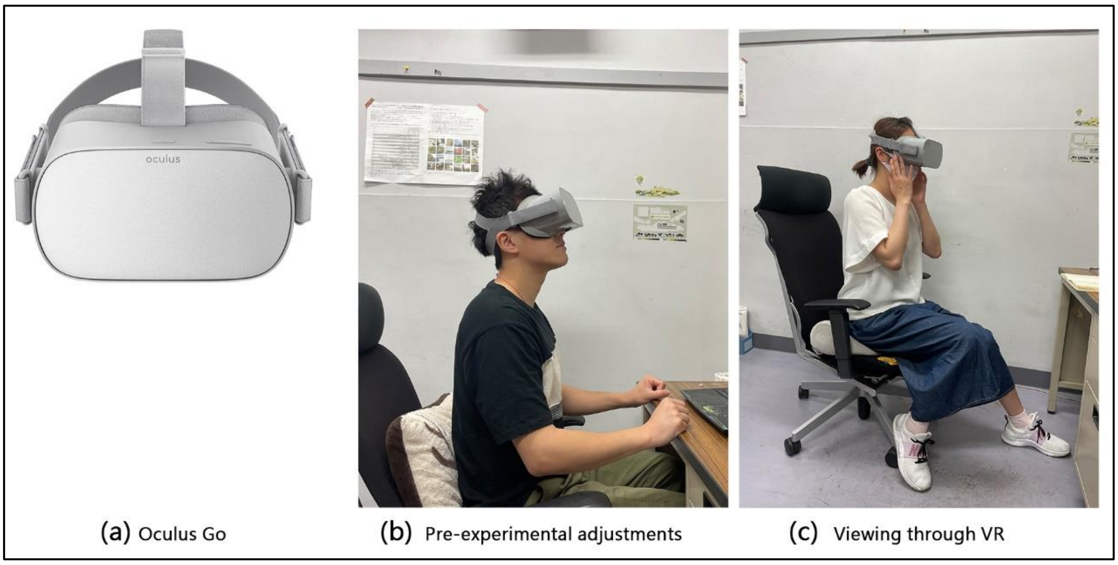


Fig. 3-6. (a) Oculus Go; (b, c) Participant viewing the panorama through the head-mounted display.

After the participants had viewed all nine pavilions, a researcher conducted a simple semi-structured interview with the participants to evaluate the VR viewing experience. Finally, the participants were rewarded with a gift and thanked for their participation. To eliminate potential interference, silent conditions were ensured for VR viewing. The entire experiment (for one individual) took approximately 15–20 min.

3.1.8 Analyses

The experimental data were compiled and statistically analyzed using Microsoft Excel. Correlation analysis was used to examine the relationships among restoration, preference, and PSD. Further, according to the degree of enclosure, the pavilions were divided into two categories in the following analysis: semi-open (pavilions 1–3) and open (pavilions 4–9). A one-way analysis of variance (ANOVA) was performed to examine the differences between open and semi-open pavilions. In addition, ordinal logistic regression was used to analyze the correlation between PSD and enclosure, and the results were presented as odds ratios (ORs) with 95% confidence intervals (Qiu & Nielsen, 2015). Finally, stepwise multiple linear regression analysis was used to explore the PSD predictors that affect mental restoration and preference. We did not analyze the differences between the sociodemographic characteristics because this aspect was not among the stated research questions of this study. All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS; version 20.0; SPSS Inc., Chicago, IL, USA), and the level of significance was set at $p < 0.05$. The effect size was measured by Cohen's d, which indicated that the d values of the small (0.2), medium (0.5), and large (0.8) effect quantities (Cohen, 1988).

3.2 The study questions

This study used VR to assess the preference and mental restoration of different pavilion settings. In addition, we explored the association of divergent restorative qualities (i.e., PSD) with preference and restoration.

Vision is a major component of human sensory perception (Portman et al., 2015) and visual information is considered most important when visiting natural environments, such as urban green spaces (Grahn & Stigsdotter, 2010). Anderson et al. (2017) stated that the absence of background noise in the test environment is important because sound can provide relaxation independent of visual stimuli. In addition, other studies have demonstrated that both touch (Ikei et al., 2017) and smell (Ikei et al., 2015) trigger independent restoration. Therefore, to focus on the purpose of this study (sitting in a pavilion to view and recover), only vision is used for evaluation, to exclude information interference from touch, hearing, and smell.

There have been no studies using VR to directly measure pavilion preference and restoration; moreover, there is still a lack of discussion on the association of pavilion enclosure with preference and restoration. Therefore, this study outlined three research questions. First, 1) can using VR to simulate sitting in a pavilion and viewing allow the subject to perceive restoration? Furthermore, according to evolutionary theory, humans tend to favor access to shelter possibilities (Lindal & Hartig, 2013), which leads to the understanding that enclosure affects human preference for the environment (Herzog, 1992) and perceived recovery (Galindo & Hidalgo, 2005). Second, 2) does the enclosure of the pavilion affect preference and perceived restoration? Research has demonstrated that PSDs are correlated with restoration and preference (Chen et al., 2019, Grahn & Stigsdotter, 2010, Peschardt & Stigsdotter, 2013, Stigsdotter et al., 2017). Third, 3) which PSDs predict restoration and preference in pavilion settings?

Furthermore, Zhang et al. (2019) indicated that experience and the presence of certain physical aspects make a place restorative. Hence, we conducted a qualitative study and semi-structured interviews to address the following two additional questions:

4) Which elements can promote the preference and mental restoration of the scene?

5) How was the experience of viewing these resting environments with VR?

3.3 Results

3.3.1 Overall evaluation across the nine selected pavilions

The reliability of PSD and mental restoration were calculated. According to Landis and Koch (1977), a Cronbach's alpha value greater than 0.8 indicates good internal consistency. Therefore, our results show that both PSD (Cronbach's alpha = 0.836) and mental restoration (Cronbach's alpha = 0.890) have good reliability.

As shown in Fig. 3-7, Pavilions 1 (3.97 ± 0.63) and 6 (3.74 ± 0.92) have the highest restoration and preference scores, while Pavilions 3 (3.33 ± 0.61), 4 (3.33 ± 0.84), and 5 (3.26 ± 0.82) demonstrate lower restoration scores. Pavilions 3 (3.23 ± 0.88), 4 (3.23 ± 0.88), 5 (3.20 ± 0.97), and 7 (3.16 ± 0.96) are the least preferred. However, all restorative scores exceeded 3, indicating that the majority of participants rated this restorative experience positively (Jeon et al., 2021).

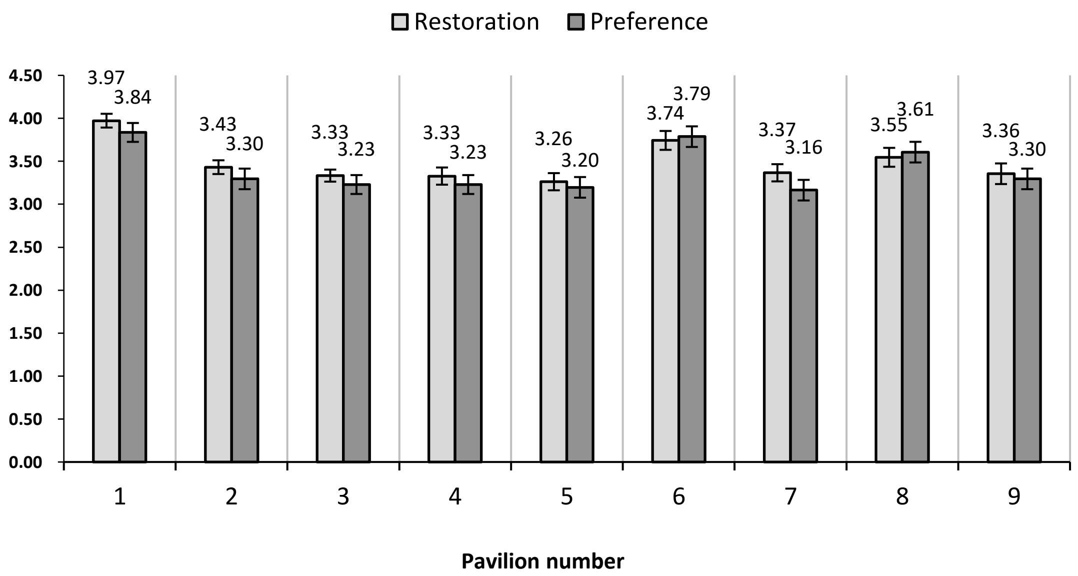


Fig. 3-7. The mental restoration and preference score of nine selected pavilions. N = 61; Mean ± Standard deviation.

The PSD results perceived by the participants are shown in Fig. 3-8. First, Pavilions 4 (3.34 ± 1.04), 8 (3.34 ± 1.02), and 9 (3.34 ± 1.04) can be perceived along the social dimension, whereas 1 (2.90 ± 1.20) and 3 (2.80 ± 1.05) have the lowest scores. For space, Pavilion 5 (3.93 ± 0.81) was the highest, whereas 3 (2.57 ± 1.02) was the lowest. In the nature dimension, the Pavilion 1 setting had the highest degree of naturalness (3.98 ± 0.88), whereas 4 had a more artificial environment (3.00 ± 0.81). In terms of refuge, Pavilion 3 had the highest score (3.34 ± 1.09). However, the six pavilion settings did not exceed the score of 3, which indicates that this dimension is not obviously perceived; in this context, Pavilion 5 had the lowest score (2.30 ± 0.91). For the prospect dimension, Pavilions 2 (3.84 ± 0.85), 5 (3.90 ± 0.88), 6 (3.82 ± 0.78), and 9 (3.93 ± 0.81) had higher scores, whereas 1 (2.69 ± 1.02) and 3 (2.62 ± 0.81) had the lowest scores. In the serene dimension, all pavilions exceeded 3, among which Pavilion 1 (4.43 ± 0.71) was considered the most peaceful environment, and 5 (3.13 ± 0.93) had the lowest score.

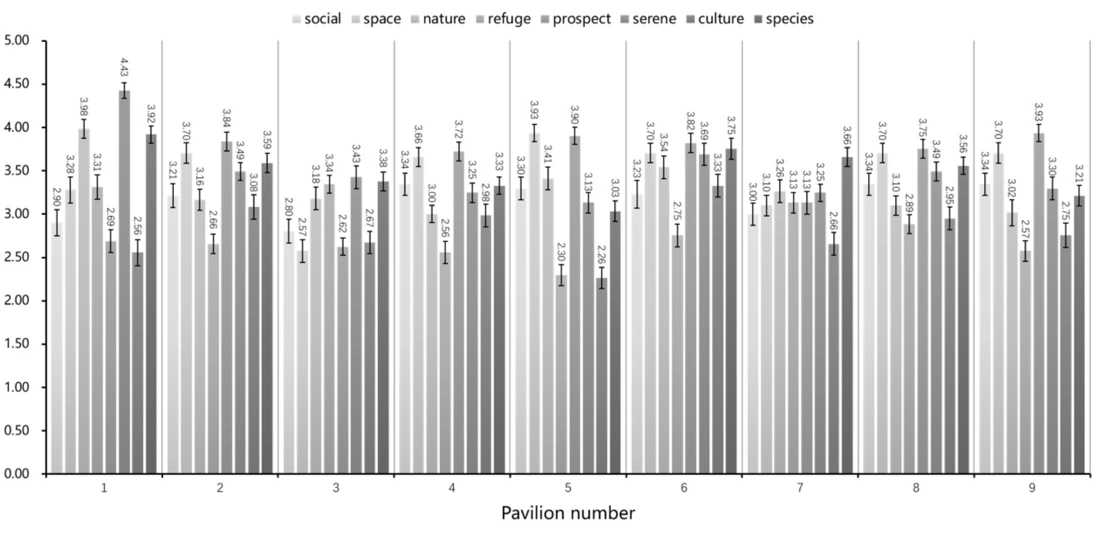


Fig. 3-8. The PSD evaluation of nine selected pavilions. N = 61; Mean ± Standard deviation.

In addition, only Pavilions 2 (3.08 ± 1.12) and 6 (3.33 ± 0.99) exceeded the score of 3 in the culture dimension, thus signifying that the participants could not clearly perceive this dimension. Rich in species is another dimension that is strongly perceived; Pavilions 1 (3.92 ± 0.80), 6 (3.75 ± 0.92), and 7 (3.66 ± 0.83) had higher scores, yet Pavilion 5 had the lowest score (3.03 ± 0.90).

3.3.2 Difference between open and semi-open pavilions

For further comparison, in the following analysis, the pavilions are divided into two categories according to the enclosure degree: semi-open pavilions (1–3) and open pavilions (4–9). An ANOVA was performed to analyze the differences. As shown in Fig. 3-9, most PSDs showed significant differences. Specifically, the two pavilion categories were significantly different across the dimensions of social ($F(1,120) = 3.968$, $p = 0.049$, Cohen's $d = 0.36$), space ($F(1,120) = 13.042$, $p < 0.001$, Cohen's $d = 0.65$), refuge ($F(1,120) = 11.711$, $p = 0.001$, Cohen's $d = 0.62$), prospect ($F(1,120) = 44.993$, $p < 0.001$, Cohen's $d = 1.21$), serene ($F(1,120) = 17.570$, $p < 0.001$, Cohen's $d = 0.76$), and richness of species ($F(1,120) = 4.137$, $p = 0.044$, Cohen's $d = 0.37$). However, there was no significant difference between mental restoration and preference, indicating that both pavilions have the same preference and mental restoration.

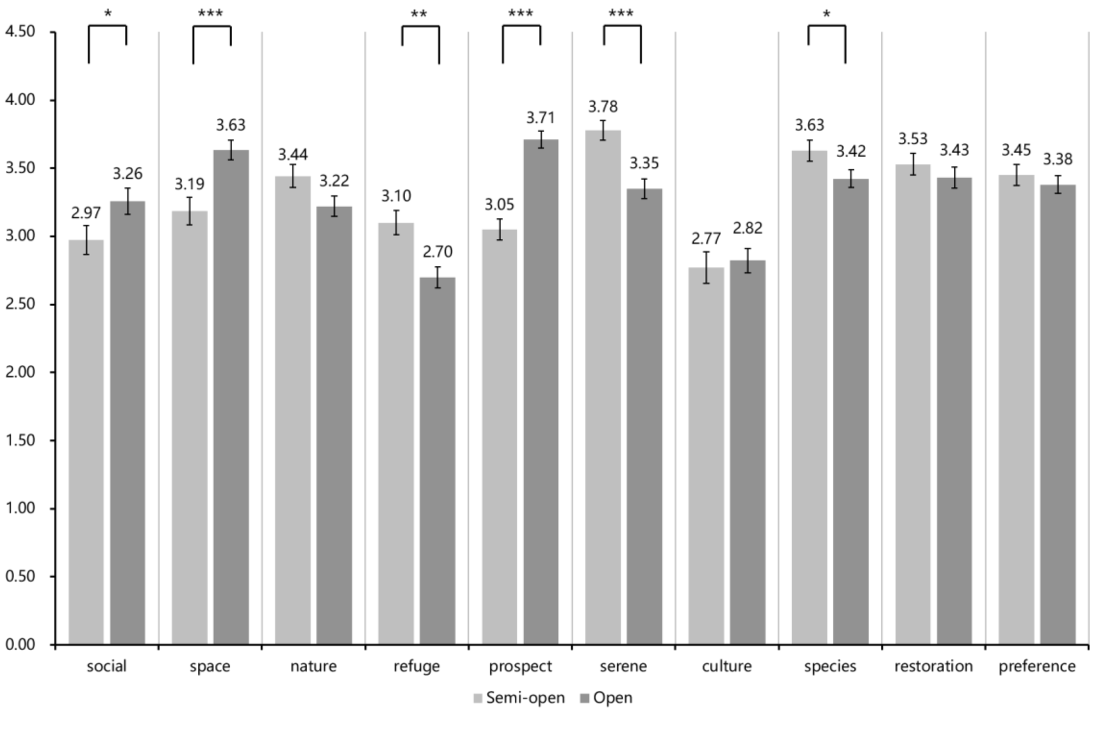


Fig. 3-9. Differences in assessment of open and semi-open pavilions.

Furthermore, to explore the relationship between the two pavilion categories and PSD, ordinal logistic regression analysis (with the semi-open pavilion as the reference group) was performed. According to the results shown in Table 3-3, the model has a good degree of fit ($\chi2 = 84.084$, $p < 0.001$, Chen et al., 2019). The prospect dimension was more likely to be perceived (OR greater than 1, $p < 0.001$) in the open-pavilion category; in contrast, the serene dimension was more likely to be perceived (OR < 1, $p = 0.002$) in the semi-open pavilion category.

Table 3-3. Ordinal logistic regression analyses results.

PSD	B	Standard error	OR	95% CI	Sig.
Social	0.172	0.130	1.188	(0.922-1.532)	0.184
Space	0.271	0.166	1.311	(0.946-1.817)	0.103
Nature	-0.197	0.143	0.821	(0.620-1.088)	0.170
Refuge	-0.201	0.132	0.818	(0.631-1.059)	0.127
Prospect	0.702	0.161	2.018	(1.473-2.765)	<0.001
Serene	-0.538	0.172	0.584	(0.417-0.818)	0.002
Culture	-0.055	0.130	0.947	(0.734-1.222)	0.675
Rich in species	0.046	0.169	1.047	(0.753-1.457)	0.783
χ^2=84.084					
Df=8					
p <0.001					

Note: a bold font indicates p < 0.05.

Reference group is the semi-open pavilion.

OR, odds ratio; CI, confidence interval; Df, degree of freedom.

3.3.3 PSD predictors of preference and mental restoration

Two stepwise multiple linear regression analyses were performed to explore the PSD that affects recovery and preference. The dependent variables of the two regression models were overall preference and mental restoration. The correlation analysis results (Table 3-4) indicate that restoration would increase with preference; all PSDs, except for the social dimension, showed a significant correlation with preference and restoration.

Table 3-4. Overall correlation results.

	Social	Space	Nature	Refuge	Prospect	Serene	Culture	Species	Restoration
Social	1								
Space	0.67^{**}	1							
Nature	0.09	0.39^{**}	1						
Refuge	0.32^{*}	0.41^{**}	0.47^{**}	1					
Prospect	0.34^{**}	0.67^{**}	0.44^{**}	0.43^{**}	1				
Serene	0.04	0.33^{**}	0.59^{**}	0.56^{**}	0.36^{**}	1			
Culture	0.31^{*}	0.46^{**}	0.39^{**}	0.46^{**}	0.56^{**}	0.53^{**}	1		
Species	0.18	0.40^{**}	0.57^{**}	0.37^{**}	0.24	0.53^{**}	0.45^{**}	1	
Restoration	0.20	0.42^{**}	0.62^{**}	0.53^{**}	0.42^{**}	0.75^{**}	0.43^{**}	0.63^{**}	1
Preference	0.18	0.37^{**}	0.46^{**}	0.46^{**}	0.46^{**}	0.58^{**}	0.43^{**}	0.44^{**}	0.62^{**}

Note: * $P < 0.05$; ** $P < 0.01$.

The results demonstrate that these variables can be used to build regression models. First, we examined the normality of model residuals, ANOVA, and multicollinearity using the Kolmogorov–Smirnov (KS) test to solve the multicollinearity problem between the predictor variables. The test results show that the residuals follow a normal distribution (for social, K-S Z value = 0.501, p = 0.963; for space, K-S Z value = 1.091, p = 0.185; for nature, K-S Z value = 0.789, p = 0.563; for refuge, K-S Z value = 0.769, p = 0.595; for prospect, K-S Z value = 0.619, p = 0.839; for serene, K-S Z value = 0.517, p = 0.952; for culture, K-S Z value = 0.574, p = 0.897; for species, K-S Z value

= 1.075, p = 0.198; for mental restoration, K-S Z value = 0.572, p = 0.899; for preference, K-S Z value = 0.814, p = 0.522). In addition, the variance analysis results show a linear correlation between PSD and preference (F = 20.213, p < 0.001) and mental restoration (F = 51.284, p < 0.001). Lastly, the occurrence of a model tolerance of < 0.2, or a variance inflation factor (VIF) > 10, is indicative of a potential multicollinearity problem (Arriaza et al., 2004). Thus, the current model results are acceptable (lowest tolerance = 0.724 and highest VIF = 1.380).

As shown in Table 3-5, “prospect” and “serene” significantly influence preference, explaining 39% of the variance, whereas for restoration, “rich in species” and “serene” are significant predictors, thus explaining 62.6% of the variance. In sum, with regard to preference or mental restoration, the serene dimension is consistently a significant predictor of the model.

Table 3-5. Significant PSD predictors of overall preference and mental restoration.

Dependent	Independent	Unstandardized Beta	Standardized Beta	t	Sig.	Collinearity statistics	
						Tolerance	VIF
Preference	(constant)	0.500		1.056	0.295		
(Adjusted	Serene	0.491	0.475	4.403	<0.001	0.873	1.146
R^2=0.390)	Prospect	0.341	0.293	2.713	0.009	0.873	1.146
Mental	(constant)	-0.330		-0.853	0.397		
restoration	Serene	0.679	0.575	6.203	<0.001	0.724	1.380
(Adjusted	Species	0.413	0.330	3.558	0.001	0.724	1.380
R^2=0.626)							

3.3.4 The generalized preference and restorative environment setting

After viewing each pavilion with VR, the participants were asked to complete an additional questionnaire to share what they wanted to do most in each scene (Fig. 3-10), as well as their favorite elements in each panorama (Fig. 3-11). Specifically, sitting (335), reading (228), chatting (387), and viewing the scenery (281) were among the favorite activities reported by most participants, while others also chose sleeping (72). In addition, lush plants (362), water bodies (267), buildings (232), natural trails (172), and meadows (159) were considered the most preferred elements within the panoramas, while animals (65), rockery (71), and artificial roads (85) were the least preferred. These results indicate that providing visitors with a space to sit, rest, socialize, read, and view the scenery is key to the preference environment setting.

Moreover, adding elements such as dense vegetation, water bodies, and meadows to these environments could be considered to build a generalized preference and restorative environment setting.

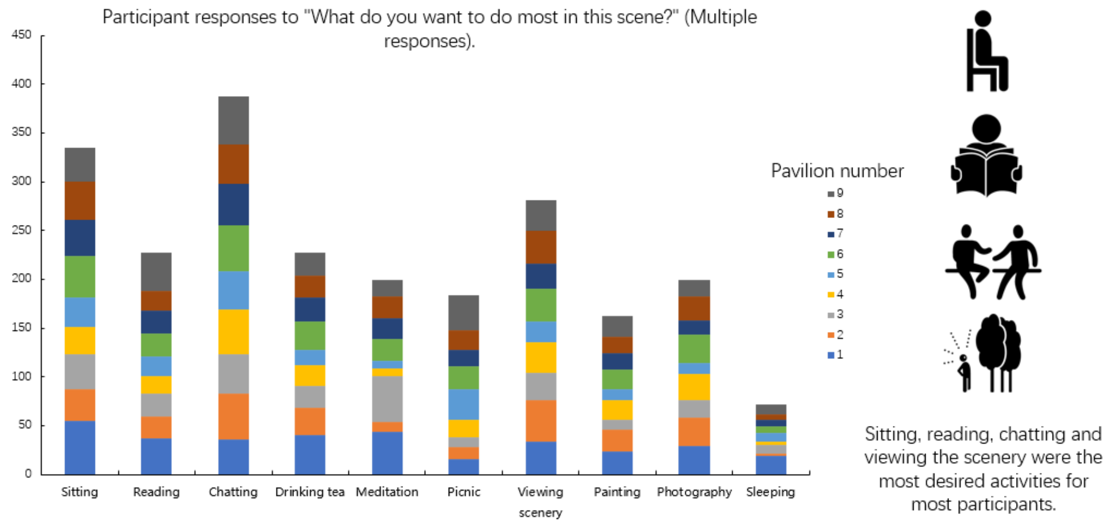


Fig. 3-10. Participant responses to "What do you want to do most in this scene?" (Multiple responses).

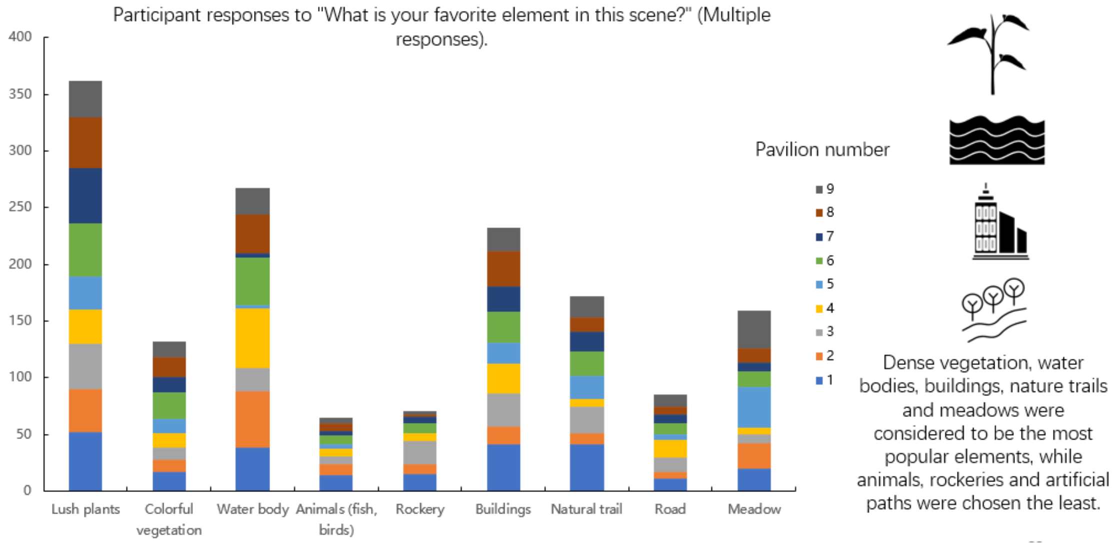


Fig. 3-11. Participant responses to "What is your favorite element in this scene?" (Multiple responses).

3.3.5 Qualitative assessment of semi-structured interviews

In the final stage, a simple semi-structured interview was conducted to evaluate the VR viewing experience. Only one participant reported feeling slightly uncomfortable during the viewing: "(for pavilion 1) *I can see the stream outside, but I feel a little uncomfortable at the beginning because of the still water in the picture…*" In addition, participants generally described the viewing experience as "relaxing," "calm," "attractive," and "a novel experience." However, few interviewees stated that some panoramas had unclear details in the distance, which may have resulted in a lower score. In addition, 38 participants (62.3%) hoped to visit these pavilions on-site (such as pavilions with 1, 6, and 9) after viewing. The quotes illustrating this fact are as follows.

(For Pavilion 1) "*…it makes me feel peaceful. I really want to sleep here.*"

(For Pavilion 6) "*…Awesome! Those high-rise buildings look just like a background, blending perfectly with the surrounding landscape.*"

(For Pavilion 9) "*The black pine on the grass is beautiful… Here is the Kyu-shiba-rikyu Garden? I will go to this place.*"

3.4 Discussion

3.4.1 Restoration through VR viewing of pavilion settings

Urban nature has become increasingly important to humanity, with the influx of migration to cities. Moreover, increasing risks of pandemics might motivate people to explore regional and urban lives, rather than long-distance travel. Several studies have discussed the health benefits of visiting urban parks, including its contributions to psychological health (Wan et al., 2020), social health (Hartig et al., 2014), physical health (Kaczynski et al., 2008), stress relief (Ulrich et al., 1991), and direct attention restoration (Kaplan, 1995). However, urban parks are extensive in scope when considered as a concept, and research on specific settings related to them is lacking. Furthermore, most studies that have explored urban parks are based on the perspectives of standing (Karacan et al., 2021, Mostajeran et al., 2021) and walking (Bielinis et al., 2020); moreover, few have simulated people sitting and resting in these natural environments. Research has employed virtual reality technology to view and recover from a variety of environments, including coastal (Tanja-Dijkstra et al., 2018), forests (Yu et al., 2018), biophilic indoor environments (Yin et al., 2018), and even VR urban (Jeon et al., 2021). Arguably, as any environment has restorative potential, all potentially restorative environmental settings should be carefully examined (Kaplan, 1995).

In this study, a self-report scale containing three dimensions was used to measure restorative experiences. The psychological recovery score for each pavilion was the average of these three dimensions. Consistent with the findings of Wan et al. (2020), the Cronbach's alpha value for this scale was greater than 0.8, indicating good reliability. The results of this study indicated that all nine pavilion settings had a mental restoration score of over 3, thus implying that most participants affirmed the restorative effect of viewing the pavilion settings (Jeon et al., 2021). Pavilions 1, 6, and 8 achieved high mental restoration scores (Fig. 3-7). The participants were able to observe water bodies and dense vegetation through VR. Meanwhile, according to the result of “favorite elements in the scene” (Fig. 3-11), lush vegetation, water bodies, and meadows were the desired elements identified by the participants. In contrast, Pavilion 5 was evaluated as the least restorative environment, which may be attributed to the lack of a water body and scant vegetation in the scene. Therefore, the result can be proven by the correlation between preference and restoration (Table 3-4); that is, people perceive mental recovery from favorite scenes (Deng et al., 2020), whereas inadequate physical environments could cause stress (Kaplan, 1995). It can be inferred that spending time in these VR natural environments could lead to mental restoration (Tsunetsugu et al., 2013). This result addresses the first research question posed in this study.

3.4.2 The role and impact of the pavilion enclosure

The nine pavilions were divided into open and semi-open categories according to the enclosure, and the ANOVA results indicated no significant difference in the preferences and mental restoration between the two types of pavilions. This suggests that pavilion enclosure does not affect these two variables. Although this result answers the second question, we also found that enclosure significantly influenced PSD.

The overall results (Fig. 3-8) show that unlike previous studies (Qiu and Nielsen, 2015, Chen et al., 2019), the highly perceived dimensions in this study were prospect, serene, and rich in species. Among these, serene and rich in species were strongly perceived dimensions, which aligns with those of prior research examining small public urban green spaces (Peschardt & Stigsdotter, 2013).

However, the dimension of culture was perceived to be weak across all pavilions, which is inconsistent with previous findings on other urban green spaces (Qiu & Nielsen, 2015). The culture dimension is generally considered to be related to a large number of artificial elements, such as fountains, sculptures, kitchen plants, and ornamental plants (Stigsdotter et al., 2017), which were rare in the environments of this study. Pavilion 6 received the highest score (3.33) in this dimension, which may be because Hibiya Park is a modern urban park (Fig. 3-12). Here, participants could view a fountain with crane sculptures and some wetland ornamental plants (e.g., less bulrush). Research has discussed restorative elements related to culture, such as artistic elements (Scopelliti et al., 2019) and historical sites (Masullo et al., 2021b). The high restoration score of Pavilion 6 appears to be related to this aspect. However, due to the limitations of the survey sample, caution should be exercised when interpreting the results.

Fig. 3-12. View from pavilion 6.

In addition, compared with the differences between open and semi-open pavilions (Fig. 3-9), the results show that the six dimensions of the eight PSDs reveal significant differences: social, space, refuge, prospect, serene, and rich species. However, the ANOVA showed only a difference in PSD. Therefore, ordinal logistic regression analysis was performed. According to Table 3-3, participants were more likely to perceive the prospect dimension in the open-pavilion category; the serene dimension was more likely to be perceived in the semi-open pavilion category. These results are reasonable. The prospect dimension can be summarized as having open and flat areas (Grahn & Stigsdotter, 2010), emphasizing no visual obstruction. In the study samples, an open pavilion enabled a broader vision compared with the semi-open pavilion, which allowed participants to see the distance and provide an overview of the surroundings (Stoltz & Grahn, 2021). The serene dimension signifies an undisturbed, not crowded, quiet, and safe environment (Grahn and Stigsdotter, 2010, Bengtsson and Grahn, 2014), and was perceived to a greater extent in the semi-open pavilion context, which is inconsistent with previous research conclusions. For instance, in a Swedish study, most interviewees experienced serene dimensions in relatively large green areas

(Qiu & Nielsen, 2015). However, the viewer in the semi-open pavilion is usually in a narrow space, and a part of the view is obstructed. Therefore, this enclosed space can increase the sense of security and create a retreat environment (Grahn & Stigsdotter, 2010). Arguably, the size of the space does not affect the user's experience of serenity (Peschardt & Stigsdotter, 2013), but the degree of enclosure does. Moreover, Bengtsson and Grahn (2014) indicated that the presence of an enclosure can separate the exterior from the interior environment, thus creating a safe and private space (undisturbed). Accordingly, even though the pavilion is semi-open, it can still reinforce the user's perception of serenity.

3.4.3 PSD predictors driving restoration and preference

Many studies have confirmed the association between PSD and users' perceived restoration and preference (Chen et al., 2019, Grahn and Stigsdotter, 2010, Peschardt and Stigsdotter, 2013, Stigsdotter et al., 2017). Our results (Table 3-3) indicate that the dimensions of prospect and serene significantly affect preference; for mental restoration, the dimensions of species richness and serene were significant predictors.

According to Appleton (1975), when ancient humans searched for habitable environments, prospect was considered an essential quality. People instinctively choose environments conducive to survival, and one of the most critical elements is the visual control of the environment, which allows them to discern danger. The prospect is usually characterized by flat and well-cut grass surfaces and vistas (Peschardt & Stigsdotter, 2013). Therefore, a good view unobstructed by vegetation (an overview of the surroundings) can boost the user's preference. Conversely, a lower prospect may mean a weakened sense of security and lesser preference among users to sit and rest in this environment (Fig 3-13).

Fig. 3-13. Exterior view of Pavilion 9.

Serene was found to be an important predictive PSD dimension of mental restoration and preference, which is consistent with the findings of a previous study (Peschardt & Stigsdotter, 2013). Usually, participants can experience a sense of security in these resting environments and in private spaces created by dense vegetation. The absence of people seems crucial for this dimension (undisturbed and not crowded). Therefore, the results show that creating a tranquil atmosphere free from external interference is important for a restorative environment (Memari et al., 2017). This observation may raise some concerns because our experiments were conducted in a silent environment. However, Pheasant et al. (2008) established that a sense of tranquility can be created using only static visual stimuli. Serene is considered a cognitive quiet, suggesting a coordination between mental and physical space, and is highly associated with natural features (Pheasant et al., 2008), such as water and greenery that provide relaxation (Bengtsson & Grahn, 2014). In this study, the participants' perception of serenity was a “pure” tranquility, which is different from what is commonly referred to as quiet. For example, viewing images of crowded streets and forests (without sound) may bring a different sense of tranquility (Fig 3-14). In addition, it has been shown that high-decibel natural sounds (birdsong, water flow) are more tranquil than low-decibel artificial noise (Jeon et al., 2021). Thus, the perception of serenity is not measured solely by sound level; visual factors must also be considered. Therefore, understanding the sense of serenity induced by visual stimuli is valuable for the design and management of the physical environment of these restorative spaces.

Fig. 3-14. High serene photo (left) and low serene photo (right).

Finally, species richness is another important predictor of mental restoration. Humans can accurately perceive species richness, and aesthetic appreciation of settings increases with species richness (Lindemann-Matthies et al., 2010). According to the theory of evolution, diversified vegetation usually represents a complex environment and the possible abundance of food in this setting (Zhao et al., 2013b). Thus, having more animals and plants is important for maintaining a restorative environment (Deng et al., 2020). For example, abundant plants (i.e., trees, bush, grass, and hydrophytes) have the effect of spatial isolation and help create a relaxing scene (Du et al., 2021). Multifarious expressions of life (i.e., trees, flowers, fruits, animals, insects) can provide users with more opportunities to interact with natural elements, thus promoting well-being and recovery (Bengtsson & Grahn, 2014) (Fig 3-15).

Fig. 3-15. Exterior view of Pavilion 4.

3.4.4 The generalized preference and restorative environment setting

According to Fig. 3-10, the participants liked to perform gentle leisure and social activities in the resting environments, which include sitting, reading, chatting, taking pictures, and viewing the scenery for recovery and relaxation. These results indicate that providing visitors with such a space could contribute to their preference of environment setting. In addition, Fig. 3-11 shows that lush plants, waterbodies, buildings, natural trails, animals, and meadows are the most preferred elements. These results are consistent with those of Deng et al. (2020), who revealed that people generally prefer environments with biodiversity (dense vegetation, small animals, water bodies, and meadows). This environment is moderately complex and is considered an essential quality of a restorative environment. Therefore, managers and designers should consider adding elements that people prefer in these rest environments to build a generalized restorative environment setting (Fig. 3-16).

The presence of buildings was an interesting issue in this study. Research has shown that humans generally prefer natural scenery, as it promotes the connection between humans, the natural environment, and natural activities (Zhao et al., 2018). However, most participants chose buildings as their preferred element, a result consistent with the findings of Chen et al. (2020b) in Tokyo's Cultural Heritage Gardens. Tourists usually have a tolerant attitude towards high-rise buildings outside these traditional gardens, and more than half of the respondents believe that artificial constructions have a positive impact on the garden landscape. Therefore, arguably, if the balance with nature is maintained, human influences could also be appreciated in these resting environments (Strumse, 1994).

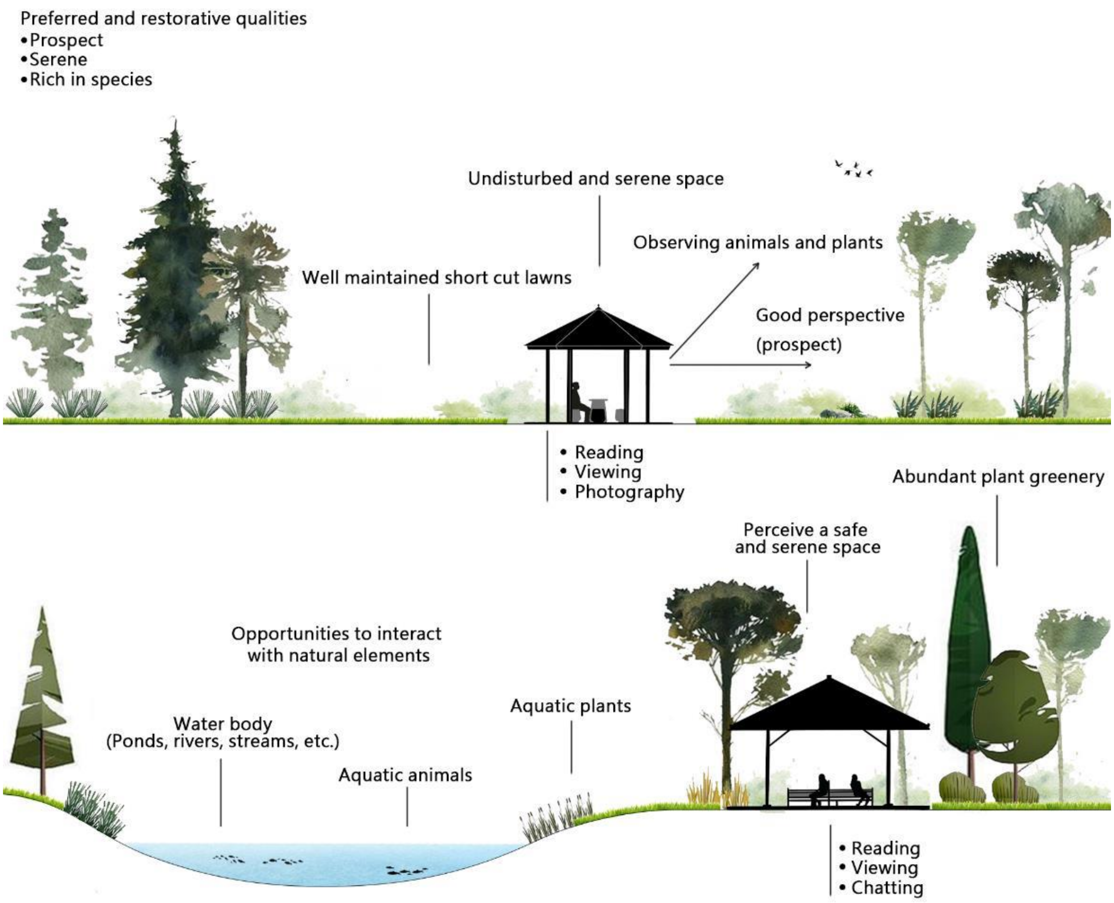


Fig. 3-16. Illustration of a generalized preference and restorative environment setting.

3.4.5 VR experience and implications

In the final interview phase, only one participant reported mild discomfort during the viewing process, which differed from the results of previous studies (Yu et al., 2020). This deviation could be related to the stimulus in this study, which was a static panorama, compared with the video format used in the study (Yu et al., 2020), with varying results. However, our study does not conclude that still pictures can effectively reduce cybersickness. Further research is required to explore this aspect. Moreover, participants reported that using VR to simulate the experience of sitting in a pavilion was "relaxing," "calming," "attractive," and "a novel experience." Consistently, Chang et al. (2008) indicated that restorative experiences require psychological and physical distance from one's usual environment. Thus, "entering the pavilion" can produce separation from the outside world, i.e., physical separation (novelty) and psychological isolation (escape), thereby facilitating restoration (Pals et al., 2009). Accordingly, the results indicated that it is feasible to use VR to simulate pavilion settings and other resting environments in urban parks for relaxation and recovery, and that VR viewing seems to motivate people to visit these outdoor natural environments on-site. Thus, VR simulation could be another way of gaining a natural experience (Yu et al., 2020); however, concerns related to image quality and cybersickness (e.g., dizziness and nausea) must be addressed (Calogiuri et al., 2018).

This study contributes to the body of knowledge in this field, highlighting the need for research pertaining to pavilions and other resting environments in the city, such as chairs in the square/parks, houses of worship (Herzog et al., 2010), watersides (Korpela et al., 2010), and museums (Kaplan et al., 1993). These resting environments in urban landscapes have a positive impact on human well-being and quality of life. According to evidence-based medicine, in the design and management of a healthy urban environment, specific evidence should be considered to provide a scientific basis for particular health effects (Tsunetsugu et al., 2013). Therefore, these results are valuable for supporting the development of healthy urban environments. Finally, restorative VR-based experiences address a growing number of public health challenges. For example, residents are restricted from going out during the COVID-19 pandemic (Xie et al., 2020), office workers look for a short-term respite from the typical office environment (Yin et al., 2018), and there are season-specific hazards (e.g., respiratory diseases and allergic diseases) that are caused by green spaces (Zhang et al., 2021). The use of VR to remotely visit these resting environments may be a practical solution to the challenges that result from these restrictions. Moreover, we can even design virtual restorative environments in the “metaverse” specifically for psychological recovery, which is an interesting and exciting topic.

3.5 Limitation

This study has some limitations which could be consider in the future. First, although several pavilion samples were investigated, it was considered difficult for participants to view all the scenes. In the future, a new round of evaluation is necessary to supplement the findings of this study. Second, research that includes participants of different ages, occupations, and cultural backgrounds could be valuable. Third, some participants reported that vagueness in vista/details in the panoramas might have affected their assessment. Panoramas with a higher resolution can reduce these concerns. The factors that lead to recovery in realistic environments are complex, such as smell (Ikei et al., 2015), sound (Deng et al., 2020), and light (Li et al., 2020). Future research could combine more sensory stimuli to produce more powerful restoratives. Furthermore, it may be interesting to discuss the influence of materials, textures, complexity, and styles of different pavilions on restoration/preferences, combined with architectural viewpoints. Finally, due to the limitations of the survey sample, this study only categorized pavilions as open and semi-open. Taking panoramic pictures of pavilions with many variable conditions requires a significant amount of effort. Therefore, creating pavilions with various shapes, height-to-width ratio, and enclosures (high, medium, low) using 3D modeling techniques can save costs, while maintaining a high level of experimental control.

Chapter 4 A Preferred Road to Mental Restoration in the Chinese Classical Garden

4.1 Methodology

4.1.1 Study Site and Locations

The most emblematic of Chengdu's ancient Chinese private gardens is the Du Fu Thatched Cottage Museum, which is in the heart of the city (Fig 4-1). The eight-hundred-acre park, named for the Tang Dynasty poet Du Fu, is divided into two parts: the Du Fu Thatched Cottage (a major historical and cultural site protected at the national level) and Huanhuaxi Park (an open urban forest park and the only five-star open park in Chengdu, China).

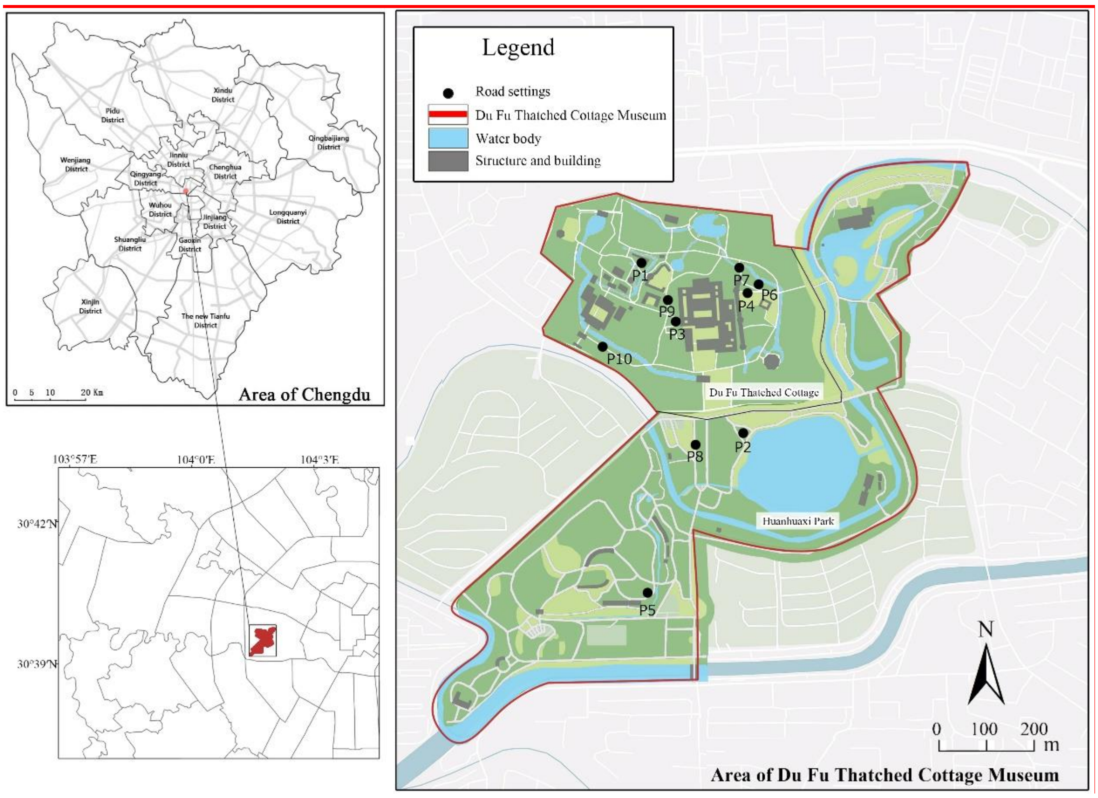


Fig. 4-1. The location of Du Fu Thatched Cottage Museum.

In this study, ten diverse road settings in the Du Fu Thatched Cottage Museum were used as study stimuli (Figure 4-2). The selection principles are as follows: (1) each road has different environmental features and design elements; (2) these roads can cover most of the tour area; and (3) there must be different road types, such as main roads, side roads, and recreational trails; (4) different levels of enclosure; and (5) no grand views in the view. The first road setting (P1) is a winding road going to the central region, with low shrubs contained by a bamboo fence, a few peach and towering trees, clusters of bamboo bushes as spatial dividers, and two thatched buildings to recreate Du Fu's life scene. P2 is a curving gravel walk with large lawns, shrubs, and unevenly spaced trees, a less noticeable sculpture in the middle, and a distant river. P3 has an eye-catching red wall, which is roughly two meters high and flanked by tall trees and bamboo plants, and a building typical of a classical garden stands to the right of the wall. P4 is a straight road with a large lawn, irregularly spaced trees on both sides of the road, and garden stones on the lawn. A promenade (building) with classical Chinese garden features and a large, wooded area can be seen in the distance. P5 is a winding gravel road with some classical garden buildings that display Chinese poetry culture on the left side of the road and a large lawn with dense and scattered trees on the right. P6 is a stone road flanked by large lawns dotted with irregular large trees as well as small trees such as chickpeas; ferns also flourish here. P7 is the main road of the park, with poems by Du Fu displayed on the white wall on the left for people to enjoy, a bonsai placed nearby, and a large lawn on the left, with stones dotted on top of the lawn and irregularly dotted trees. P8 is a winding road through sparse lawns, dominated by tall trees and open lawns, creating a tranquil, open scene. A sparse lawn area mainly includes tall trees and open lawns, creating an artistic conception of the dimensions of serene and prospect. P9 is a straight road that leads people to the attraction (bonsai garden). On both sides of the road are gray walls with bamboo bushes and some tall trees on the outside of the walls, and in the distance is the garden gate, which has a rich variety of bonsai. P10 is a main road, which is wide and flanked by lawns and irregular tall trees, mainly heather, camphor, and so forth. The trees completely cover the road in its shadow, granting visitors the feeling of being in the forest.

Fig. 4-2. The ten selected road settings.

4.1.2 Data Collection

The data for this study were gathered through convenience sampling from visitors to Du Fu Cao Tang. The surveys were gathered on weekends from 23 November to 13 December 2020. Twenty research assistants were pre-trained to comprehend the study's goal and the specifics of the questionnaires (Table 4-1). Thus, two study assistants were assigned to each road to deliver questionnaires to visitors in a random order. The study assistants were expected to stand by while the visitors completed the surveys so that they could answer any questions. The entire survey took roughly 10 to 15 min per visitor. The first part of the questionnaire consisted of four sections, the first being an assessment of landscape elements (multiple choice), including the presence of positive and negative landscape elements that they perceived to be present in the current road settings. The second section is the core part of the questionnaire, with the eight sensory dimensions of green space, each of which is explained with informative text to facilitate the understanding of the eight dimensions. A five-point Likert scale (1 = "not at all", 2 = "a little", 3 = "moderately", 4 = "very much", and 5 = "extremely") was used to assess each respondent's level of perception of each PSD in the area. The third component was to measure mental restoration, where respondents were asked about their perceived restoration in terms of "restorative experiences", "positive emotions", and "stress reduction" (Wan et al., 2020). A five-point Likert scale (1 = "completely disagree", and 5 = "completely agree") was used to assess each item; the mean value of the three components was used as the final restorative score for each road setting. The fourth part is the landscape preference evaluation, where we asked respondents how attractive they found the landscape of the road from 1 (not attractive at all) to 7 (very attractive) and hope to revisit from 1 (do not want to visit again at all) to 7 (very much want to visit again). This was to ascertain respondents' preferences for the ten road settings. The average of the two components was used as the final preference score for each road setting. Information on the socio-demographic characteristics of the visitors was not collected and analyzed, as this was not the purpose of this study.

Table 4-1. Questionnaire of the study.

Section	Item	Statement	Option/Score
Landscape elements	Positive element	Presence of positive landscape elements	Trees, shrubs, lawns, roads, wooden fences, walls, decorations, and buildings
	Negative element	Presence of negative landscape elements	Trees, shrubs, lawns, roads, wooden fences, walls, decorations, and buildings
Sensory dimensions	Social	An environment suitable for social events	Not at all 1–5 Extremely
	Space	I feel spacious and free here.	Not at all 1–5 Extremely
	Nature	I feel wild and natural here.	Not at all 1–5 Extremely
	Refuge	This is a closed and safe place.	Not at all 1–5 Extremely
	Prospect	This is an open area with a broad view.	Not at all 1–5 Extremely
	Serene	I feel quiet and peaceful here.	Not at all 1–5 Extremely
	Culture	It is an artificial environment influenced by history/culture.	Not at all 1–5 Extremely
	Richness in species	There are many species of flora and fauna here.	Not at all 1–5 Extremely
Mental restoration	Restorative experiences	I forget daily worries and feel restored here.	Strongly disagree 1–5 Strongly agree
	Positive emotions	I feel happy and comfortable here.	Strongly disagree 1–5 Strongly agree
	Stress reduction	I feel relaxed and calm here.	Strongly disagree 1–5 Strongly agree
Landscape preference	Attractiveness	How attractive did you find the landscape?	Not at all 1–7 Very attractive
	Revisit	Do you want to visit here again?	Not at all 1–7 Very want

Since each road had different visitor flows, it was difficult to ensure that the same number of questionnaires were collected at all locations. Therefore, during the final two weekends of questionnaire collection, experimental assistants who had already collected a larger number of questionnaires for other roads were reassigned to the remaining experimental locations to assist with questionnaire collection. Finally, the range of questionnaires collected for the 10 roads was 73–79; thus, 73 questionnaires were used as the sample size for the analysis of each road setting.

4.1.3 Data Analysis

The respondents' answers were statistically analyzed using the statistical software SPSS20.0, and the level of significance was set at $p < 0.05$. The relationships between different landscape elements, restorability, and preference were explored using Spearman correlations. Stepwise multiple linear regression was used to explore the drivers of restorability and aesthetic preference for all road settings.

4.2 The study questions

The impact that classical gardens have on the well-being and quality of life of visitors, especially city dwellers, is an important topic. Scholars have previously focused on landscape aspects, such as water bodies, plants, rocks, chairs, pavilions, and public squares, in various green spaces but have overlooked the road settings that visitors walk on. This study investigates the following:

1) Which elements of the road setting can influence the preferences and mental restoration of respondents?

2) How do PSDs behave in classical garden road settings?

3) Which PSDs are associated with mental restoration and preference for road settings?

4.3 Results

4.3.1 Assessment of Road Landscape Elements

Participants were asked to assess two types of landscape elements, namely natural elements (trees, shrubs, lawns) and artificial elements (roads, wooden fences, walls, decorations, and buildings), which were used to understand whether these different garden elements were perceived as positive or negative (Table 4-2). Generally, most of the landscape elements in classical garden path settings were assessed as positive elements, but some visitors still perceived these landscape elements as negative. Specifically, trees were perceived as the most positive (456) landscape element, followed by garden roads (392) and lawns (371), while garden roads (101) and shrubs (92) were perceived as more negative elements of the landscape. These results indicate that trees are the most important landscape element in the path setting of gardens, while shrubs are less popular. Lawns are a positive element but are much less attractive than trees. Roads were both a positive element (392) and the most negative element (101), which illustrates the controversy in respondents' perceptions of different roads. Furthermore, walls, buildings, and fences were perceived as positive by some visitors, while decorations (i.e., infrastructure in the garden, bonsai, and landscape placement stones) were not as popular.

Table 4-2. Participant responses to positive and negative landscape elements.

Elements	Trees	Shrubs	Lawns	Roads	Walls	Buildings	Fences	Decorations
Positive	456	264	371	392	189	263	135	72
Negative	53	92	40	101	70	36	23	60

A correlation analysis was performed to understand the relationship between the different landscape elements in classical garden paths as well as preference and restorability (Table 4-3). For natural elements, lawns, trees, and shrubs significantly influenced restoration. Among the artificial elements, roads and decorations were also able to significantly influence restoration but with a lower impact coefficient compared to the natural elements. In terms of respondents' preference evaluations, all artificial and natural landscape elements demonstrated significant impact. The coefficient magnitudes were as follows: trees > lawn > roads > fence > shrubs > walls > decorations > buildings.

Table 4-3. Correlation analysis results.

	Trees	Shrubs	Lawns	Roads	Walls	Buildings	Fences	Decorations	Restoration
Shrubs	0.118 **	1							
Lawns	0.233 **	0.210 **	1						
Roads	0.023	-0.016	0.087 *	1					
Walls	−0.155 **	−0.165 **	−0.282 **	0.041	1				
Buildings	−0.137 **	−0.048	−0.135 **	0.067	0.240 **	1			
Fences	0.180 **	0.244 **	0.052	0.089 *	−0.048	0.076 *	1		
Decorations	0.038	0.047	0.050	0.031	0.193 **	0.096 **	0.138 **	1	
Restoration	0.302 **	0.234 **	0.0277 **	0.199 **	−0.026	0.008	0.230 **	0.083 *	1
Preference	0.253 **	0.124 **	0.0232 **	0.174 **	0.109 **	0.077 *	0.144 **	0.108 **	0.754 **

Note: n = 730, * $p < 0.05$, ** $p < 0.01$.

4.3.2 Overall PSD Evaluation across the Ten Road Settings

With no invalid responses, all respondents demonstrated a good understanding of the eight PSDs, as shown in Table 4-4. First, P4 (4.26 ± 0.70), P8 (4.38 ± 0.59), and P10 (4.19 ± 0.73) were the strongest road settings for the nature dimension, while P3 (2.97 ± 1.01) and P9 (2.66 ± 1.06) were the weakest. For the culture dimension, P3 (4.56 ± 0.57), P5 (4.15 ± 0.59), P7 (4.21 ± 0.62), and P9 (4.29 ± 0.75) could be perceived along the culture dimension, while in P6 (2.52 ± 1.11), P8 (2.47 ± 1.11) and P10 (2.68 ± 1.20), it was difficult to perceive this dimension. For the prospect dimension, P4 (4.38 ± 0.63) was the most significantly perceived, while P1 (2.52 ± 0.98), P3 (2.48 ± 1.04), P7 (2.99 ± 0.93), P9 (2.19 ± 1.11), and P10 (2.86 ± 1.17) all scored below three, indicating that visitors did not significantly perceive this dimension. For the social dimension, P4 (3.77 ± 0.99) and P5 (3.90 ± 0.89) were significantly perceived, while P1 (2.99 ± 1.27), P3 (2.56 ± 1.30), P9 (2.33 ± 1.22), and P10 (2.70 ± 1.29) were not significantly perceived. For the space dimension, P4 (4.26 ± 0.68) was considered the most perceived spatial dimension, while P3 (2.60 ± 1.13) and P9 (2.29 ± 1.07) had the lowest scores. For species diversity (richness in species), one of P3 (2.60 ± 1.17) and P9 (2.37 ± 1.18) had scores lower than 3, while P6 (4.00 ± 0.83) and P10 (4.21 ± 0.84) had the highest scores. For refuge, all roads were able to better project this dimension, with the exception of P9 (2.85 ± 1.12), which did not exceed 3, with P4 (3.96 ± 0.85) demonstrating visitors' highest perception. In addition, the serene dimension was the most perceived dimension, as all roads exceeded 3; P1 (4.34 ± 0.67) scored the highest, while P5 (3.77 ± 0.87) scored the lowest.

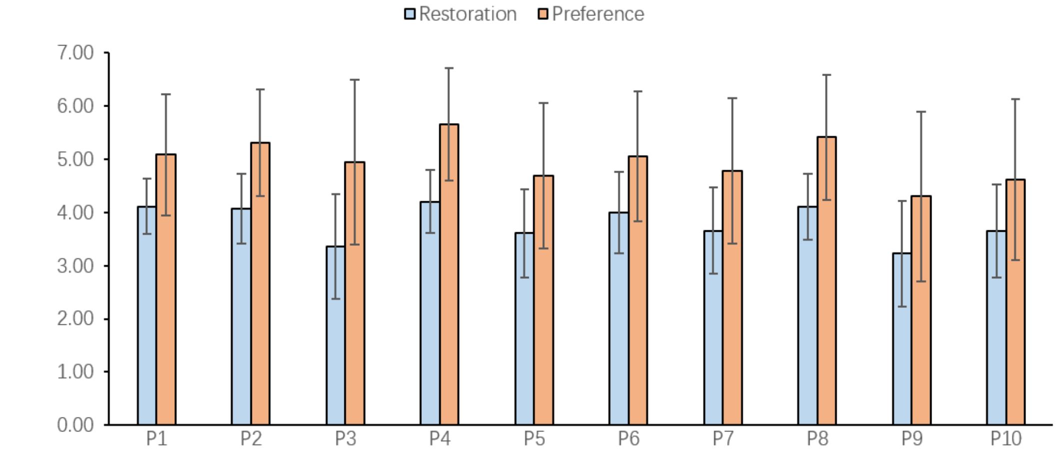
Table 4-4. The PSD evaluation of ten selected road settings.

PSD	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	**Mean**	**SD**	Rank
Nature	3.81	4.05	2.97	4.26	3.42	4.18	3.49	4.38	2.66	4.19	**3.74**	**0.55**	*2*
Culture	3.66	2.89	4.56	3.33	4.15	2.52	4.21	2.47	4.29	2.68	**3.48**	**0.80**	*4*
Prospect	2.52	3.93	2.48	4.38	3.53	3.63	2.99	3.74	2.19	2.86	**3.23**	**0.75**	*7*
Social	2.99	3.34	2.56	3.77	3.90	3.15	3.11	3.10	2.33	2.70	**3.09**	**0.99**	*8*
Space	3.37	3.84	2.60	4.26	3.75	3.74	3.34	3.79	2.29	3.22	**3.42**	**0.85**	*6*
Species	3.70	3.64	2.60	3.88	3.25	4.00	3.29	3.74	2.37	4.21	**3.47**	**0.90**	*5*
Refuge	3.68	3.82	3.16	3.96	3.86	3.59	3.59	3.60	2.85	3.15	**3.53**	**0.95**	*3*
Serene	4.34	4.05	3.88	4.03	3.77	4.23	3.82	4.30	4.03	4.12	**4.06**	**0.95**	*1*

It can be found by the mean value that the PSDs of the road settings that were most easily perceived by respondents in the classical garden were serene (4.06 ± 0.95), followed by nature (3.74 ± 0.55), refuge (3.53 ± 0.95), culture (3.48 ± 0.80), richness in species (3.47 ± 0.90), and space (3.42 ± 0.85), while social (3.09 ± 0.99) followed by prospect (3.23 ± 0.75) had the lowest values (Table 4-4).

4.3.3 Significant PSD Predictors of Preference and Restoration

As shown in Figure 4-3, P4 (4.20 ± 0.59) and P8 (4.11 ± 0.62) had the highest restoration and preference scores, while P9 (3.22 ± 0.99), P3 (3.37 ± 0.99), and P5 (3.612 ± 0.83) demonstrated lower restoration scores. P9 (4.30 ± 1.59), P10 (4.62 ± 1.51), and P5 (4.68 ± 1.36) were least preferred. However, all restoration scores exceeded 3, and all preference scores exceeded 4, indicating that most participants rated this experience restorative and desirable.



	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Restoration	4.11	4.06	3.37	4.20	3.61	4.00	3.66	4.11	3.22	3.65
Preference	5.08	5.30	4.95	5.66	4.68	5.05	4.78	5.41	4.30	4.62

Figure 4-3. The mental restoration and preference score of ten selected road settings; mean ± standard deviation.

Two stepwise multiple linear regression analyses were conducted to explore the effects of PSDs on mental restoration and preference. The dependent variables for both regression models were preference and mental restoration. The results of the correlation analysis (Table 4-5) indicate that recovery increased with preference. The culture dimension was not significantly correlated with the restorative, prospect, space, and serene dimensions, while the remaining seven PSDs had significant positive correlations with both preference and restoration.

Table 4-5. Overall correlation results.

	Restoration	Nature	Culture	Prospect	Social	Space	Species	Refuge	Serene	Preference
Restoration	1									
Nature	0.622 **	1								
Culture	0.063	−0.151 **	1							
Prospect	0.517 **	0.521 **	−0.050	1						
Social	0.422 **	0.330 **	0.176 **	0.560 **	1					
Space	0.590 **	0.557 **	−0.036	0.699 **	0.609 **	1				
Species	0.482 **	0.627 **	−0.165 **	0.428 **	0.329 **	0.530 **	1			
Refuge	0.530 **	0.385 **	0.117 **	0.502 **	0.608 **	0.569 **	0.362 **	1		
Serene	0.481 **	0.365 **	0.050	0.134 **	0.126 **	0.264 **	0.347 **	0.269 **	1	
Preference	0.787 **	0.540 **	0.177 **	0.445 **	0.397 **	0.520 **	0.371 **	0.465 **	0.377 **	1

Table 4-6. Significant PSD predictors of preference and mental restoration.

Dependent	Independent	Unstandardized Coefficient		Standardized	t	Sig.	Collinearity Diagnosis	
		B	SE	Beta			Tolerance	VIF
Aesthetic preference (R = 0.679; Adjusted R2 = 0. 455)	Constant	−0.187	0.24		−0.78	0.436		
	Nature	0.478	0.054	0.347	8.853	0.000	0.486	2.058
	Culture	0.23	0.033	0.206	7.043	0.000	0.872	1.147
	Space	0.231	0.056	0.186	4.119	0.000	0.365	2.741
	Refuge	0.178	0.049	0.136	3.644	0.000	0.537	1.863
	Serene	0.272	0.052	0.161	5.249	0.000	0.791	1.264
Perceived restoration (R = 0.761; Adjusted R2 = 0.574)	Constant	0.214	0.133		1.606	0.109		
	Nature	0.275	0.03	0.318	9.167	0.000	0.486	2.058
	Culture	0.066	0.018	0.094	3.627	0.000	0.872	1.147
	Prospect	0.086	0.026	0.118	3.247	0.001	0.443	2.257
	Space	0.131	0.031	0.168	4.207	0.000	0.365	2.741
	Refuge	0.146	0.027	0.177	5.376	0.000	0.537	1.863
	Serene	0.265	0.029	0.25	9.202	0.000	0.791	1.264

Furthermore, a stepwise multiple linear regression analysis was employed to establish a quantitative association among PSDs, restoration, and preference for road settings. The association among the eight PSDs, preference ($F = 77.03$; $p < 0.001$), and restorability ($F = 123.83$; $p < 0.001$) are shown in the results (Table 4-6). The presence of model tolerances (tolerance < 0.2) or variance inflation factors (VIF > 10) indicate a potential multicollinearity problem (Arriaza et al., 2004), whereas there is no cointegration problem in the current model (the lowest tolerance = 0.365; the highest VIF = 2.741); thus, the results are considered acceptable. According to the model's findings, the dimensions of nature, culture, space, shelter, and serene have a substantial impact on preference evaluation, whereas the dimensions of nature, culture, prospect, space, refuge, and serene have a large impact on the restorability of road settings. Thus, the model's five sensory dimensions of nature, culture, space, refuge, and serene are consistently significant predictors.

4.4 Discussion

4.4.1 The Preferred Landscape Elements of Road Settings

According to the results (Table 4-2), the majority of landscape elements were evaluated as good and positively connected with preference and restoration. Landscape elements were divided into two types in this study: natural and artificial landscape elements. Natural landscape components were divided into three groups: trees in the upper space, shrubs in the middle space, and grass in the lower space. Plants are the most important landscape element in green spaces; numerous previous studies have reported on people's preferences for different types and characteristics of plants in the landscape as well as the effects of different types of plants on people's aesthetic preferences and restoration potential (Kendal et al., 2012). In terms of trees, classical gardens typically have older trees than are found in newly constructed modern parks. In addition, Du Fu Thatched Cottage Museum is renowned as Chengdu's urban forest due to its diverse tree species and enormous area of vegetation. In this context, our findings reveal that people generally regard trees and the woodlands they create as beneficial components, with a strong link between restoration and preference. This result is consistent with previous research: Nordh et al. (2011) discovered that increasing the number of trees improves aesthetic preferences and restoration potential, while Kaplan (1995) found that increasing the number of trees enriches the landscape environment, attracting more animals and creating a new ecological space. Furthermore, when compared to other natural features, respondents tended to place the least value on shrubs, which is consistent with the findings of Nordh et al. (2011). According to Ignatieva et al. (2020), lawns in urban parks are typically considered one of the most essential components of the environment and one of the most commonly used types of urban green infrastructure and recreational locations. One of the primary values of lawns is that they provide space for social activities, such as picnics, resting, sunbathing, dog walking, games, and sports (Ignatieva, 2017). Although lawns are one of the landscape elements that can significantly influence preference and restoration in the results, lawns were not the most popular natural element in this study. One reason for this is that most of the lawns in Du Fu Thatched Cottage Museum are forbidden for visitors, prohibiting such interactive experiences. Second, the towering and lush trees appear to effectively pull people's attention away from the lawns, making them less appealing.

Artificial landscape elements are often viewed negatively (De Vries et al., 2012). However, some studies have found that certain culture-related elements (Deng et al., 2020, Arriaza et al., 2004, Bulut, Z & Yilmaz, 2008, Bulut & Yilmaz, 2008, Tempesta, 2010), such as local traditional houses, historic buildings, historic landscapes, corridors, poetry walls, pavilions, and landscape statues, are considered positive man-made elements because of their traditional architecture and unique cultural qualities and thus have a significant impact on restorative attributes. The architecture of the Du Fu Thatched Cottage Museum was largely rebuilt and built throughout the Ming and Qing periods and are historically and culturally significant. Despite the fact that the walls are primarily new constructions, unlike general walls, they not only have an enclosing function. Simultaneously, the poems of Du Fu on the walls also contribute to the cultural quality of the surroundings. Most respondents stated that culture-related items with historical and cultural significance (such as architecture, landscape decoration, walls, roads, and bamboo fences) have a favorable impact on their preferences. Furthermore, although walkways are commonly thought of as negative artificial aspects in modern parks (Bulut & Yilmaz, 2008), this study discovered that road elements have a considerable positive effect on both preference and restorability. While in classical gardens, the "winding road to somewhere serene" is a typical form of expression, according to Lai et al. (2020), people like small, unguided roads with specific curves because such paths serve to provide a peaceful environment for them to engage in psychological repair, hence appealing to their desire to explore. Moreover, classical gardens include distinct road elements (paving materials, textures, and fences) that are dissimilar to city streets, which may contribute to a sense of being away from home and work as well as allowing people to forget about some of life's pressures and problems, thereby boosting recovery.

In brief, natural landscape elements, on the one hand, are more restorative than man-made landscape elements. However, some man-made landscape components with cultural significance can have a significant and positive impact on people's restorative potential. On the other hand, some culturally significant artificial elements (roads and fences) outweigh natural elements in terms of preference (shrubs). As a result, the findings of this study imply that culturally relevant artificial components can be appreciated by visitors and contribute to the aesthetic appeal of the environment.

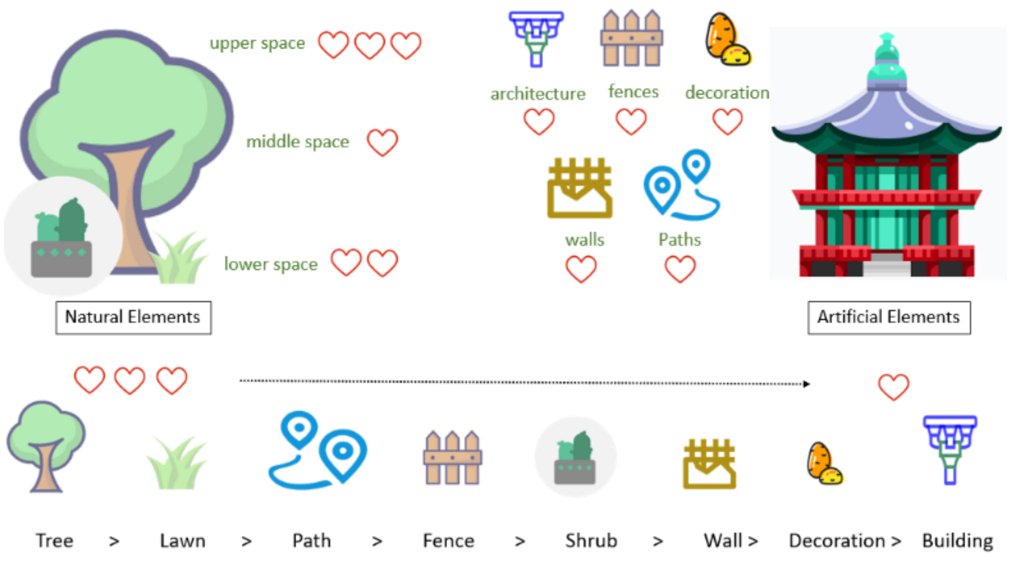


Figure 4-4. The Preferred Landscape Elements of Road Settings.

4.4.2 The Representation of PSDs in Classical Garden Road Settings

Currently, PSDs are being used in a variety of green spaces across various nations and regions, with the goal of (1) determining people's perceptions of different dimensions and (2) determining the relationship between users' perceptions of recovery and preferences (Grahn & Stigsdotter, 2010, Qiu & Nielsen, 2015, Chen et al., 2019, Malekinezhad et al., 2020). In this study, we focus on people's experiences of classical garden road settings and examine them through the identification of the eight PSDs.

Our results (Table 4-4) indicate that serene is the most generally perceived dimension in classical garden road settings, which is consistent with the results of Grahn and Stigsdotter (2010), who found that serene is one of the commonly perceived dimensions. The second dimension is nature. Gray spaces such as buildings and streets are busy areas, limiting the amount of space available for people's activities to be managed and allocated to specified areas; however, in the road settings of green spaces, people's inherent cognition of green spaces is that they may more freely undertake all types of green activities, such as running, strolling, sitting, lying down, and so on. This natural experience boosts pleasant emotions and meets people's non-material and non-consumption requirements (Chiesura, 2004). The third dimension is that of refuge, which shows that classical gardens' enclosed and safe environmental attributes have been manifested (Grahn & Stigsdotter, 2010, Chen et al., 2019). Grahn and Stigsdotter (2010) support the idea that the dimensions of refuge, nature, and calm are the most desired dimensions for highly stressed people. Fourth, culture is a perceptible component that is inconsistent with other forms of green space results (Grahn & Stigsdotter, 2010, Chen et al., 2019, Memari et al., 2021) and can be linked to the presence of cultural heritage in the classical garden. Moreover, the dimensions of richness of species and space are less noticeable. The experiment was conducted in the winter, making it almost impossible to detect wildlife (birds, butterflies, squirrels, etc.) and difficult to find colorful plants, resulting in a lower perceived species richness. Chen argues that in China, green space users only experience species richness in urban forests, which are often located far from cities, rather than in natural and semi-natural green spaces in overcrowded cities (Chen et al., 2016). This is most likely due to the high population and scarcity of natural and semi-natural green spaces in the metropolitan environmental settings of China. According to Grahn and Stigsdotter (2010), too many roads and paths would disrupt the spatial dimension because the roads themselves are meant to connect public spaces with various attractions; thus, the space dimension is an uncommon perceived dimension in road settings. Finally, prospect and social are among the most uncommon dimensions in road settings. This could be due to the lack of defined areas for social activities and the presence of enclosures (e.g., dense vegetation and walls) that limit the view.

4.4.3 PSD Predictors Driving Restoration and Preference

The results (Table 4-6) show that in a classical garden's road setting, nature, culture, space, refuge, and serene are significant factors affecting preference; for mental restoration, the dimensions of nature, culture, space, refuge, serene, and prospect are significant predictors. In total, nature, culture, space, refuge, and serene were found to be important predictive dimensions of mental restoration and preference.

First, the nature dimension was found to be a strong predictor of restoration and preference, as in prior research. Stigsdotter et al. (2020) discovered that a city park with a strong presence of nature could be preferred. According to Kaplan (1990), nature is the best environment for involuntary attention and resting-directed attention, which means that the dimension of nature has a significant impact on restoring directed attention for urban individuals. Moreover, Pálsdóttir et al. (2014) suggested that nature's restorative effect is rich in many aspects not only because it can have a positive impact on recovery but also because experiences in nature can inspire people to discover new and natural things. Since they were established long ago and are protected, classical gardens, as a type of cultural heritage in the city, have more lush, historical trees or woods than the urban environment, making it easier for people to experience the natural dimension. As a result, the nature dimension in the road settings of classical gardens is an important characteristic that influences restorability and preference.

Cultural heritage has been demonstrated to be highly restorative (Packer & Bond, 2010). In the Western context, the experience of manmade components shaped by humans, such as fountains, statues, and canals, is referred to as culture-related elements (Stigsdotter et al., 2020). However, in the Chinese cultural context, culture is more likely to be portrayed through the artistic conception of honoring ancient people or historical figures in addition to figurative items, such as sculptures and cultural walls. Chinese classical gardens can promote place attachment and identification for respondents as a physical symbol of Chinese culture, leading to increased restorative and aesthetic preferences (Menatti et al., 2019). Culture, as an important factor in aesthetic pleasure, is more likely to be perceived in road settings and increase restorative experiences, which is in accordance with the current findings. As a result, improving visitors' perceptions of cultural dimensions to boost their restorative levels is a key proposition for future urban green spaces.

Grahn and Stigsdotter (2010) found that the dimension of serene is the most popular among visitors. According to den Bosch et al. (2015), serene can greatly reduce the risk of mental illness. People feel comfortable and calm in a tranquil atmosphere where they are not bothered by other people or traffic, that is, away from the city's noise and crowds (Mathey & Rink, 2020). The serene dimension, however, does not imply that there is perfect quiet (Grahn & van den Bosch, 2014); some natural sounds, such as the wind, water, birdsong, and insects, can still be heard. As with culture, the restorative intensity of serene is dependent on the quality of the surroundings, which means keeping them well-maintained and clean, devoid of weeds, litter, and graffiti, which improves restoration (Memari et al., 2021). Thus, in terms of serene, the preservation of environmental quality and the restriction of pedestrian movement are two key variables that influence the preference and restorative quality of road settings in classical gardens.

Space is an important predictive PSD of mental restoration and preference. Space is described as a wide-open area with a degree of connection. Qiu and Nielsen (2015) discovered that space is easy to perceive in green spaces. People are free to move and play in green spaces that are spacious enough because they live in crowded urban environments (gray spaces) for lengthy periods of time. According to Kaplan and Kaplan (1989), the desire for space and restoration stems from a natural human desire to migrate away from heavily populated regions in pursuit of a naturally coherent environment that allows people to feel as if they are stepping into another world. Around the road settings in classical gardens, there are many forests or enclosing walls, and these elements add to the sensation of the enclosure of the landscape, making visitors feel psychologically secluded from the outside world. As a result, the spatial dimension can provide a high level of restoration and preference.

Consistent with previous studies (Grahn & Stigsdotter, 2010, Memari et al., 2021), the dimension of refuge has one of the strongest and most significant positive connections with stress. People can self-regulate by spending time alone, resting, and meditating in a sheltered environment to reflect on their current situation and understand their real emotions (Lückmann et al., 2013). Meanwhile, refuge could influence people's preferences. This is because the ability to seek refuge is critical for human survival, and the adaptive function of a preference for specific landscape elements improves people's mood (Appleton, 1996). This implies that the road settings in classical gardens are environmental attributes associated with security and enclosure and that they may provide people with restorative and preferable experiences.

Finally, prospect is another important predictive dimension of mental restoration. According to Appleton (1975), when ancient humans searched for habitable environments, prospect was considered an essential quality. One of the most important aspects of visual control of the environment, which allows us to perceive danger, is that people intuitively choose an environment that is conducive to survival (Luo et al., 2022). Even though plants and walls help to create a sense of enclosure in these settings, visitors standing on the roads can plainly see both ends of the walk, giving them a greater sense of control over their surroundings. Therefore, proper views in the road settings are essential, as they can help the visitor have a more restorative experience by boosting their understanding of environmental information.

4.5 Limitation

Firstly, this experiment only selected ten different types of roads in a classical garden for study, but there are some other road types in other Chinese classical gardens that are not covered in this study. Therefore, more road settings could be selected in future studies. Secondly, this study did not collect demographic characteristics. Future research that includes participants of different ages, occupations, and cultural backgrounds could be more valuable. Lastly, the study was only conducted in November and December when it was almost winter. This season may cause some bias in the perception of species diversity (such as animal activity, plant coloration), and other seasons could be further consideration to increase reliability of the results.

Chapter 5 Assessing the Preference and Restorative Potential of Urban Park Blue Space

5.1 Methodology

5.1.1 Study Stimuli

This research used photographic images instead of real landscapes. Despite the presence of disadvantages, this method has been widely used by previous researchers and is generally accepted as highly reliable and cost-effective (Wang et al., 2019a). Furthermore, according to Karmanov and Hamel (2008), a site visit is believed not to change their perception of the recovery potential and environmental attractiveness. Thus, photographs were used as visual stimuli for estimating aesthetic preference, restorative potential, and perceived naturalness. The images used in this study were taken from Huanhuaxi Park (Figure 5-1), which is the only five-star urban natural park in Chengdu, China (Deng et al., 2020). We chose this park for the following reasons:

(a) It is an open park for investigation and photography,

(b) it is the largest in the region with many types of water bodies,

and (c) visitors are allowed only to walk; hence, no bikes or cars are visible.

The authors freely photographed the park, capturing all the blue spaces that visitors can approach. In addition, to ensure reliability in the perception and measurement process, we chose similar weather and light conditions for photography. To ensure seasonal consistency, all photos were taken in July 2020. A total of 98 photos were taken, and a screening procedure was executed to avoid excessive evaluation by the subjects. The exclusion criteria were unclear photos, unrecognized water bodies, too many visible visitors in an image, and repeated blue space types. Finally, we screened 10 unique images that can represent different UPBS types. Each image has its own water body type, spatial characteristics, and major focal views. Detailed information about the 10 images studied is shown in Table 5-1.

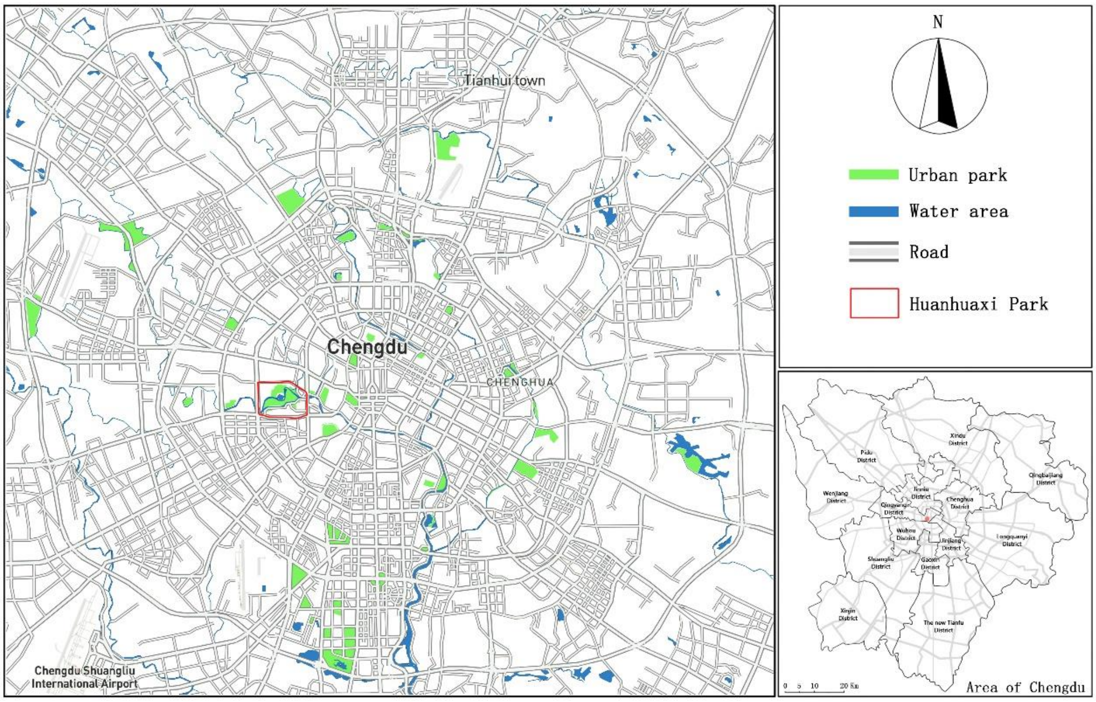


Figure 5-1. The location of Huanhuaxi Park.

Table 5-1. Description of the ten urban park blue spaces.

No.	Image	Description
1		A natural creek in the forest uses an artificial revetment built of stones. A little bonsai is located randomly on the riverside. A pavilion can be seen in the distance.
2		A small channel in a semi-open space with a nature trail and a traditional Chinese building located on the right side. On the left is a natural forest, surrounded by many bamboos, trees, and shrubs.

3		A public leisure space with a small pond, surrounded by many trees and shrubs. Tourists can rest and watch carp here. Lotus flowers are planted in the center of the pond, and a traditional Chinese-style veranda is on the right side of the image.
4		A small pond in the green space, surrounded by bamboo and a large lawn, forming a highly natural environment. This is a blue space commonly seen in this park and is one of the sunniest areas.
5		A large pond in a semi-open space, surrounded by many bamboos. Some traditional Sichuan residential buildings (thatched huts) can be seen. Tourists can tour around this pond and enjoy the waterscape.
6		A river in Huanhuaxi Park. There are some trees on the banks of the river and some well-kept shrubs and lawns. Visitors can cross the river from a stone bridge deep in the picture.
7		A natural river with both sides surrounded by dense forests, forming a highly natural blue space. Tourists can visit, walk, or enjoy the landscape along the boardwalk along the river bank.
8		A small river in front of traditional Chinese architectures, surrounded by trees and bamboos to form a semi-open space. There are many rockeries and some bonsais along the riverbank and a stone arch bridge in the middle of the river.
9		A small pond next to a leisure pavilion, surrounded by artificial stone scenery, well-maintained shrubs, and little trees. Visitors can walk around the pond and rest in this semi-enclosed blue space.
10		A small blue space for rest, and a pavilion and corridor are above the pond. Many artificial rockeries and bonsais form this highly artificial environment. Many tourists enjoy the landscape and take photos here.

5.1.2 Study subjects

The use of university student subjects to represent a public sample is valid according to previous research (Deng et al., 2020, Wang & Zhao, 2017). In total, 93 volunteers were recruited for our study. Participants were recruited from a local university campus through social media following the criteria (a) normal eyesight and (b) without the influence of any medication. Participants were from different disciplines, and this study divided them into two groups for comparison (major in landscape architecture and others). Similar research findings indicate that familiarity does not significantly affect preference and restorativeness (Carrus et al., 2013). Therefore, recruiting participants locally is considered appropriate. There was no examination of the human body or physiological data in this study, and all participants were kept anonymous.

5.1.3 Measurements and Procedure

In this study, we mainly investigated the restorative potential, aesthetic preference, and perceived naturalness of different UPBSs through subjective perception.

First, to help participants better understand and follow the Chinese language's expression habits, aesthetic preference was defined as "the landscape is beautiful" in our survey (Wang et al., 2019a). This item was rated on a seven-point scale (1 = "totally disagree", 7 = "totally agree"). Restorative potential was measured as the extent to which subjects agreed that the UPBSs had "the potential to ease mental fatigue caused by directed attention" (Kaplan, 1995). Based on other similar studies (Deng et al., 2020, Abdulkarim & Nasar, 2014), this study used a short version of the Perceived Restorativeness Scale (PRS), adapted from the full version of the PRS (Hartig et al., 1996). Unlike the full-length version of the PRS, the short version PRS has five items that measures "extent" by "scope" and "coherence". Each item was rated on a seven-point scale (1 = "totally disagree", 7 = "totally agree"). The overall restorative potential score is the combined average score of these five items. For perceived naturalness, a single item that was used to measure ("this place is natural", Carrus et al., 2013) rated on a seven-point scale (1 = "totally disagree", 7 = "totally agree"). A description of each problem is shown in Table 5-2.

The evaluation part of the study was conducted in October 2020. Our study's questionnaire was completed in a quiet laboratory to ensure that the subjects were not disturbed. Each subject was provided with detailed information in advance, and we obtained the oral consent of each participant. In addition, participants were told that they were free to stop and leave the experiment at any time.

This experiment was only conducted on weekends to avoid conflict with students' regular class period. Ninety-three subjects were divided into nine groups (10 or 11 participants in each group) and entered the laboratory in turn. After entering, the volunteers were arranged to sit in front of different computers to view slides (i.e., images) prepared before, with 1 min for each slide. The participants were asked to imagine that they were in each projected scene and fill in the questionnaire; they were informed that they were free to change their choices before submission. Only after all the participants of one group completed the questionnaire and left could the next group of participants enter. Finally, participants were required to report their age, gender, major, and living environment during childhood.

Table 5-2. Restoration, aesthetic preference, and perceived naturalness scale for the UPBS.

Measurement		Description	Scale						
Restoration	Fascination	That place is fascinating.	1	2	3	4	5	6	7
	Compatibility	I can enjoy myself in this setting and do anything I like.	1	2	3	4	5	6	7
	Being away	This is a place away from daily routine and stress.	1	2	3	4	5	6	7
	Scope	There are few hard boundaries here to limit me.	1	2	3	4	5	6	7
	Coherence	Everything here seems to have a proper place.	1	2	3	4	5	6	7
Aesthetic preference		The landscape is beautiful.	1	2	3	4	5	6	7
Perceived naturalness		This place is natural.	1	2	3	4	5	6	7

5.1.4 UPBS Landscape Characteristics Evaluation

The measurement scale of UPBS landscape features refers to the previous literature and represents the main 13 landscape characteristics of UPBS studied (Arriaza et al., 2004, Wang & Zhao, 2019, Du et al., 2016) (Table 5-3). Ten landscape architects (five doctoral students and five postgraduates majoring in landscape architecture) were invited to evaluate the landscape characteristics of each UPBS. In the office, after viewing the UPBS pictures projected on the white wall, five landscape architects evaluated the landscape properties of each image according to the scale of Table 5-3. The next image was not presented until everyone had completed the landscape characteristic survey for the current image, and the entire evaluation process took about 20 min.

Table 5-3. The scale of landscape characteristics to measure.

Landscape Characteristics	Scores
Landscape elements	Single = 0; two = 1; three = 2; four = 3
Color contrast	Strong = 0; clear = 1; weak = 2
Percentage of vegetation covered	No vegetation = 0; <25% = 1; 25–50% = 2; >50% = 3
Land vegetation types	None = 0; only grasses = 1; only tree and grass = 2; mixed type = 3
Perceived vegetation diversity	Single vegetation = 0; low = 1; moderate = 2; high = 3
Vegetation maintenance	Bad = 0; moderate = 1; good = 2
Percentage of water	<15% = 0; 15–50% = 1; >50% = 2
Visual naturalness of water	Orderly form = 0; semi-natural form = 1; natural form = 2
Accessibility of water	Difficult to access = 0; neutral = 1; easy to access = 2
Water quality	Bad = 0; moderate = 1; good = 2
Number of aquatic plants	No aquatic plants = 0; low = 1; moderate = 2; high = 3
Man-made elements	None = 0; few = 1; some = 2; many = 3
Water movement	No movement = 0; movement = 1

Note: Based on the research of Zhao et al. (2013b), landscape elements are divided into buildings, topographical variation, water bodies, and plants.

5.1.5 Statistical Analyses

Nonparametric tests (Mann–Whitney U test and the Kruskal–Wallis H test) were performed to assess the differences between demographic characteristics and restoration, aesthetic preference, and perceived naturalness. The stepwise multiple linear regression analysis method was used to explore the driving factors of UPBS restoration potential and aesthetic preference. The correlation analysis method (Spearman) was used to study the relationship between restoration potential and preference.

All statistical analyses were performed using SPSS 20.0 (SPSS Inc., Chicago, IL, USA), and the level of significance was set to <0.05.

5.2 The study questions

Different landscape characteristics have been proven to enhance aesthetic preference or mental restoration (Deng et al., 2020, Wang et al., 2019a, Parry-Jones, 1990). Similarly, landscape characteristics of blue spaces have significant influences on aesthetic preference and restorative potential. Arriaza et al. (2004) found that “amount of water” and “water movement” have a significant positive correlation with the landscape’s visual quality. Zhao et al. (2013a) found that “river accessibility” and “number of colors” are reliably positive predictors of aesthetic preferences of urban rivers, while “coverage of riparian vegetation”, “perspective”, and “wood diversity index” for rural rivers. A natural environment with water features and wavy terrain where plants grow well will comfort male eyes (Wang & Zhao, 2017). Moreover, it has been discovered that highly accessible water features and flat terrain can effectively improve the quality of landscape restoration (Zhao et al., 2018). Exploration of these characteristics provides explicit keystones for the design and management of the blue space. However, it is still not well understood what kind of blue space people like when visiting an urban park, the restorative potential of different blue spaces, and how to design and improve these blue spaces. Understanding these can more effectively create a restorative environment with a high aesthetic value.

As far as health research is concerned, the current blue spaces mainly focus on the marine environment or a giant water body scale at the urban or regional level (i.e., canals, coast, lakes, see Thomas, 2015, Karmanov & Hamel, 2008). However, freshwater blue spaces (e.g., rivers, creeks, ponds, see McDougall et al., 2020) are relatively neglected. Simultaneously, as public spaces that promote restoration, urban parks have always been regarded as restorative places to improve citizens’ health and wellbeing, while there is a lack of research on urban parks' blue spaces (UPBSs, mainly freshwater blue spaces). Thus, clarifying the health-promoting potential of these blue spaces is valuable.

Overall, our research questions are as follows:

1. How is the restorativeness of UPBS evaluated?
2. Is the restorativeness associated with the aesthetic preference of UPBS?
3. What are the driving factors for restorative potential and aesthetic preference of UPBS?

Moreover, Carrus et al. (2013) found that the more participants that rated a scene as natural, the higher their perceived restorativeness and preference scores. Therefore, this leads us to another question:

4. Do the restorative potential and preferences of UPBS change with its naturalness?

5.3 Results

5.3.1 Demographic Characteristics of Respondents

Table 5-4 shows the demographic characteristics of the respondents. To summarize, the female participants were slightly higher in number than males (43 men and 50 women), and the ages were mainly distributed between 23 and 26 years (24.73 ± 4.09), which accounted for more than half of the total number of participants. Regarding education level, postgraduate students had a higher chance of participating, and the number of participants belonging to the landscape architecture major (59%) was like that of other majors. More than 60% lived in an urban environment during their childhood.

Table 5-4. Profile of participant attributes.

Item	Subgroup	n	%
Sex	Male	43	46.2
	Female	50	53.8
Age	22	9	9.6
	23	15	16.1
	24	19	20.4
	25	15	16.1
	26	13	14.0
	27	5	5.4
	28	5	5.4
	29	4	4.3
	30	8	8.6
Education	Graduate	36	38.7
	Postgraduate	57	61.3
Major	Landscape Architecture	50	53.8
	Others	43	46.2
Living environment	Rural area	36	38.7
	Urban area	57	61.3

5.3.2 Demographic Characteristics' Differences among Overall Assessment

The difference between demographic characteristics, restoration, aesthetic preference, and perceived naturalness was investigated using the Mann–Whitney U test (two groups)/Kruskal–Wallis H test (more than two groups). As shown in Table 5-5, none of the three items found significant differences in the evaluation of all subgroups, which indicates that demographic characteristics does not affect the subjects' perception of UPBS on aesthetic preference, restoration potential, and naturalness. Therefore, in the following, the assessment results of all participants were combined for further analysis.

Table 5-5. Demographic characteristics, aesthetic preference, restoration potential, and perceived naturalness.

Demographic (n = 93)		Restorativeness (SD)	p	Preference (SD)	p	Naturalness (SD)	p
Gender	Male	4.85 (0.55)	0.068	5.21 (0.86)	0.166	5.01 (0.91)	0.150
	Female	4.66 (0.50)		5.02 (0.75)		4.71 (0.85)	
Age	22	5.02 (0.55)	0.404	5.44 (0.96)	0.608	5.33 (1.09)	0.775
	23	4.76 (0.66)		5.12 (1.04)		4.83 (1.07)	
	24	4.68 (0.42)		5.02 (0.58)		4.76 (0.65)	
	25	4.66 (0.45)		4.91 (0.64)		4.82 (0.84)	
	26	4.68 (0.50)		5.05 (0.83)		4.82 (0.83)	
	27	4.80 (0.69)		5.24 (1.00)		4.52 (1.47)	
	28	4.30 (0.48)		4.62 (0.94)		4.50 (0.92)	
	29	5.03 (0.77)		5.35 (0.88)		4.90 (0.96)	
	30	4.98 (0.44)		5.43 (0.63)		5.07 (0.62)	
Education	Graduate	4.81 (0.50)	0.534	5.21 (0.72)	0.277	4.92 (0.81)	0.491
	Postgraduate	4.71 (0.56)		5.04 (0.86)		4.81 (0.94)	
Major	Landscape Architecture	4.83 (0.54)	0.101	5.25 (0.83)	0.051	4.96 (0.92)	0.154
	Others	4.66 (0.52)		4.94 (0.75)		4.73 (0.84)	
Living environment	Rural area	4.70 (0.57)	0.322	5.09 (0.88)	0.984	4.89 (0.86)	0.696
	Urban area	4.78 (0.51)		5.12 (0.76)		4.83 (0.91)	

Mean (SD) for each subgroup in this item; p-value for the difference results for each demographic characteristic item. The significance level of 5% was based on the Mann-Whitney U test (two groups) or Kruskal-Wallis H test (more than two groups).

5.3.3 Reliability of the scales and Overall Evaluation

According to Landis and Koch (1977), the assessment is considered excellent internal consistency if Cronbach's alpha is greater than 0.8. Our study results of the Cronbach's Alpha calculated were 0.834 (being away), 0.848 (fascination), 0.828 (scope), 0.827 (coherence), 0.833 (compatibility), 0.846 (aesthetic preference), 0.853 (perceived naturalness). Thus, the results indicated very good internal reliabilities of these items.

According to the summary statistics (as shown in Figure 5-2), image 5 was rated as the most preferred (5.67 ± 1.33) blue space and had the highest restoration score (5.10 ± 0.71), while image 2 was the least preferred (4.25 ± 1.28) and considered the lowest restorative scene (4.20 ± 0.84). However, image 7 was considered the most natural blue space (5.77 ± 1.01), and image 3 had the lowest naturalness score (4.06 ± 1.41). In short, blue spaces that are considered more natural (such as images 1, 4, 5, 7, and 9) usually obtain higher restorative and landscape quality scores. Furthermore, according to the correlation analysis results (Spearman), there is a significant positive correlation between aesthetic preference and restorative potential ($R = 0.832$, $p < 0.01$), which means that when participants evaluate UPBS, their aesthetic preference increases as the blue space restorativeness increases, and vice versa. In addition, the restorative potential of UPBS ($R = 0.637$, $p < 0.01$) and preference scores ($R = 0.628$, $p < 0.01$) also showed a significant positive correlation with perceived naturalness. This means that the restorative potential and preferences of UPBS change with its naturalness (Table 5-6).

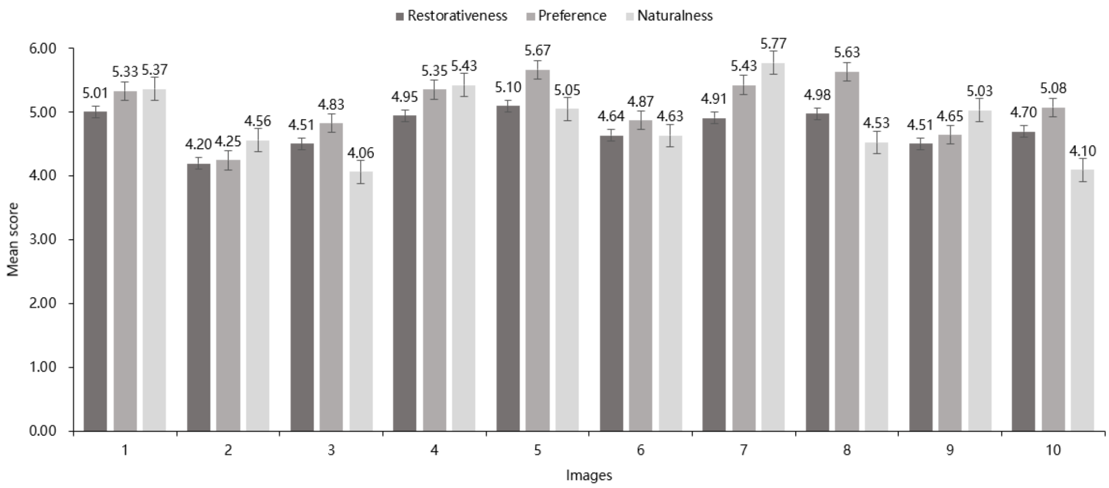


Figure 5-2. The aesthetic preference, restoration potential, and perceived naturalness of 10 images (n = 93); Mean ± error.

Table 5-6. Correlation analysis results.

	Restorativeness	Naturalness	Preference
Restorativeness	1		
Naturalness	0.637 *	1	
Preference	0.832 *	0.628 *	1

Note: * $p < 0.01$.

5.3.4 Significant Predictors of Aesthetic Preference and Restorative Potential

A stepwise multiple linear regression analysis was performed to establish quantitative relationships between UPBS landscape characteristics and restorative potential and preferences. We tested the normality of model residuals through the Kolmogorov–Smirnov (K-S) test. The test result indicated that the residuals followed a normal distribution (K-S Z value = 1.608, $p = 0.204$ for aesthetic preference; K-S Z value = 0.787, $p = 0.565$ for perceived naturalness; K-S Z value = 0.763, $p = 0.605$ for overall restorative potential; K-S Z value = 0.839, $p = 0.482$ for being away; K-S Z value = 0.72, $p = 0.677$ for fascination; K-S Z value = 0.706, $p = 0.702$ for scope; K-S Z value = 0.855, $p = 0.458$ for coherence; K-S Z value = 0.695, $p = 0.719$ for compatibility). Moreover, the variance analysis results in the regression analysis showed a significant relationship between the UPBS landscape characteristics with preference ($F = 21.233$, $p < 0.01$), restorative potential ($F = 24.873$, $p < 0.01$), and with five subscales of the short version of PRS (being away, $F = 19.051$, $p < 0.01$; fascination, $F = 29.96$, $p < 0.01$; scope, $F = 19.521$, $p < 0.01$; coherence, $F = 14.473$, $p < 0.01$; compatibility, $F = 18.008$, $p < 0.01$). In previous studies (Deng et al., 2020, Arriaza et al., 2004, Wang & Zhao, 2019), if the model tolerance value was <0.2 or VIF > 10, it indicated that there was a multicollinearity problem. The current model did not find the problem of multicollinearity (the lowest tolerance = 0.410 and the highest VIF = 2.437) and was considered acceptable.

In summary, as shown in Table 5-5, “water quality”, “visual naturalness of water”, “landscape elements”, and “accessibility of water” are significant predictors of overall restoration potential in UPBS, explaining 48.9% of the variance. This result indicated that visual naturalness of water, water quality, number of landscape elements might positively affect the psychological restorative effect, while the accessibility of water is negative. Likewise, “water quality”, “visual naturalness of water”, “accessibility of water”, “man-made elements”, and “vegetation diversity” are positive predictors of preference in UPBS, explaining 48.7% of the variance, which showed a similar result to overall restoration potential. For the five subscales of PRS, “water quality”, “visual naturalness of water”, and “landscape elements” are significant predictors of “being away”, “fascination”, and “compatibility”. The “water quality” and “vegetation type” are significant predictors of “scope”. Two predictors of “coherence” included “visual naturalness of water” and “plant maintenance degree”.

Table 5-5. Significant predictors of UPBS aesthetic preference and restorative potential.

Dependent	**Independent**	**Unstandardized Beta**	**Standardized Beta**	**t**	**Sig.**	**Collinearity Statistics Tolerance**	**VIF**
Overall restoration potential (adjusted R2 = 0.489)	(constant)	0.313		0.857	0.392		
	water quality	0.717	0.215	5.848	0.000	0.720	1.388
	visual naturalness of water	0.533	0.186	5.331	0.000	0.801	1.248
	landscape elements	0.474	0.187	5.626	0.000	0.887	1.127
	accessibility of water	−0.167	−0.097	−2.784	0.000	0.796	1.256
Aesthetic preference (adjusted R2 = 0.487)	(constant)	−2.590		−2.743	0.006		
	water quality	1.439	0.268	6.469	0.000	0.564	1.774
	visual naturalness of water	0.780	0.169	4.803	0.000	0.567	1.764
	accessibility of water	−0.314	−0.114	−3.225	0.001	0.781	1.280
	man-made elements	0.665	0.303	6.569	0.000	0.456	2.191
	vegetation diversity	0.901	0.185	3.798	0.000	0.410	2.437
Being away (adjusted R2 = 0.104)	(constant)	0.445		1.092	0.275		
	water quality	0.568	0.154	4.615	0.000	0.892	1.122
	visual naturalness of water	0.621	0.196	5.564	0.000	0.802	1.247
	landscape elements	0.429	0.153	4.563	0.000	0.888	1.126
Fascination (adjusted R2 = 0.107)	(constant)	−0.153		−0.364	0.716		
	water quality	0.627	0.165	4.966	0.000	0.892	1.122
	visual naturalness of water	0.524	0.160	4.569	0.000	0.802	1.247
	landscape elements	0.653	0.225	6.765	0.000	0.888	1.126
Scope (adjusted R2 = 0.074)	(constant)	0.250		0.500	0.617		
	water quality	0.825	0.215	6.624	0.000	0.966	1.035
	land vegetation type	0.595	0.142	4.376	0.000	0.966	1.035
Coherence (adjusted R2 = 0.080)	(constant)	1.564		4.816	0.000		
	visual naturalness of water	0.803	0.241	6.967	0.000	0.859	1.165
	plant maintenance degree	0.293	0.133	3.863	0.000	0.859	1.165
Compatibility (adjusted R2 = 0.058)	(constant)	0.330		0.724	0.469		
	water quality	0.635	0.156	4.625	0.000	0.892	1.122
	visual naturalness of water	0.328	0.094	2.636	0.009	0.802	1.247
	landscape elements	0.525	0.170	5.003	0.000	0.888	1.126

5.4 Discussion

5.4.1 Findings of Demographic Characteristics

Humans are the subject of observing the environment; therefore, understanding how different individuals perceive and evaluate is essential for designers of blue space. According to Sevenant and Antrop (2010), observer characteristics (e.g., childhood dwelling place, personal income, age class, gender) are factors affecting positive perception. A recent study also indicated that the subjects' majors would significantly affect the restorative potential and aesthetic preference. This difference may come from different educational backgrounds (Deng et al., 2020). However, this study's results did not support this view because all three assessments (aesthetic preference, restoration potential, and perceived naturalness) found no significant differences in any sociodemographic characteristics. Although the samples of different subgroups are inconsistent, the results of this research are still meaningful. First, the previously studied target areas usually chose green spaces (Van den Berg et al., 2003, Deng et al., 2020, Wang et al., 2019a) and urban environments (Sevenant & Antrop, 2010). The selected scene for the research was only the blue spaces in the urban park, and the research results expand the knowledge in this field. Simultaneously, it can be assumed that the crowd's evaluation is different when perceiving blue space and green space or other environments.

Therefore, in future research and practice, we need to treat these different spaces differently. Furthermore, conflicting results can stimulate more related research since the existing evidence for the effect of demographic characteristics is far from conclusive.

5.4.2 Driving Factors for Aesthetic Preference of Urban Park Blue Space

According to previous studies, aesthetic preference is usually related to the number of trees (Wang et al., 2019a), human activities (Deng et al., 2020), environmental value orientations (Kaltenborn & Bjerke, 2002), number of colors (Wang & Zhao, 2017), and safety level (Lis et al., 2019). However, most of the driving factors related to the aesthetic preference of UPBS in this study are related to the characteristics of water bodies, such as water quality, visual naturalness of water, and accessibility of water. This is reasonable and meets the study's purpose. First, Yamashita (2002) emphasized the importance of water quality in water landscape design, and adults and children prefer clear rivers without garbage, dead grass, or other litter. Simultaneously, poor water quality makes observers think of bad smells and reduces UPBS attractiveness. The visual naturalness of water is also an important indicator of scene preference. The more natural the form of water, the higher the preference for blue space. This is similar to the conclusion of Zhao et al. (2018) that humans generally prefer natural scenes for evolutionary reasons because these scenes can promote human associations with the natural environment and natural activities. Unexpectedly, accessibility of water was negatively correlated with UPBS's aesthetic preferences, which is inconsistent with the research results of Zhao et al. (2013a). They found that for urban river landscapes, river accessibility is a reliable positive predictor of aesthetic preferences. However, the blue spaces selected in this article are mainly located in an urban park, where visitors come from all ages. Therefore, each water body was designed with safety in mind, such as the scenes shown in images 3 and 8. Tourists in these areas usually can only view the water body from a certain distance without touch, resulting in the images' lower accessibility, yet they are still preferred. However, since this study only selected a limited number of UPBS samples, the results cannot summarize general rules from the limited data. Biodiversity is a critical issue in landscape planning. It has been proven that people can accurately perceive species richness, and aesthetic appreciation increases as species richness increases (Lindemann-Matthies et al., 2010). This is consistent with the regression model results of this study: The higher the vegetation diversity of UPBS, the more people prefer it. In addition, the number of man-made elements is another potential contributor to preferences, which may be contrary to general knowledge that the more the human-made elements, the more likely the scene is to be considered artificial rather than natural, resulting in a decline in preference. However, Strumse (1994) pointed out that if the balance with nature is maintained, human influences can be appreciated, such as old buildings, stone walls, or stone bridges contained in natural scenes. Moreover, the results of the model did not find a significant relationship between water area and preference. It can be considered that this may not be a relationship between attraction of UPBS and scale/area. In other words, whether it is a river or a pond, they may have the same attraction.

In summary, this study found that people prefer water bodies with good water quality and natural visual forms. Simultaneously, blue spaces with high vegetation diversity are preferred, and artificial elements should be evaluated more carefully when added to the scene to avoid disharmony and conflict with the surrounding environment (Fig. 5-3).

5.4.3 Driving Factors for Restorative Potential of Urban Park Blue Space

The perception of inadequate resources causes humans mental stress (Kaplan, 1995). Water is important for relieving mental stress (Zhao et al., 2018), and the blue space (i.e., water body) enhances human health and wellbeing (Voelker & Kistemann, 2013). It is interesting and important to consider which landscape characteristics contribute to the restorative potential of UPBS. The regression analysis suggested that "water quality" and "visual naturalness of water" are positive indicators of evaluation, while "accessibility of water" is a negative indicator, like the aesthetic preference. The correlation analysis results show that the restorative potential of UPBS is positively correlated with aesthetic preference and naturalness. Therefore, for the blue space in urban parks, its restorative potential increases as the landscape's attractiveness and naturalness increase, which is consistent with the research results of Carrus et al. (2013) in green space. Furthermore, the number of landscape elements is another positive indicator of restorative potential. The point of view of evolution can explain this. The coexistence of multiple elements can increase the complexity of an environment (the possibility of providing food) and enhance the mystery of an environment (the possibility of exploration) (Zhao et al., 2013b). However, Deng et al. (2020) believe that complexity is an important quality of restorative environments. When viewers imagine that they are in such an environment, they prefer the existence of small animals, natural water, dense vegetation, rest facilities, and viewing platforms for relaxation and recovery.

In summary, good water quality and high naturalness are important characteristics of blue space as a restorative environment. At the same time, the proportions of plants, buildings, topographical changes, and water should be coordinated to maintain the heterogeneity of the landscape.

5.4.4 The Measurement to Restorative Potential

In this study, a shortened version of the PRS was used to measure the restorative potential of UPBS. The regression model results show that the “compatibility” has the lowest adjusted R2, which is consistent with the model result of Wang et al. (2019a). Participants need to imagine themselves in the blue space of this urban park (mainly river, creek, pond); hence, unlike the green space, they may not associate leisure activities (e.g., walking dogs, jogging, picnics) with these water bodies. In addition, “extent” (measured by scope and coherence) emphasizes the importance of the scene’s coherence. The rich vegetation types and natural forms of water in the image create a complex environment and comprise a whole world, stimulating the viewer’s desire to explore. Moreover, landscape characteristics related to water (water quality and visual naturalness of water) positively correlate with the restorative effect by attracting attention (fascination). Landscape elements in the blue space, such as bamboo, traditional architecture, bonsais, and stone bridges together form a natural and harmonious scene, allowing visitors to rest and relax here (being away). Arguably, the natural environment’s characteristics can help people recover from attention fatigue since they promote a restorative experience. However, both active involvement and observation are essential for restoring experience (Parry-Jones, 1990). Consequently, UPBS can provide more leisure activities and interactions for better recovery.

5.4.5 Natural or Artificial? Far from a Decisive Conclusion

Water is highly attractive to people in urban green spaces and open spaces (Zube et al., 1983). Humans prefer more natural water features (Nasar & Li, 2004), according to previous studies, which fits the psychological theory of preference for naturalness (Kaplan & Kaplan, 1989). However, another study showed that artificial features seem to be preferred (especially for women and children) because they provide active outdoor activities (e.g., water fights, boating, splashing in the stream, Bozkurt & Woolley, 2020). As a result, the results regarding whether people prefer natural or artificial water features remain ambiguous.

In this study, according to the results in Table 5-6, the correlation coefficient between naturalness and restorability as well as preference was greater than 0.6, which represents a strong correlation. Arguably, the more natural respondents perceived the UPBS, the more they preferred the scene, and the more likely they were to feel restored and relaxed. However, image 3, which had the lowest perceived naturalness (4.06), had a moderate preference score (4.83), while image 2, which was perceived as more natural (4.56), had the lowest preference (4.25) and the lowest restorative potential (4.20). Therefore, it seems that we cannot conclude that the UPBS assessed as more natural is more attractive (preferred). However, the contradictory result is consistent with the study of Ngiam et al. (2017); that is, visitors to urban parks desire natural landscapes on the one hand but also have cultural expectations for care and maintenance. In other words, in addition to aesthetic preferences, the public likes a tidy and managed landscape (Iverson Nassauer, 1995). In addition, Bulut and Yilmaz (2009) indicate that the most preferred water type is the urban water feature designed in a natural way, with the intrinsic motivation of integrating landscape architecture with natural elements. The results of this study agree with the point above, as the most preferred image 5 (5.67) is assessed as only moderately natural (5.05) but is a scene that blends highly natural environments and artificial elements—a large pond surrounded by bamboo forests and traditional buildings, with a platform in the foreground where visitors can view the water (a passive opportunity to play with water). Similarly, image 8 (5.63) is highly preferred, and there are numerous artificial landscape components in the image (rockeries, traditional structures, bonsais, a bridge) that blend nicely with the surrounding bamboo forest and sequoia. Furthermore, both scenes are well managed and cared for.

Therefore, based on the above discussion, this study concludes that public preference for natural or artificial water features is far from decisive. Managers of urban parks should create interactive artificial water features where visitors may participate in both active and passive outdoor activities. Natural water features, on the other hand, must be provided or capitalized on and their upkeep and management maintained. Most importantly, nature does not equal wilderness, and designers need to emphasize the balance of natural and artificial elements to improve the visual quality of water features.

5.5 Limitation

There are still some limitations and deficiencies in this research. First, knowledge about restorative potential and preferences is complex; more population samples from different countries and cultural backgrounds need to be emphasized. Although this study did not find differences between individuals, population groups' differences in landscape assessment should not be ignored. For those who design and manage blue spaces, it is crucial to keep in mind diverse views, preferences, and experiences to avoid permanent retention of the dominant position of certain groups (Pitt, 2019). Second, considering the experimental cost, only the visual stimulation method was performed. However, bringing participants to these locations was not considered to significantly change their assessment of the scene's restoration potential and aesthetic preferences (Karmanov & Hamel, 2008). Moreover, the physical environment characteristics of the site (such as smell, weather, temperature) may affect the judgment of participants. Therefore, these potential problems can be eliminated through visual simulation techniques. In addition, this study only selected 10 types of UPBS, and more types (more landscape features) of UPBS need to be considered for evaluation in future research. Lastly, this is a cross-sectional study, and longitudinal perspectives are also required to test the long-term impact on preferences and experiences.

Chapter 6 The effect of the perceived physical and aesthetic quality of urban blue spaces on user preferences

6.1 Methodology

6.1.1 Study sites

During the desk study phase (March–April 2021), we compiled and screened information on all accessible water bodies in the proximity of their institutions. First, in light of the COVID-19 pandemic, we excluded sites that were far away and less accessible (requiring multiple transportation changes). Second, they had to be in an urban environment in order to be consistent with the purpose of the study. Third, they were areas that were more commonly used by local residents, such as places for walking, running, recreation, and other outdoor activities; and fourth, they had different environmental characteristics. Correspondingly, three UBSs commonly used in urban environments were selected as survey sites, two of which are in the city of Matsudo, Chiba Prefecture, and the other in the city of Koshigaya, Saitama Prefecture, Japan.

Sakagawa (the urban river, Figure 6-1) is a river with a long history, originating in Kashiwa City and eventually flowing into the Edo River. The river has plenty of aquatic plants, and many trees have been planted on either side, thus resulting in an area that is a blend of natural and man-made environments. In addition, as the river is part of Matsudo City's river revitalization program, many water-friendly promenades have been designed for people to walk and ride. Shinsakagawa (an urban channel, Figure 6-2) is a man-made waterway located in the center of the city of Matsudo. It is an engineered channel built for drainage management and the river is lined mainly with commercial buildings and residential houses. Every day, many residents use the area for running, walking, or commuting. Osagamicyousetuike (an urban lake, Figure 6-3) is in Koshigaya City, Saitama Prefecture, and is a reservoir designed to resist urban flooding. As part of the Koshigaya Lake City business district, it is surrounded by commercial buildings and residential communities. It is also a highly artificial environment that many visitors and residents use for outdoor activities and recreation every day.

Figure 6-1. The environmental photo of Sakagawa (by authors)

Figure 6-2. The environmental photo of Shinsakagawa (by authors)

Figure 6-3. The environmental photo of Osagamicyousetuike (by authors)

The three survey sites offer a variety of environmental features and design elements: naturalness (Sakagawa is a natural form of river filled with extensive vegetation surrounding it, giving it a high degree of naturalness; the other two UBS are highly artificial environments), human intervention (the intensively managed Osagamicyousetuike, the moderately intervened Shinsakagawa, and lightly managed Sakagawa), visible water body size (Osagamicyousetuike is an artificial lake with an open view resulting in the largest visible water body size, followed by Shinsakagawa for urban drainage management, and Sakagawa), traffic conditions (the roads on both sides of Sakagawa are mainly used for walking and a small amount of motorized commuting, but do not distinguish between pedestrians and transportation; the roads on both sides of Shinsakagawa are more spacious and are mainly used for walking and motorized commuting, and distinguish between pedestrians and transportation. The Osagamicyousetuike road along the lake shore is divided into two main sections, one for outdoors alone and the other allowing motorized traffic in residential areas, with both the sections connected by two bridges), and recreational facilities (there are many waterfront promenades on either side of Sakagawa for visitors to interact with water bodies at close range; Osagamicyousetuike provides waterfront platforms and waterfront trails; while Shinsakagawa has only a few recreational facilities). Sites of different environmental qualities are included to capture preference trends from diverse UBS.

6.1.2 The questionnaire

In order to measure the physical and aesthetic quality of the UBS, we referred to a number of relevant studies and developed a questionnaire containing two statements. For physical quality, we mainly refer to studies by Wan et al. (2020), Mishra et al. (2020), Baran et al. (2014), Prins et al. (2009). The authors of these studies concluded that the physical factors (or physical characteristics) of an environment significantly influence the relationship between users and the environment and lead to higher intention to use, such as perceived safety, site maintenance, functionality, and attractiveness of artificial elements. Additionally, we reworded some of these items to better match the subjects of our study (i.e., blue spaces, not green spaces). However, unlike other green spaces such as parks, there were no options involving the presence of recreational facilities commonly found in green spaces (e.g., gazebos, swings, fitness equipment), as this is not compatible with most UBS. Furthermore, it has been shown that water proportion, water quality, and accessibility influence preferences (White et al., 2010, Zhao et al., 2013, Yamashita, 2002), and we added these items to the questionnaire as well. Thus, the final version of the statement consisted of 17 items from 5 components mainly. The statement was assessed on a Likert scale from 1 to 7, with different items assessed on different criteria, generally speaking 1 indicates a low level of perception (very poor/very little) and 7 indicates a very high level of perception (very good/very high/very adequate), see Table 6-1 for details.

For aesthetic quality, we refer to the study of Subiza-Pérez et al. (2019). Subiza-Pérez et al. (2019) proposed a self-reporting tool through factor analysis for assessing the perceived environmental aesthetic quality of blue-green spaces. This tool contains 23 statements of 5 components and shows good internal consistency, proving useful in urban planning studies. However, by pre-surveying we removed some items that were considered difficult to answer as well as some similar ones, and obtained the simplified version used in this study, which contains 16 items in 4 components. The statements were assessed by a Likert scale from 1 to 7, ranging from 1 indicating complete disagreement to 7 indicating complete agreement (Table 6-2). Moreover, two questions were used to measure preferences for UBS, including "To what extent do you like this place?" (1=very unlikely, 7=very likely), and "How likely are you to revisit this place?" (1=not at all, 7=very likely). Each preference score is the average of these two items.

Table 6-1 Statements regarding UBS physical quality assessments

Component	Statement	Score
Safety Support		
	Pedestrian personal safety protection.	High risk of traffic accidents 1------7 Low risk of traffic accidents
	Protection against falling water.	Almost no protection 1------7 Adequate protection
	Lighting in this area.	Hardly 1------7 Adequate
	Perceived safety from crime and antisocial behavior.	Feeling extremely unsafe 1------7 Feeling very safe
Sidewalk Conditions		
	Visual appearance of the sidewalk on the site.	Very poor 1------7 Very good
	Function of the sidewalk on the site.	Inability to meet walking needs 1------7 Meeting walking needs
	Maintenance and management of sidewalks.	Very poor 1------7 Very good
Environmental Management		
	Hard surface (e.g., Square, viewing platform) maintenance.	Very poor 1------7 Very good
	Vegetation management.	Very poor 1------7 Very good
	Street facilities maintenance.	Very poor 1------7 Very good
	Guardrail and other security facilities maintenance.	Very poor 1------7 Very good
Water Conditions		
	Proportion of water bodies.	Hardly 1------7 Very high
	Water Quality.	Very poor 1------7 Very good
	Water Accessibility.	Low 1------7 High
Artificial Elements		
	The attractiveness of the buildings on the site.	Low 1------7 High
	The attractiveness of the decorations on the site.	Low 1------7 High
	The attractiveness of greenery on site.	Low 1------7 High

Table 6-2 Statements regarding UBS aesthetic quality assessments

Component	Statement	Score
Harmony		
	This place fits well with its surroundings.	Strongly disagree 1------7 Strongly agree
	It is easy to understand this place.	Strongly disagree 1------7 Strongly agree
	The scale of this place is pleasing for me.	Strongly disagree 1------7 Strongly agree
	The different parts of this place form a coherent whole.	Strongly disagree 1------7 Strongly agree
	This is an interesting place.	Strongly disagree 1------7 Strongly agree
Mystery		
	This is an exciting environment.	Strongly disagree 1------7 Strongly agree
	This place is mysterious.	Strongly disagree 1------7 Strongly agree
	I feel like exploring this place.	Strongly disagree 1------7 Strongly agree
	The manifold materials here attract to touch and feel.	Strongly disagree 1------7 Strongly agree
	This environment could provide me with surprises.	Strongly disagree 1------7 Strongly agree
Multisensority & Nature		
	There are many scents in the air.	Strongly disagree 1------7 Strongly agree
	Nature is diverse here.	Strongly disagree 1------7 Strongly agree
	The soundscape here is pleasant.	Strongly disagree 1------7 Strongly agree
Visual spaciousness & diversity		
	Visibility here is good.	Strongly disagree 1------7 Strongly agree
	This place is spacious.	Strongly disagree 1------7 Strongly agree
	The view here is diverse.	Strongly disagree 1------7 Strongly agree

6.1.3 Study samples and data collection

Invitations were sent via social media software and 28 students were recruited from the Department of Horticulture at Chiba University. The recruitment message required that the subjects be non-smokers, not have any mental illness, and be physically functioning. However, three students were excluded because they indicated that they were unable to participate in the entire experiment. A final sample of 25 students (11 males and 14 females; they are 10 PhD students and 15 graduate students) was recruited, and all students visited the three study sites. The study was conducted according to the guidelines of the Declaration of Helsinki and with the approval of the Research Ethics Committee of the Institute of Horticulture, Chiba University (approval code: 21-05; 2021). Subjects were fully informed of the purpose and procedures involved and signed a consent form prior to the experiment. All participants were asked to abstain from alcohol and smoking for 24 hours before the experiment.

The two questionnaires for the experiment were filled out after the volunteers had completed another physical-psychological restoration experiment which not reported in this thesis (Figure 6-4, 6-5, 6-6). The specific dates and times of the experiment were organized according to their own schedules, as participants may be required to attend classes or work part-time. The experiments were conducted from October 10 to November 20, 2021 (autumn was chosen because of the hot summers and cold winters in Japan), and the time periods for each experiment were 9:00 a.m. to 11:00 a.m. and 1:00 p.m. to 3:00 p.m. We only conducted field surveys in comfortable weather (no rain or strong winds) to control the potential effects of weather on the results.

Figure 6-4 Photos of volunteers surveying at the study site (Sakagawa)

Figure 6-5 Photos of volunteers surveying at the study site (Shinsakagawa)

Figure 6-6 Photos of volunteers surveying at the study site (Osagamicyousetuike)

6.1.4 Statistical analysis

First, the reliability (internal consistency) of the scales was assessed, as measured by the Cronbach's alfa index. Subsequently, a one-way analysis of variance (ANOVA) was performed to examine the differences between the different UBS on each component; if the differences were significant then a post hoc test (multiple comparisons) was continued. Effect sizes for variance were obtained through Cohen's d statistic and interpreted according to Cohen's (1988) guidelines: $d \leq 0.20$ for small effects; $d = 0.50$ for medium effects and $d \geq 0.80$ for large effects. Furthermore, Pearson correlation coefficients were used to illustrate the correlations between the subscales and preferences. Finally, multiple linear regression analyses (introduced method as "entry") were performed to find predictors of preference in physical and aesthetic quality.

All statistical analyses were performed using IBM SPSS Statistics v.20.

6.2 The study questions

Zube et al. (1982) proposed four paradigms to guide research on environmental perception—the expert, experiential, psychophysical, and cognitive psychological approaches. The experiential approach is described as the subjective experience of the observer interacting with the environment in a holistic manner and with the primary purpose of designing applications, which became the basis for the feasibility of this study.

Overall, the main objective of this study is to establish a relationship between UBS preferences and environmental quality by investigating users' perception of the environmental quality (physical and aesthetic) of UBS. Our research questions are as follows:

1) Which physical environmental quality components significantly influence user preferences?

2) Which aesthetic environmental quality components significantly influence user preferences?

The results can guide city managers and planners as to which environmental qualities predict to what extent users' preferences for UBS, thereby providing insights for the effective use or enhancement of the natural environment in cities. However, considering time and cost constraints, it was difficult to investigate all types; therefore three types of UBS (an urban river, urban canal, and urban lake) that are more commonly used in urban environments were selected as survey sites.

6.3 Results

6.3.1 Overall statistics

All data of the study were compiled (Table 6-3). For physical quality, overall, Osagamicyousetuike received the highest score (5.63±0.66), followed by Sakagawa (4.47±0.72) and Shinsakagawa the lowest (4.38±0.91). Specifically, Osagamicyousetuike received the highest ratings on all five components, M_{SS}=5.94(±0.72), M_{SC}=5.87(±0.88), M_{EM}=5.76(±0.84), M_{WC}=5.12(±0.87), M_{AE}=5.45(±0.87). Sakagawa received the second highest rating on four components, M_{SS}=4.48(±0.80), M_{SC}=4.48(±1.26), M_{WC}=4.09(±1.28), M_{AE}=4.87(±0.82); while being assessed with the lowest score on the Environmental Management component, M_{EM}=4.44(±1.06). Shinsakagawa received the lowest scores on most components, M_{SS}=4.41(±1.07), M_{SC}=4.31(±1.30), M_{WC}=3.75(±0.99), M_{AE}=4.79(±1.14); and received a medium rating on the Environmental Management component, M_{EM}=4.67(±1.23).

For aesthetic quality, the rating trend was similar to the results of physical quality, with Osagamicyousetuike receiving the highest rating (5.14±0.77), followed by Sakagawa (4.37±0.86) and Shinsakagawa the lowest (4.04±0.87). Specifically, Osagamicyousetuike received the highest ratings on four components, M_H=5.69(±0.99), M_M=4.29(±1.06), M_{MN}=4.47(±1.08), M_V=6.11(±0.55). Sakagawa received a medium score on three components, M_H=5.30(±0.95), M_M=3.82(±1.33), M_{MN}=4.08(±1.09); while the lowest score on the Visual spaciousness & diversity component, M_V=4.31(±1.11). Similarly, Shinsakagawa received the lowest scores on most components, M_H=4.74(±1.06), M_M=3.34(±1.15), M_{MN}=3.68(±0.99); while received a medium score on the Visual spaciousness & diversity component, M_V=4.40(±1.19).

For preference, Sakagawa obtained the highest score (5.34±1.27), followed by Osagamicyousetuike (5.28±1.08), and Shinsakagawa scored the lowest (3.98±1.33). Moreover, the reliability of all components was checked and Cronbach's alpha ranged from 0.601-0.911, the result showed a high internal consistency.

Table 6-3 Overall statistics of the study

Component	S (SD)	SH (SD)	O (SD)	All	α
Physical Quality	**4.47(0.72)**	**4.38(0.91)**	**5.63(0.66)**	**4.83(0.96)**	-
Safety Support (SS)	4.48(0.80)	4.41(1.07)	5.94(0.72)	4.94(1.12)	0.685
Sidewalk Conditions (SC)	4.48(1.26)	4.31(1.30)	5.87(0.88)	4.88(1.34)	0.911
Environmental Management (EM)	4.44(1.06)	4.67(1.23)	5.76(0.84)	4.96(1.19)	0.862
Water Conditions (WC)	4.09(1.28)	3.75(0.99)	5.12(0.87)	4.32(1.20)	0.652
Artificial Elements (AE)	4.87(0.82)	4.79(1.14)	5.45(0.87)	5.04(0.98)	0.740
Aesthetic Quality	**4.37(0.86)**	**4.04(0.87)**	**5.14(0.77)**	**4.52(0.95)**	-
Harmony (H)	5.30(0.95)	4.74(1.06)	5.69(0.99)	5.24(1.06)	0.904
Mystery (M)	3.82(1.33)	3.34(1.15)	4.29(1.06)	3.82(1.23)	0.899
Multisensority & Nature (MN)	4.08(1.09)	3.68(0.99)	4.47(1.08)	4.08(1.09)	0.601
Visual spaciousness & diversity (V)	4.31(1.11)	4.40(1.19)	6.11(0.55)	4.94(1.28)	0.850
Preference	**5.34(1.27)**	**3.98(1.33)**	**5.28(1.08)**	**4.87(1.37)**	0.824

Note. S, Sakagawa; SH, Shinsakagawa; O, Osagamicyousetuike. α, Cronbach's alpha; SD, Standard deviation.

6.3.2 Differences examination among the study sites

Table 6-4 demonstrates the results of the difference test between the different study sites. ANOVA results showed significant differences among the three study sites for all components, $F_{SS}(2, 74)=24.307$, $p<0.001$, $F_{SC}(2, 74)=13.551$, $p<0.001$, $F_{EM}(2, 74)=11.162$, $p<0.001$, $F_{WC}(2, 74)=11.360$, $p<0.001$, $F_{AE}(2, 74)=3.666$, $p=0.030$, $F_{H}(2, 74)=5.625$, $p=0.005$, $F_{M}(2, 74)=3.973$, $p=0.023$, $F_{MN}(2, 74)=3.464$, $p=0.037$, $F_{V}(2, 74)=26.187$, $p<0.001$, $F_{preference}(2, 74)=9.695$, $p<0.001$.

Subsequently, multiple comparisons (LSD) (Table 6-4, Figure 6-7) were performed to continue comparing differences. Specifically, for physical quality, there was no significant difference between Sakagawa's and Shinsakagawa's scores on Safety Support (p=0.778), Sidewalk Conditions (p=0.599), Environmental Management (p=0.443), and Artificial Elements (p=0.767); and both UBS scores on these four components were significantly smaller than Osagamicyousetuike (p<0.05). However, Osagamicyousetuike was significantly higher than the other two UBS in terms of Water Conditions component scores (p<0.05) and Sakagawa was not significantly higher than Shinsakagawa (p=0.251).

For aesthetic quality, Osagamicyousetuike scored significantly higher on Visual spaciousness & diversity components than the other two UBS (p<0.001); while Sakagawa scored no significantly differences with Shinsakagawa on all four components: Harmony (p=0.055), Mystery (p=0.163), Multisensority & Nature (p=0.185), and Visual spaciousness & diversity (p=0.740). Besides, Osagamicyousetuike scored significantly higher on three components than Shinsakagawa, Harmony (p=0.001), Mystery (p=0.006), and Multisensority & Nature (p=0.010).

For preference, there was no significant difference between Sakagawa and Osagamicyousetuike (p=0.864), and both were significantly higher than Shinsakagawa (p<0.001), indicating that respondents mostly preferred Sakagawa and Osagamicyousetuike. Effect sizes were calculated by Cohen's d and ranged from 0.65 (medium) to 2.05 (large) (Cohen, 1988).

Table 6-4. ANOVA results, multiple comparison results show pairwise comparisons of study site means with statistically significant differences (p < 0.05), where < and > indicate which site has the higher mean score.

Component	ANOVA		Multiple comparison		
	F (2, 74)	P	LSD	P	d
Physical Quality					
Safety Support (SS)	24.307	<0.001	S < O	<0.001	1.92
			SH < O	<0.001	1.68
			S, SH	0.778	-
Sidewalk Conditions (SC)	13.551	<0.001	S < O	<0.001	1.28
			SH < O	<0.001	1.41
			S, SH	0.599	-
Environmental Management (EM)	11.162	<0.001	S < O	<0.001	1.38
			SH < O	<0.001	1.03
			S, SH	0.443	-
Water Conditions (WC)	11.360	<0.001	S < O	0.001	0.94
			SH < O	<0.001	1.47
			S, SH	0.251	-
Artificial Elements (AE)	3.666	0.030	S < O	0.032	0.69
			SH < O	0.015	0.65
			S, SH	0.767	-
Aesthetic Quality					
Harmony (H)	5.625	0.005	SH < O	0.001	0.93
			S, O	0.170	-
			S, SH	0.055	-
Mystery (M)	3.973	0.023	SH < O	0.006	0.86
			S, O	0.163	-
			S, SH	0.163	-
Multisensority & Nature (MN)	3.464	0.037	SH < O	0.010	0.77
			S, O	0.200	-
			S, SH	0.185	-
Visual spaciousness & diversity (V)	26.187	<0.001	S < O	<0.001	2.05
			SH < O	<0.001	1.84
			S, SH	0.740	-
Preference	9.695	<0.001	S > SH	<0.001	1.05
			S, O	0.864	-
			SH < O	<0.001	1.07

Note. S, Sakagawa; SH, Shinsakagawa; O, Osagamicyousetuike. d, Cohen's d; LSD, Fisher's least significant difference test.

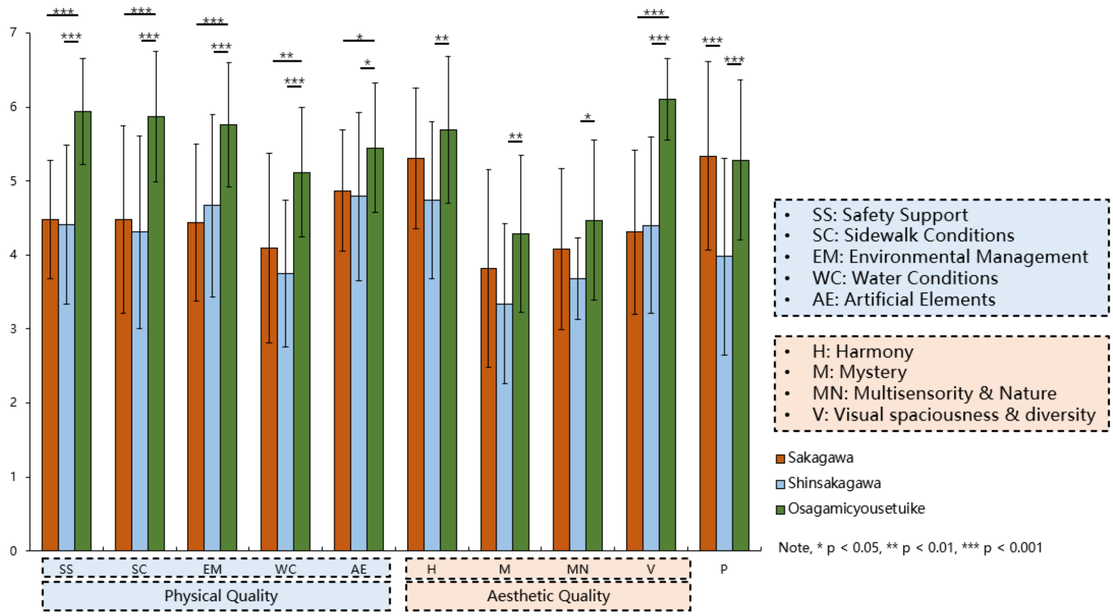


Figure 6-7. Multiple comparison results of three study sites

Note, SS, Safety Support; SC, Sidewalk Conditions; EM, Environmental Management; WC, Water Conditions; AE, Artificial Elements; H, Harmony; M, Mystery; MN, Multisensority & Nature; V, Visual spaciousness & diversity; P, Preference; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

6.3.3 Environmental quality components for predicting environmental preferences in urban blue spaces

Before performing regression analyses, Pearson correlation coefficients were used to illustrate the correlation between each subscale and preference (Table 6-5). According to the correlation results, all environmental quality components showed a significant positive correlation with respondents' preference for UBS (correlation coefficients ranging from 0.379 to 0.761), i.e., the higher the visitors' ratings for these components, the more they preferred the visited UBS.

Table 6-5. Correlation results between UBS preference and environmental quality components (Pearson)

Component	SS	SC	EM	WC	AE	H	M	MN	V
SC	0.714**								
EM	0.642**	0.788**							
WC	0.518**	0.505**	0.493**						
AE	0.544**	0.669**	0.634**	0.415**					
H	0.449**	0.596**	0.531**	0.427**	0.771**				
M	0.285*	0.380**	0.369**	0.426**	0.592**	0.682**			
MN	0.290*	0.244*	0.286*	0.197	0.382**	0.462**	0.481**		
V	0.572**	0.635**	0.584**	0.477**	0.673**	0.701**	0.627**	0.439**	
P	0.409**	0.440**	0.405**	0.450**	0.668**	0.761**	0.660**	0.379**	0.536**

Note. <0.4 0.4~0.6 >0.6

SS, Safety Support; SC, Sidewalk Conditions; EM, Environmental Management; WC, Water Conditions; AE, Artificial Elements; H, Harmony; M, Mystery; MN, Multisensority & Nature; V, Visual spaciousness & diversity; P, Preference. N= 75, * $P < 0.05$, ** $P < 0.01$.

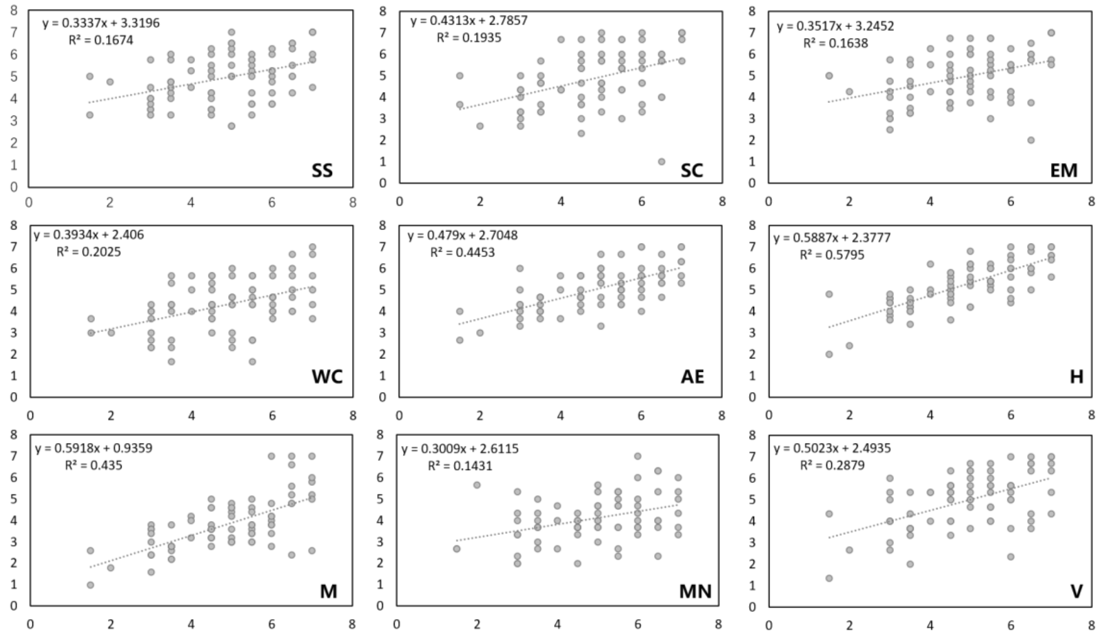


Figure 6-8. Linear relationship between each component and preferences

However, correlation analysis only considers the relationship between preferences and independent environmental components, and does not consider the problem of multicollinearity among components (Wang & Zhao, 2019). Therefore, the multiple linear regression analysis (introduced method as "entry") was performed. According to Arriaza et al. (2004), the presence of multicollinearity problems is indicated if the model tolerance value is <0.2 or the variance inflation factor (VIF) >10. No multicollinearity problem was found in the current model (minimum tolerance = 0.278 and maximum VIF = 3.600), which was considered acceptable. According to the results in Table 6-6 and Table 6-7, overall, the multiple linear regression analysis showed preferred statistical significance results for physical quality, $F_{(5, 74)} = 13.354$, $p < 0.001$; for aesthetic quality, $F_{(4, 74)} = 28.466$, $p < 0.001$. Moreover, the adjusted R-squared equaled 0.455 for physical quality, and 0.598 for aesthetic quality, indicating that the model was able to explain 45.5% and 59.8% of the amount of variance separately. For predictors, “Water Conditions” (β= 0.241, p = 0.024), “Artificial

Elements” (β= 0.657, $p < 0.001$), “Harmony” (β= 0.625, $p < 0.001$), and “Mystery” (β= 0.288, $p = 0.009$) components were all reliable predictors of preference.

Table 6-6. Significant predictors of physical quality on UBS preference (N = 75)

Independent variable	Unstandardized Beta	Standardized Beta	t	Sig.	Collinearity statistics	
					Tolerance	VIF
(constant)	-0.258		-0.377	0.708		
Safety Support (SS)	0.054	0.044	0.346	0.731	0.445	2.246
Sidewalk Conditions (SC)	-0.075	-0.073	-0.449	0.655	0.278	3.600
Environmental Management (EM)	-0.117	-0.101	-0.693	0.491	0.344	2.907
Water Conditions (WC)	0.276	0.241	2.312	**0.024**	0.679	1.474
Artificial Elements (AE)	0.915	0.657	5.496	**<0.001**	0.516	1.939

Dependent variable is Preference, $R^2 = 0.492$; adjusted $R^2 = 0.455$. Model standard estimation error is 1.01.

Table 6-7. Significant predictors of aesthetic quality on UBS preference (N = 75)

Independent variable	Unstandardized Beta	Standardized Beta	t	Sig.	Collinearity statistics	
					Tolerance	VIF
(constant)	-0.177		-0.215	0.830		
Harmony (H)	0.808	0.625	5.388	**<0.001**	0.405	2.471
Mystery (M)	0.321	0.288	2.672	**0.009**	0.468	2.135
Multisensority & Nature (MN)	-0.019	-0.015	-0.179	0.858	0.725	1.379
Visual spaciousness & diversity (V)	-0.080	-0.075	-0.691	0.492	0.461	2.169

Dependent variable is Preference, $R^2 = 0.619$; adjusted $R^2 = 0.598$. Model standard estimation error is 0.87.

The results of the regression analysis clearly demonstrate how the dependent variable changes with the independent variable. According to the multiple linear regression equation:

$Y= \beta_0 + \beta_1 X_1 + \ldots + \beta_n X_n$

Where y = the predicted value of the dependent variable;

β_0 = the intercept, i.e., the value of y when the other parameters are 0;

$\beta_1 X_1$= the first independent variable and the regression coefficient;

$\beta_n X_n$= the nth independent variable and the regression coefficient.

Based on Table 6-6, for the relationship between UBS preferences and physical quality components can be expressed as the following equation:

$$\text{Preference} = -0.258 + (0.276 * WC) + (0.915 * AE) \quad (1)$$

Besides, the relationship between UBS preferences and aesthetic quality components (Table 6-7) can be expressed as the following equation:

$$\text{Preference} = -0.117 + (0.808 * H) + (0.321 * M) \quad (2)$$

Therefore, it can be found after multiple linear regression analysis that: for every 1 increase in the rating of Water Conditions, preference increased by 0.276; and for every 1 increase in the rating of Artificial Elements, preference increased by 0.915. Moreover, preference increased by 0.808 for each 1 increase in Harmony, and 0.321 for each 1 increase in Mystery.

6.4 Discussion

6.4.1 General discussion

Environmental quality assessments are widely used to analyze the environment and thus further provide a reference for environmental planning and management (Zhao et al., 2013a). The relationship between environmental quality and preferences has been highlighted (Hagerhall, 2001, Wang et al., 2016). However, which environmental quality components may potentially influence users' preferences for UBS? What are the environmental quality components that significantly predict preferences? What are the associations of these components with environmental preferences? These questions remain ambiguous. Then, we will present a qualitative and quantitative discussion based on the obtained results.

First, as in our study setup, all three UBS showed different trends in environmental quality scores (Table 6-1). This result demonstrates that the environmental quality of the three selected UBS is significantly different. In other words, respondents were able to perceive differences in environmental quality due to different design elements and environmental features, which indicates that the experimental setup of this study is acceptable, i.e., capturing preference trends from the diverse UBS.

UBS are favored by residents as an important urban natural environment and attract visitors with different purposes (Völker et al., 2016). Previous studies have found that even if both belong to blue and green spaces, preferences can differ due to different environmental characteristics, for example, Lin et al. (2019) found that medium-sized urban green spaces received the highest preference scores, and Luo et al. (2021) found that the preference for different types of blue spaces in urban parks was different, which is similar to our findings. In this study, three UBS, which are more common in urban environments, were selected as survey sites based on different environmental characteristics, and the results indicated significant differences among the preferences of these UBS. Specifically, respondents gave higher scores to Sakagawa and Osagamicyousetuike, and although there was no significant difference in preference scores between the two UBS, both were significantly higher than Shinsakagawa's score. However, such a statement may cause some controversy because we only surveyed three UBS.

Therefore, we do not want to draw conclusions similar to the preference for urban river (Sakagawa) and urban lake (Osagamicyousetuike) over urban canal (Shinsakagawa), but rather want to give the premise of the analysis that preferences for different UBS will show differences. As stated earlier, UBSs with different environmental characteristics and design elements were intentionally selected to establish relationships between preferences and environmental quality, and these links will be analyzed in depth subsequently.

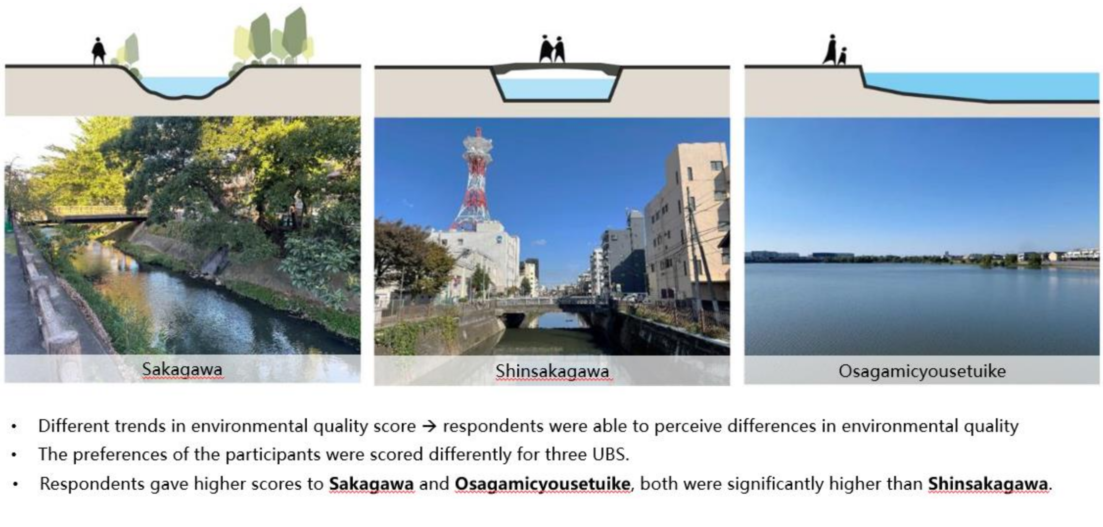


Figure 6-9. Three kinds of the UBS

6.4.2 Environmental quality components that significantly affect preferences

As highlighted at the beginning, physical quality in addition to aesthetics needs to be considered when discussing the relationship between preferences and environmental quality. Accordingly, the questionnaire used in this investigation refers to previous studies that set the physical quality of five components as well as the aesthetic quality of four components as components that potentially influence environmental preferences. The reliability results show a range of Cronbach's alpha from 0.601-0.911, indicating a high internal consistency, which suggests that the setting of 9 components is reasonable.

Of these, for physical quality, two components (Water Conditions, and Artificial Elements) significantly influenced the preference scores. First, water bodies are important elements of blue space and it has been shown that the proportion of water bodies, water quality, and accessibility influence preferences (White et al., 2010, Zhao et al., 2013a, Yamashita, 2002), and we placed these items in the Water Conditions component. However, this component had the lowest correlation among all significant components in the regression equation (β=0.142), probably because only three statements were included. It is well known that water bodies contain many complex features such as reflectance, dynamics/stasis, water form, color, but the association of these features with preferences (positive or negative?) remains ambiguous. Taking the form of water bodies as an example, Bulut & Yilmaz (2009) found that urban water features designed in a natural way were most preferred, while Bozkurt & Woolley (2020) had a different conclusion. Therefore, from the current data results, it can only be inferred that respondent prefer large-scale water bodies with good water quality and good accessibility. Third, buildings, decorations, and greenery are important artificial elements of UBS, and the results show that the quality of these man-made attractions shows a positive correlation with environmental preferences, which is similar to previous studies (Wan et al., 2020, Zhang et al., 2013, Zhang et al., 2022). Greenery has been shown to be associated with higher preferences in many studies because humans usually prefer natural scenery and these plants facilitate the connection between humans, the natural environment and natural activities (Zhao et al., 2018). Buildings are often perceived as negative elements, but Chen et al. (2020b) suggest that the impact of architecture on the environment should be discussed through a more inclusive and pluralistic perspective, and visitors will rate it positively if it is balanced with the natural elements of the scene (Strumse, 1994). Moreover, the common blue space in an urban environment is difficult not to include any buildings, where it is different from the coast. Therefore, buildings are inevitable in UBS, and how to improve the attractiveness of these buildings and try to integrate them into the scene is a critical issue for design and management. Decorations usually include some structures (e.g., promenades, bridges) and landscape sketches (e.g., signage, landscape seats) that are considered as a kind of micro-landscape and allow visitors to experience and interact with them, thus having recreational and aesthetic value and leading to a higher preference (Zhang et al., 2022).

For aesthetic quality, two components (Harmony, and Mystery) had a significant effect on preference. First, Harmony is derived from the concept of coherence, which is interpreted as the readability of the landscape and the unity of the scene (Tveit et al., 2006). Van Mansvelt & Kuiper (1999) believe that this unity is produced by the combination of landscape elements in a scene, rather than by any single element. Therefore, the understanding of the whole is more important than the meaning of the individual parts. Furthermore, water features are considered harmonious and have focal quality, thus increasing the coherence of the scene (Litton, 1974), which could explain the high scores obtained by all three UBS on the Harmony component, resulting in the highest correlation coefficient for this component (β=0.688). Mystery is the promise that one can see more if one goes deeper into an environment (Herzog & Bryce, 2007). In Kaplan & Kaplan's (1989) preference theory, mystery is associated with perceived complexity, attraction, excitement, and a desire to explore the place. Mystery can occur in a variety of settings, and curved paths, partial concealment, and shadows are all the features that enhance mystery (Herzog & Bryce, 2007). However, some studies in forests have shown that the low visual accessibility and potential danger of scenes can trigger negative emotions leading to a negative correlation between mystery and preference (Herzog et al., 1982). In this study, the selected UBSs are outdoor open spaces with high visual accessibility, which reduces the perception of danger. In addition, some environmental settings, such as Sakagawa, with its winding paths with moderate vegetation shading, trigger the desire of users to continue exploring; in Osagamicyousetuike, the large water bodies bring visitors a feeling of surprise, and the water-friendly facilities inspire them to continue staying. Therefore, this component is another essential aesthetic quality that influences environmental preferences (Subiza-Pérez et al., 2019).

Moreover, the R-square indicates that there are still other aspects that significantly influence users' preferences for UBS, such as behavioral expectations (Purcell et al., 1994), and value orientation (Kaltenborn & Bjerke, 2002). However, this paper focuses on the quality aspects of the environment (physical quality, aesthetic quality), so the study of environmental preferences is far from conclusive and the scale needs to continue to be developed to cover more physical and aesthetic components.

More importantly, the scale could be considered for inclusion in a larger scale to expand the scope and purpose of the survey, adding dimensions such as social, therapeutic, leisure values, learning, etc., to develop a more comprehensive framework for environmental assessment (Inoue et al., 2022).

Surprisingly, some components that intuitively should significantly affect preferences were not found to be significant, such as the Environmental Management and Multisensority & Nature. While White et al. (2016) argue that good environmental conditions are critical to the blue space visit experience, the current findings suggest that this relationship may not be as important, since tourists generally perceive Shinsakagawa to have better environmental management than Sakagawa, but prefer the latter. Furthermore, Chen et al., (2009) emphasized the multisensory nature of the aesthetic experience, such as pleasurable sounds and smells. However, all three UBS respondents gave low scores on this component (4.08, 3.68, and 4.47, respectively), as most respondents at the time of the field survey reported that these places had little to no odor and no pleasant sounds. The multisensory results may be related to the site we chose; the most mentioned site is Osagamicyousetuike, which is a commercial area and therefore has some music playing in the nearby plaza to attract customers; while Shinsakagawa, which has the lowest score, has many commuter car roads passing by every day, and this may have contributed to the low score for this component. In addition, the lack of odor makes sense, as the UBS we chose is a freshwater environment and therefore does not have a seawater-like odor. Of course, unlike green spaces, it is difficult to make a water body emit a pleasant odor, so avoiding bad odors and planting flowering plants appropriately may be beneficial.

6.4.3 Study implications

Finally, in terms of study implications. First, the environmental quality scale demonstrated reliability and can be continued to be used in future investigations of environmental quality for a wider range of blue spaces. Second, in the field of urban planning, most of the studies involving the relationship between environmental quality and preferences have focused on green spaces such as urban parks, forests, and grasslands (Lis et al., 2019, Zhang et al., 2013, Wan et al., 2020, Chen et al., 2020b, Herzog & Bryce, 2007, Zheng et al., 2011, Strumse, 1994), with less focus on blue spaces, the current findings are an important supplement to the field, such as what is the propensity of residents to prefer UBS, the effect of different environmental quality components on preferences, and the extent of the effect. Third, urban natural environmental constraints are creating a public health challenge. As a part of urban nature, a high-quality water environment will attract more outdoor recreational behaviors (e.g., walking, running, biking, Gabr, 2004), and these recreational behaviors will be a good medicine for reducing urban health care costs (Figure 6-10). At the same time, a pleasant environment (feeling comfortable, appropriate urban furniture, adequate lighting, presence of trees) leads to increased physical activity, which promotes health (Vaeztavakoli et al., 2018). Therefore, the results of the study can help us understand how to effectively use these natural capitals in the city and provide guidance for the environmental design of blue spaces (van den Bogerd et al., 2021). Fourth, the current study establishes a relationship between environmental quality (physical, aesthetic) and preferences, whereas previous research has demonstrated that environmental preferences can be used to reflect other indicators of social behavior (Figure 6-11), such as higher prices paid for real estate (Anderson & Cordell, 1988), willingness to protect the environment (Kaltenborn & Bjerke, 2002), satisfaction with the workplace (Kaplan, 2007), and physical activity levels (Wan et al., 2020). Thus, city managers and policy makers can base their interventions and development plans on these relationships; planners and designers could predict the environmental value of different blue spaces in the future through the results of extensive preference surveys.

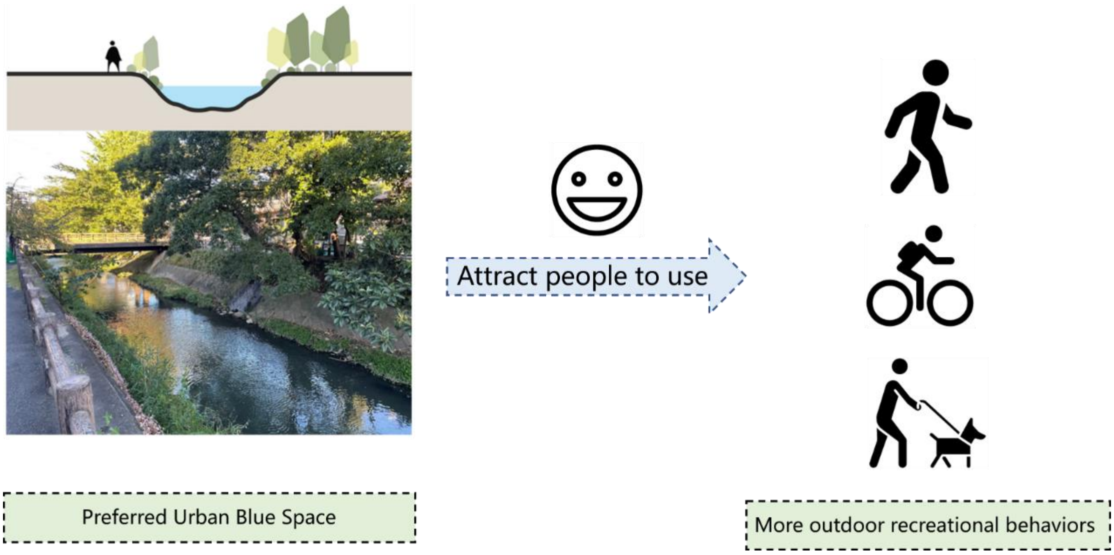


Figure 6-10. The high-quality water environment will attract more outdoor recreational behaviors.

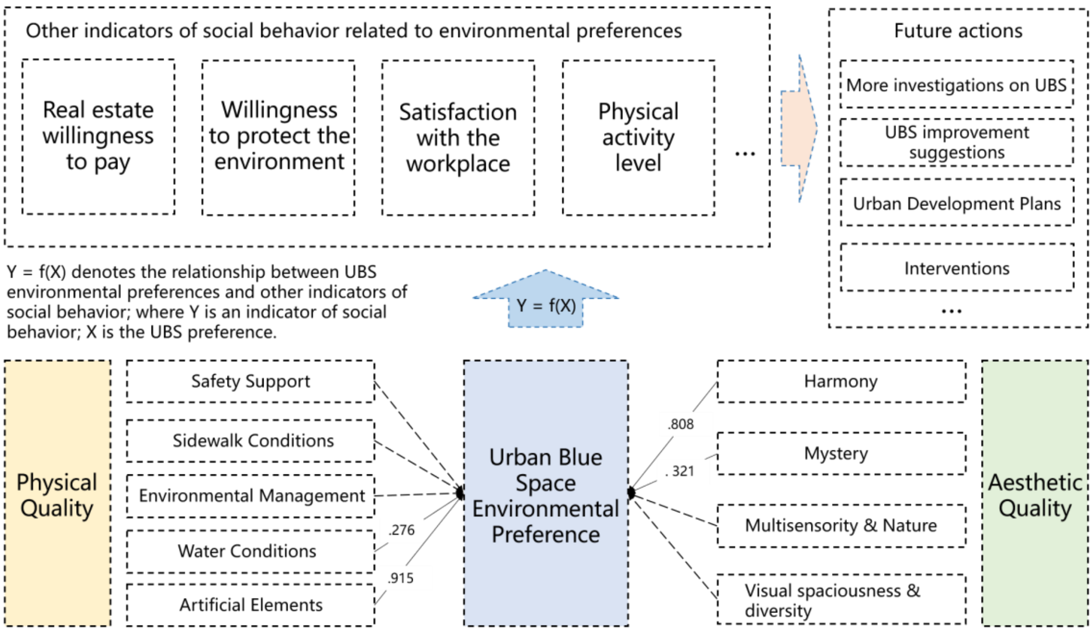


Figure 6-11. The relationship between environmental quality (physical, aesthetic) and blue space environmental preferences, and the reflection of preferences on other indicators of social behavior.

6.5 Limitation

The fourth study had some limitations that should be considered in future studies. First, we selected only freshwater blue spaces, excluding urban coastal and seaside environments where the perception may differ from other freshwater UBS. Second, despite the high value of Cronbach's alpha, there is still a need to test the reliability of the scale through more cases. Third, as mentioned in the previous discussion section, physical and aesthetic qualities are complex, so these scales need to be further developed to cover a wider range of perceptual items. Fourth, it has been recognized that preferences are associated with perceived restorativeness (Luo et al., 2021). Future research could be meaningful for the investigation of urban health promotion resources by linking environmental quality and perceived restorativeness in UBS. Finally, due to space limitations, differences in population perceptions were not analyzed, e.g., whether the elderly population would be more concerned about road conditions and whether the female population would be more concerned about aesthetic quality, results that would be useful for city-specific intervention policies.

Chapter 7 Comparing restoration potential and restorative environmental features of urban blue and green spaces

7.1 Methodology

7.1.1 Study sites

According to the purpose of the study, two representative urban green spaces (UGS) and urban blue spaces (UBS), an urban park and an urban lake, respectively, were selected in Japan because they allow visitors to fully immerse themselves in the green and blue environments. Unlike Gidlow et al. (2016), no built environment (e.g., streets, squares) was used as a control group, as this was not the purpose of the present study.

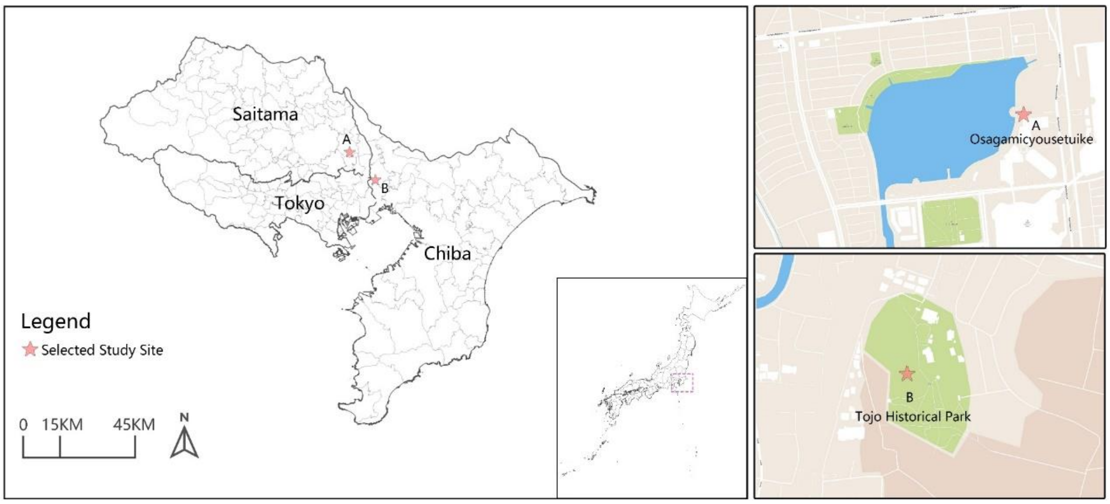


Figure 7-1. Location of study sites.

Fig. 7-1 and 7-2 show information on the two experimental sites. Osagamicyousetuike, which represents the urban blue space, is a reservoir with a capacity of 1.2 million m3 of water in Koshigaya City, Saitama Prefecture, designed to resist urban flooding. As part of the commercial district of Koshigaya Lake Town, it is surrounded by commercial buildings and residential communities, where many residents and visitors enjoy recreational activities daily. Tojo Historical Park, which represents the urban green space, is in Matsudo City, Chiba Prefecture, and is currently open to visitors as a free-admission urban park. This park was the residence of Tokugawa Akitake, who was the brother of Tokugawa Yoshinobu, the last shogun of the Edo Shogunate, and was designated as an important national cultural asset in 2006 and listed among the 100 Best Historical Parks in Japan in 2007.

a) Osagamicyousetuike b) Tojo Historical Park

Figure 7-2. Image of study sites; a) Urban blue space; b) Urban green space.

7.1.2 Recruitment and experimental objects

In the current study, “within-subject” experiments were performed. Invitations to participate in the study were sent through social media software (Line), and 25 students (11 men, 14 women; Table 7-1) were recruited from the Department of Horticulture at Chiba University. The recruitment information included the study procedures, voluntary nature, anonymity, and contact information of the project leader and required that subjects be non-smokers, free of any mental illness, and in normal physical condition. The study was conducted in accordance with the guidelines of the Declaration of Helsinki and with the approval of the Research Ethics Committee of the Institute of Horticulture, Chiba University (approval code: 21-05; 2021). The subjects were fully informed of the purpose and procedures involved and signed a consent form prior to the experiment. All participants were asked to prohibit alcohol and coffee consumption, as well as smoking for 24 h prior to the experiment.

Table 7-1. Subject information (N=25).

Information	Value (Mean ± SD)
Male	11
Female	14
Age	26.9 ± 2.2
Weight (kg)	60.7 ± 12.5
Height (cm)	169.2 ± 9.4
BMI (kg/m2)	21.1 ± 1.9

7.1.3 Measurements

Two psychological scales were used to measure the participants' self-reported psychological restoration outcomes (Table 7-2). All outcomes were measured using a seven-point Likert scale ranging from 1 (not at all) to 7 (completely).

First, the Restoration Outcome Scale (ROS) was used to measure restorative experiences (Korpela et al., 2008). It contains six items, three of which reflect relaxation and calmness ("I feel restored and released," "I feel very calm," and "I grow enthusiastic and energetic about my daily life"), one item reflects restored attention ("I feel focused"), and the remaining two items reflect clearing one's thoughts ("I can forget my daily worries" and "My thoughts are clear"). The Subjective Vitality Scale (SVS) (Ryan & Frederick, 1997) contains five items to measure self-reported feelings of vitality and being alive: "I feel alive and vital," "I feel very energetic," "I look forward to each new day," "I feel alert and awake," and "I feel so alive I just want to burst".

Table 7-2. Two psychological scales of this study.

Scale	Items	Score
Restoration Outcome Scale (ROS)	I feel restored and released	Not at all 1-----7 Extremely Agree
	I feel very calm	Not at all 1-----7 Extremely Agree
	I grow enthusiastic and energetic about my daily life	Not at all 1-----7 Extremely Agree
	I feel focused	Not at all 1-----7 Extremely Agree
	I can forget my daily worries	Not at all 1-----7 Extremely Agree
	My thoughts are clear	Not at all 1-----7 Extremely Agree
Subjective Vitality Scale (SVS)	I feel alive and vital	Not at all 1-----7 Extremely Agree
	I feel very energetic	Not at all 1-----7 Extremely Agree
	I look forward to each new day	Not at all 1-----7 Extremely Agree
	I feel alert and awake	Not at all 1-----7 Extremely Agree
	I feel so alive I just want to burst	Not at all 1-----7 Extremely Agree

The IRCS was used to measure restorative environmental features (Herzog et al., 2003; Ivarsson & Hagerhall, 2008; Pals et al., 2009). The IRCS consists of 21 items in five main categories (Fig. 7-3):

1) Fascination (five items, Including: "The environment here has a fascinating quality" and "I want to spend more time observing my surroundings.");

2) Novelty (three items, including: "I can engage in activities different from my daily activities here" and "There are many novelties here")

3) Escape (four items, including: "This place makes me feel like I am away from my daily worries" and "This place makes me feel like I don't have to worry about other people's expectations")

4) Extent (four items, including: "There is a confusing place" and "It is very disorganized

here”);

and 5) Compatibility (five items, including: “This place fits with what I want to do at this moment” and “Staying in this place is very much in line with my personality”).

Participants indicated their level of agreement with the items on a 7-point Likert scale ranging from 1 ("completely disagree") to 7 ("completely agree"). The Extent score was reversed in the subsequent analysis. All statements were adjusted according to the purpose and setting of the study.

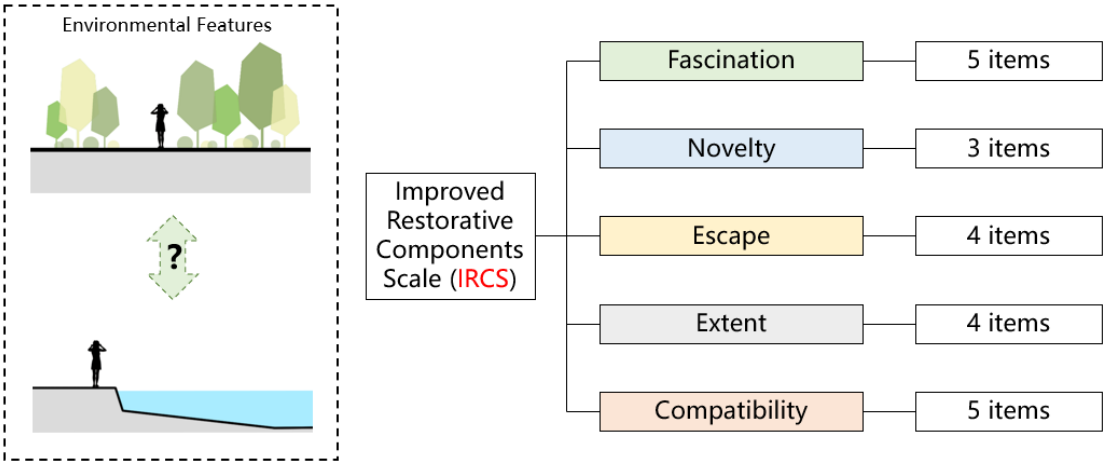


Figure 7-3. The restorative environmental features measurement tool.

7.1.4 Experimental design and procedure

In accordance with Tyrväinen et al. (2014), a within-subjects design was used to ensure the validity of the study, with all 25 participants visiting the blue and green spaces. The dates of the experiment were scheduled according to the participants' own availability, as they may need to attend classes or work part time. To avoid residual effects, each participant visited one site at a time. The experiments were conducted October 23–November 5, 2021, with time slots of 09:00–11:00 am and 01:00–03:00 pm for each experiment. Similar weather conditions were chosen to during which conduct the experiments to eliminate external disturbances. Furthermore, autumn was chosen because Japanese summers are intensely hot and winters are intensely cold and exposing subjects to extreme climatic conditions would have affected the experimental results. Additionally, the experimental staff recorded the environmental conditions, including humidity, temperature, light, and noise, every 3 min during the experiment (Table 7-3).

Table 7-3. Comparison of the environmental factors of the two environmental sites (M±SD)

Parameter	Blue Space	Green Space
Temperature (°C)	22.96 (±1.68)	20.44 (±1.16)
Humidity (%)	33.25 (±4.73)	40.20 (±6.80)
Absolute illumination (lx)	50774 (±2476)	39150 (±1957)
Noise (dB)	44.66 (±2.89)	43.42 (±3.24)

Upon arrival at the experimental site (UBS or UGS), the participants were arranged to assemble in the waiting room. The experimental assistant then explained the entire experiment and collected consent forms signed by the participants. The psychological data (ROS and SVS) of the participants were subsequently recorded as pre-viewing data. Thereafter, the participants were led to the viewing location to start the experiment. The group size was limited to six people in a single experiment to avoid interruptions between participants. They were also asked to focus on their own viewing experience and to remain quiet, not talk to each other, and not use their cell phones during the whole process. After 15 min of viewing, psychological (ROS and SVS) data were recorded again, and the IRCS scale was completed to assess the restorative environmental features of the blue space and green spaces (Figure 7-4).

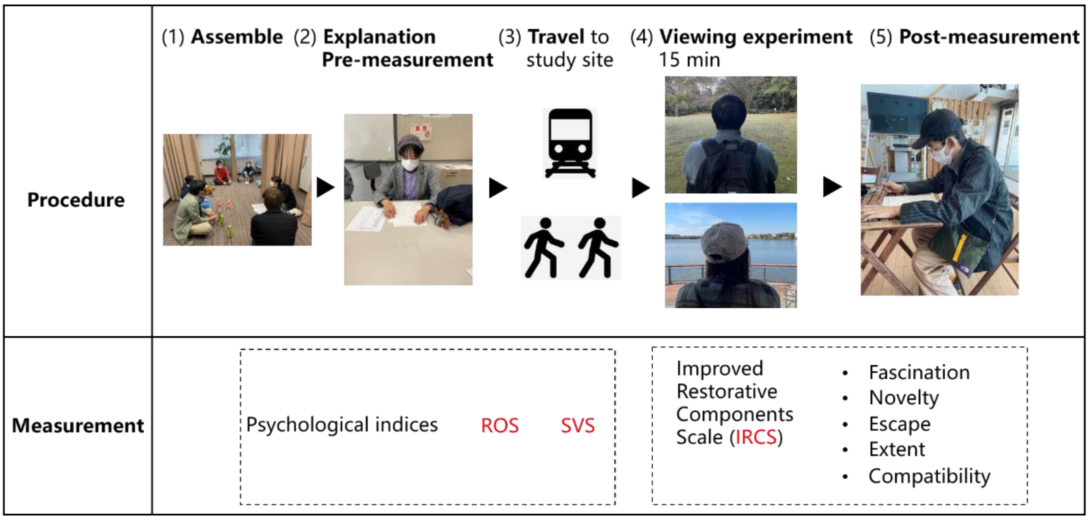


Figure 7-4. Experimental design and procedure of the study

7.1.5 Statistical analysis

SPSS 20.0 software (IBM Corp., Armonk, NY, USA) was used for all analyses. In all experiments, statistical significance was set at $p < 0.05$. The Shapiro-Wilk test was performed to analyze the normality of the data, and the results showed that all data conformed to a normal distribution. Therefore, paired t-tests were used to examine the differences between UBS and UGS data: 1) the differences between UBS and UGS pre-viewing data, 2) the differences between pre- and post-viewing data in UBS, 3) the differences between pre- and post-viewing data in UGS, and 4) the differences between UBS and UGS post-viewing data. In addition, Pearson correlations were calculated for the post-viewing-scale data. Finally, a one-way analysis of variance (ANOVA) was used to calculate the differences between UBS and UGS data on the IRCS to clarify the differences between the two restorative environmental features.

7.2 The study questions

This study aimed to investigate the differences in the physio-psychological restoration between green and blue spaces in urban environments. According to Hartig et al. (2014), interaction with the natural environment can elicit health and restorative outcomes, and simply viewing natural elements (such as trees and plants) or pictures of nature can exhibit measurable positive effects (Grinde & Patil, 2009). In addition, the restorative benefits of viewing behaviors have broader implications, as walking and other physical activities in urban natural environments are less likely than viewing behaviors owing to time constraints, physical barriers, and low accessibility (Yin et al., 2018; Luo et al., 2022).

Thus, the purpose of this study was to investigate the restorative benefits of "viewing" behaviors in urban green and blue spaces, and the IRCS was used to assess the features of both restorative environments.

7.3 Results

7.3.1 Overall statistics

A paired t-test was performed to examine the differences between the pre-viewing data for UBS and UGS, and there were no significant differences in the pre-viewing data for SVS ($t = 1.534$, $p = 0.138$), and ROS ($t = -0.228$, $p = 0.822$).

All data from the two experimental sites are listed in Table 7-4. For all scales, the mean sum scores were calculated, and the scores of the Extent items were calculated in reverse. Cronbach's α values for all scales (SVS, ROS, and IRCS) were positive, ranging 0.74–0.95, with only the Extent being a lower but acceptable reliability score for both sites (Extent (UBS) = 0.65, Extent (UGS) = 0.60), which may be related to the scores being reversed.

Table 7-4. Data from the two experimental sites

Site	Urban Blue Space (N = 25)			Urban Green Space (N = 25)		
Measures	M	SD	Cronbach's α	M	SD	Cronbach's α
Before Viewing (BV)						
SVS	4.25	1.02	0.85	3.86	0.97	0.74
ROS	3.78	0.98	0.87	3.83	0.96	0.85
After Viewing (AV)						
SVS	4.34	1.07	0.84	4.52	0.91	0.79
ROS	5.12	0.92	0.86	5.44	0.95	0.89

Novelty	5.16	1.05	0.77	5.45	1.09	0.77
Escape	5.36	1.24	0.89	5.32	1.18	0.90
Fascination	5.05	1.20	0.92	5.75	0.77	0.83
Extent (reversed)	5.42	0.92	0.65	5.28	0.77	0.60
Compatibility	4.36	1.45	0.95	5.18	1.09	0.90

Abbreviations: M, mean value; SD, standard deviation

7.3.2 Correlation of scale data after viewing

The correlation matrices for the post-viewing-scale data are presented in Tables 7-5 and 7-6. As shown by Table 7-5 (UBS), participants' post-viewing SVS was significantly positively correlated with ROS, Novelty, Escape, and Fascination ($r = 0.486$ [$p < 0.05$]–0.766 [$p < 0.01$]) and was not significantly correlated with Extent or Compatibility. Furthermore, ROS was significantly correlated with all the items except Extent ($r = 0.591$ [$p < 0.01$]–0.861[$p < 0.01$]). Of the five components of the IRCS, the other four components, except Extent, showed significant positive correlations with each other ($r = 0.562$ [$p < 0.01$]–0.714 [$p < 0.01$]).

According to Table 7-6 (UGS), participants' post-viewing SVS was significantly positively correlated with ROS, Novelty, Escape, Fascination, and Compatibility ($r = 0.492$ [$p < 0.05$]–0.833 [$p < 0.01$]) and not significantly correlated with Extent. In addition, ROS was significantly correlated with all items except Extent ($r = 0.510$ [$p < 0.01$]–0.784 [$p < 0.01$]).

For IRCS, most components showed significant positive correlations ($r = 0.408$ [$p < 0.05$]–0.729 [$p < 0.01$]). Extent was significantly correlated only with Compatibility ($r = 0.415$, $p < 0.05$), whereas Compatibility was not significantly correlated with Escape ($r = 0.354$, $p > 0.05$).

Table 7-5. Correlation matrix of the scales (UBS)

After Viewing (UBS)	ROS	Novelty	Escape	Fascination	Extent	Compatibility
SVS	0.766**	0.486*	0.567**	0.731**	-0.076	0.394
ROS	1	0.591**	0.861**	0.796**	0.026	0.663**
Novelty		1	0.604**	0.690**	-0.057	0.562**
Escape			1	0.677**	0.014	0.714**
Fascination				1	-0.129	0.585**
Extent					1	0.086

* $p < 0.05$, ** $p < 0.01$

Table 7-6. Correlation matrix of the scales (UGS)

After Viewing (UGS)	ROS	Novelty	Escape	Fascination	Extent	Compatibility
SVS	0.833**	0.556**	0.540**	0.492*	0.006	0.670**
ROS	1	0.510**	0.622**	0.539**	0.092	0.784**
Novelty		1	0.729**	0.667**	-0.047	0.408*
Escape			1	0.506**	-0.038	0.354
Fascination				1	-0.089	0.518**
Extent					1	0.415*

* $p < 0.05$, ** $p < 0.01$

7.3.3 Effects of two spaces and viewing behaviors on participants' psychological data

Figure 7-5 shows the effects of both spaces and viewing behaviors on the SVS and ROS. For SVS, no significant effect was detected following 15 min of viewing exposure to UBS (before viewing: 4.25 ± 1.02, after viewing: 4.34 ± 1.07, $t = -0.516$, $p = 0.611$), whereas SVS was significantly increased following viewing in UGS (before viewing: 3.86 ± 0.97, after viewing: 4.52 ± 0.91, $t = -3.495$, $p = 0.002$). However, there was no significant difference in SVS values between the two experimental settings ($t = -0.885$, $p = 0.385$).

Moreover, viewing behavior in both experimental settings significantly increased ROS (UBS, before viewing: 3.78 ± 0.98, after viewing: 5.12 ± 0.92, $t = -5.819$, $p < 0.001$; UGS, before viewing: 3.83 ± 0.96, after viewing: 5.44 ± 0.95, $t = -6.686$, $p < 0.001$), whereas UBS and UGS had no significant differences in post-viewing ROS values ($t = -1.906$, $p = 0.069$).

This result suggests that sitting in both spaces for 15 min of viewing significantly enhances the feeling of perceived restoration; 15 min of viewing in the UGS significantly enhanced participants' SVS.

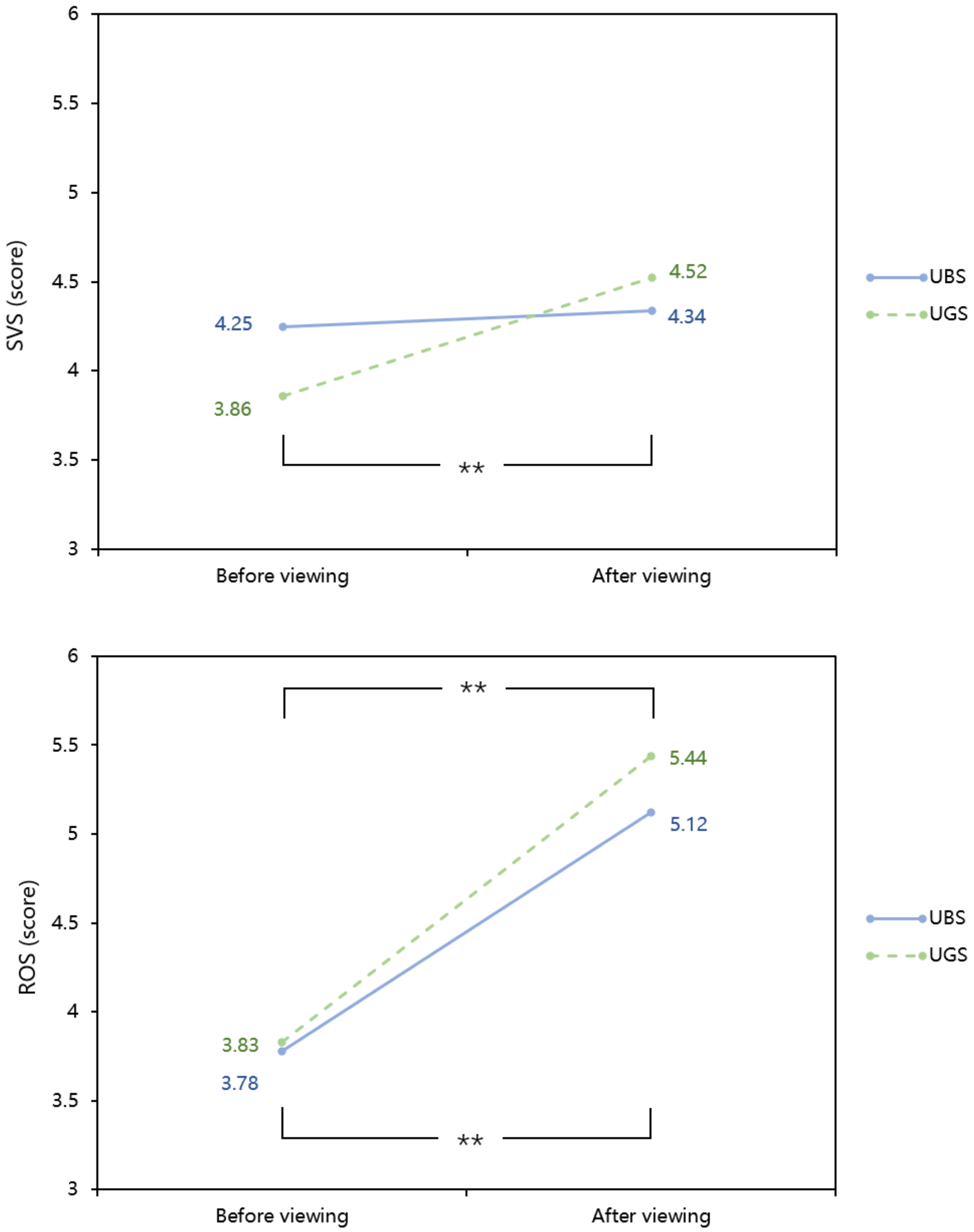


Figure. 7-5 Comparison of SVS and ROS before and after viewing in UBS and UGS

7.3.4 Differences in restorative environmental features between UBS and UGS

To compare the differences between UBS and UGS in terms of restorative environmental features, a one-way ANOVA was performed on the five components of the IRCS. Figure 7-6 shows the restorative features perceived by the experimental participants in each of the two restorative environmental settings. Specifically, the five environmental restorative features were strongly perceived by most participants in both environmental settings, as all the scores exceeded 4. However, Compatibility scored the lowest among the five components in both UBS and UGS (M_{UBS} = 4.36, M_{UGS} = 5.18). UBS scored higher than UGS on components Escape (5.36 ± 1.24) and Extent (5.42 ± 0.92), but not significantly ($p > 0.05$). UGS scored higher than UGS on Novelty (5.45 ± 1.09), Fascination (5.75 ± 0.77), and Compatibility (5.18 ± 1.09), but the difference in Novelty was not significant ($p > 0.05$). Overall, the results indicate that most participants agreed that UBS and UGS were restorative environments and that higher levels of Fascination and Compatibility attributes were perceived in UGS, leading to UGS generally providing a stronger restorative experience.

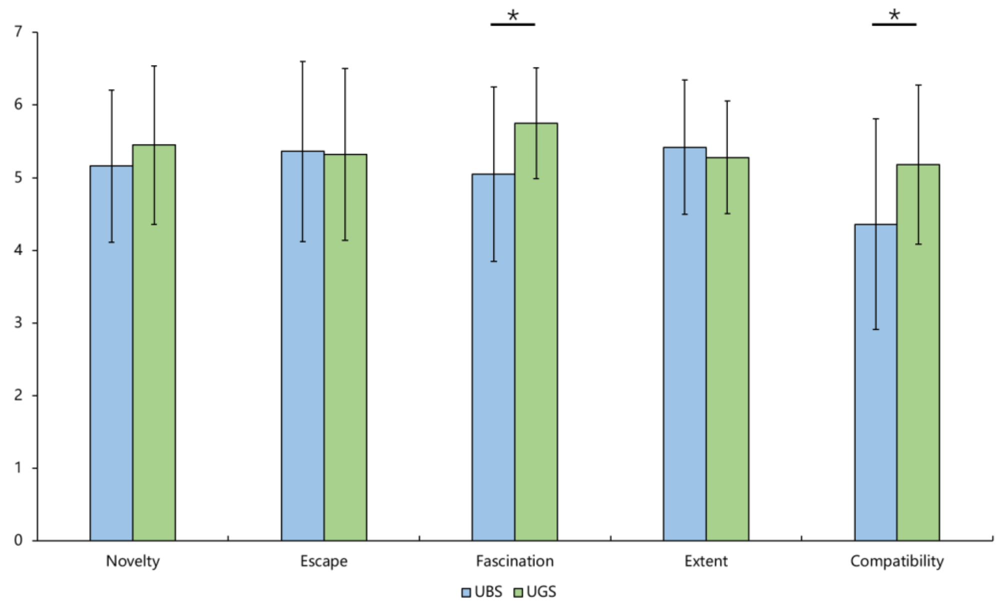


Fig. 7-6 Differences in restorative environmental features between UBS and UGS; * $p < 0.05$.

7.4 Discussion

7.4.1 General discussion

The current study investigated the psychological recovery outcomes of 15 min of viewing in urban blue and green spaces through a field experiment. Consistent with previous studies (Lin et al., 2019; Bielinis et al., 2018), room conditions were used as a pre-experimental setting before entering the viewing location to avoid early exposure to the experimental environment. In addition, UGS (urban parks) and UBS (urban lakes) were chosen because they allow visitors to fully immerse themselves in green and blue environments, which enhances the scientific validity and reliability of this study. The results of the paired t-test indicated that there was no significant difference in any measurement statistics between the pre-experimental UBS and UGS participants, suggesting that the after-viewing data in the two experimental settings could be used for comparison.

7.4.2 Psychological restorative effects of viewing in UBS and UGS

In terms of psychological recovery, SVS and ROS were measured before and after participant viewing, using a psychological questionnaire. For SVS, only the 15 min viewing in UGS significantly improved participants' SVS, while no significant change was found for viewing in UBS. This result indicates that exposure to 15 min of viewing in a green space was effective in improving positive mental states, which is consistent with the findings of Tyrväinen et al. (2014) and Simkin et al. (2020). Furthermore, viewing in both UBS and UGS significantly improved participants' ROS after viewing, suggesting that viewing for 15 min while sitting in both spaces significantly improves the perception of perceived restoration. This result is consistent with previous findings for blue spaces (White et al., 2010; Zhang et al., 2021b; Gidlow et al., 2016) and green spaces (Liu et al., 2021; Tyrväinen et al., 2014; Simkin et al., 2020).

In summary, 15 min viewing in the UGS significantly enhanced the SVS compared to the UBS, which indicates that green space has a stronger effect on the improvement of subjective vitality. Moreover, both spaces were effective in enhancing participants' perceptions of perceived restoration, and no significant differences were found between the post-viewing ROS. These empirical results provide fundamental insight into the management and utilization of urban UBS and UGS in the future. Further analysis of the differences in restorative environmental features between UBS and UGS is performed in the next section.

7.4.3 Restorative environmental features of UBS and UGS and the differences

According to previous studies, the psychological effects triggered by restorative environmental features need to be explained in relation to environmental psychological theories (Lin et al., 2019; Pals et al., 2009; White et al., 2010), such as ART (Kaplan, 2001) and stress reduction theory (Ulrich et al., 1991). In addition, evidence-based medical findings can help explain the differences in the restorative qualities of the two spaces.

Figure 7-7 Restoration differences between UBS and UGS.

First, according to Park et al. (2011) and Tsunetsugu et al. (2010), green natural environments (such as forests) trigger recovery and relaxation in humans because of their scenery (visual), smell of wood (olfactory), and rustling of leaves (auditory). The UGS in our experiment was an urban park, and the viewing site where the participants were located was surrounded by a forest completely immersed in greenery. Additionally, during the exposure, the participants smelled the trees and heard the wind blowing through the plants, which led to a more intense relaxation experience. In contrast, the UBS was a large man-made lake. Unlike the coastal environment, the smell of water was almost non-existent, and the still body of water could barely be heard as a wave-like lapping sound, leading to a single-sensory restorative stimulus where participants could experience restoration only by viewing the water body (visual) (Figure 7-7).

According to the IRCS (Figure 7-6), most participants strongly perceived the restorative features of the five environments in both settings, as all scores exceeded 4, indicating that most participants agreed that the UBS and UGS were restorative environments. However, UGS scored significantly higher than UBS in both the Fascination and Compatibility dimensions, indicating higher attractiveness and compatibility attributes of UGS.

The Fascination dimension indicates that the scene can effortlessly attract attention, whereas fatigue is usually associated with effortful "voluntary" attention (also called "directed attention") (Kaplan, 1995). Humans have spent more than 99.99% of their evolutionary history in natural environments; therefore, the human body is designed to adapt to nature (Song et al., 2017). Research has shown that people respond most positively to fractal images with fractal dimensions that are common in nature, suggesting that the visual system may be suitable for processing natural information (Taylor et al., 2011). The inhibition system is not activated when viewing natural scenes and people easily move from one feature to another (Berto et al., 2008). Furthermore, natural environments tend to be characterized by a moderate degree of visual complexity, which seems to be a suitable approach for moderate pleasing eye appeal (Van den Berg et al., 2016). Thus, when viewed in the UGS, the fractal complexity of plants leads to green elements (such as lawns and forests) that can trigger a stronger "soft fascination" than flat water surfaces (Figure 7-8).

The Compatibility dimension is an important feature of restorative environments, representing human-environmental fit, which is high if an environment allows people to be inclined or feel the desire to do certain things (Kaplan, 2001; Pals et al., 2009). Packer and Bond (2010) found that among places considered restorative, art galleries, aquariums, and museums have higher compatibility because they provide recreational activities and interactive experiences, such as viewing exhibits and encountering animals closely. In the present study, the viewers in the UGS had a large lawn in front of them, which allowed them to imagine some recreational activities in the green space, such as sitting on the lawn to rest, picnicking, and playing badminton, whereas the UBS was a large man-made lake that is usually only accessible to visitors for viewing and lacks physical interaction. Thus, potentially providing recreational activities and interactions is important for an environment to be more restorative (Luo et al., 2021), which is in agreement with the findings of Gao et al. (2019). Blue spaces are typically less restorative than green spaces because participants can only watch and not interact with the environment in a physical way, which can influence the restoration effect (Figure 7-9).

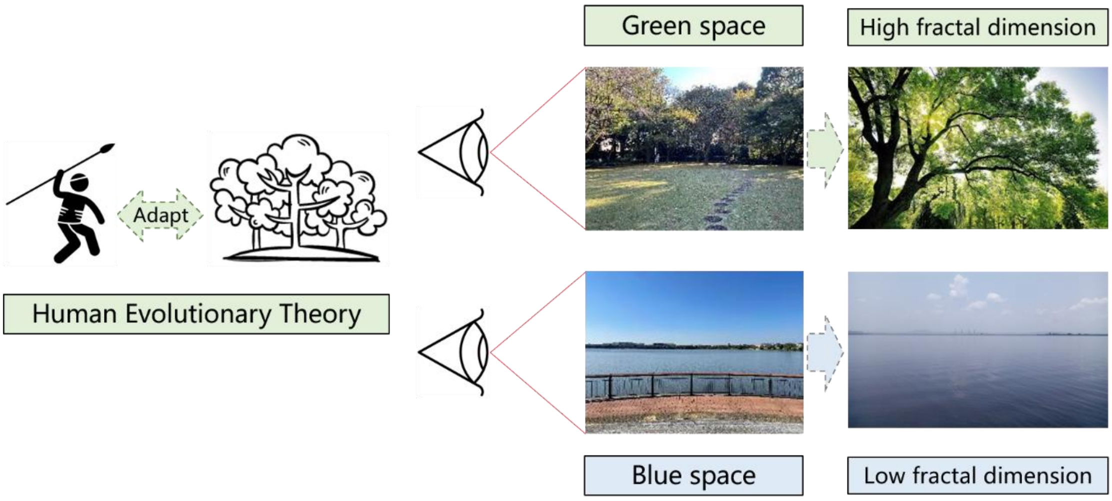


Figure 7-8 The fractal complexity of plants leads to stronger recovery.

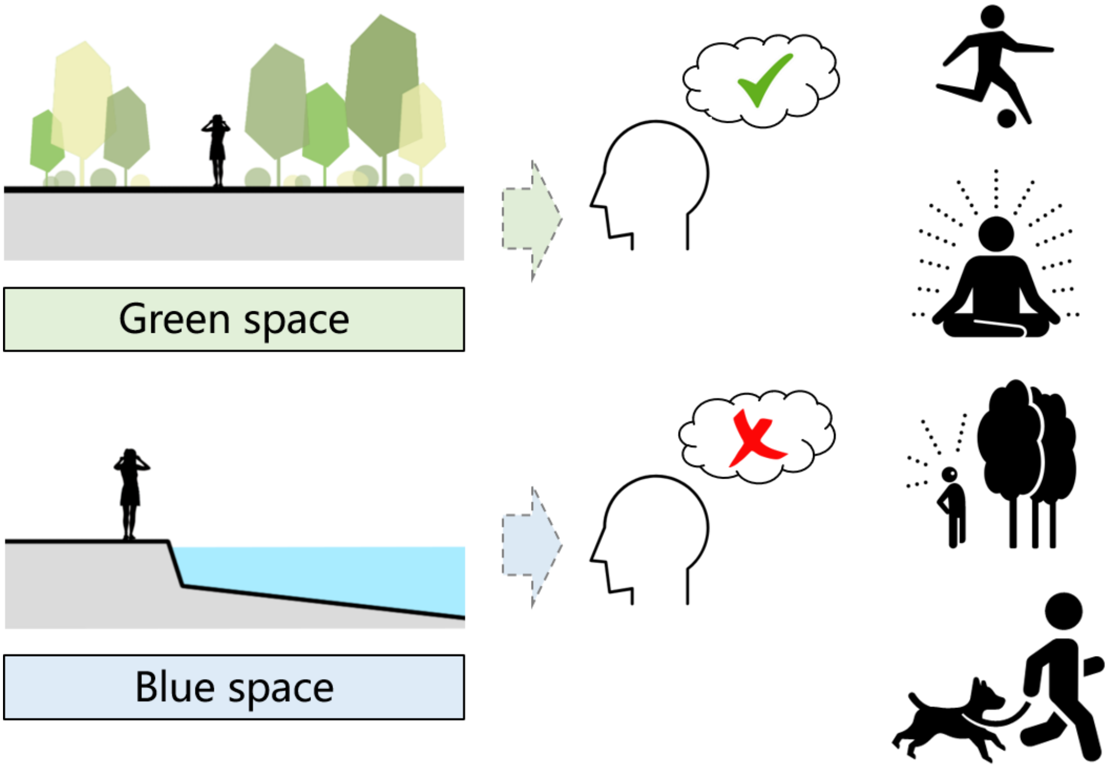


Figure 7-9 Potentially providing recreational activities and interactions is important for an environment to be more restorative.

7.4.4 Theoretical and practical implications

The findings of this study have several theoretical and practical implications. First, in terms of theoretical contributions, responses and measurements in real environments are ecologically more valid (Gidlow et al., 2016) and there is still a lack of such evidence. Therefore, as an empirical study, these results contribute to our understanding of how blue and green spaces in real urban environments provide direct health benefits. Second, with regard to existing research (Gidlow et al., 2016), this study focused on a "pure" blue environment (a large artificial lake that allows for complete immersion in blue) in a blue space setting, enhancing the scientific validity and reliability of the comparison results. Third, to the authors' knowledge, an empirical study has been conducted for the first time to systematically compare restorative differences (psychological recovery) between blue and green spaces, as well as differences in restorative environmental features.

In terms of practical implications, first, UGS are effective in promoting SVS, which is important for maintaining well-being and reducing anxiety (Arslan et al., 2020). Therefore, city managers and healthcare providers should develop health promotion and interventions according to the health status of the target population. Second, 15 minutes of viewing in both blue and green spaces has been shown to provide significant psychological benefits, suggesting that office workers or hospitalized patients (those who must stay indoors for long periods of time) can also have a restorative experience through short periods of exposure behavior (15 minutes of viewing or walking) (Tsunetsugu et al., 2013). Third, the allocation and utilization of accessible green and blue spaces in cities should be emphasized. In particular, it is essential to increase the number of recreational activities and interactions associated with blue spaces, such as bird, fish, and aquatic plant viewing, creating "Blueway" to support waterfront running and walking, planning water-friendly platforms that facilitate outdoor activities, and developing water-based activities related to environmental education (Zhang et al., 2021b). Fourth, although it is difficult to make water bodies smell pleasant, it is beneficial to maintain the water quality to avoid odors. Fifth, using speakers to apply appropriate water flow sounds around specific blue spaces can enhance visitors' restoration experience (Wang & Zhao, 2019).

7.5 Limitation

The last experiment also had some limitations that should be considered in future studies. First, to fully immerse participants in blue and green environments, we selected only two experimental sites: an urban park and a large artificial lake. However, according to previous studies (Dzhambov et al., 2018; White et al., 2010; Jiang et al., 2014), different doses of "blue" and "green" lead to different restorative experiences; therefore, more empirical research is needed to analyze the restorative benefits of different blue and green spaces. Second, season-specific investigations are relevant, with studies showing (Bielinis et al., 2018) that viewing forests in winter can have psychological benefits; similarly, studies on the health benefits of viewing lakes (frozen water) in winter are valuable for public health in certain regions/municipalities with prolonged cold climates. Third, our study involved only passive viewing. Examining the potential medical effects of active behaviors in different settings (e.g., physical activity in blue and green environments) would be valuable for evidence-based medicine. Fourth, physical contact with bodies of water (Tanja-Dijkstra et al., 2018) as well as with plants (Ikei et al., 2017) through touch may lead to different recovery experiences. Further research is required in the future.

Chapter 8 Conclusions and Limitations

8.1 Conclusions

8.1.1 The benefit of green experience in urban park pavilions

Urban parks are essential components of healthy urban environments. However, most research exploring these spaces is generalized and lacks focus-specific settings. The first study used VR equipment to simulate the experience of sitting in a pavilion of an urban park to evaluate different pavilion settings' preferences and mental restoration. The results showed that viewing these environmental settings through VR effectively promoted mental recovery. The enclosure of the pavilion did not significantly affect people's preferences and perceived recovery in this environment. The dimensions of prospect and serene significantly influenced preferences; for mental restoration, the richness of species and serene were significant predictors. Therefore, the results of this study suggest that:

1) a lower prospect may mean a weakened sense of security and lesser preference for users sitting and resting in this environment;

2) creating a tranquil atmosphere free from external interference is important for a restorative environment;

and 3) the abundance of flora and fauna can provide users with more opportunities to interact with natural elements, thus promoting well-being and recovery. In addition, the results indicated that providing visitors with a space to sit, rest, socialize, read, and view the scenery can help in the development of preference environment settings.

Therefore, urban park managers could consider adding elements such as dense vegetation, water bodies, and meadows to these environments to build a generalized preference and restorative environment setting. If the balance with nature is maintained, artificial elements such as buildings and roads can also be appreciated by visitors. Finally, the results demonstrated that it would be feasible to use VR to simulate pavilion settings and other resting environments in urban parks for relaxation and recovery.

8.1.2 The green experience in classical garden road settings

Roads are the most important components for people to explore green spaces. However, studies on green spaces disregard these crucial components, namely visitors' perceived preferences and the restoration of road settings. In the second research, a field questionnaire was used to collect a sample of 73 visitors for each road setting, and the PSDs, preferences, and mental restoration of 10 different classical garden road settings were analyzed. The results indicate that:

(1) for preference, some culture-related artificial elements will have a stronger influence than natural elements in the following order: tree > lawn > path > fence > shrub > wall > decoration > building; in terms of restoration, the artificial landscape elements of road settings can also significantly and positively influence mental restoration but are all weaker than the natural elements as follows: tree > lawn > shrub > fence > path > decoration;

(2) in the road settings of classical gardens, serene is the most perceived dimension, followed by nature, refuge, culture, richness in species, and space.

(3) Nature, culture, space, refuge, and serene were found to be important dimensions of mental restoration and preference. Furthermore, this study is the first to apply PSDs to analyze different road settings in classical Chinese gardens. Finally, it is demonstrated that PSDs can be effectively applied to specific settings and objects in urban green spaces based on visitors' perception level of eight sensory dimensions.

8.1.3 Preferences and mental health benefits of Urban Park Blue Spaces

Urban parks are essential parts of a city's natural environment and provide residents with daily healthy places. The blue space in urban parks needs to be emphasized as an important dimension to promote visitors' physical and mental health. The results of third study provide valuable clues for enhancing the aesthetic quality and restorative potential of UPBS. In general, a water body with good water quality and natural visual form may be more attractive and have restorative potential. Furthermore, blue spaces with high vegetation diversity are preferred, and artificial elements should be evaluated more carefully when added to the scene to avoid disharmony and conflict with the surrounding environment (such as old buildings, stone walls, or stone bridges). In practical design, the proportions of plants, buildings, topographical changes, and water should be coordinated to maintain the heterogeneity of the landscape. Moreover, this study indicates that UPBS can provide more leisure activities and interactions for better recovery. Finally, designers need to emphasize the balance of natural and man-made elements to enhance the visual quality of the water feature.

In terms of possible future studies, samples from larger populations are still needed to enhance the generalizability of this study. Multisensory (auditory, olfactory) stimuli could be considered to create a more immersive laboratory environment. In addition, more types (more landscape features) of UPBS need to be considered for evaluation in future research.

This study indicates that landscape characteristics and landscape elements for restorative experience should be emphasized when designing blue spaces in urban parks. Furthermore, as an essential part of the urban natural environment and a daily healthy place for residents, this initiative may be useful for improving the urban population's quality of life by utilizing the positive impact of blue space on health.

8.1.4 The relationship between the environmental quality of urban blue spaces and user preferences

The fourth study discussed the association between the environmental quality of urban blue spaces and user preferences through the results of a field survey on three UBS with different environmental characteristics. By referring to previous studies, two scales were used to measure users' perceived levels of physical and aesthetic quality of the UBS, and the reliability results indicated that the settings of the nine components were acceptable.

Furthermore, we found that four components had a significant effect on the environmental preferences of UBS, with Artificial Elements having the highest effect, while Harmony and Mystery had a medium effect, and Water Conditions had the least effect. Based on the survey methodology of this study, we can identify the preferred blue spaces in the city and the critical environmental components that influence the preference. Additionally, the results of the study can help us understand how to effectively utilize these natural capitals in cities and provide guidance for the environmental design of blue spaces. More importantly, city managers, policy makers, planners and designers can all benefit from the findings.

8.1.5 Restoration potential and restorative environmental features of urban blue and green spaces

In the field of medicine, there is a current trend to incorporate scientific evidence into clinical practice, making evidence-based medicine possible (Tsunetsugu et al., 2013). Furthermore, a better understanding of the health benefits of urban natural resources is critical for future urban development, and it is important to work with land users and planners to translate this knowledge into planning guidelines and specifications. Scientific data that provide concrete evidence of specific effects should be considered when designing and planning healthy urban environments. The last experiment investigated the restorative benefits of "viewing" behaviors in UBS and UGS through an empirical study, and compared the features of the two restorative environments using IRCS. Specifically, the findings indicate that:

1) 15 min of viewing in UGS significantly enhanced SVS, whereas the improvement in UBS was not significant;

2) UGS exhibited higher Fascination and Compatibility properties;

3) the restorative experience in UGS was multisensory, resulting in a stronger restorative effect;

and 4) the results of the analysis revealed how restorative experiences in UBS could be enhanced. These results have both theoretical and practical value.

8.1.6 General conclusions of the doctoral thesis

Urban green and blue spaces have many health and aesthetic benefits that have been highlighted in previous studies. However, most of the current research is general and there is still relatively little research addressing specific blue (e.g., urban park blue spaces) and green spaces (e.g., specific green environmental settings in urban parks) in cities. A variety of specific green spaces in cities have health benefits that are worth discussing. In densely populated and congested cities, urban parks (as part of urban nature) are valuable to citizens and visitors. However, most of these studies have focused on exploring general aspects of urban parks (i.e., in parks) and not on specific resting environment settings. Furthermore, the health benefits of blue spaces as restorative environments have been found. However, most of the current research on blue space focuses on city/regional level population survey data. There is still a lack of studies on the health outcomes of specific blue spaces in urban environments (like urban park blue spaces). Moreover, although studies have begun to link green and blue spaces, these studies are still discussed in the context of macro-based perspectives such as distance, residential blue and green accessibility, perceived neighborhood blue and green, and the Blue-Green Space Landscape Pattern Index. There is still a lack of empirical evidence from field experiments, which is necessary to increase our understanding of how blue and green spaces in real urban environments provide direct health benefits.

This thesis discusses the mental recovery and preference of specific green and blue spaces in urban environments through five experiments: The first study used virtual reality to create a simulation of people sitting in a pavilion, to evaluate the preferences and mental restoration of nine pavilions in Tokyo. The results showed that VR viewing effectively promoted mental restoration. The enclosure of the pavilion did not significantly affect people's preferences and perceived mental restoration in the environment setting. Moreover, the regression analysis revealed that the prospect and serene dimensions significantly influenced preferences; for restoration, the dimensions of “richness in species” and “serene” were significant predictors. The second study used the Du Fu Thatched Cottage Museum as the subject region and employed a convenience sampling method to analyze the preference and mental restoration of different road settings of Chinese classical gardens. According to the findings, the majority of visitors felt that the road settings in these classical gardens provided psychological recovery, and half of the roads received a preference score of five or above. The regression results indicated that nature, culture, space, refuge, and serene were found to be important predictive dimensions for both mental restoration and preference. The third experiment involving 10 different urban park blue spaces in Huanhuaxi park was conducted to assess urban park blue spaces’ aesthetic preference and restorative potential. The results indicated that (1) a water body with good water quality and natural visual form may be more attractive and have restorative potential; (2) blue spaces with high vegetation diversity are preferred, and artificial elements should be evaluated more carefully when added to the scene to avoid disharmony and conflict with the surrounding environment; (3) in practical design, the proportions of plants, buildings, topographical changes, and water should be coordinated to maintain the blue space’s landscape heterogeneity; (4) more leisure activities and interactions should be considered for better recovery; and (5) designers need to emphasize the balance of natural and man-made elements to enhance the visual quality of the water feature. The fourth study involved a field survey of blue spaces in three cities. In this survey, users' perceptions of the environmental quality (physical and aesthetic quality) of each blue space were assessed using a questionnaire. Afterwards, a regression model between the environmental quality of the blue spaces and the users' preferences was developed. The last study empirically investigated the restorative benefits of “viewing” behaviors in urban blue spaces and urban green spaces and compared the features of the two restorative environments using the Improved Restorative Components Scale. The results showed that: 1) 15 min viewing in UGS significantly enhanced subjective vitality, while the improved results in UBS were not significant; 2) UGS exhibited higher Fascination and Compatibility attributes; 3) the restorative experience in UGS was multisensory, leading to a stronger restorative effect; and 4) the results of the analysis revealed that the restorative experience of UBS could be enhanced. These findings increase understanding of how specific blue and green spaces in urban environments provide direct health benefits, and have theoretical and practical value for the future design and planning of "healthy cities".

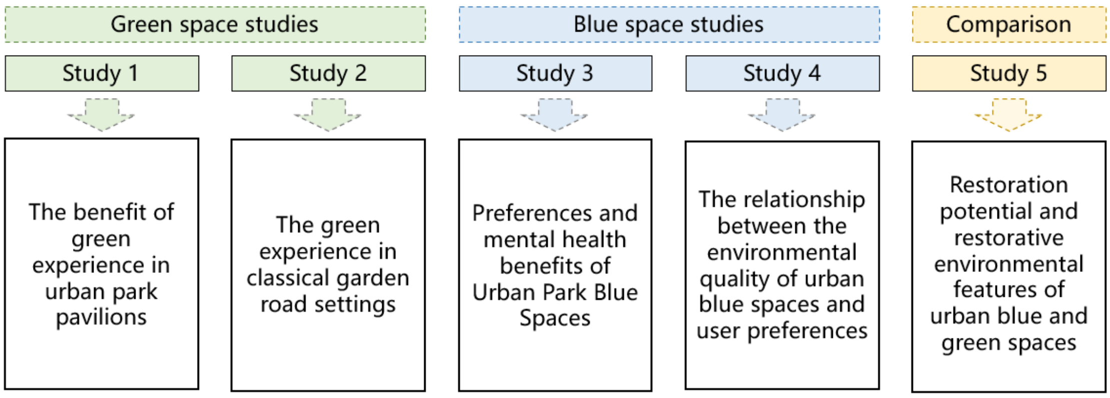


Figure 8-1. The general conclusion of the doctoral thesis

8.2 Limitations of the doctoral thesis

Overall, this doctoral thesis has some limitations and shortcomings.

First, the urban green spaces in the thesis investigate only the green environment settings in urban parks. There are many different kinds and functions of green spaces in urban environments, and the aesthetic preferences and mental restoration of these green spaces may differ.

Second, similarly, for the urban blue spaces, only a limited study sample (mostly freshwater environments) was selected for investigation. Unlike coastal environments, the public's aesthetic response to marine blue spaces and the perception of mental restoration are different.

Third, none of the five studies considered the bias introduced by the different attributes of the experimental subjects (country, cultural background). Future studies could consider investigating volunteers of different nationalities and cultural backgrounds. Furthermore, although the fifth experiment (blue space vs. green space) collected data on environmental conditions, no statistical analysis was conducted to compare variability, which may create some potential bias.

Fourth, the sample size was small due to the cost constraints of the study.

Besides, most of the experiments recruited only student samples, which may lead to limitations in the significance of the study. A new round of experiments targeting residents and the general public would be valuable.

Finally, the current data analysis is insufficient due to writing time constraints. In future studies, I will continue to perform larger analyses to report additional findings.

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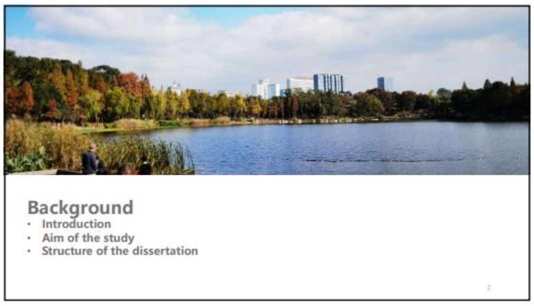
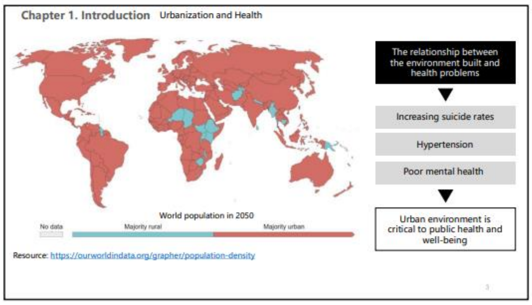
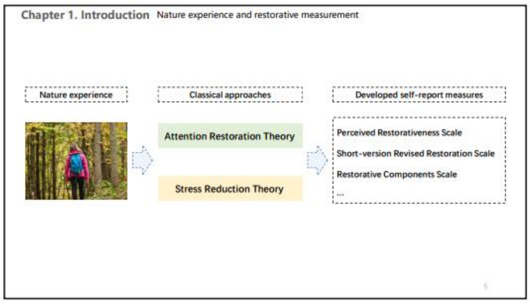
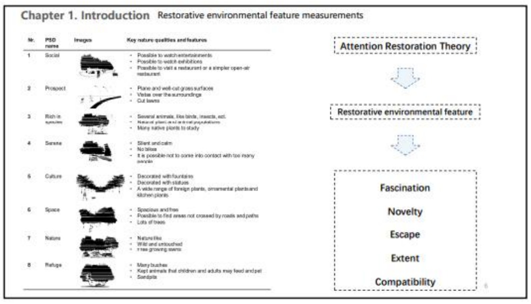
Appendix

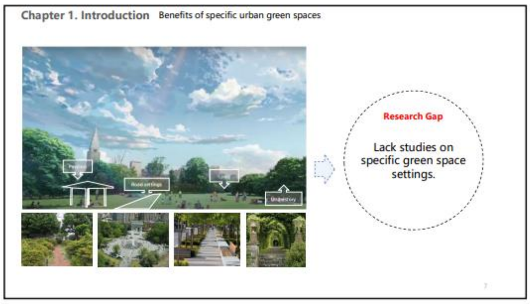
The following slides were used in the doctoral defense:

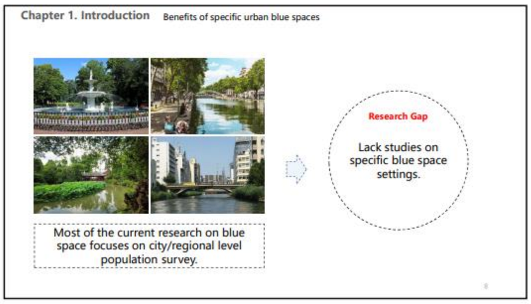


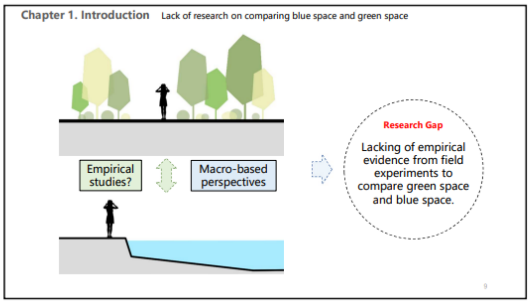


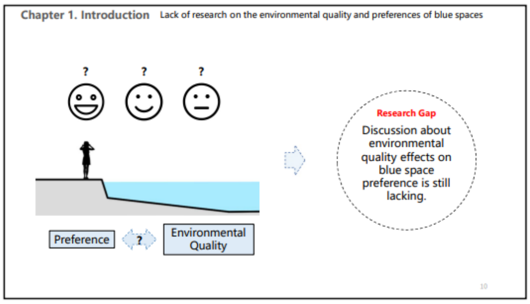












Chapter 1. Introduction-Aim of study

Urban green and blue spaces have many health and aesthetic benefits that have been highlighted in previous studies. However, most of the current research is **general** and there is still relatively little research addressing **specific blue** (e.g., urban park blue spaces) and **green spaces** (e.g., specific green environmental settings in urban parks) in cities.

a) To study the **preference** and **mental restoration** of **specific urban green space** settings, and the factors that influence them. **[Study 1 and Study 2]**

b) To study the **preference and mental restoration** of **specific urban blue space** settings, and the factors that influence them. **[Study 3]**

c) To identify the **physical and aesthetic environmental components** that significantly influence the perceived **preference for urban blue space**. **[Study 4]**

d) Compare the **difference** in mental restoration between **urban blue space and urban green space**, and the difference in restorative environmental features. **[Study 5]**

Chapter 1. Introduction-Structure of the dissertation

A Study of Mental Restoration and Preferences for Specific Urban Blue and Green Spaces

Chapter 1. Introduction
Background; Aim of study; Structure

Chapter 2. Methodology
Study method and procedure

Chapter 3-7. Results and Discussion
I. Chapter 3, Study 1
II. Chapter 4, Study 2
III. Chapter 5, Study 3
IV. Chapter 6, Study 4
V. Chapter 7, Study 5

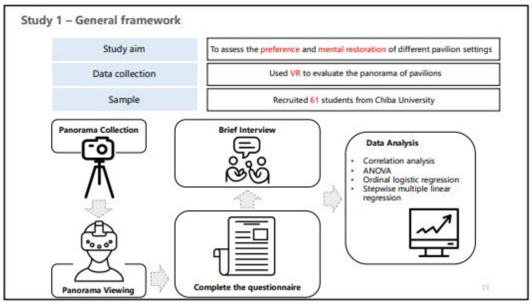
Chapter 8. Conclusion and Limitations
General discussion, limitations, and further works

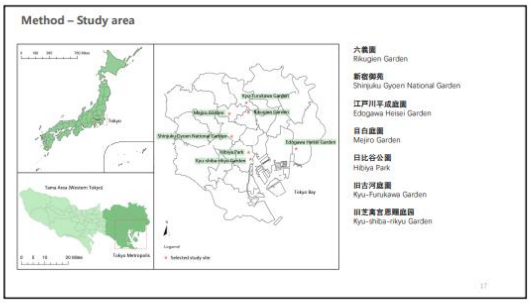
Related journal articles:

1. Luo, S., Shi, J., Lu, T., & Furuya, K. (2022). Sit down and rest: Use of virtual reality to evaluate preferences and mental restoration in urban park pavilions. *Landscape and Urban Planning*, 220, 104336.
2. Xie, J., Luo, S., Furuya, K., Kagawa, T., & Yang, M. (2022). A Preferred Road to Mental Restoration in the Chinese Classical Garden. *Sustainability*, 14(8), 4422.
3. Luo, S., Xie, J., & Furuya, K. (2021). Assessing the Preference and Restorative Potential of Urban Park Blue Space. *Land*, 10(11), 1233.
4. Luo, S., Xie, J., Xiang, Q., Kagawa, T., & Furuya, K. (2022). Blue water or green trees? Empirical study comparing restoration potential and restorative environmental features of urban blue and green spaces. *Urban Forestry & Urban Greening*. (Under Review)
5. Luo, S., Xie, J., Furuya, K. (2022). Effects of perceived physical and aesthetic quality of urban blue spaces on user preferences. *Journal of Outdoor Recreation and Tourism*. (With Editor)

Chapter 1. Introduction-Profile of the five studies

Item	Study 1	Study 2	Study 3	Study 4	Study 5
Aim	To assess the preference and mental restoration of different pavilion settings	To assess the preference and mental restoration of different road settings	To assess the preference and mental restoration of urban park blue spaces	To identify the physical and aesthetic environmental components that significantly influence the perceived preference for urban blue space	Compare the difference in mental restoration between urban blue space and urban green space
Data Collection	Used VR to evaluate the panorama of pavilions	On-site questionnaire survey	Photo-elicitation method	On-site questionnaire survey	On-site survey
Sample	61 students from Chiba University	730 visitors from the study area	93 students from Sichuan Agricultural University	Recruited 25 students from Chiba University	Recruited 25 students from Chiba University
Data Analysis	• Correlation analysis • ANOVA • Ordinal logistic regression • Stepwise multiple linear regression	• Data statistics • Correlation analysis • Stepwise multiple linear regression	• Mann–Whitney U test • Kruskal–Wallis H test • Stepwise multiple linear regression • Correlation analysis	• ANOVA • Cohen's d • Pearson correlation • Multiple linear regression analyses	• Shapiro-Wilk test • Paired t-test • Pearson correlations • ANOVA

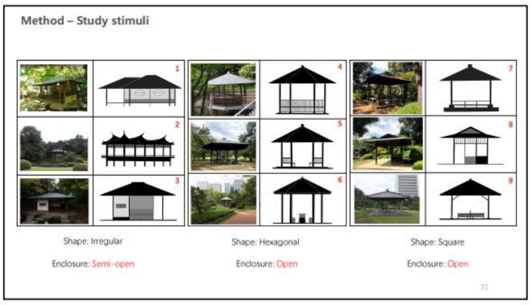


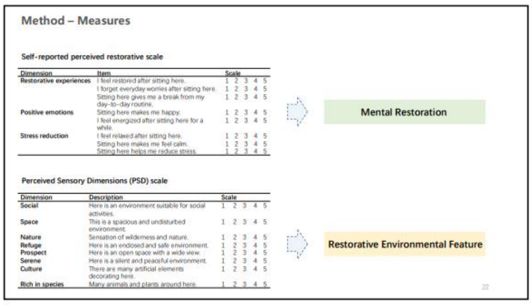

Method – Study area
六義園
Rikugien Garden
新宿御苑
Shinjuku Gyoen National Garden
江戸川平成庭園
Edogawa Heisei Garden
目白庭園
Mejiro Garden
日比谷公園
Hibiya Park
旧古河庭園
Kyu-Furukawa Garden
旧芝離宮恩賜庭園
Kyu-shiba-rikyu Garden

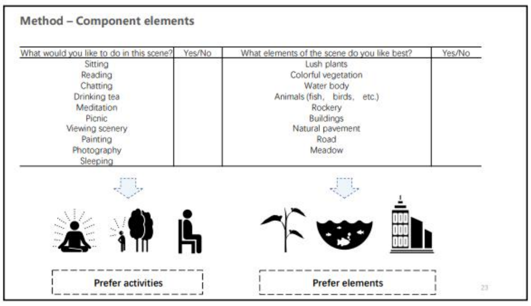

Method – Study stimuli
Rikugien Garden
Shinjuku Gyoen National Garden
Edogawa Heisei Garden
Mejiro Garden
Hibiya Park
Kyu-Furukawa Garden
Kyu-shiba-rikyu Garden

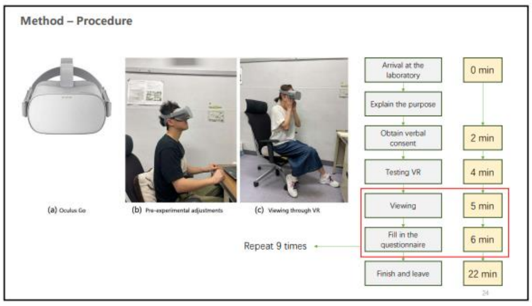

Method – Study stimuli


Method – Study stimuli


Method – Study stimuli
Shape: Irregular
Enclosure: Semi-open
Shape: Hexagonal
Enclosure: Open
Shape: Square
Enclosure: Open


Method – Measures
Self-reported perceived restorative scale
Dimension
Item
Scale
Restorative experiences
I feel restored after sitting here. 1 2 3 4 5
I forget everyday worries after sitting here. 1 2 3 4 5
Sitting here gives me a break from my day-to-day routine. 1 2 3 4 5
Positive emotions
Sitting here makes me happy. 1 2 3 4 5
I feel energized after sitting here for a while. 1 2 3 4 5
Stress reduction
I feel relaxed after sitting here. 1 2 3 4 5
Sitting here makes me feel calm. 1 2 3 4 5
Sitting here helps me reduce stress. 1 2 3 4 5
Mental Restoration
Perceived Sensory Dimensions (PSD) scale
Dimension
Description
Scale
Social
Here is an environment suitable for social activities. 1 2 3 4 5
Space
This is a spacious and undisturbed environment. 1 2 3 4 5
Nature
Sensation of wilderness and nature. 1 2 3 4 5
Refuge
Here is an enclosed and safe environment. 1 2 3 4 5
Prospect
Here is an open space with a wide view. 1 2 3 4 5
Serene
Here is a silent and peaceful environment. 1 2 3 4 5
Culture
There are many artificial elements decorating here. 1 2 3 4 5
Rich in species
Many animals and plants around here. 1 2 3 4 5
Restorative Environmental Feature


Method – Component elements
What would you like to do in this scene?
Yes/No
Sitting
Reading
Chatting
Drinking tea
Meditation
Picnic
Viewing scenery
Painting
Photography
Sleeping
What elements of the scene do you like best?
Yes/No
Lush plants
Colorful vegetation
Water body
Animals (fish, birds, etc.)
Rockery
Buildings
Natural pavement
Road
Meadow
Prefer activities
Prefer elements


Method – Procedure
(a) Oculus Go
(b) Pre-experimental adjustments
(c) Viewing through VR
Arrival at the laboratory
0 min
Explain the purpose
Obtain verbal consent
2 min
Testing VR
4 min
Viewing
5 min
Fill in the questionnaire
6 min
Repeat 9 times
Finish and leave
22 min

Method – Data analysis

1. The experimental data were compiled and statistically analyzed using Excel software. Correlation analysis was used to examine the relationship between restoration, preference, and PSD.

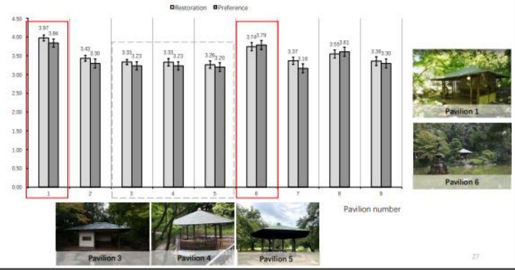
2. Further, according to the degree of enclosure, pavilions were divided into two categories in the following analysis: semi-open (pavilions 1-3) and open (pavilions 4-9). A one-way analysis of variance was performed to examine the difference between the open and semi-open pavilions.

3. In addition, ordinal logistic regression was used to analyze the correlation between PSD and enclosure, and the results were presented as odds ratios (ORs) with 95% confidence intervals.

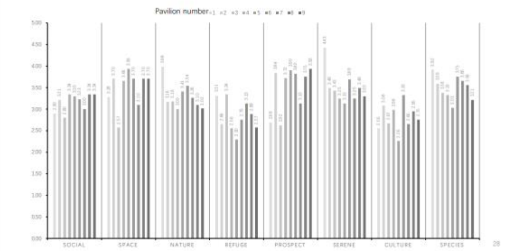
4. Finally, stepwise multiple linear regression analysis was used to explore PSD predictors that affect mental restoration and preference.

All statistical analyses were performed using SPSS (version 20.0; SPSS Inc., Chicago, IL, USA), and the level of significance was set at < 0.05. The effect size was measured by **Cohen's d**, which indicated that the d values of the small (0.2), medium (0.5), and large (0.8) effect quantities.

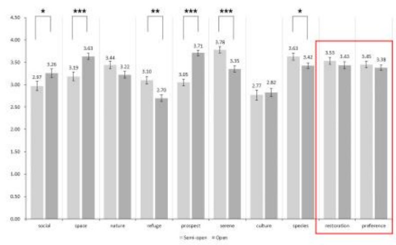
Results – Overall evaluation



Results – Overall evaluation



Results – Difference between open and semi-open pavilions



Results – Difference between open and semi-open pavilions

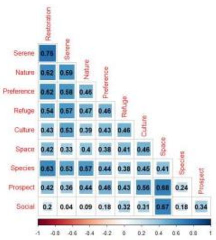
- Open pavilions were more likely to perceive the prospect dimension;
- Semi-open pavilions were more likely to perceive the dimension of Serene

Table. Ordinal logistic regression

PSD	B	Standard error	OR	95% C.I.	Sig.
Social	0.172	0.130	1.188	(0.922-1.532)	0.184
Space	0.271	0.166	1.311	(0.946-1.817)	0.103
Nature	-0.197	0.143	0.821	(0.620-1.088)	0.170
Refuge	-0.201	0.132	0.818	(0.631-1.059)	0.127
Prospect	0.702	0.161	**2.018**	(1.473-2.765)	**<0.001**
Serene	-0.538	0.172	**0.584**	(0.417-0.818)	**0.002**
Culture	-0.055	0.130	0.947	(0.734-1.222)	0.675
Rich in species	0.046	0.169	1.047	(0.753-1.457)	0.783
χ^2=84.084					
Df=8					
P<0.001					

Note: a bold font indicates P<0.05;
Reference group is the semi-open pavilion;
OR: odds ratios; C.I.: Confidence interval; Df: Degree of freedom.

Results – PSD predictors of preference and mental restoration

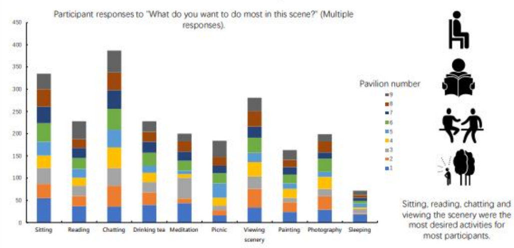


Overall correlation results

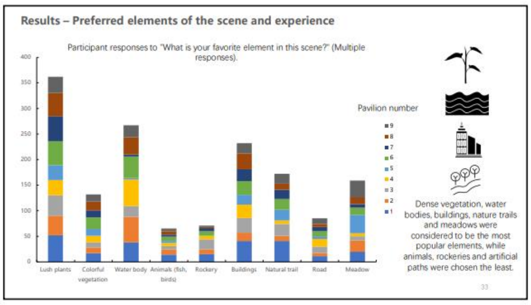
Dependent	Independent	Unstandardized Beta	Standardized Beta	t	Sig.	Collinearity statistics	
						Tolerance	VIF
Preference (Adjusted R^2=0.390)	(constant)	0.500		1.056	0.295		
	Serene	0.491	0.475	4.403	<0.001	0.873	1.146
	Prospect	0.341	0.293	2.713	0.009	0.873	1.146
Mental restoration (Adjusted R^2=0.626)	(constant)	-0.330		-0.853	0.397		
	Serene	0.679	0.575	6.203	<0.001	0.724	1.380
	Species	0.413	0.330	3.558	0.001	0.724	1.380

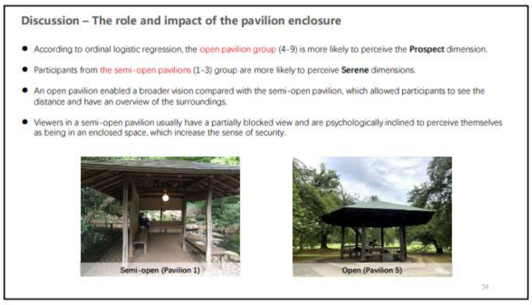
Significant PSD predictors of overall preference and mental restoration

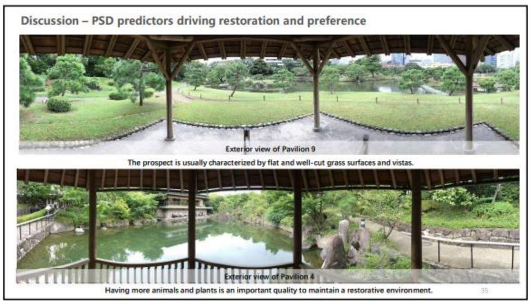
Results – Preferred elements of the scene and experience

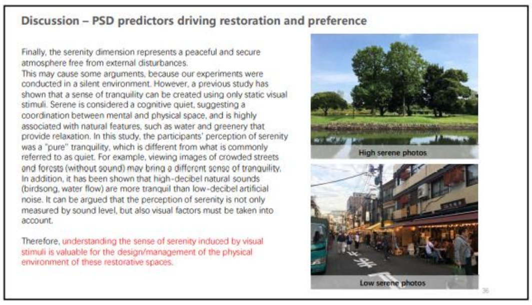


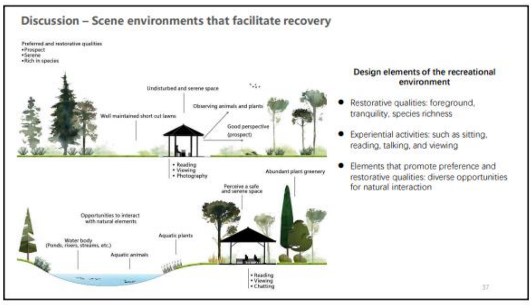
Sitting, reading, chatting and viewing the scenery were the most desired activities for most participants.


Results – Preferred elements of the scene and experience
Participant responses to "What is your favorite element in this scene?" (Multiple responses).
400
350
300
250
200
150
100
50
0
Lush plants
Colorful vegetation
Water body
Animals (fish, birds)
Rockery
Buildings
Natural trail
Road
Meadow
Pavilion number
9
8
7
6
5
4
3
2
1
Dense vegetation, water bodies, buildings, nature trails and meadows were considered to be the most popular elements, while animals, rockeries and artificial paths were chosen the least.
33


Discussion – The role and impact of the pavilion enclosure
According to ordinal logistic regression, the open pavilion group (4-9) is more likely to perceive the Prospect dimension.
Participants from the semi-open pavilions (1-3) group are more likely to perceive Serene dimensions.
An open pavilion enabled a broader vision compared with the semi-open pavilion, which allowed participants to see the distance and have an overview of the surroundings.
Viewers in a semi-open pavilion usually have a partially blocked view and are psychologically inclined to perceive themselves as being in an enclosed space, which increase the sense of security.
Semi-open (Pavilion 1)
Open (Pavilion 5)
34

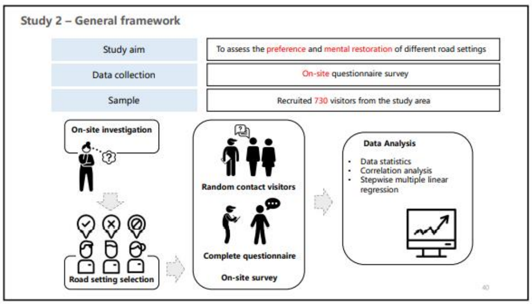

Discussion – PSD predictors driving restoration and preference
Exterior view of Pavilion 9
The prospect is usually characterized by flat and well-cut grass surfaces and vistas.
Exterior view of Pavilion 4
Having more animals and plants is an important quality to maintain a restorative environment.
35

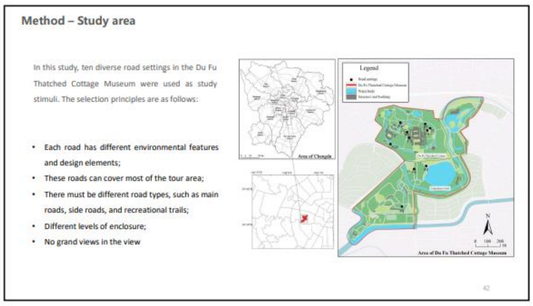

Discussion – PSD predictors driving restoration and preference
Finally, the serenity dimension represents a peaceful and secure atmosphere free from external disturbances.
This may cause some arguments, because our experiments were conducted in a silent environment. However, a previous study has shown that a sense of tranquility can be created using only static visual stimuli. Serene is considered a cognitive quiet, suggesting a coordination between mental and physical space, and is highly associated with natural features, such as water and greenery that provide relaxation. In this study, the participants' perception of serenity was a "pure" tranquility, which is different from what is commonly referred to as quiet. For example, viewing images of crowded streets and forests (without sound) may bring a different sense of tranquility. In addition, it has been shown that high-decibel natural sounds (birdsong, water flow) are more tranquil than low-decibel artificial noise. It can be argued that the perception of serenity is not only measured by sound level, but also visual factors must be taken into account.
Therefore, understanding the sense of serenity induced by visual stimuli is valuable for the design/management of the physical environment of these restorative spaces.
High serene photos
Low serene photos
36

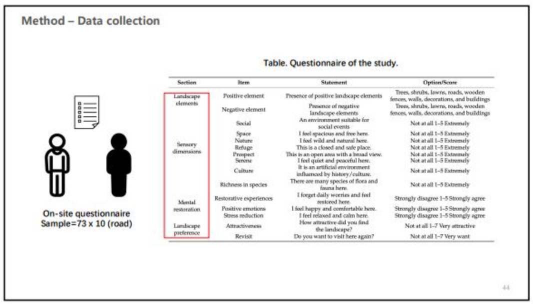

Discussion – Scene environments that facilitate recovery
Preferred and restorative qualities
•Prospect
•Serene
•Rich in species
Undisturbed and serene space
Observing animals and plants
Well maintained short cut lawns
Good perspective (prospect)
• Reading
• Viewing
• Photography
Abundant plant greenery
Perceive a safe and serene space
Opportunities to interact with natural elements
Water body (Ponds, rivers, streams, etc.)
Aquatic plants
Aquatic animals
• Reading
• Viewing
• Chatting
Design elements of the recreational environment
Restorative qualities: foreground, tranquility, species richness
Experiential activities: such as sitting, reading, talking, and viewing
Elements that promote preference and restorative qualities: diverse opportunities for natural interaction
37


Discussion – VR experience and implications
It is argued that VR simulation could be another way of gaining a natural experience.
According to evidence-based medicine, in the design and management of a healthy urban environment, specific evidence should be considered to provide a scientific basis for specific health effects.
Finally, restorative VR-based experiences are helping to address a growing number of public health challenges.
People with physical disabilities need to put in extra effort to reach these places;
Office workers looking for a short-term respite from the typical office environment;
Season-specific hazards caused by green space (like respiratory diseases and allergic diseases).
The use of VR to remotely visit these resting environments may be a practical solution to the challenges that result from these restrictions.
38

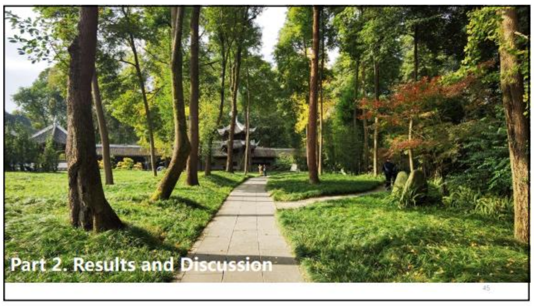

Study 2. Methodology, Results and Discussion
A Preferred Road to Mental Restoration in the Chinese Classical Garden
39

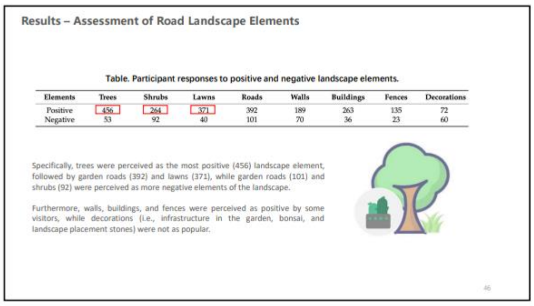

Study 2 – General framework
Study aim
To assess the preference and mental restoration of different road settings
Data collection
On-site questionnaire survey
Sample
Recruited 730 visitors from the study area
On-site investigation
Road setting selection
Random contact visitors
Complete questionnaire
On-site survey
Data Analysis
Data statistics
Correlation analysis
Stepwise multiple linear regression
40



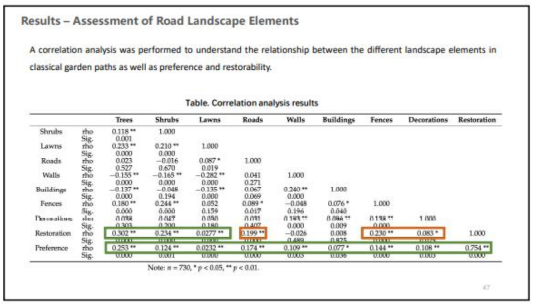


Section	Item	Statement	Option/Score
Landscape elements	Positive element	Presence of positive landscape elements	Trees, shrubs, lawns, roads, wooden fences, walls, decorations, and buildings
	Negative element	Presence of negative landscape elements	Trees, shrubs, lawns, roads, wooden fences, walls, decorations, and buildings
Sensory dimensions	Social	An environment suitable for social events	Not at all 1–5 Extremely
	Space	I feel spacious and free here.	Not at all 1–5 Extremely
	Nature	I feel wild and natural here.	Not at all 1–5 Extremely
	Refuge	This is a closed and safe place.	Not at all 1–5 Extremely
	Prospect	This is an open area with a broad view.	Not at all 1–5 Extremely
	Serene	I feel quiet and peaceful here.	Not at all 1–5 Extremely
	Culture	It is an artificial environment influenced by history/culture.	Not at all 1–5 Extremely
	Richness in species	There are many species of flora and fauna here.	Not at all 1–5 Extremely
Mental restoration	Restorative experiences	I forget daily worries and feel restored here.	Strongly disagree 1–5 Strongly agree
	Positive emotions	I feel happy and comfortable here.	Strongly disagree 1–5 Strongly agree
	Stress reduction	I feel relaxed and calm here.	Strongly disagree 1–5 Strongly agree
Landscape preference	Attractiveness	How attractive did you find the landscape?	Not at all 1–7 Very attractive
	Revisit	Do you want to visit here again?	Not at all 1–7 Very want



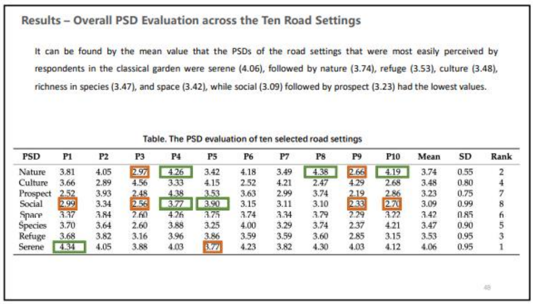


Elements	Trees	Shrubs	Lawns	Roads	Walls	Buildings	Fences	Decorations
Positive	456	264	371	392	189	263	135	72
Negative	53	92	40	101	70	36	23	60



		Trees	Shrubs	Lawns	Roads	Walls	Buildings	Fences	Decorations	Restoration
Shrubs	rho	0.118 **	1.000							
	Sig.	0.001								
Lawns	rho	0.233 **	0.210 **	1.000						
	Sig.	0.000	0.000							
Roads	rho	0.023	−0.016	0.087 *	1.000					
	Sig.	0.527	0.670	0.019						
Walls	rho	−0.155 **	−0.165 **	−0.282 **	0.041	1.000				
	Sig.	0.000	0.000	0.000	0.271					
Buildings	rho	−0.137 **	−0.048	−0.135 **	0.067	0.240 **	1.000			
	Sig.	0.000	0.194	0.000	0.069	0.000				
Fences	rho	0.180 **	0.244 **	0.052	0.089 *	−0.048	0.076 *	1.000		
	Sig.	0.000	0.000	0.159	0.017	0.196	0.040			
Decorations	rho	0.038	0.047	0.050	0.031	0.183 **	0.096 **	0.138 **	1.000	
	Sig.	0.303	0.200	0.180	0.407	0.000	0.009	0.000		
Restoration	rho	0.302 **	0.234 **	0.0277 **	0.199 **	−0.026	0.008	0.230 **	0.083 *	1.000
	Sig.	[illegible]	[illegible]	[illegible]	[illegible]	0.489	0.825	[illegible]	[illegible]	
Preference	rho	0.253 **	0.124 **	0.0232 **	0.174 **	0.109 **	0.077 *	0.144 **	0.108 **	0.754 **
	Sig.	0.000	0.001	0.000	0.000	0.003	0.036	0.000	0.003	0.000

Note: $n = 730$, * $p < 0.05$, ** $p < 0.01$.



PSD	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Mean	SD	Rank
Nature	3.81	4.05	2.97	4.26	3.42	4.18	3.49	4.38	2.66	4.19	3.74	0.55	2
Culture	3.66	2.89	4.56	3.33	4.15	2.52	4.21	2.47	4.29	2.68	3.48	0.80	4
Prospect	2.52	3.93	2.48	4.38	3.53	3.63	2.99	3.74	2.19	2.86	3.23	0.75	7
Social	2.99	3.34	2.56	3.77	3.90	3.15	3.11	3.10	2.33	2.70	3.09	0.99	8
Space	3.37	3.84	2.60	4.26	3.75	3.74	3.34	3.79	2.29	3.22	3.42	0.85	6
Species	3.70	3.64	2.60	3.88	3.25	4.00	3.29	3.74	2.37	4.21	3.47	0.90	5
Refuge	3.68	3.82	3.16	3.96	3.86	3.59	3.59	3.60	2.85	3.15	3.53	0.95	3
Serene	4.34	4.05	3.88	4.03	3.77	4.23	3.82	4.30	4.03	4.12	4.06	0.95	1

Results – Significant PSD Predictors of Preference and Restoration

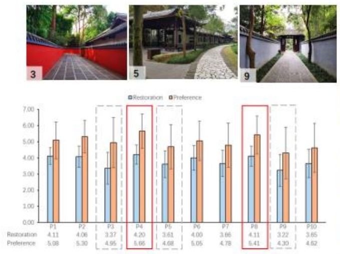


Figure. The mental restoration and preference score of ten selected road settings

Results – Significant PSD Predictors of Preference and Restoration

Table. Significant PSD predictors of preference and mental restoration

Dependent	Independent	Unstandardized Coefficient B	Unstandardized Coefficient SE	Standardized Beta	t	Sig.	Collinearity Diagnosis Tolerance	Collinearity Diagnosis VIF
Aesthetic preference (R = 0.679; Adjusted R2 – 0. 455)	Constant	−0.187	0.24		−0.78	0.436		
	Nature	0.478	0.054	0.347	8.853	0.000	0.486	2.058
	Culture	0.23	0.033	0.206	7.043	0.000	0.872	1.147
	Space	0.231	0.056	0.186	4.119	0.000	0.365	2.741
	Refuge	0.178	0.049	0.136	3.644	0.000	0.537	1.863
	Serene	0.272	0.052	0.161	5.249	0.000	0.791	1.264
Perceived restoration (R = 0.761; Adjusted R2 = 0.574)	Constant	0.214	0.133		1.606	0.109		
	Nature	0.275	0.03	0.318	9.167	0.000	0.486	2.058
	Culture	0.066	0.018	0.094	3.627	0.000	0.872	1.147
	Prospect	0.086	0.026	0.118	3.247	0.001	0.443	2.257
	Space	0.131	0.031	0.168	4.207	0.000	0.365	2.741
	Refuge	0.146	0.027	0.177	5.376	0.000	0.537	1.863
	Serene	0.265	0.029	0.25	9.202	0.000	0.791	1.264

Discussion – The Preferred Landscape Elements of Road Settings

Landscape elements were divided into two types in this study: **natural and artificial landscape elements.**

Natural landscape components were divided into three groups: trees in the upper space, shrubs in the middle space, and grass in the lower space.

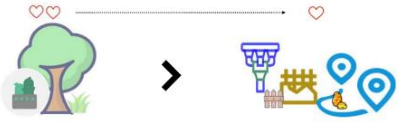
Discussion – The Preferred Landscape Elements of Road Settings

Most respondents stated that culture- related items with historical and cultural significance (such as architecture, landscape decoration, walls, roads, and bamboo fences) have a favorable impact on their preferences.

Discussion – The Preferred Landscape Elements of Road Settings

Restoration

In brief, natural landscape elements, on the one hand, are more restorative than man-made landscape elements. However, some man-made landscape components with cultural significance can have a significant and positive impact on people's restorative potential.

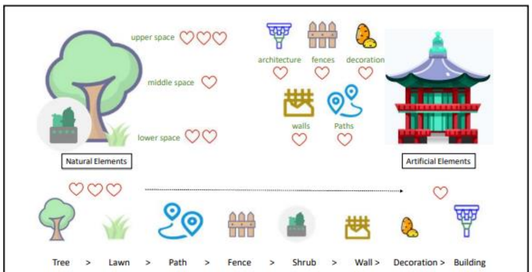


tree>lawn>shrub>fence>path>decoration

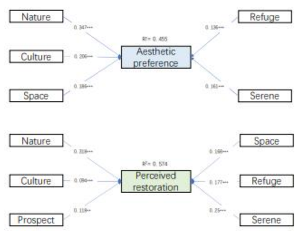
Discussion – The Preferred Landscape Elements of Road Settings

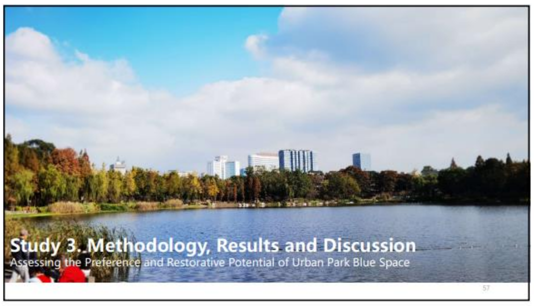
Preference

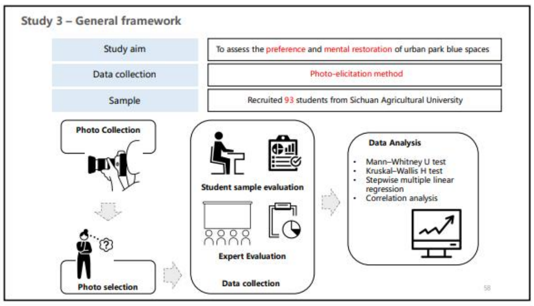
On the other hand, some culturally significant artificial elements (roads and fences) outweigh natural elements in terms of preference (shrubs). As a result, the findings of this study imply that culturally relevant artificial components can be appreciated by visitors and contribute to the aesthetic appeal of the environment.

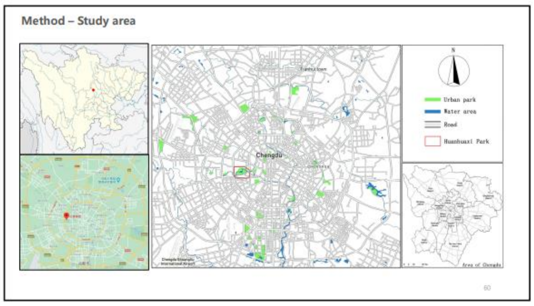


Discussion – PSD Predictors Driving Restoration and Preference









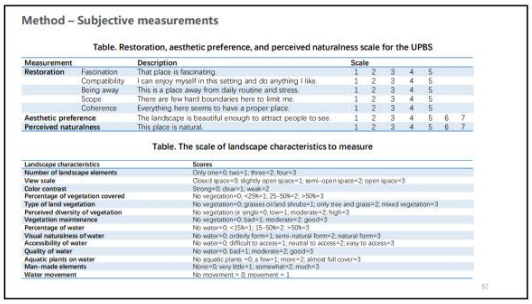
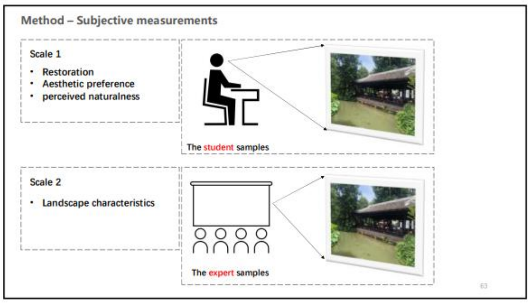


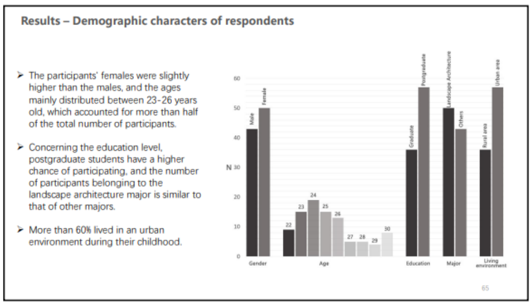
Table. Restoration, aesthetic preference, and perceived naturalness scale for the UPBS

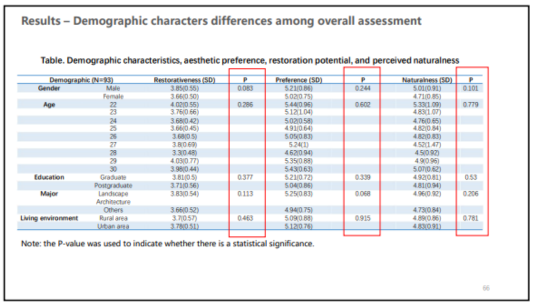
Measurement		Description	Scale						
Restoration	Fascination	That place is fascinating.	1	2	3	4	5		
	Compatibility	I can enjoy myself in this setting and do anything I like.	1	2	3	4	5		
	Being away	This is a place away from daily routine and stress.	1	2	3	4	5		
	Scope	There are few hard boundaries here to limit me.	1	2	3	4	5		
	Coherence	Everything here seems to have a proper place.	1	2	3	4	5		
Aesthetic preference		The landscape is beautiful enough to attract people to see.	1	2	3	4	5	6	7
Perceived naturalness		This place is natural.	1	2	3	4	5	6	7

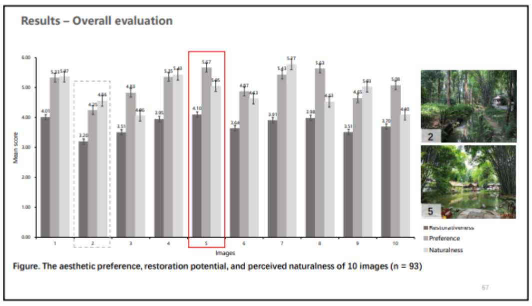
Table. The scale of landscape characteristics to measure

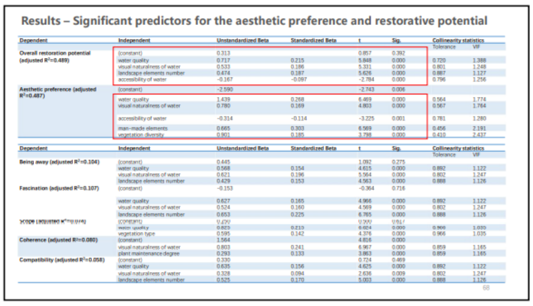
Landscape characteristics	Scores
Number of landscape elements	Only one=0; two=1; three=2; four=3
View scale	Closed space=0; slightly open space=1; semi-open space=2; open space=3
Color contrast	Strong=0; clear=1; weak=2
Percentage of vegetation covered	No vegetation=0; <25%=1; 25-50%=2; >50%=3
Type of land vegetation	No vegetation=0; grasses or/and shrubs=1; only tree and grass=2; mixed vegetation=3
Perceived diversity of vegetation	No vegetation or single=0; low=1; moderate=2; high=3
Vegetation maintenance	No vegetation=0; bad=1; moderate=2; good=3
Percentage of water	No water=0; <15%=1; 15-50%=2; >50%=3
Visual naturalness of water	No water=0; orderly form=1; semi-natural form=2; natural form=3
Accessibility of water	No water=0; difficult to access=1; neutral to access=2; easy to access=3
Quality of water	No water=0; bad=1; moderate=2; good=3
Aquatic plants on water	No aquatic plants =0; a few=1; more=2; almost full cover=3
Man-made elements	None=0; very little=1; somewhat=2; much=3
Water movement	No movement = 0; movement = 1

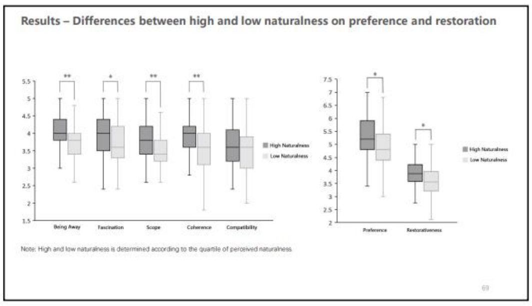


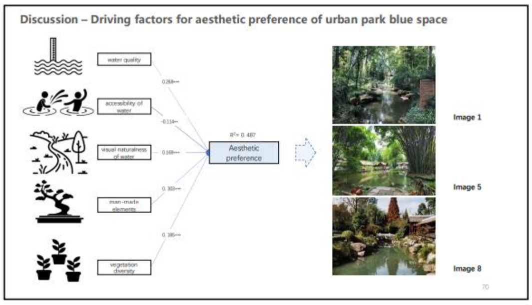

Results – Demographic characters of respondents
The participants' females were slightly higher than the males, and the ages mainly distributed between 23-26 years old, which accounted for more than half of the total number of participants.
Concerning the education level, postgraduate students have a higher chance of participating, and the number of participants belonging to the landscape architecture major is similar to that of other majors.
More than 60% lived in an urban environment during their childhood.

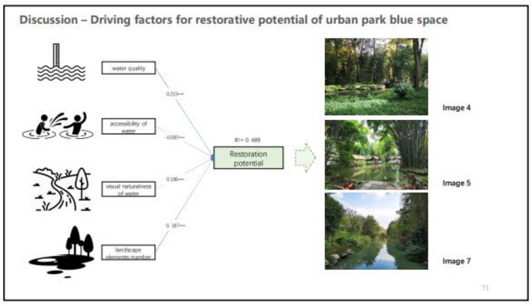

Results – Demographic characters differences among overall assessment
Table. Demographic characteristics, aesthetic preference, restoration potential, and perceived naturalness
Note: the P-value was used to indicate whether there is a statistical significance.


Results – Overall evaluation
Figure. The aesthetic preference, restoration potential, and perceived naturalness of 10 images (n = 93)

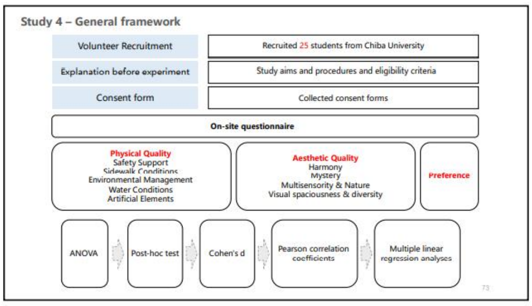

Results – Significant predictors for the aesthetic preference and restorative potential


Results – Differences between high and low naturalness on preference and restoration


Discussion – Driving factors for aesthetic preference of urban park blue space
Image 1
Image 5
Image 8


Discussion – Driving factors for restorative potential of urban park blue space
Image 4
Image 5
Image 7


Study 4. Methodology, Results and Discussion
The effect of the perceived physical and aesthetic quality of urban blue spaces on user preference



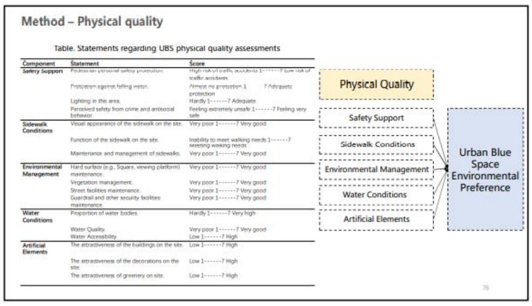


Table. Statements regarding UBS physical quality assessments

Component	Statement	Score
Safety Support	Pedestrian personal safety protection.	High risk of traffic accidents 1------7 Low risk of traffic accidents
	Protection against falling water.	Almost no protection 1 7 Adequate protection
	Lighting in this area.	Hardly 1------7 Adequate
	Perceived safety from crime and antisocial behavior.	Feeling extremely unsafe 1------7 Feeling very safe
Sidewalk Conditions	Visual appearance of the sidewalk on the site.	Very poor 1------7 Very good
	Function of the sidewalk on the site.	Inability to meet walking needs 1------7 meeting walking needs
	Maintenance and management of sidewalks.	Very poor 1------7 Very good
Environmental Management	Hard surface (e.g., Square, viewing platform) maintenance.	Very poor 1------7 Very good
	Vegetation management.	Very poor 1------7 Very good
	Street facilities maintenance.	Very poor 1------7 Very good
	Guardrail and other security facilities maintenance.	Very poor 1------7 Very good
Water Conditions	Proportion of water bodies.	Hardly 1------7 Very high
	Water Quality.	Very poor 1------7 Very good
	Water Accessibility.	Low 1------7 High
Artificial Elements	The attractiveness of the buildings on the site.	Low 1------7 High
	The attractiveness of the decorations on the site.	Low 1------7 High
	The attractiveness of greenery on site.	Low 1------7 High

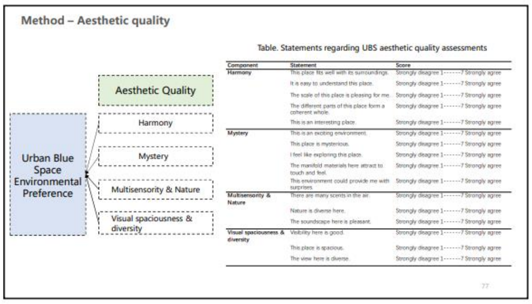


Table. Statements regarding UBS aesthetic quality assessments

Component	Statement	Score
Harmony	This place fits well with its surroundings.	Strongly disagree 1------7 Strongly agree
	It is easy to understand this place.	Strongly disagree 1------7 Strongly agree
	The scale of this place is pleasing for me.	Strongly disagree 1------7 Strongly agree
	The different parts of this place form a coherent whole.	Strongly disagree 1------7 Strongly agree
	This is an interesting place.	Strongly disagree 1------7 Strongly agree
Mystery	This is an exciting environment.	Strongly disagree 1------7 Strongly agree
	This place is mysterious.	Strongly disagree 1------7 Strongly agree
	I feel like exploring this place.	Strongly disagree 1------7 Strongly agree
	The manifold materials here attract to touch and feel.	Strongly disagree 1------7 Strongly agree
	This environment could provide me with surprises.	Strongly disagree 1------7 Strongly agree
Multisensority & Nature	There are many scents in the air.	Strongly disagree 1------7 Strongly agree
	Nature is diverse here.	Strongly disagree 1------7 Strongly agree
	The soundscape here is pleasant.	Strongly disagree 1------7 Strongly agree
Visual spaciousness & diversity	Visibility here is good.	Strongly disagree 1------7 Strongly agree
	This place is spacious.	Strongly disagree 1------7 Strongly agree
	The view here is diverse.	Strongly disagree 1------7 Strongly agree

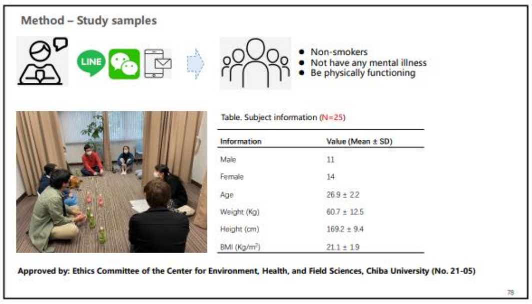
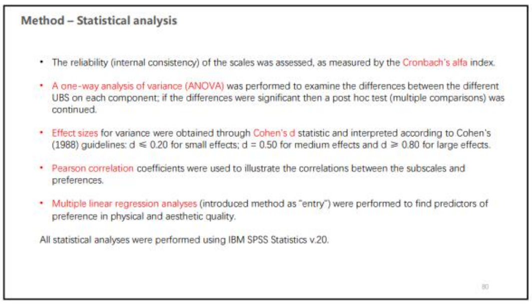


Table. Subject information (N=25)

Information	Value (Mean ± SD)
Male	11
Female	14
Age	26.9 ± 2.2
Weight (Kg)	60.7 ± 12.5
Height (cm)	169.2 ± 9.4
BMI (Kg/m^2)	21.1 ± 1.9



Results – Overall statistics

Table. Overall statistics of the study

Component	S (SD)	SH (SD)	O (SD)	All	α
Physical Quality	4.47(0.72)	4.38(0.91)	5.63(0.66)	4.83(0.96)	-
Safety Support (SS)	4.48(0.80)	4.41(1.07)	5.94(0.72)	4.94(1.12)	0.685
Sidewalk Conditions (SC)	4.48(1.26)	4.31(1.30)	5.87(0.88)	4.88(1.34)	0.911
Environmental Management (EM)	4.44(1.06)	4.67(1.23)	5.76(0.84)	4.96(1.19)	0.862
Water Conditions (WC)	4.09(1.28)	3.75(0.99)	5.12(0.87)	4.32(1.20)	0.652
Artificial Elements (AE)	4.87(0.82)	4.79(1.14)	5.45(0.87)	5.04(0.98)	0.740
Aesthetic Quality	4.37(0.86)	4.04(0.87)	5.14(0.77)	4.52(0.95)	-
Harmony (H)	5.30(0.95)	4.74(1.06)	5.69(0.99)	5.24(1.06)	0.904
Mystery (M)	3.82(1.33)	3.34(1.15)	4.29(1.06)	3.82(1.23)	0.899
Multisensority & Nature (MN)	4.08(1.09)	3.68(0.99)	4.47(1.08)	4.08(1.09)	0.601
Visual spaciousness & diversity (V)	4.31(1.11)	4.40(1.19)	6.11(0.55)	4.94(1.28)	0.850
Preference	5.34(1.27)	3.98(1.33)	5.28(1.08)	4.87(1.37)	0.824

Note. S, Sakagawa; SH, Shinsakagawa; O, Osagamicyousetuike. α, Cronbach's alpha; SD, Standard deviation.

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Results – Differences examination among the study sites

Table. Overall statistics of the study

Component	ANOVA $F_{(2, 74)}$	P	Multiple comparison LSD	P	d
Physical Quality					
Safety Support (SS)	24.307	**<0.001**	S < O	<0.001	1.92
			SH < O	<0.001	1.68
			S, SH	0.778	-
Sidewalk Conditions (SC)	13.551	**<0.001**	S < O	<0.001	1.28
			SH < O	<0.001	1.41
			S, SH	0.599	-
Environmental Management (EM)	11.162	**<0.001**	S < O	<0.001	1.38
			SH < O	<0.001	1.03
			S, SH	0.443	-
Water Conditions (WC)	11.360	**<0.001**	S < O	0.001	0.94
			SH < O	<0.001	1.47
			S, SH	0.151	-
Artificial Elements (AE)	3.666	**0.030**	S < O	0.032	0.69
			SH < O	0.015	0.65
			S, SH	0.767	-
Aesthetic Quality					
Harmony (H)	5.625	**0.005**	SH < O	0.001	0.93
			S, O	0.170	-
			S, SH	0.055	-
Mystery (M)	3.973	**0.023**	SH < O	0.006	0.86
			S, O	0.163	-
			S, SH	0.163	-
Multisensority & Nature (MN)	3.464	**0.037**	SH < O	0.010	0.77
			S, O	0.200	-
			S, SH	0.185	-
Visual spaciousness & diversity (V)	26.187	**<0.001**	S < O	<0.001	2.05
			SH < O	<0.001	1.84
			S, SH	0.740	-
Preference	9.695	**<0.001**	S > SH	<0.001	1.05
			S, O	0.864	-
			SH < O	<0.001	1.07

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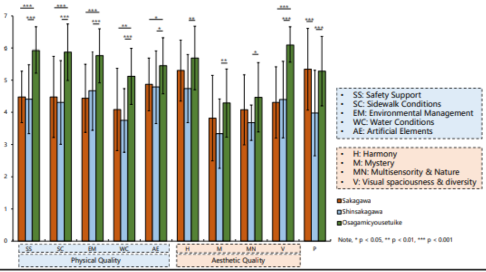
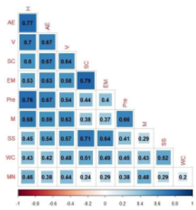
Results – Differences examination among the study sites



Results – Pearson correlation coefficients results



Created by R programming ggplot package.

Table. **Pearson correlation coefficients** results (three study sites data)

Component	SS	SC	EM	WC	AE	H	M	MN	V
SC	0.714**								
EM	0.642**	0.788**							
WC	0.518**	0.505**	0.493**						
AE	0.544**	0.669**	0.634**	0.415**					
H	0.449**	0.596**	0.531**	0.427**	0.771**				
M	0.285*	0.380**	0.369**	0.426**	0.592**	0.682**			
MN	0.290*	0.244*	0.286*	0.197	0.382**	0.462**	0.481**		
V	0.572**	0.635**	0.584**	0.477**	0.673**	0.701**	0.627**	0.439**	
P	0.409**	0.440**	0.405**	0.450**	0.668**	0.761**	0.660**	0.379**	0.536**

<0.4 0.4~0.6 >0.6

Note. SS, Safety Support; SC, Sidewalk Conditions; EM, Environmental Management; WC, Water Conditions; AE, Artificial Elements; H, Harmony; M, Mystery; MN, Multisensority & Nature; V, Visual spaciousness & diversity; P, Preference.
N= 75, * P < 0.05, ** P < 0.01.

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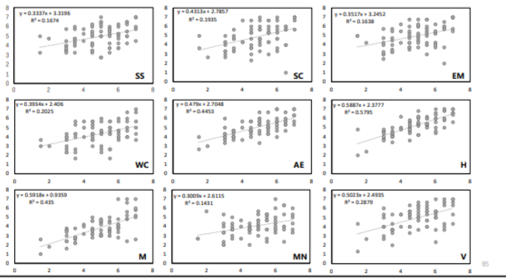
Results – Linear relationship



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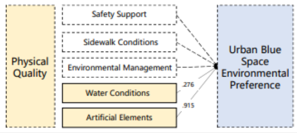
Results – Multiple linear regression analysis

Table. Significant predictors of **physical quality** on UBS preference (N = 75)

Independent variable	Unstandardized Beta	Standardized Beta	t	Sig.	Collinearity statistics Tolerance	VIF
(constant)	-0.258		-0.377	0.708		
Safety Support (SS)	0.054	0.044	0.346	0.731	0.445	2.246
Sidewalk Conditions (SC)	-0.075	-0.073	-0.449	0.655	0.278	3.600
Environmental Management (EM)	-0.117	-0.101	-0.693	0.491	0.344	2.907
Water Conditions (WC)	0.276	0.241	2.312	**0.024**	0.679	1.474
Artificial Elements (AE)	0.915	0.657	5.496	**<0.001**	0.516	1.939

Dependent variable is Preference, R2 =0.492; **adjusted R2 = 0.455**. Model standard estimation error is 1.01.



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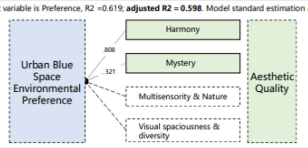
Results – Multiple linear regression analysis

Table. Significant predictors of **aesthetic quality** on UBS preference (N = 75)

Independent variable	Unstandardized Beta	Standardized Beta	t	Sig.	Collinearity statistics Tolerance	VIF
(constant)	-0.177		-0.215	0.830		
Harmony (H)	0.808	0.625	5.388	**<0.001**	0.405	2.471
Mystery (M)	0.321	0.288	2.672	**0.009**	0.468	2.135
Multisensority & Nature (MN)	-0.019	-0.015	-0.179	0.858	0.725	1.379
Visual spaciousness & diversity (V)	-0.080	-0.075	-0.691	0.492	0.461	2.169

Dependent variable is Preference, R2 =0.619; **adjusted R2 = 0.598**. Model standard estimation error is 0.87.



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Results – Multiple linear regression equation

Y= β0 + β1X1 + … + βnXn

- y = the predicted value of the dependent variable;
- β0 = the intercept, i.e., the value of y when the other parameters are 0;
- β1X1= the first independent variable and the regression coefficient;
- βnXn= the nth independent variable and the regression coefficient.

For **physical quality** components

Preference = - 0.258 + (0.276 * WC) + (0.915 * AE) (1)

For **aesthetic quality** components

Preference = - 0.117 + (0.808 * H) + (0.321 * M) (2)

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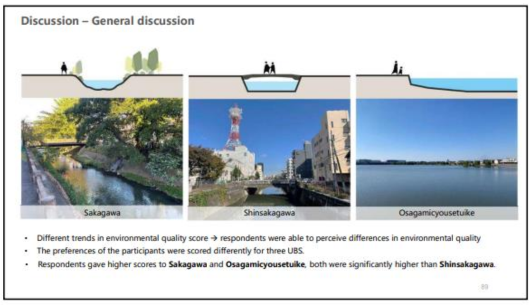
Discussion – General discussion
Sakagawa
Shinsakagawa
Osagamicyousetuike
• Different trends in environmental quality score → respondents were able to perceive differences in environmental quality
• The preferences of the participants were scored differently for three UBS.
• Respondents gave higher scores to Sakagawa and Osagamicyousetuike, both were significantly higher than Shinsakagawa.
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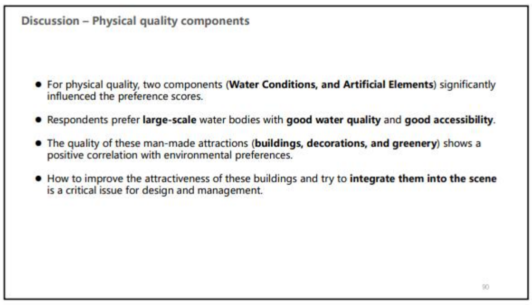
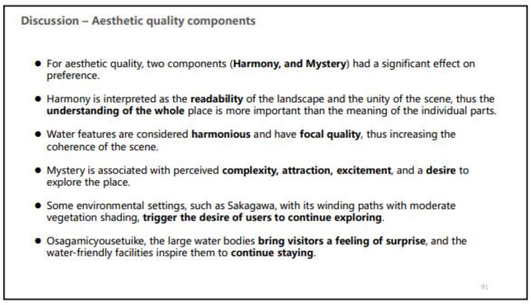

Discussion – Physical quality components
• For physical quality, two components (Water Conditions, and Artificial Elements) significantly influenced the preference scores.
• Respondents prefer large-scale water bodies with good water quality and good accessibility.
• The quality of these man-made attractions (buildings, decorations, and greenery) shows a positive correlation with environmental preferences.
• How to improve the attractiveness of these buildings and try to integrate them into the scene is a critical issue for design and management.
90


Discussion – Aesthetic quality components
• For aesthetic quality, two components (Harmony, and Mystery) had a significant effect on preference.
• Harmony is interpreted as the readability of the landscape and the unity of the scene, thus the understanding of the whole place is more important than the meaning of the individual parts.
• Water features are considered harmonious and have focal quality, thus increasing the coherence of the scene.
• Mystery is associated with perceived complexity, attraction, excitement, and a desire to explore the place.
• Some environmental settings, such as Sakagawa, with its winding paths with moderate vegetation shading, trigger the desire of users to continue exploring.
• Osagamicyousetuike, the large water bodies bring visitors a feeling of surprise, and the water-friendly facilities inspire them to continue staying.
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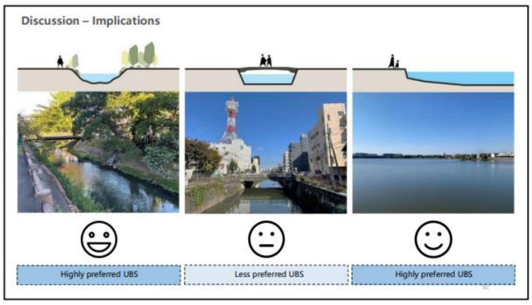
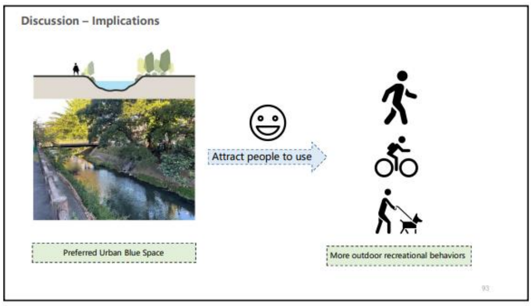
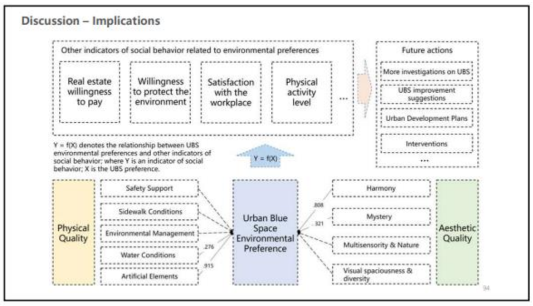
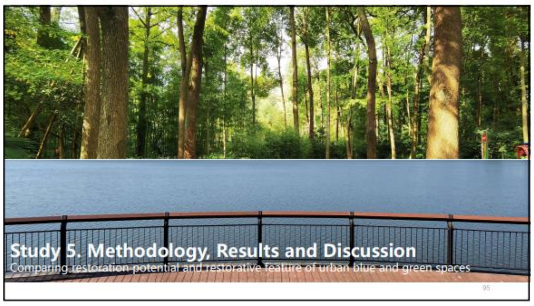
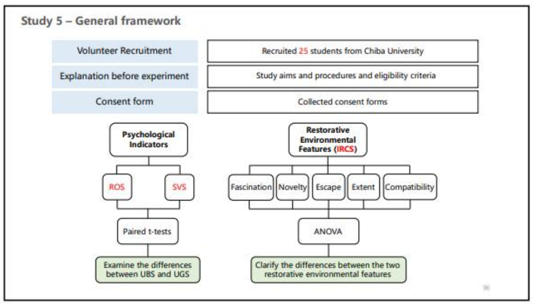

Discussion – Implications
Highly preferred UBS
Less preferred UBS
Highly preferred UBS


Discussion – Implications
Attract people to use
Preferred Urban Blue Space
More outdoor recreational behaviors
93


Discussion – Implications
Other indicators of social behavior related to environmental preferences
Real estate willingness to pay
Willingness to protect the environment
Satisfaction with the workplace
Physical activity level
...
Future actions
More investigations on UBS
UBS improvement suggestions
Urban Development Plans
Interventions
...
Y = f(X) denotes the relationship between UBS environmental preferences and other indicators of social behavior; where Y is an indicator of social behavior; X is the UBS preference.
Y = f(X)
Physical Quality
Safety Support
Sidewalk Conditions
Environmental Management
Water Conditions
Artificial Elements
.276
.915
Urban Blue Space Environmental Preference
.808
.321
Harmony
Mystery
Multisensority & Nature
Visual spaciousness & diversity
Aesthetic Quality
94


Study 5. Methodology, Results and Discussion
Comparing restoration potential and restorative feature of urban blue and green spaces


Study 5 – General framework
Volunteer Recruitment
Recruited 25 students from Chiba University
Explanation before experiment
Study aims and procedures and eligibility criteria
Consent form
Collected consent forms
Psychological Indicators
ROS
SVS
Paired t-tests
Examine the differences between UBS and UGS
Restorative Environmental Features (IRCS)
Fascination
Novelty
Escape
Extent
Compatibility
ANOVA
Clarify the differences between the two restorative environmental features
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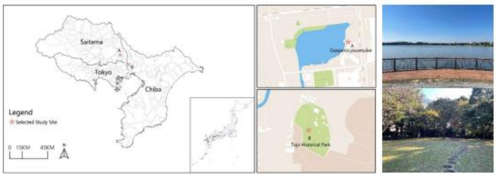
Method – Study area

Urban Blue Space
- Urban lake
- Osagamicyousetuike

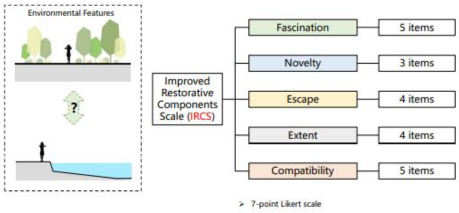
Urban Green Space
- Urban park
- Tojo Historical Park



Method – Psychological measurements

Scale	Items	Score
Restoration Outcome Scale (ROS)	I feel restored and released	Not at all 1------------7 Extremely Agree
	I feel very calm	Not at all 1------------7 Extremely Agree
	I grow enthusiastic and energetic about my daily life	Not at all 1------------7 Extremely Agree
	I feel focused	Not at all 1------------7 Extremely Agree
	I can forget my daily worries	Not at all 1------------7 Extremely Agree
	My thoughts are clear	Not at all 1------------7 Extremely Agree
Subjective Vitality Scale (SVS)	I feel alive and vital	Not at all 1------------7 Extremely Agree
	I feel very energetic	Not at all 1------------7 Extremely Agree
	I look forward to each new day	Not at all 1------------7 Extremely Agree
	I feel alert and awake	Not at all 1------------7 Extremely Agree
	I feel so alive I just want to burst	Not at all 1------------7 Extremely Agree

Method – Restorative environmental features



Method – Study samples

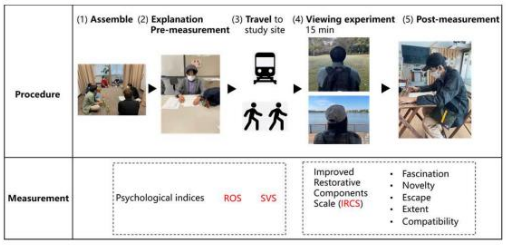
- Non-smokers
- Not have any mental illness
- Be physically functioning

Table. Subject information (N=25)

Information	Value (Mean ± SD)
Male	11
Female	14
Age	26.9 ± 2.2
Weight (Kg)	60.7 ± 12.5
Height (cm)	169.2 ± 9.4
BMI (Kg/m^2)	21.1 ± 1.9

Approved by: Ethics Committee of the Center for Environment, Health, and Field Sciences, Chiba University (No. 21-05)

Method – Experimental design and procedure



Method – Data analysis

The Shapiro-Wilk test was performed to analyze the normality of the data, and the results showed that all data conformed to a normal distribution. Therefore, paired t-tests were used to examine the differences between UBS and UGS data:

1) the differences between UBS and UGS pre-viewing data,
2) the differences between pre- and post-viewing data in UBS,
3) the differences between pre- and post-viewing data in UGS, and
4) the differences between UBS and UGS post-viewing data.

In addition, Pearson correlations were calculated for the post-viewing-scale data.

Finally, a one-way analysis of variance (ANOVA) was used to calculate the differences between UBS and UGS data on the IRCS to clarify the differences between the two restorative environmental features.

SPSS 20.0 software (IBM Corp., Armonk, NY, USA) was used for all analyses.

In all experiments, statistical significance was set at $p < 0.05$.

Results – Scale statistics

Table. Data from the two experimental sites

Study Site	Urban Blue Space (N = 25)			Urban Green Space (N = 25)		
Measures	M	SD	Cronbach's α	M	SD	Cronbach's α
Before Viewing (BV)						
SVS	4.25	1.02	**0.85**	3.86	0.97	**0.74**
ROS	3.78	0.98	**0.87**	3.83	0.96	**0.85**
After Viewing (AV)						
SVS	4.34	1.07	**0.84**	4.52	0.91	**0.79**
ROS	5.12	0.92	**0.86**	5.44	0.95	**0.89**
Novelty	5.16	1.05	**0.77**	5.45	1.09	**0.77**
Escape	5.36	1.24	**0.89**	5.32	1.18	**0.90**
Fascination	5.05	1.20	**0.92**	5.75	0.77	**0.83**
Extent (reversed)	5.42	0.92	**0.65**	5.28	0.77	**0.60**
Compatibility	4.36	1.45	**0.95**	5.18	1.09	**0.90**

Abbreviations: M, mean value; SD, standard deviation

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Results – Correlation of scale data after viewing

Table. Correlation matrix of the scales (UBS)

After Viewing (UBS)	ROS	Novelty	Escape	Fascination	Extent	Compatibility
SVS	0.766**	0.486*	0.567**	0.731**	-0.076	0.394
ROS	1	0.591**	0.861**	0.796**	0.026	0.663**
Novelty		1	0.604**	0.690**	-0.057	0.562**
Escape			1	0.677**	0.014	0.714**
Fascination				1	-0.129	0.585**
Extent					1	0.086

* $p < 0.05$, ** $p < 0.01$

Table. Correlation matrix of the scales (UGS)

After Viewing (UGS)	ROS	Novelty	Escape	Fascination	Extent	Compatibility
SVS	0.833**	0.556**	0.540**	0.492*	0.006	0.670**
ROS	1	0.510**	0.622**	0.539**	0.092	0.784**
Novelty		1	0.729**	0.667**	-0.047	0.408*
Escape			1	0.506**	-0.038	0.354
Fascination				1	-0.089	0.518**
Extent					1	0.415*

* $p < 0.05$, ** $p < 0.01$

UBS=Urban Blue Space, UGS=Urban Green Space.

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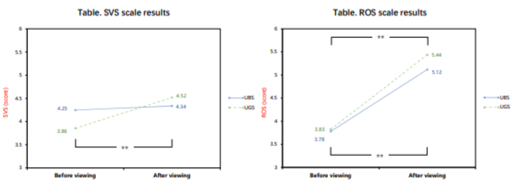
Results – Effects of viewing behaviors on psychological data



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Results – Differences in restorative environmental features

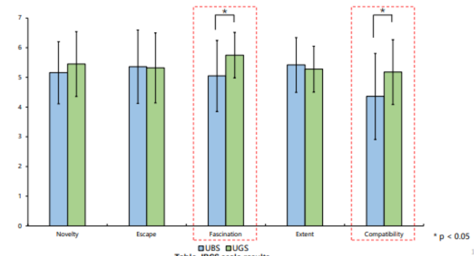

Table. IRCS scale results

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Discussion – Restorativeness differences

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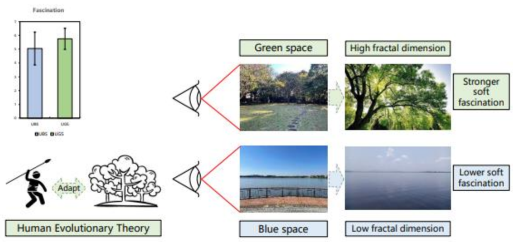
Discussion – Restorative environmental features differences



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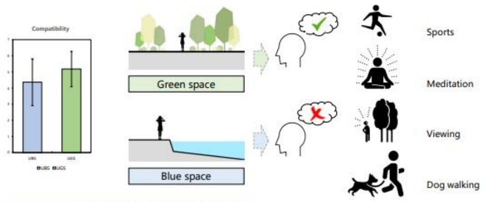
Discussion – Restorative environmental features differences



Potentially providing recreational activities and interactions is important for an environment to be more restorative.

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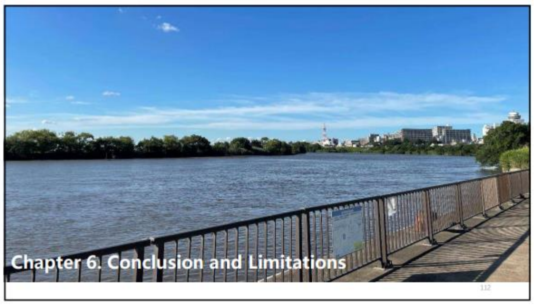

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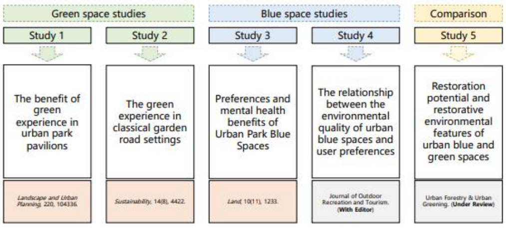
Conclusion



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Limitations

- For study 1, first, although **several pavilion samples** were investigated, it was considered difficult for participants to view all the scenes. In the future, a new round of evaluation is necessary to supplement the findings of this study.
- For study 2, firstly, this experiment only selected **ten different types of roads** in a classical garden for study, but there are some other road types in other Chinese classical gardens that are not covered in this study.
- For study 3, **only selected 10 types of UPBS**, and more types (more landscape features) of UPBS need to be considered for evaluation in future research.
- For study 4, we selected only **freshwater blue spaces**, excluding **urban coastal and seaside environments** where the perception may differ from other freshwater UBS.
- For study 5, to fully immerse participants in blue and green environments, we selected **only two experimental sites**: an urban park and a large artificial lake. Besides, this study involved only passive viewing. Examining the potential medical effects of active behaviors in different settings (e.g., physical activity in blue and green environments) would be valuable for evidence-based medicine.

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ご清聴ありがとうございました　Thanks for your listening

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Graduate School of Horticulture
Landscape Planning Lab

CHIBA UNIVERSITY

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First, words cannot express my gratitude to my supervisor, the Professor Furuya for his invaluable patience and feedback. I also could not have undertaken this journey without my defense committee (Professor Iwazaki, Professor Honjo, Professor Akida, and Professor Kagawa) who generously provided knowledge and expertise. Additionally, this endeavor would not have been possible without the generous support from the Japan Science and Technology Agency (JST), who financed my research.

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2022.8.3

Shixian Luo