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Natural Dose of Blue Restoration: A Field Experiment on Mental Restoration of Urban Blue Spaces

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Abstract: Urban Blue Spaces (UBS) have been found to be beneficial to people's mental health. Yet, the empirical evidence for how and why different types of urban blue spaces could promote residents' mental health is still limited. Accordingly, 164 observation samples were collected for this experiment relating to the restorative perception of environmental exposure. The effects of two exposure behaviors (15 min of viewing and 15 min of walking) on psychological recovery in three different urban blue spaces settings (Urban River, Urban Canal, Urban Lake) were investigated in a field experiment. These are the main findings of this current study: (1) all three UBSs increased vitality, feelings of restoration, and positive emotions, and decreased negative emotions; (2) the mental restoration effects between walking and viewing among the three UBSs showed no significant differences; (3) of the three UBSs, urban rivers and urban lakes were the most restorative, while urban canals were less so; (4) the concept of "natural health dose" is proposed, where the health experiences of different UBSs in urban settings can show differences depending on the natural components and their levels of the environment (blue, blue + green, blue + blue). The results of this experiment can provide fundamental evidence that can contribute to building healthy cities through the management and design of different blue spaces.

Keywords: urban blue space; natural health dose; perceived blue level; perceived green level; environment and mental health

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1. Introduction

1.1. Urban Health Problems and Blue-Green Solutions

Rapid urbanization and unhealthy lifestyles are threatening human health and quality of life [1]. According to reports, there is a link between the built environment and health problems. For example, densely developed artificial urban environments reduce the health of residents [2]; urban residents are at a significantly increased risk of anxiety and mood disorders [3]; more urban living environments are associated with higher rates of prescriptions for psychotropic medications for anxiety, depression, and psychosis [4]; spending time in urban environments significantly reduces positive emotions and increases stress and fatigue [1]. Accordingly, there is 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 [5]. It has been proposed to provide and maintain health-promoting natural elements/resources in the urban environment, such as blue spaces (rivers, creeks, ponds) [6] and green spaces (urban forests, parks, green roofs) [7]. These blue–green spaces, as natural extensions of the city, can improve the urban living environment and positively influence the health level of citizens [7].

1.2. Lack of Empirical Studies on the Restorative Effects of Urban Blue Space

Evidence for the importance of blue spaces for human health is also increasing but remains limited compared to green space studies [8]. 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" [9]. 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 [10]. These urban blue elements can be permanent or non-permanent, natural or artificial [10]. Many studies have begun to highlight the various benefits of blue spaces, such as higher life satisfaction [11], better self-reported general and mental health [12], higher physical activity [13], self-reported recreational visits [14], and increased aesthetic experiences and positive emotions [10]. However, most of the current research on blue space focuses on city/regional level population survey data (e.g., a deprived neighborhood of Plymouth in the United Kingdom [15], England [11], the city of Plovdiv, Bulgaria [12], 18 countries and regions around the globe [13], 40 small towns in central and northeast Pennsylvania [14]), and theoretical studies in laboratory settings (e.g., 10 urban park blue space images [16], 120 photographs of natural and built scenes [17], the six types of waterscapes [18], the four models as surrogates for real ponds [19], 70 color slides of natural environments containing water [20]). There is still a lack of field-based empirical studies on the health outcomes of blue spaces in urban environments. Hermanski et al. (2022) showed that although both viewing and visiting blue spaces can improve mental health, visiting blue spaces has greater benefits for mental health [21]. Therefore, field-based experimental evidence is necessary because it can increase our understanding of how blue spaces in real urban environments provide health benefits. Although previous studies at the city/regional level have a solid evidence base [22–24], empirical studies provide a more direct understanding of how blue space affects mental recovery and are more realistic and reliable relative to laboratory settings [25]. Furthermore, the findings could provide urban planners/managers with important knowledge and insights into natural interventions that promote the health of urban residents.

1.3. Restorative Effects May Differ between UBSs

UBS often includes different types of blue spatial structures that are distributed in cities [8], forming a blue health network in urban environments in the form of points (fountain, pool), lines (creek, river, canal) and planes (lake, pond, lagoon). However, not all UBSs are thought to provide health benefits, as some waterways appear to result in negative health experiences, such as decreased feelings of safety and reduced positive emotions [26,27]. Furthermore, the restorative properties of different characterized natural environments have been discussed [28–31], and these findings suggest that even though the studied environments are all considered restorative, the positive effects of different environmental settings may be different for its different environmental content. Although the study by McDougall et al. (2022) has demonstrated that blue space types can vary in their ability to promote health, the results are still based on national-level online surveys [32]. Therefore, more empirical studies are needed to clarify the health benefits (or the existence of such benefits, if any) of different UBSs.

1.4. The Current Research Objectives

In previous studies, psychological recovery from the environment has focused on its positive effects on psychological indicators, such as stress relief, increased attention, reduced anxiety, improved emotional state, and increased subjective vitality [5,30,31,33,34]. Similarly, this study aimed to measure the restorative benefits of UBS through the improvements in physiological indicators in participating subjects after the field experiment. The restorative outcomes of these indicators are usually measured using questionnaires [31].

In summary, the main objective of this study was to investigate the psychological recovery effects of different UBSs in an urban environment. Similar to other studies [1,5], built-up areas without water bodies were used as a control group for the experiment. Furthermore, previous studies have shown that different behavioral and experimental phases lead to different recovery effects [30,31,35]. Therefore, specifically, the aim was to investigate the effects of the two behaviors "viewing" and "walking" on psychological indicators (subjective vitality, emotions, and perceived restoration) in different UBSs, and to discuss the reasons for the differences (if any exist) in the restorative effects of different types of UBS.

2. Methodology

2.1. Study Sites

Blue spaces with different characteristics in the urban environment were selected for field experiments in this study. Additionally, owing to the study setting, we primarily selected freshwater blue spaces (i.e., coastal blue spaces such as harbors and waterfronts were not included). Although the spatial coverage of freshwater is much smaller than that of marine environments, investigating freshwater blue spaces is of great value in promoting broader urban health, as more than 50% of the global population lives within 3 km of freshwater [6]. Furthermore, Poulsen et al. (2022) highlighted how the health effects of non-coastal freshwater blue spaces remain underexplored [15]. Moreover, little is known about the potential of different freshwater blue space types, such as lakes, rivers, and canals, to contribute to health and well-being [32]. Therefore, three freshwater UBSs commonly found in urban environments (urban river, urban canal, urban lake) were selected as sites for investigation.

To avoid residual effects, participants visited one of four different environmental settings located in a Japanese city on different days. These four study locations were: (1) Sakagawa; (2) Shinsakagawa; (3) Osagamicyousetuike; and (4) Sengyokaidou, which represent urban river, urban canal, urban lake, and built-up urban environment as a control group, respectively (Figure 1). See Table 1 for details of the vegetation and environmental features of the four study sites.

Table 1. Study sites profile.

Site (Code in Figure 1)	Category	Features	Main Vegetation around the Site	Description
Sakagawa (B)	Urban River	Mainly vegetation and water bodies	*Quercus myrsinifolia; Zelkova serrata; Celtis sinensis; Cornus officinalis; Acorus calamus; Prunus subgen.Cerasus; Rhododendron; Hydrangea macrophylla*	Sakagawa is a river with a long history, originating in Kashiwa City and eventually flowing into the Edo River. There are many aquatic plants in the river, and many trees have been planted on both sides of the river, resulting in an area that is a blend of natural and artificial environments.
Shinsakagawa (C)	Urban Canal	Mainly water bodies and buildings	*Parthenocissus tricuspidate; Rhododendron; Hydrangea macrophylla; Quercus myrsinifolia; Cornus officinalis*	An artificial waterway located in the center of Matsudo City. It is an engineered channel built for drainage management, and the river is lined mainly with commercial buildings and residential houses. This area has little vegetation or natural elements and is therefore a highly artificial environment.
Osagamicyousetuike (A)	Urban Lake	Mainly water bodies		It is located in Koshigaya City, Saitama Prefecture, and is a reservoir (with a capacity of 1.2 million cubic meters of water) 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 where many visitors and residents come to walk and relax every day.

Table 1. *Cont.*

Site (Code in Figure 1)	Category	Features	Main Vegetation around the Site	Description
Sengyokaidou (D)	Control Group	Mainly buildings		Sengyokaidou, as a control group, is a street located in the central urban area of Matsudo City, which is used by many pedestrians and vehicles every day. It only has a small amount of vegetation and does not contain any water bodies, so it is a completely built-up urban environment.

Figure 1. (Red box) The location of the study sites; (A) Osagamicyousetuike, (B) Sakagawa, (C) Shinsakagawa, (D) Sengyokaidou.

2.2. Study Sample

We performed "within-subject" experiments. Invitations were sent via social media software (LINE and WeChat) and 50 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, nine students were excluded because they indicated that they were unable to participate in the entire experiment. A final sample of 41 students (19 males and 22 females; Table 2) was recruited, and all students visited the four experimental 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 h before the experiment.

Table 2. Subject information.

Information	Value (Mean ± SD)
Male	19
Female	22
Age	26.8 ± 2.9
Weight (Kg)	59.1 ± 11.2
Height (cm)	168.1 ± 8.7
BMI (Kg/m^2)	20.8 ± 2.5

2.3. Measurements

During the experiment, several psychological scales were used to measure participants' self-reported restorative experiences, subjective vitality, and emotional states. All scales 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 [36] and contains six items, three of which measure 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 other two reflect clearing one's thoughts ("I can forget my daily worries" and "My thoughts are clear").

The Subjective Vitality Scale (SVS) [37] 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".

Positive and negative affect are measured by the self-reported Positive and Negative Affect Scale (PANAS) [38]. The PANAS test contains two scales reflecting positive affect (PANAS POS) and negative affect (PANAS NEG). Both scales consist of ten items (Positive: Enthusiastic, Interested, Strong, Excited, Proud, Attentive, Inspired, Determined, Alert, Active; Negative: Distressed, Upset, Guilty, Scared, Hostile, Irritable, Ashamed, Nervous, Jittery, Afraid).

Finally, different levels of perceived natural elements (i.e., green, blue) may lead to different psychological recovery effects [17,39,40]. Therefore, based on previous studies [17,41], two additional questions were sent to participants about their perception of natural element levels in the three UBSs: "To what extent can you perceive the level of green here? including various vegetation and aquatic plants", and "To what extent can you perceive the proportion of water bodies in the whole site here?" Participants were asked to respond to these two questions using a Likert scale of 1 (not at all) to 7 (very high). The overall perceived natural element level was the average of these two items.

2.4. Experimental Procedure

The study procedures of Simkin et al. (2020) [35] and Tyrväinen et al. (2014) [30] were referenced. To eliminate order effects, all four experimental sites were visited in random order and on random days. To ensure the validity of the study, a within-subjects design was used, with each participant visiting one site per week and all participants visiting all four settings. 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 first round of experiments (25 samples) was conducted from 10 October to 20 November 2021, and the second round of experiments (16 samples) was conducted from April 20 to 20 May 2022 (autumn and spring were chosen because of the hot summers and cold winters in Japan). 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. To eliminate external disturbances, similar weather conditions were chosen to conduct the experiments. In addition, the experimenters carried instruments to record environmental conditions, including humidity, temperature, light, and noise, every three minutes during the experiments. These values were not analyzed further and were only used for experimental condition reference (Table 3).

Table 3. Comparison of the environmental factors of the four environmental sites (M ± SD).

Parameter	Urban River	Urban Canal	Urban Lake	Control Group
Temperature (°C)	23.09 (±2.22)	22.62 (±1.36)	22.96 (±1.68)	23.44 (±1.43)
Humidity (%)	38.63 (±4.49)	35.38 (±7.23)	33.25 (±4.73)	32.25 (±4.92)
Absolute illumination (lx)	43,539 (±8051)	50,331 (±2492)	50,774 (±2476)	55,945 (±5001)
Noise (dB)	50.81 (±5.85)	50.55 (±3.27)	44.66 (±2.89)	63.13 (±3.90)

Figure 2 illustrates the process for a single experimental site, which was the same for all four sites. Participants were placed in a waiting room to rest upon arrival at the experimental site, and the experimental assistant introduced the experimental procedure to them. Subsequently, basic information about the subjects was collected (only before the first experiment) and the participants signed a written consent form for voluntary participation. After completion of the first questionnaire (ROS, SVS, and PANAS), the subjects were taken to the experimental site to commence the experiment. The group size for each trial was kept small, with a maximum of six people and a minimum of one person at a time, to minimize the influence of participants on each other. They were asked to focus on their own experience, remain quiet throughout the experiment, not talk to others, and not check their cellphones. The first phase of the experiment involved sitting in a chair in the field for 15 min to observe the environment of the site (Figure 3). After viewing, participants filled out a second questionnaire (ROS and SVS). The viewing phase was followed by a 15-min slow walk (Figure 4) led by a research assistant to ensure that all groups walked the same route (approximately 550 m long at each location) at the same speed. Participants were asked to walk in a line, retaining at least two meters between each other to avoid interfering with themselves. Simultaneously, another experimental assistant followed the group with an instrument to measure environmental factors. After the walk, participants returned to the waiting room and completed a third questionnaire (ROS, SVS, PANAS, and perceived natural element level). The whole experiment took about an hour, and participants were informed that they could withdraw from the experiment at any time.

2.5. Statistical Analysis

A one-way analysis of variance (ANOVA) was performed to calculate the differences in each psychological indicator before the intervention (T1) and between genders. Moreover, non-metric multidimensional scaling (NMDS) with the Raup-Crick index as a distance metric revealed the overall pattern of the data and described the differences and similarities of participants in different study settings (different types of UBSs) [42]. The NMDS and the multi-response permutation procedure (MRPP) were run in R to validate the study settings (different types of UBSs) and to initially explore the variability between data from different sites. NMDS is a method of condensing information from multiple variables into a two-dimensional representation, where the closer the samples in the sorted space, the more similar their properties [43]. MRPP is used to complement the differences between test samples, where more negative T-values indicate greater differences between groups [44]. Both NMDS and MRPP are executed through the vegan package in R version 4.1.2 [45].

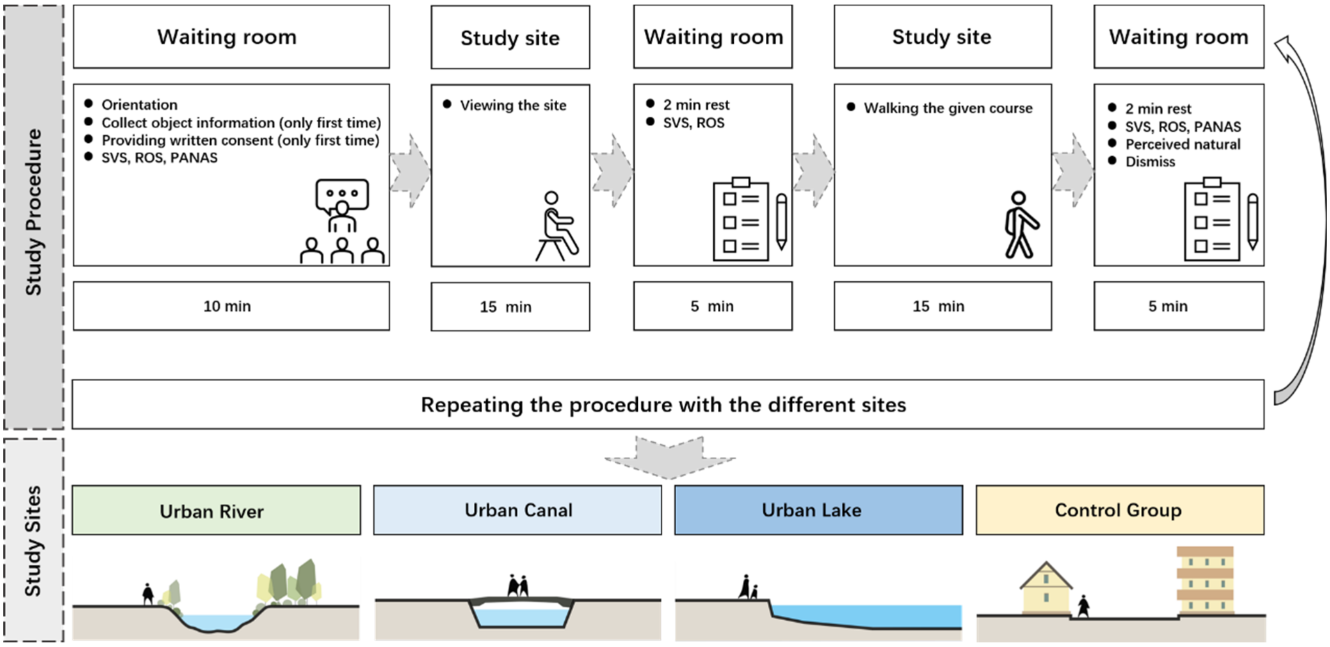

Figure 2. Experimental procedures.

Figure 3. Viewing session in the study sites (authorized photos). (**a**) Sakagawa, (**b**) Shinsakagawa, (**c**) Osagamicyousetuike, (**d**) Sengyokaidou.

Figure 4. Walking session in the study sites (authorized photos). (**a**) Sakagawa, (**b**) Shinsakagawa, (**c**) Osagamicyousetuike, (**d**) Sengyokaidou.

Repeated-measures ANOVA were then used to calculate the effects of the intervention on the four different environmental settings. First, four different sites (coded Place, i.e., Urban River, Urban Canal, Urban Lake, and Control Group) and three intervention time points (coded Time, i.e., before the experiment (T1), after viewing (T2), and after walking (T3)) were used as independent variables for main effects and interaction effects analyses. The purpose of this step was to compare the differences in psychological indicators under the influence of a single variable. Next, simple effects analysis was performed on indicators that interacted significantly with "Place" and "Time" to further compare differences in indicators under different combinations of the two variables (Place and Time). Finally, for the three UBS levels of perceived natural elements (blue, green, total), the Kruskal-Wallis H test (with post hoc test) was used to determine if there was a significant difference between the three data groups.

The SPSS v.20 (IBM, Armonk, NY, USA) software was used for all analyses. In all cases, p-values less than 0.05 were considered statistically significant. To calculate the minimum observed sample size required for the repeated-measures ANOVA, an a priori power analysis was performed using G*Power [46]. We set up four groups and four response variables per group and achieved 95% statistical power at the alpha level of 0.05. The results indicate that a minimum of 144 observation samples is required to achieve a moderate global effect with $f^2(V) = 0.0625$. Thus, in total, a sample of 164 observations from 41 volunteers at 4 sites was used as the final experimental data for analysis.

3. Results

3.1. Scale Statistics

One-way ANOVA results showed no statistically significant differences for four psychological indicators between males and females at T1 time point (Appendix A Table A1), indicating that it was acceptable to analyze females and males together. Moreover, no statistically significant differences between sites for each psychological indicator before the intervention (T1) were found: SVS ($F_{(3,160)} = 0.211$, $p = 0.889$), ROS ($F_{(3,160)} = 1.120$, $p = 0.343$), PANAS POS ($F_{(3,160)} = 0.907$, $p = 0.439$), PANAS NEG ($F_{(3,160)} = 0.371$, $p = 0.774$). This indicates that the experimental procedure was acceptable because there was no significant difference in the participants' pre-experimental status (T1) and therefore the data from T2 and T3 were able to be used for subsequent analysis.

Table 4 demonstrates the scale statistics. Cronbach's α values were good for all scales, ranging from 0.73 to 0.96, with only one data point having a lower but acceptable reliability score (SVS $_{(T2, CG)} = 0.60$). For all psychological indicators, mean sum scores were calculated. Furthermore, the correlation matrix between the four psychological indicators for the three time points is shown in Appendix A Table A2. Only the correlations within each time point were observed. SVS and ROS were significantly positively correlated at all time points in all experimental sites. SVS, ROS, and PANAS POS were significantly positively correlated at T1 and T3 time points in all experimental sites. Not surprisingly, PANAS NEG showed negative correlations with the other three indicators, but in a few cases, this relationship was not statistically significant ($p > 0.05$). The correlation results suggest that the scale data from the four experimental sites fit the scale characteristics, as the SVS, ROS, and PANAS POS scales represent positive psychological states, whereas the PANAS NEG reflects negative psychological states, and an increase in PANAS NEG values would lead to a decrease in other scale evaluations. Therefore, it was preliminarily determined that the results of the four scales in all experimental sites were able to correctly reflect the participants' psychological states at the corresponding time points (T1–T3).

Table 4. Data of all psychological scales at the four experimental sites (164 observation samples).

Place	**UR (N = 41)**			**UC (N = 41)**			**UL (N = 41)**			**CG (N = 41)**		
Measures	**M**	**SD**	**α**	**M**	**SD**	**α**	**M**	**SD**	**α**	**M**	**SD**	**α**
Before the experiment (T1)												
SVS	4.18	1.03	0.88	4.01	1.00	0.85	4.10	0.84	0.80	4.04	1.05	0.84
ROS	4.24	0.98	0.89	3.93	0.90	0.88	3.89	0.97	0.87	4.05	0.91	0.84
PANAS POS	4.06	0.78	0.88	3.78	0.97	0.94	3.88	1.01	0.91	3.76	0.92	0.91
PANAS NEG	2.37	0.89	0.93	2.29	0.96	0.93	2.20	1.10	0.96	2.16	0.90	0.93
After viewing (T2)												
SVS	4.74	1.05	0.83	4.42	0.93	0.73	4.35	1.03	0.81	3.95	0.93	0.60
ROS	5.39	1.19	0.93	4.85	1.11	0.91	5.03	1.06	0.90	3.58	1.24	0.91
After walking (T3)												
SVS	4.62	0.97	0.78	4.63	1.00	0.77	4.44	1.09	0.79	4.15	0.97	0.76
ROS	5.06	1.29	0.95	4.85	1.20	0.93	5.02	1.20	0.93	3.65	1.13	0.90
PANAS POS	4.64	1.02	0.92	4.53	1.03	0.91	4.59	1.04	0.91	3.74	0.94	0.89
PANAS NEG	1.78	0.78	0.93	1.64	0.64	0.91	1.57	0.82	0.96	2.45	1.20	0.95

Note. UR, Urban River; UC, Urban Canal; UL, Urban Lake; CG, Control Group; M, mean value; SD, standard deviation; α, Cronbach's α.

3.2. The NMDS and MRPP Results

Referring to a previous study [42], NMDS and MRPP were run in R to validate the study setting (different types of UBSs) and to initially explore the variability between data from different sites. NMDS results based on a sample of 164 observations from four experimental sites show similarities between the results of the UC, UL, and UR and distinguishes them from those of the CG. Our analysis results showed that there was a statistically significant difference when participants described the environment perception between CG and the other three UBSs. Specially, MRPP results indicated significant differences between CG and UC (T-value = −8.327, $p = 0.001$), UL (T-value = −10.389, $p = 0.001$), and UR (T-value = −12.573, $p = 0.001$). The statistical results suggest that the environment perception of participants at the urban environment (CG) varied from the environment perception in the other three UBSs. It is worth noticing that the most significant difference of restorative perception was urban environment (CG) and urban river (UR), followed by urban lake (UL). In contrast, the perceived differences between the control group and the urban canal (UC) were smaller than the other two UBSs (Figure 5).

3.3. The Repeated-Measures ANOVA Results

A repeated measures ANOVA was performed (Table 5). For the analyses, we used four within-subject factors (Urban River (UR), Urban Canal (UC), Urban Lake (UL), and Control Group (CG)). Additionally, three intervention time points (before the experiment (T1), after viewing (T2), and after walking (T3)) were used for SVS and ROS, while the PANAS POS and PANAS NEG scales were tested only at T1 and T3.

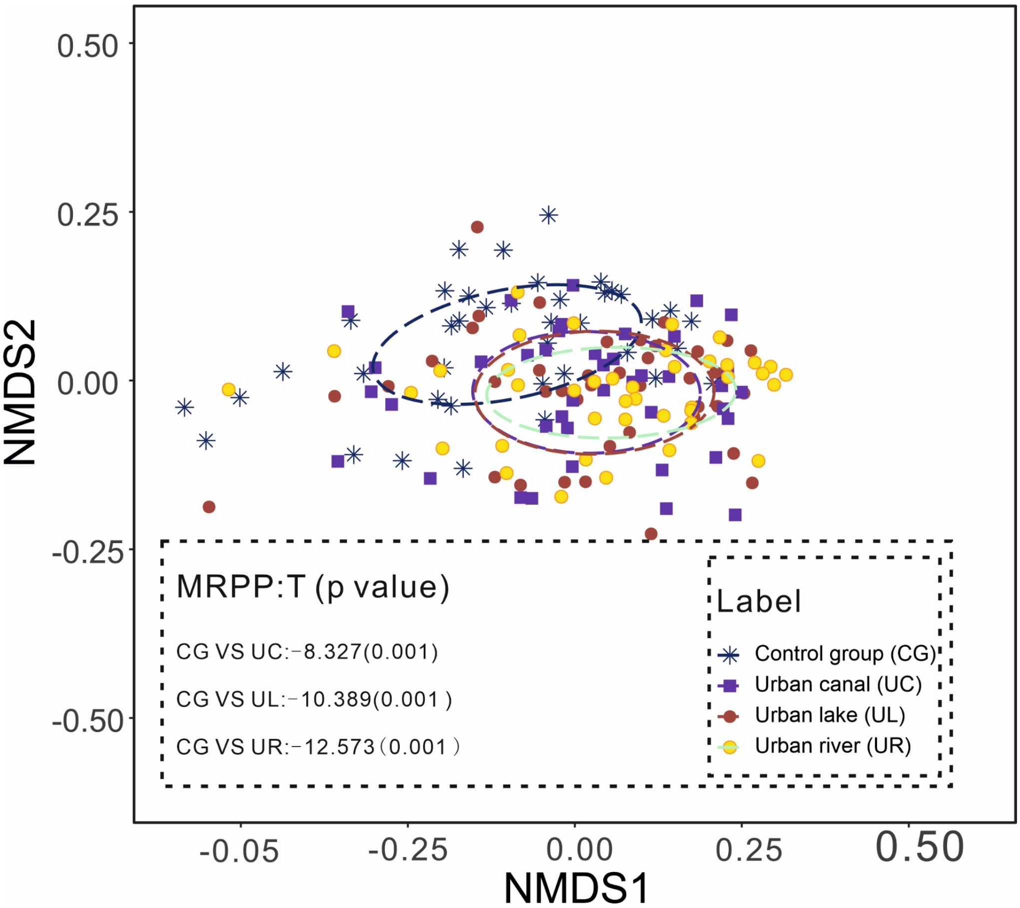

Figure 5. NMDS and MRPP results of 164 observation samples. The ellipse in the figure indicates the standard deviation. T describes the size of the difference, and the larger the absolute value of T, the greater the difference. Different colored dots represent different experimental sites.

Table 5. Main effect and interaction effect of experimental sites and time on SVS, ROS, PANAS POS, and PANAS NEG (164 observation samples).

Indicators	Sum of Squares	df	Mean Square	F	Sig.	Partial η^2	Pairwise Comparisons
SVS (score)							
Constant	9106.542	1	9106.542	8992.726	0.000	0.949	
Place	13.991	3	4.664	4.605	0.003 **	0.028	UR, UC, UL > CG
Time	12.753	2	6.376	6.297	0.002 **	0.026	T3, T2 > T1
Place × Time	6.048	6	1.008	0.995	0.428	0.012	
Error	486.075	480	1.013				
(Adj R2 = 0.201)							
ROS (score)							
Constant	9797.722	1	9797.722	7821.063	0.000	0.942	
Place	88.706	3	29.569	23.603	0.000 **	0.129	UR, UL > UC > CG
Time	46.839	2	23.420	18.695	0.000 **	0.072	T3, T2 > T1
Place × Time	45.443	6	7.574	6.046	0.000 **	0.070	
Error	601.313	480	1.253				
(Adj R2 = 0.314)							
PANAS POS (score)							
Constant	5569.581	1	5569.581	5806.570	0.000	0.948	
Place	16.724	3	5.575	5.812	0.001 **	0.052	UR, UC, UL > CG
Time	20.801	1	20.801	21.686	0.000 **	0.063	T3 > T1
Place × Time	7.675	3	2.558	2.667	0.048 *	0.024	
Error	306.940	320	0.959				
(Adj R2 = 0.209)							

Table 5. *Cont.*

Indicators	Sum of Squares	df	Mean Square	F	Sig.	Partial η^2	Pairwise Comparisons
PANAS NEG (score)							
Constant	1391.159	1	1391.159	1576.624	0.000	0.831	
Place	8.024	3	2.675	3.031	0.030 *	0.028	CG > UR, UL, UC
Time	12.684	1	12.684	14.375	0.000 **	0.043	T1 > T3
Place × Time	12.906	3	4.302	4.876	0.002 **	0.044	
Error (Adj R2 = 0.217)	282.357	320	0.882				

Note. UR, Urban River; UC, Urban Canal; UL, Urban Lake; CG, Control Group; * $p < 0.05$, ** $p < 0.01$.

For SVS, there was a significant main effect of experimental sites on the scores of subjective vitalities, $F_{Place} = 4.605$, $p = 0.003$, Partial $\eta^2 = 0.028$ (Table 5). Paired comparison results indicated that urban river (M = 4.51), urban canal (M = 4.36), and urban lake (M = 4.30) were equal in measure and higher than urban environments (control group, M = 4.04) (Figure 6a). There was also a significant main effect of time, $F_{Time} = 6.297$, $p = 0.002$, Partial $\eta^2 = 0.026$ (Table 5). Comparisons showed that scores for T2 (M = 4.37) and T3 (M = 4.46) were significantly greater than T1 (M = 4.08) (Figure 6b), indicating that both viewing and walking behaviors positively influenced participants' subjective vitalities. Furthermore, the insignificant interaction effect ($F_{Place \times Time} = 0.995$, $p = 0.428$, Partial $\eta^2 = 0.012$, Figure 7a) indicates that no significant differences were shown between the exposure results of two different behaviors (viewing and walking) performed in the four experimental sites.

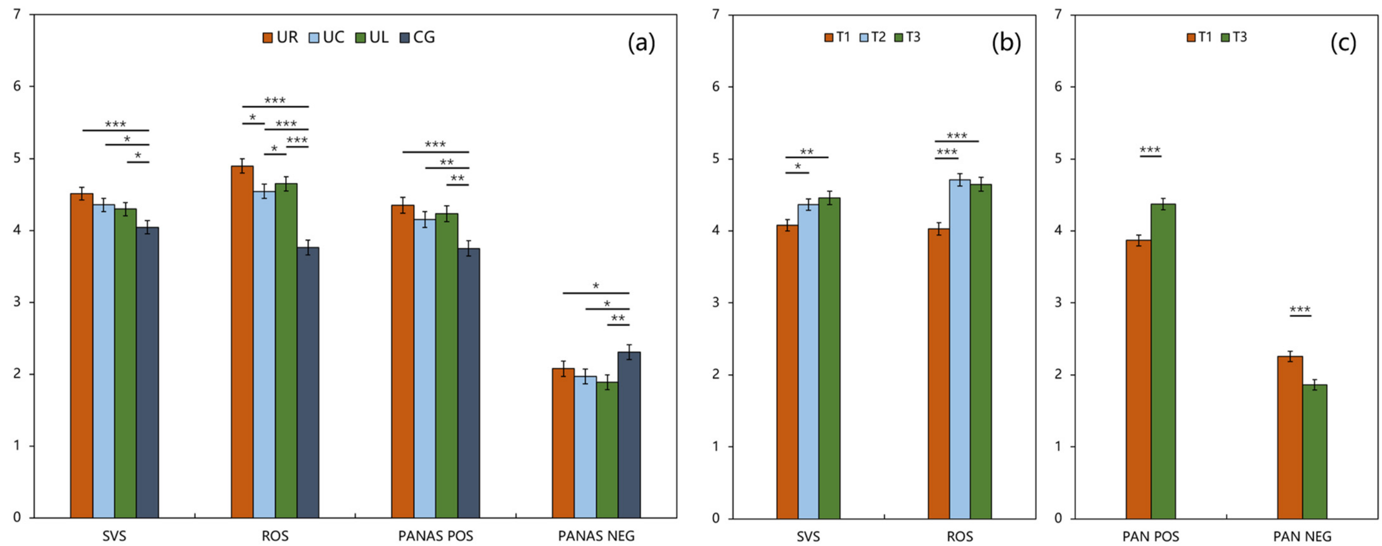

Figure 6. SVS, ROS, PANAS POS, and PANAS NEG in the main effects analysis (mean ± standard error; UR, Urban River; UC, Urban Canal; UL, Urban Lake; CG, Control Group; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$). (**a**) Main effect of Place (SVS, ROS, PANAS POS), (**b**) Main effect of Time (SVS, ROS), (**c**) Main effect of Time (PAN POS, PAN NEG).

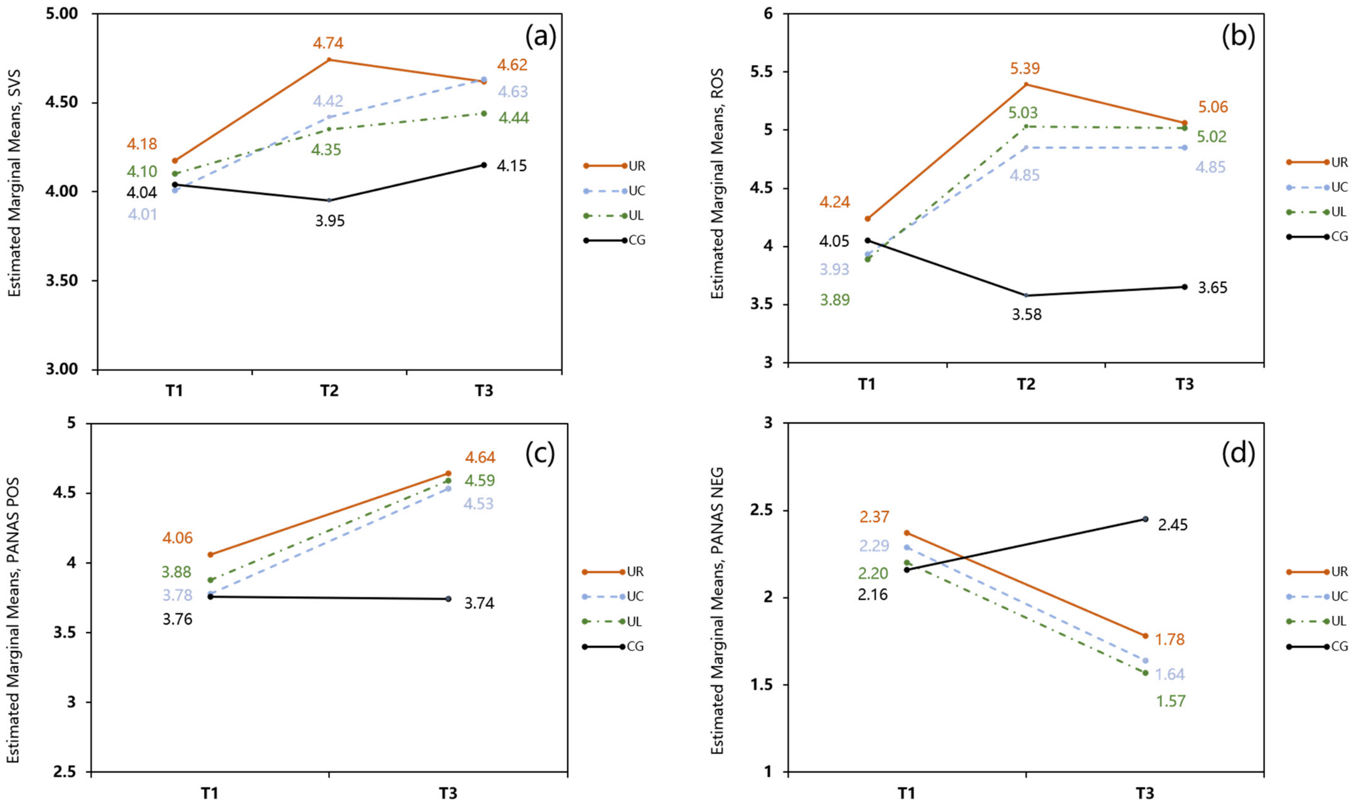

Figure 7. Interaction graphs for SVS (**a**), ROS (**b**), PANAS POS (**c**), and PANAS NEG (**d**); UR, Urban River; UC, Urban Canal; UL, Urban Lake; CG, Control Group.

For ROS, there was a significant main effect of experimental sites on the restorative outcome scores, $F_{Place} = 23.603$, $p < 0.001$, Partial $\eta^2 = 0.129$ (Table 5). Paired comparison results indicated that urban river (M = 4.90) and urban lake (M = 4.65) were equally restorative and more restorative than urban canal (M = 4.54) and urban environments (M = 3.76) (Figure 6a). There was also a significant main effect of time on the restorative outcome scores, $F_{Time} = 18.695$, $p < 0.001$, Partial $\eta^2 = 0.072$ (Table 5). Comparisons showed that scores for T2 (M = 4.71) and T3 (M = 4.65) were significantly greater than T1 (M = 4.02) (Figure 6b), indicating that both viewing and walking behaviors positively influenced participants' perceptions of restoration. Furthermore, the significant interaction effect of time and place ($F_{Place \times Time} = 6.046$, $p < 0.001$, Partial $\eta^2 = 0.070$, Table 5) indicated that the subjects felt recovery in different ways at different times and sites. Simple effects (Table 6) analyses were performed separately for place and time, and the results indicated that place differed significantly at time points T2 (UR (M = 5.39), UL (M = 5.03) > UC (M = 4.85) > CG (M = 3.58)) and T3 (UR (M = 5.06), UL (M = 5.03), UC (M = 4.85) > CG (M = 3.65)) (Figure 7b), which suggests that the restorative effect of viewing in UR and UL for 15 min was significantly stronger than in UC and CG, while the restorative effect of walking was significantly higher in all three UBS than in the urban environment. Time was significantly different across the three experimental sites in urban river (T3 (M = 5.06), T2 (M = 5.39) > T1 (M = 4.24)), urban canal (T3 (M = 4.85), T2 (M = 4.85) > T1 (M = 3.93)), and urban lake (T3 (M = 5.02), T2 (M = 5.03) > T1 (M = 3.89)) (Table 6, Figure 7b), suggesting that 15 min of viewing as well as 15 min of walking at all three UBSs significantly and positively influenced restorative scores. No significant effects were caused after viewing and walking in the urban setting.

Table 6. Simple-effects analysis of the indicators that have significant interaction effects on ROS, PANAS POS, and PANAS NEG.

Indicators	Sum of Squares	df	Mean Square	F	Sig.	Partial η^2	Pairwise Comparisons
ROS (score)							
Place (Time = T1)	3.038	3	1.013	0.808	0.490	0.005	
Error	601.313	480	1.253				
Place (Time = T2)	76.100	3	25.367	20.249	0.000 **	0.112	UR, UL > UC > CG
Error	601.313	480	1.253				
Place (Time = T3)	55.012	3	18.337	14.638	0.000 **	0.084	UR, UC, UL > CG
Error	601.313	480	1.253				
Time (Place = UR)	28.745	2	14.373	11.473	0.000 **	0.046	T3, T2 > T1
Error	601.313	480	1.253				
Time (Place = UC)	23.072	2	11.536	9.209	0.000 **	0.037	T3, T2 > T1
Error	601.313	480	1.253				
Time (Place = UL)	35.282	2	17.641	14.082	0.000 **	0.055	T3, T2 > T1
Error	601.313	480	1.253				
Time (Place = CG)	5.183	2	2.592	2.069	0.127	0.009	
Error	601.313	480	1.253				
PANAS POS (score)							
Place (Time = T1)	2.378	3	0.793	0.826	0.480	0.008	
Error	306.940	320	0.959				
Place (Time = T3)	22.020	3	7.340	7.652	0.000 **	0.067	UR, UC, UL > CG
Error	306.940	320	0.959				
Time (Place = UR)	6.792	1	6.792	7.081	0.008 **	0.022	T3 > T1
Error	306.940	320	0.959				
Time (Place = UC)	11.494	1	11.494	11.983	0.001 **	0.036	T3 > T1
Error	306.940	320	0.959				
Time (Place = UL)	10.185	1	10.185	10.619	0.001 **	0.032	T3 > T1
Error	306.940	320	0.959				
Time (Place = CG)	0.004	1	0.004	0.005	0.946	0.000	
Error	306.940	320	0.959				
PANAS NEG (score)							
Place (Time = T1)	1.069	3	0.356	0.404	0.750	0.004	
Error	282.357	320	0.882				
Place (Time = T3)	19.861	3	6.620	7.503	0.000 **	0.066	CG > UR, UC, UL
Error	282.357	320	0.882				
Time (Place = UR)	7.024	1	7.024	7.961	0.005 **	0.024	T1 > T3
Error	282.357	320	0.882				
Time (Place = UC)	8.629	1	8.629	9.779	0.002 **	0.030	T1 > T3
Error	282.357	320	0.882				
Time (Place = UL)	8.181	1	8.181	9.271	0.003 **	0.028	T1 > T3
Error	282.357	320	0.882				
Time (Place = CG)	1.756	1	1.756	1.990	0.159	0.006	
Error	282.357	320	0.882				

Note. UR, Urban River; UC, Urban Canal; UL, Urban Lake; CG, Control Group; ** $p < 0.01$.

For PANAS POS, there was a significant main effect of experimental sites on positive emotions, $F_{Place} = 5.812$, $p = 0.001$, Partial $\eta^2 = 0.052$ (Table 5). Paired comparison results indicated that urban river (M = 4.35), urban canal (M = 4.15), and urban lake (M = 4.23) have higher positive emotions than urban environments (M = 3.75) (Figure 6a). Additionally, there was a significant main effect of time on positive emotions, $F_{Time} = 21.686$, $p < 0.001$, Partial $\eta^2 = 0.063$ (Table 5). Comparisons showed that scores for T3 (M = 4.37) were significantly greater than for T1 (M = 3.87) (Figure 6b), suggesting that a 15-min walk improved participants' positive emotions. Furthermore, the significant interaction effect of time and place ($F_{Place \times Time} = 2.667$, $p = 0.048$, Partial $\eta^2 = 0.024$, Table 5) indicated that the subjects felt emotion improvement in different ways at different times and sites. Simple effects (Table 6) results indicated that place differed significantly at time points T3 (UR (M = 4.64), UL (M = 4.59), UC (M = 4.53) > CG (M = 3.74)) (Figure 7c), which suggests that the emotion improvement effect of walking in UR, UC, and UL for 15 min was significantly stronger than in CG. Time was significantly different across the three experimental sites in UR (T3(M = 4.64) > T1(M = 4.06)), UC (T3(M = 4.53) > T1(M = 3.78)), UL (T3(M = 4.59) > T1(M = 3.88)) (Table 6, Figure 7c), suggesting that 15 min of walking at all three UBSs positively influenced the positive emotions of the participants. No significant effects were caused after walking in the CG (T3(M = 3.74), T1(M = 3.76), $p = 0.127$, Table 6, Figure 7c).

With PANAS NEG, a significant main effect of the experimental site on negative emotions was found, $F_{Place} = 3.031$, $p = 0.030$, Partial $\eta^2 = 0.028$. Paired comparison results indicated that urban river (M = 2.076), urban canal (M = 1.968), and urban lake (M = 1.889) were lower than urban environments (M = 2.31) (Figure 6a). There was a significant main effect of time on negative affect, $F_{Time} = 14.375$, $p < 0.001$, Partial $\eta^2 = 0.043$ (Table 5). Pairwise comparisons showed that scores for T1 (M = 2.26) were significantly greater than those for T3 (M = 1.86) (Figure 6b), indicating that the 15-min walk was effective in reducing participants' negative emotions. Moreover, the interaction effect of time and place was statistically significant ($F_{Place \times Time} = 4.876$, $p = 0.002$, Partial $\eta^2 = 0.044$, Table 5). Simple effects results showed that place differed significantly at time points T3 (UR (M = 1.78), UC (M = 1.64), UL (M = 1.57) < CG (M = 2.45)), time at urban river (T3 (M = 1.78) < T1 (M = 2.37)), time at urban canal (T3 (M = 1.64) < T1 (M = 2.29)), and time at urban lake (T3(M = 1.57) < T1(M = 2.20)), with significant differences among the three UBSs (Table 6, Figure 7d). This suggests that walking for 15 min in the three UBSs has a significantly stronger effect on the improvement of negative emotions than the urban environment (control group).

3.4. Natural Element Level Perception of Three UBSs

The final part of the questionnaire collected participants' perceived natural element levels of the three urban blue spaces. Figure 8 and Table 7 show the differences in the perceived natural element levels between the three UBSs, as well as the results and effect sizes of the Kruskal-Wallis H test (with post hoc test). According to the results, perceived blue levels were highest in Urban Lake (6.34 ± 0.52) and significantly higher than in Urban River (4.46 ± 1.47, adj $p < 0.001$) and Urban Canal (5.22 ± 0.98, adj $p < 0.001$), while no significant differences were found between Urban River and Urban Canal (adj $p = 0.157$). For perceived green levels, Urban River was the highest (6.34 ± 1.20) and significantly higher than Urban Canal (3.20 ± 1.47, adj $p < 0.001$) and Urban Lake (3.34 ± 1.39, adj $p < 0.001$), while no significant differences were found between Urban Lake and Urban Canal (adj $p = 1.000$). For total natural perception, Urban Canal (4.21 ± 1.02) was significantly lower than Urban River (4.80 ± 0.97, adj $p = 0.016$) and Urban Lake (4.84 ± 0.74, adj $p = 0.005$), while no significant differences were found between Urban Lake and Urban River (adj $p = 1.000$).

Table 7. Kruskal-Wallis H test (multiple comparisons) results with effect sizes.

		N	Test Statistic	df	Sig.	η^2	Cohen's d
Perceive Blue		123	47.121	2	<0.001	0.376	1.553
	UR vs. UC	41	−14.659		0.157		
	UR vs. UL	41	−50.427		<0.001		
	UC vs. UL	41	−35.768		<0.001		
Perceive Green		123	33.360	2	<0.001	0.261	1.19
	UC vs. UR	41	40.146		<0.001		
	UL vs. UR	41	36.866		<0.001		
	UC vs. UL	41	−3.280		1.000		
Perceive of Total Nature		123	11.790	2	0.003	0.082	0.596
	UC vs. UR	41	21.707		0.016		
	UC vs. UL	41	−24.354		0.005		
	UR vs. UL	41	−2.646		1.000		

Note. UR, Urban River; UC, Urban Canal; UL, Urban Lake.

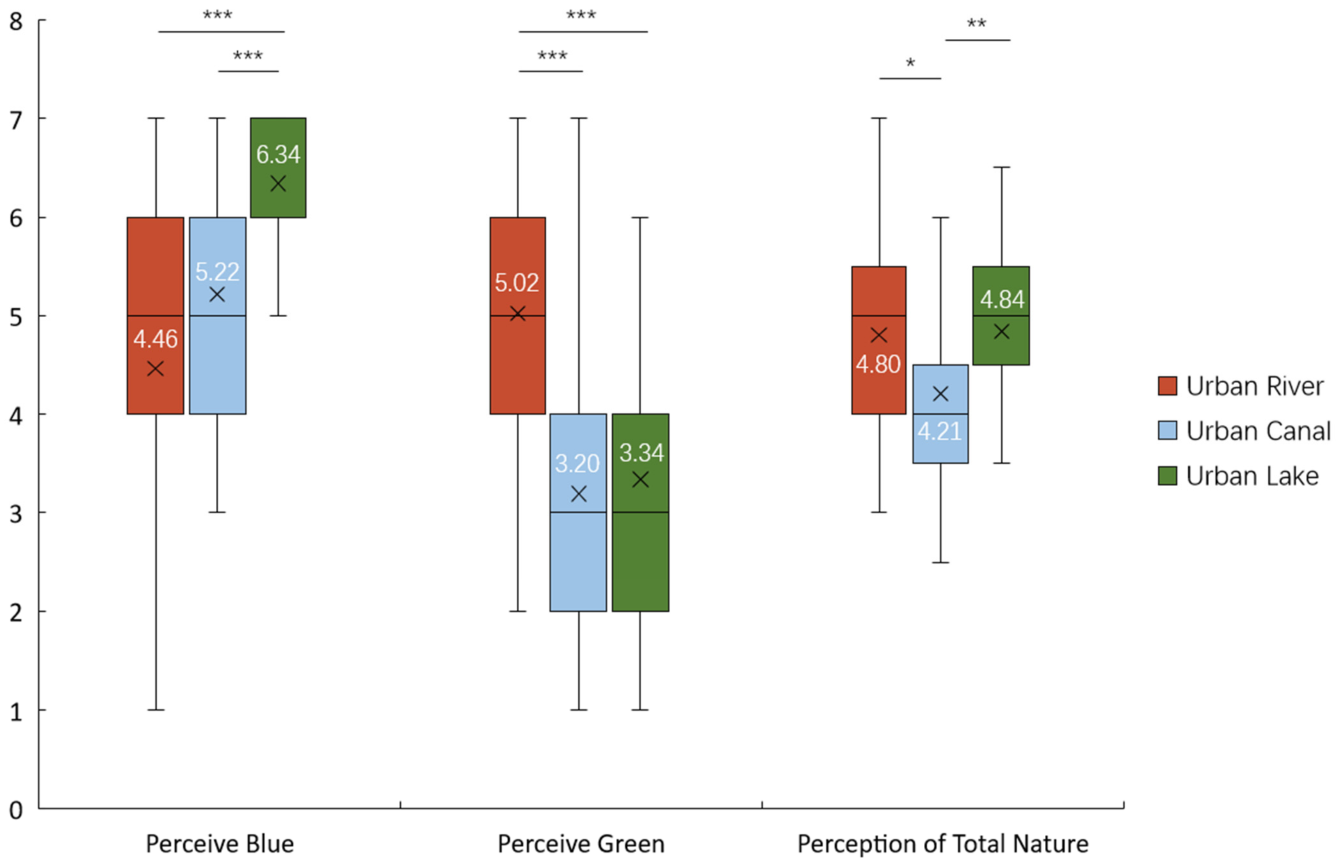

Figure 8. Difference results of perceived natural element levels in the three UBSs by Kruskal-Wallis H test. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. The "×" in the box represents the mean value.

4. Discussion

4.1. Summary of the Major Findings

First, we investigated the effects of the four environmental settings on the subjects by using multiple psychological measures, which include Subjective Vitality (SVS) as an indicator of well-being and which has been conceptualized as a positive psychological state [47], the Restorative Outcome Scale (ROS) as a reliable scale developed based on previous research and observations of the restoration phenomenon [48], and improvements in emotion (PANAS) that have been consistently linked to psychological well-being [49]. In particular, higher SVS scores represented higher perceptions of subjective vitality; higher ROS scores represented greater perceived restorative outcomes (relaxation, calmness, concentration, and clarity of thought); higher PANAS POS scores and lower PANAS NEG scores represented better improvements in emotion.

In sum, all three UBSs increased vitality, feelings of restoration, and positive emotions, and decreased negative emotions; while the urban environment did not significantly improve these indicators. Consistent with the results of previous related studies [30,35,50], the results confirm that the restorative benefits of UBSs are similar to those of other green environments (e.g., urban parks, urban forests). Furthermore, no significant differences of mental restoration were observed between walking (T3) and viewing (T2) in the three UBSs. Moreover, taken together, the main effects of study sites showed that the urban river (UR) and the urban lake (UL) had the highest restorative scores, followed by the urban canal (UC), with the lowest in the control group (urban environment), confirming that different urban blue spaces may have different restorative outcomes. The reasons and implications of these findings will be discussed in depth in the following sections.

4.2. Restorative Benefits Were Found at Different Time Points, but Not Significantly Different

Previous research has demonstrated that spending time in blue spaces improves mental health, such as by viewing water bodies [21] and walking around a waterside [51]. So far, there has been a great deal of discussion about the causes of the mental restoration of blue space. One possible interpretation is from the perspective of evolutionary psychology; blue space provides humans with the natural space and resources (e.g., fresh water, food) they need to survive [52]. Second, according to Ulrich et al. (1991) [40], if an individual encounters a natural environment that is not threatening, there will be stress-reducing and restorative effects. The three UBSs we selected are all common types of water bodies in Japanese cities and are used daily by local residents in these areas. Therefore, for study subjects, unlike lakes in the wilderness or rivers in the forest, blue spaces in urban areas are less likely to feel threatening. Third, similar to numerous discussions of the restorative nature of green space, unconscious attention or fascination can lead to restorative impacts [39,40]. Thus, unlike the marine blue space, the freshwater blue space selected for this study was "soft" in that the water flow was gentle for the most part, with no rough waves to attract the subjects' voluntary attention, thus allowing participants' brains to relax and recover from mental fatigue. This can be particularly beneficial for individuals who are experiencing stress or mental exhaustion. Finally, Subiza-Pérez et al. (2019) stated that the sublime, a sense of connection to something larger than ourselves, can also be experienced even in daily natural environments such as urban blue spaces which can promote feelings of awe and wonder, which have been linked to positive emotions and well-being [7]. For example, in this study, the urban lake has a large body of water, and this large natural element in an urban environment may have surprised the subjects and evoked a sense of sublimity, thus leading to mental restoration.

However, it is interesting to see that there was not much difference between T2 and T3, suggesting that the mental restoration effects of walking and viewing in UBSs are the same. Previous studies have shown that the viewing stage is almost a psychological experience (sedentary), while the walking stage includes both the psychological and physical interactions with the landscapes, and the physical activity may also contribute to the restoration [30,35]. In this regard, we propose the following three possible explanations:

(1) Due to the plateau effect [53], the act of 15 min of viewing already caused subjects to perceive a high level of mental restoration. Therefore, a walking session (15 min of viewing combined with 15 min of physical activity) would hardly lead to a higher level of perceived mental recovery for the subjects compared to 15 min of viewing.

(2) Second, the health effects of physical activity typically come from a reduction in blood pressure and heart rate. However, a previous study showed that no positive cardiovascular effects were observed for the walking behavior in the blue space [54]. Therefore, we speculate that unlike the green space [31,34,55], the walking behavior in the UBS had a limited effect on physical health and therefore led to the same psychological recovery outcome as the 15 min viewing.

(3) Moreover, the exposure time was not sufficient. Both the viewing session and the walking session in the present study were 15 min, unlike two previous similar studies, which had 30 min walking sessions, leading to a higher level of recovery outcomes [30,35].

4.3. The Restorative Effect of Different UBS Is Different

Until recently, the restorativeness of different types of natural environments was still being discussed. Korpela et al. (2010) found that the restorative experiences of extensively managed natural areas (large forest areas, small-scale wooded areas) and built-up green spaces (large green lots, decorative plantations) were different [28]. An experiment in Finland showed that three old forests had stronger restorative effects compared to a young commercial forest [35]. Other studies have found different positive impacts on stress relief between large urban woodlands and intensively managed urban parks, although this difference is smaller [30]. Additionally, the green space type with the most natural elements (peri-urban green area) was found to be the most restorative, while the green space type with predominantly built elements (urban square) was found to be the least restorative [29]. These findings all confirm the conclusion that even though thought to be restorative environments, the positive effects of different environmental settings are different.

Similarly, differences in the restorativeness of the three UBSs were found in the results of this study: the urban river as well as the urban lake were the most restorative, while the urban canal was less restorative. Reviewing the components of these environmental settings, UR is a blend of natural and artificial environments as many aquatic plants and street trees are planted, UL is a large artificial lake, and UC is an artificial waterway located in a built-up area which has a smaller water body area compared to UL. According to previous studies, higher perceived blue space and perceived green space within settlements are significantly associated with higher restorative quality [13], perceived restorativeness increases with increasing naturalness in green space [29], and there is a positive correlation between restorativeness scores and the proportion of water in the scene [17]. These findings all affirm that there is a positive relationship between the dose of natural elements in the scene and the intensity of the restorative experience [17,56].

Along these same lines, arguably, the higher the overall dose of visible/accessible natural elements in an environment, the higher the restorative quality of the environment, whether these natural elements are green (vegetation) or blue (water bodies), which is consistent with the Biophilia Hypothesis [57]. Accordingly, it appears possible to propose the concept of a "natural health dose" to emphasize the complementary effects of blue and green elements (Figure 9), which could explain why health outcomes may be different for different restorative environments. For example, compared to the UC, the UR had a similar level of visibility in its water bodies (in fact, the UC and UR are different areas of the same waterway, Figure 1), but the addition of many natural plants resulted in a significant increase in the overall total number of visible natural elements in the scene (Figure 8), which greatly enhanced the restorative effects of the environment. Similarly, both the UL and UC are highly artificial environments (the lower perceived green levels), but the UL has a larger area of water, so the subjects were able to observe a higher proportion of water in the scene (Figure 8), leading to a better restorative experience [17], which is perhaps also consistent with the coherence of the scene in Attention Restoration Theory [39]. However, as Jiang et al. (2014) [56] highlight the existence of a threshold of natural elemental dose to ensure moderate benefits, there is also a threshold of "natural health dose" for different blue spaces/blue-green spaces in the city, which will be another topic of continued discussion in the future.

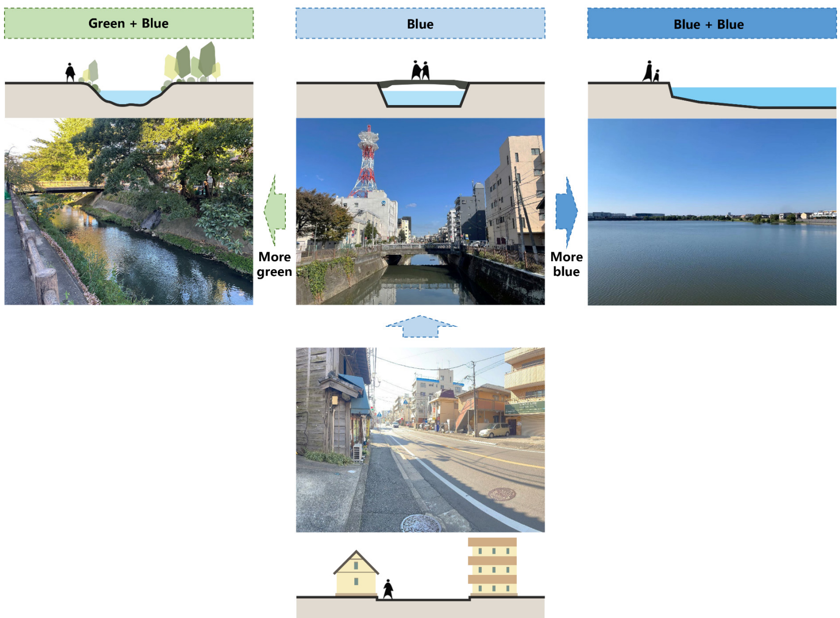

Figure 9. Natural health dose reflecting the complementary effect of blue and green elements.

In summary, as a response to previous research [15,32], the current field study findings suggest that the mental health benefits of different freshwater blue spaces may vary depending on the different environmental content (natural element dose) in different environments.

4.4. Implications

The research implications are obvious. First, the results of this experiment may provide foundational evidence for building healthy cities. The "Blue Gym" program, which has been emphasized in several countries, aims to connect people to blue spaces and thus improve psychological health and social well-being [58]. Thus, planners and city managers can determine the areas of residential and urban "blue recreation areas" based on the blue resources (water bodies) available in the city. According to Dzhambov et al. (2018), perceived blue spaces are associated with higher physical activity [13]. In these areas, residents can interact with nature through proximity to water bodies and engage in sports and recreational activities (walking, running, dog walking, socializing). Additionally, viewing natural elements can be a restorative experience [59], and similar to Elsadek et al.'s (2020) study [60], residents can view nearby water bodies through windows for relaxation and psychological recovery. One suggestion involves targeting specific populations (experiencing high stress or low mental health) with appropriate interventions to encourage greater exposure to these blue spaces, such as by increasing aquatic features in buildings and organizing tours of watery environments [17].

Second, the management and design of different blue spaces in a city can also have benefits. For example, if conditions permit, it is desirable to increase the vegetation cover of artificial waterways in a city by adding aquatic plants and vegetation at the water's edge. Additionally, unlike green spaces, expanding water bodies is more difficult owing to high costs, so it is more feasible to develop various blue spaces in a city (e.g., daylighting buried waterways or adding artificial lakes and ponds [61]). Furthermore, landscape architects should provide adequate facilities to use these UBSs, such as benches to support viewing behavior and a "Blueway" for walking (corresponding to the greenway). Finally, maintaining the quality of water and the UBS is necessary, and although this study did not measure relevant data, previous research has shown that low-quality urban waterways (dirty water, odors, floating trash) can reduce therapeutic experiences [26].

Finally, in terms of theoretical contributions, there is less direct health evidence involving blue spaces (e.g., [54]). This study investigated the psychological recovery effects of short visits (15 min of viewing, 15 min of walking) in three different UBS settings through a field experiment, and our current results add to this research gap. Moreover, this experimental design refers to other green space studies [30,35] and obtains high scale reliability, which suggests that this empirical research process can be extended to other potentially restorative spaces, such as gray space [62] and yellow space [63]. Furthermore, the proposed "natural health dose" may raise an interesting discussion about whether there are other restorative elements in the urban environment other than green and blue elements. For example, some studies have found that cultural [64] or artificial elements [65] can also trigger restoration, yet such restoration may need to be achieved through design methods or a degree of coherence with the environment. Therefore, it is recommended to refer to the subjective perception measurement approach in this study to discover the level of various types of restorative elements in different care environments.

4.5. Limitations

It is imperative to acknowledge that this study has some limitations that should be considered in future studies. First, we selected only freshwater blue spaces, excluding urban coastal and seaside environments where the restorative experience may differ from other UBSs. Second, although we speculate that the effect of blue space on physiological health is limited, it is worthwhile to conduct more experiments to verify this hypothesis. Third, seasonal-specific investigations are beneficial, such as that by Bielinis et al. (2018) [47], who found that forest viewing in winter led to psychological relaxation. Along the same lines, future studies could consider exploring the health-improving effects provided by viewing a frozen lake, as well as the benefits of physical activity in blue spaces in winter. Fourth, exposure time affects the level of psychological recovery [30], so longer walks (30 min or more) and viewing may yield different findings. Fifth, because of the limitations of the sample size, gender, age, and occupational differences were not compared, and future studies could investigate the effects of these different variables on restoration. Sixth, the sample in this study was a healthy population without mental illness, so experimental samples such as high stress, depression, and other mental illnesses are meaningful for urban public health. Seventh, owing to cost and time constraints, only three common types of blue spaces in urban environments were investigated in this study, and investigations of additional types of UBS (e.g., stream, coastal, harbor) are encouraged to complement the results of this manuscript. Eighth, outcomes such as clinical/administrative or sensor data could be used to reflect the psychological restoration in more empirical studies. Finally, the concept of "natural health dose" is proposed. However, owing to space limitations, we did not discuss it in depth, and future studies could quantify the value of "dose" by using visual indices to discuss the complementary effects of green and blue.

5. Conclusions

Even though water covers more than two-thirds of the Earth, systematic investigations into blue spaces remain neglected. Different blue spaces in cities have been identified as important contributors to urban public health, but empirical data on this issue is lacking [10], and our current results add to this research gap. Overall, the present study investigated the psychological recovery effects of short visits (15 min of viewing, 15 min of walking) in three different UBS settings through a field experiment. The results confirmed that:

(1) all three UBSs increased vitality, feelings of restoration, positive emotions, and decreased negative emotions, which suggest that the restorative benefits of UBSs are similar to those of other green environments;
(2) the mental restoration effects between walking and viewing among three UBSs showed no significant differences;
(3) of the three UBSs, urban rivers and urban lakes were the most restorative, while urban canals were less so;
(4) the health experiences of different UBSs in urban settings can show differences depending on the natural components and their levels in the environment (blue, blue + green, blue + blue).

The current findings highlight the health value of the different types of blue spaces in cities that structure the blue health network in the urban environment. The results can provide insights for city managers, planners, and landscape architects to better develop appropriate uses and interventions.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Differential results for gender on each psychological indicator at the four sites before the intervention (ANOVA).

Place	Psychological Indicators	Levene Statistic (Sig.)	Sum of Squares	F	Sig.
UR (N = 41)	SVS	0.471 (0.497)	0.032	0.029	0.867
	ROS	0.474 (0.495)	0.026	0.026	0.873
	PANAS POS	0.028 (0.867)	0.199	0.316	0.577
	PANAS NEG	0.177 (0.676)	0.230	0.277	0.602
UC (N = 41)	SVS	0.680 (0.415)	1.257	1.222	0.276
	ROS	1.249 (0.271)	0.115	0.135	0.715
	PANAS POS	0.524 (0.473)	0.431	0.438	0.512
	PANAS NEG	0.277 (0.602)	0.000	0.000	0.999
UL (N = 41)	SVS	0.488 (0.489)	2.638	3.933	0.054
	ROS	0.554 (0.461)	1.176	1.227	0.275
	PANAS POS	0.656 (0.423)	2.638	3.933	0.054
	PANAS NEG	0.056 (0.814)	0.024	0.019	0.892
CG (N = 41)	SVS	0.085 (0.772)	0.703	0.613	0.438
	ROS	0.114 (0.738)	0.441	0.519	0.476
	PANAS POS	0.118 (0.733)	0.472	0.534	0.469
	PANAS NEG	0.024 (0.879)	0.238	0.284	0.597

Note. UR, Urban River, UC, Urban Canal, UL, Urban Lake, CG, Control Group.

Table A2. Correlation (Pearson) matrix for four psychological indicators.

Place	Correlation		Before the Experiment (T1)				After Viewing (T2)		After Walking (T3)			
			SVS	ROS	POS	NEG	SVS	ROS	SVS	ROS	POS	NEG
UR (N = 41)	Before the experiment (T1)	SVS	1	0.69	0.84	−0.35	0.73	0.55	0.66	0.59	0.54	−0.38
		ROS		1	0.73	−0.46	0.63	0.54	0.52	0.53	0.43	−0.39
		POS			1	−0.32	0.71	0.59	0.70	0.59	0.63	−0.42
		NEG				1	−0.34	−0.43	−0.17	−0.24	0.13	0.41
	After viewing (T2)	SVS					1	0.78	0.79	0.65	0.63	−0.48
		ROS						1	0.71	0.82	0.71	−0.65
	After walking (T3)	SVS							1	0.81	0.81	−0.53
		ROS								1	0.87	−0.71
		POS									1	−0.65
		NEG										1
UC (N = 41)	Before the experiment (T1)	SVS	1	0.76	0.77	−0.34	0.54	0.28	0.37	0.39	0.39	−0.29
		ROS		1	0.75	−0.43	0.51	0.42	0.31	0.47	0.37	−0.34
		POS			1	−0.34	0.59	0.50	0.38	0.53	0.47	−0.26
		NEG				1	0.18	0.05	0.20	0.03	0.13	0.60
	After viewing (T2)	SVS					1	0.75	0.79	0.69	0.70	−0.17
		ROS						1	0.71	0.80	0.73	−0.42
	After walking (T3)	SVS							1	0.81	0.81	−0.31
		ROS								1	0.88	−0.47
		POS									1	−0.33
		NEG										1

Table A2. *Cont.*

Place	Correlation		Before the Experiment (T1)				After Viewing (T2)		After Walking (T3)			
			SVS	ROS	POS	NEG	SVS	ROS	SVS	ROS	POS	NEG
UL (N = 41)	Before the experiment (T1)	SVS	1	0.59	0.72	−0.22	0.71	0.63	0.69	0.52	0.55	−0.50
		ROS		1	0.78	−0.45	0.42	0.42	0.37	0.39	0.26	−0.41
		POS			1	−0.34	0.50	0.51	0.53	0.46	0.51	−0.40
		NEG				1	−0.10	−0.13	0.03	0.06	0.19	0.48
	After viewing (T2)	SVS					1	0.71	0.73	0.67	0.70	−0.46
		ROS						1	0.71	0.73	0.69	−0.41
	After walking (T3)	SVS							1	0.77	0.83	−0.51
		ROS								1	0.89	−0.54
		POS									1	−0.42
		NEG										1
CG (N = 41)	Before the experiment (T1)	SVS	1	0.77	0.78	−0.31	0.73	0.46	0.70	0.35	0.49	−0.19
		ROS		1	0.77	−0.51	0.78	0.59	0.68	0.45	0.45	−0.40
		POS			1	−0.47	0.66	0.51	0.70	0.41	0.53	−0.33
		NEG				1	−0.34	−0.45	−0.27	−0.43	−0.30	0.71
	After viewing (T2)	SVS					1	0.61	0.72	0.53	0.62	−0.34
		ROS						1	0.56	0.70	0.57	−0.58
	After walking (T3)	SVS							1	0.67	0.77	−0.37
		ROS								1	0.80	−0.63
		POS									1	−0.44
		NEG										1

Note. UR, Urban River, UC, Urban Canal, UL, Urban Lake, CG, Control Group. The numbers in the table represent the correlation coefficients. Green cells indicate $p < 0.05$ and blue cells indicate $p < 0.01$ while the cells without color indicate insignificance.

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