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Attention and Emotion Recovery Effects of Urban Parks during COVID-19—Psychological Symptoms as Moderators

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Abstract: Previous research that compared the restorative effects of natural settings with poor-quality urban settings may have exaggerated the restorative benefits of greenspace. Few studies have been conducted to examine the restorative benefits of green streets and other types of park landscapes on attention and emotion. In addition, it is not clear how negative psychological symptoms (e.g., stress, depression) affect natural's restorative benefits, especially as the current COVID-19 pandemic has added to people's psychological burden. In this study, 125 participants were randomly assigned to view one of five videos (green street, lawn, plaza, forest, waterside) for a break after completing an emotion and attention fatigue induction task. Attention function and emotion were measured using the backward digit span test and the Self-Assessment Manikin scale. Stress and depressive symptoms experienced over the last month were measured using the Perceived Stress Scale(PSS-10) and the Patient Health Questionnaire(PHQ-9). Our results indicate that the four park settings showed significant attention function recovery and valence improvement compared to the green streets, while subjects' arousal changed only over time. Hardscapes (plazas) could provide the same attentional and emotional restorative benefits as natural landscapes (forests, watersides, lawns). In addition, we also found that the mood-improving benefits of natural environments may decrease with increasing depressive symptoms, although chronic stress symptoms did not show the same trend.

Keywords: attention recovery; emotional improvement; urban park landscapes; green street; stress symptoms; depressive symptoms

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1. Introduction

1.1. Background

In 2020, countries worldwide spent less than 2% of their total spending on mental health during the COVID-19 pandemic [1]. The COVID-19 epidemic has increased people's psychological stress and caused mental health problems [2], leading to a surge in the number of people with depression [3–5]. Contact with nature, through a variety of means, may alleviate this problem. Previous research has found that greenspace exposure may affect emotions [6], stress [7], learning ability [8–10], cognitive function [11,12], attention [13,14], and intelligence [15,16]. However, relevant experimental studies often choose low-quality urban environments (such as busy roadways, industrial regions, streets without greening, and viaduct roads) to compare with natural environments, which may exaggerate the restorative benefits of the natural environment. In addition, few studies compare the restorative benefits of different landscape types. The COVID-19 pandemic has brought additional psychological stress, which may inhibit or enhance the attentional and emotional benefits people derive from nature. Understanding the recovery benefits of different virtual landscapes and the effects of individual negative psychological symptoms on these recovery effects is crucial. In particular, people may not have direct access to green spaces during the COVID-19 pandemic. Therefore, more research is needed to analyze the differences in recovery benefits across settings and consider how an individual's mental health affects this recovery process.

This paper investigates whether there are differences in attention recovery and mood improvement after viewing different environment videos, as well as whether individual depressive symptoms and stress levels in the last month affect these restorative benefits. First, we review studies on recovery effects in different park landscapes and the impact of psychological symptoms on these restorative benefits. Then, we describe the improvement effects on attention function and mood of different settings based on an experiment involving 125 individuals. Furthermore, we analyze whether depressive symptoms and stress levels may have modulated those benefits. Finally, we discuss the implications of the results for urban landscape design and planning.

1.2. Restorative Benefits of Natural Settings

Unlike truly natural settings, restorative settings in the urban context primarily result from human activity. Parks, urban forests, artificial lakes, and other similar settings are common in cities. In terms of restorative benefits, such places, designed and managed by humans, are not inferior to true natural settings [17–19]. This study focuses on urban park settings. Like other related studies, this paper is based on the following two theories. Stress Reduction Theory (SRT) holds that the driving force of natural environments' recovery effect comes from people's immediate emotional response to natural environments [7,20]. On the other hand, Attention Restoration Theory (ART) focuses on the potential cognitive benefits of interaction with natural environments [21–23].

To further explore the restorative benefits of nature, researchers began to investigate different natural settings. Many studies have been conducted to compare various natural environments in urban contexts, such as blue space, green space, and urban forests. Although several studies found no differences in perceived restoration [24], stress-relief [25–27], or emotional improvement [26] across different natural environments, other studies found mixed results. Three studies showed that open grass areas have the best restorative benefits. Huang et al. report that the increase in positive feelings was greater in a courtyard with grass than in ones with trees or no vegetation [28]. Participants in a Norwegian study rated pocket parks with lots of grass as having a high likelihood of restoration [29]. Another study discovered that partially open green spaces had the greatest beneficial influence on negative emotions, whereas closed green spaces had the least significant positive effect [30]. Two studies, however, showed that forests may be more suited for relaxing. Deng et al. discovered that respondents' meditation and attention scores were greater in a mountain forest than at a lakeside or on grass [31]. Similarly, a field study found that urban forests provide more perceived restoration than parks [32]. Finally, one study discovered that nature-based scenarios (small lakes and lawns) were more effective than hardscapes (plazas) in galvanic skin reduction [33]. In general, the differences in restorative benefits between different natural environments do not yield consistent results.

Another topic of debate is whether the restorative benefits of a green street environment are comparable to that of natural settings. One of the primary criticisms of the above studied is that, to contrast dramatically with natural environments, these relevant studies chose areas that were least likely to have restorative potential to represent urban environments, such as busy highways [34], industrial zones [35], streets without greening [24], and viaduct roads [33]. This bias may cause the literature to exaggerate the restorative effects of nature. Scholars have begun using ordinary urban environments as control groups, such as greenery-filled streets [36], calm residential districts [26], and pedestrianized areas [37]. In keeping with past studies, the current study employed streets with greening as a control group. As street greening is a rigorous urban planning measure in China, such an environment is prevalent in China's large cities.

1.3. Psychological Symptoms and Restorative Benefits

Physically healthy individuals may also exhibit negative psychological symptoms (e.g., subclinical depressive symptoms [38]). Psychological symptoms may affect the restorative benefits that individuals derive from natural environments in two opposing ways. One possibility is that individuals with negative psychological symptoms might benefit more from natural environments. Individuals who experience high levels of stress or depressive symptoms have a greater need for recovery [39], and this motivation can make them more adaptable to natural environments. Individuals with depressive symptoms tend to conserve cognitive resources when faced with complex tasks [40], whereas natural environments can reduce cognitive load and negative emotions. As a result, individuals with higher recovery needs may benefit more significantly from natural environments. In a 2006 study by Hartig and Staats, fatigued people had higher subjective ratings of attention recovery and restoration likelihood from a forest simulation walk than non-fatigued people [41]. Similarly, other studies have shown that nature may provide greater restorative benefits for people under more emotional stress [42–44]. Recent studies further expand this idea. Nature provides greater emotional, stress-related, and cognitive benefits to people with more negative psychological symptoms [45–47]. In short, individuals suffering from depression and stress may be more adapted to natural environments due to their greater restorative needs, resulting in these people gaining more restorative benefits from nature.

Conversely, the other possibility is that people with depressive or stress symptoms are less likely to benefit from natural settings. Individuals with depressive symptoms, according to the cognitive theory of depression, selectively pay attention to negative stimuli (biased attention), have stronger perceptions of negative stimuli (biased processing), and repeatedly recall negative memories (biased memory and rumination) [48,49]. This rumination state leads to intensified negative emotions in depressed individuals and may impair short-term/working memory [50–52], exhibiting blunted emotional responses [53]. Several studies confirm this possibility, with individuals with significant depressive symptoms failing to obtain the benefits of nature, including attention recovery [54], mood improvement [55], and mental health improvement [56]. Thus, one might expect that individuals with more negative psychological symptoms would receive fewer restorative benefits from contact with natural environments.

1.4. Study Aims

Previous studies compared the restorative benefits of natural settings versus low-quality urban settings. Nevertheless, it remains unclear whether there are differences in the recovery effects of green streets versus different park landscapes. Moreover, psychological conditions, such as depression or stress, may influence the restorative effects of environments. Therefore, we included the individual's depressive and stress symptoms as control variables. We tested whether viewing 10-min videos of various environments would improve emotion (Self-Assessment Manikinm, SAM) and attention function (Backward Digit Span, BDS), and whether psychological symptoms modulated these recovery effects. The research questions were as follows: Are there differences in emotional and attentional recovery effects among different environments (green streets, lawns, plazas, forests, and watersides)? Are the emotional and attentional recovery effects obtained from the environment affected by individual psychological symptoms?

2. Materials and Methods

Our study used a within-between subject design, in which environment treatment was the between-subjects variable and time was the within-subjects variable. Participants were randomly assigned to one of five environments, with 25 in each group. Participants had no idea what kind of video they were about to watch. The individuals' valence and arousal levels were collected as a baseline (T0), then after the induction task (T1), and the simulated viewing (T2); their BDS score was collected after the induction task (T1) and the simulated viewing (T2).

2.1. Measures

2.1.1. Attention Function

We used the Backward Digit Span (BDS) task to measure the attention function of the participants because it is the primary assessment of working memory [57–59]. In a BDS task, the computer automatically reads out a sequence of numbers at a rate of one per second. The subjects then repeat the sequence backward aloud. The length of the sequence increases from three to ten digits, with two tests at each level. For example, the seven digits level consists of two tests. If a participant correctly answers one or both tests, the sequence length increases by one digit. This process is repeated until the subject fails to complete the two tests in one level correctly or reaches the maximum length of ten digits. One point is scored for each test completed. The total score represents an individual's score on the BDS task, with a maximum score of 16. Participants were not allowed to use a pen, paper, or other aid during the test. In this experiment, participants had to perform the BDS task twice: once after the emotion and attention fatigue induction events, and once after watching the video.

2.1.2. Emotion

To assess the participants' emotional response, we used the valence and arousal subscales of the Self-Assessment Manikin (SAM) scale [60]. Valence and arousal are derived from the circumplex model of effect [61]. This model, developed in psychology and now used in neuroscience [62], can be used to understand human affective responses. It proposes that all human reactions or emotional states arise from two overlapping systems. Each emotion can be understood as a linear combination of valence (unpleasure to pleasure) and arousal (deactivation to activation). For example, the emotions 'excited' and 'relaxed' are both associated with a positive valence, yet they involve different degrees of arousal. Many restorative studies use the SAM scale to measure human affective responses [63–67]. Participants were asked to describe their feelings along these dimensions using a 9-point scale (with facial expressions pictured). During the experiment, participants performed the SAM scale three times: first as a baseline, then after the emotion and attention fatigue induction task, and lastly, after watching the video.

2.1.3. Control Variables

Before the experiment began, we collected the following variables because they may influence attention and emotion. We collected participants' depressive and stress symptom scores using the Patient Health Questionnaire (PHQ-9) [68] (Cronbach's $\alpha = 0.844$) and the Perceived Stress Scale (PSS-10) [69] (Cronbach's $\alpha = 0.83$), which both have proven to be reliable and are used in clinical diagnosis. We also measured perceived physical health and chronic attention fatigue using 7-point single-item scales (e.g., how do you consider your physical health level to have been in the last month? 1 = very unhealthy, 7 = very healthy)

2.2. The Emotion and Attention Fatigue Induction

Previous restoration research used a variety of induction tasks, such as the Trier Social Stress Test (TSST) [70,71], mental arithmetic [58], and speech [33]. We used mental arithmetic and English speech as induction tasks to cause negative emotions and consume the subject's attention resources. Mental arithmetic tasks are enough to consume participants' attention resources for short periods [58,66,72,73]. Furthermore, non-native speakers frequently experience anxiety when speaking English or other foreign languages [74,75]. Specifically, the task flow was as follows: First, participants were given three minutes to prepare. Then they were asked to select five questions from a list to introduce themselves in English. The examiner prompted the subject if they paused for more than 30 s during the speech. All tasks were completed in front of two examiners and a video camera. Participants were told their performance would be videotaped and used for evaluation, but no video was actually taken. During the task, no pens or paper could be used.

2.3. Environmental Stimulus

We randomly assigned participants to one of five treatments, including green streets, lawns, plazas, forests, and watersides. Participants were required to watch five similar environment videos for 10 min (5 × 2 min) for each treatment. The videos were shown in a random sequence. One author chose 442 sites from parks and streets in Wuhan, China, based on the following guidelines: (1) Choose open areas in park with flat terrain and excellent visibility. (2) Exclude special features and designs that may impact environmental restoration (e.g., billboards, construction sites, fences, holiday decorations, animals and people, historical features, flowers, and small garden ornaments). (3) Because different vegetation colors may impact restorative potentials, the vegetation color should be limited to green [76,77]. (4) Panoramic photos should be taken at noon on a cloudy or sunny day. Two landscape experts evaluated all sites and provided a list of unsuitable scenarios. Sites with two votes were removed from the sample pool, while sites with one vote were reconsidered. To avoid the uniqueness of a single site, we selected five different sites which were nonetheless very similar in physical characteristics for each treatment group, ultimately leaving 25 scenes from the 442 candidate sites (5 for each treatment) (Figure 1). We matched each video to sound to increase immersion. The soundscape for the street treatment was moderate traffic noise, and the soundscapes for the four park settings included rustling leaves and birds chirping.

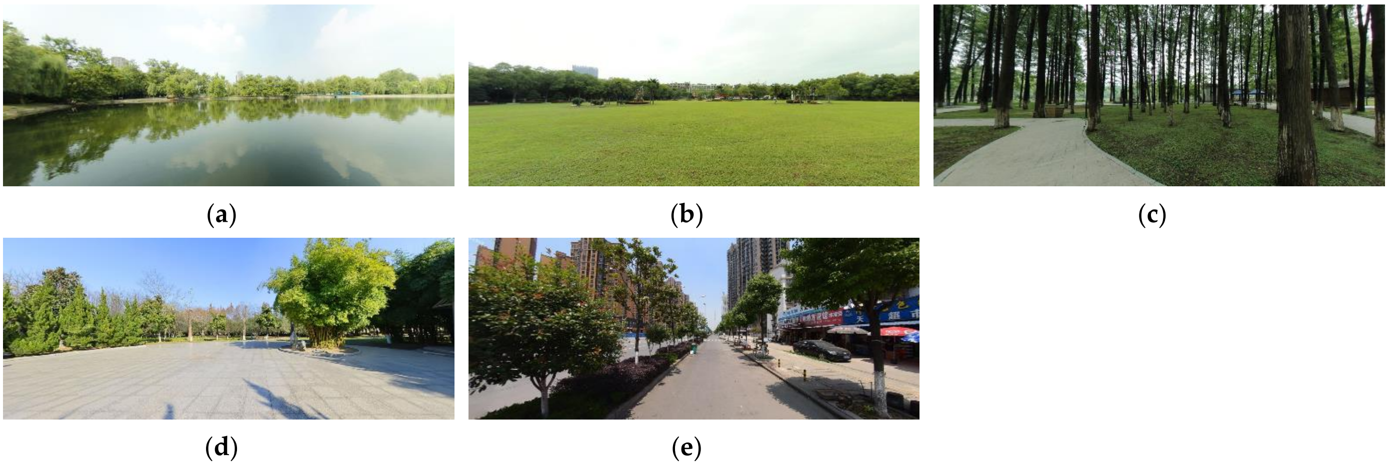


Figure 1. Example screenshots of five environment treatments: waterside (**a**), lawn (**b**), forest (**c**), plaza (**d**), and green street (**e**).

Scenarios chosen for each treatment group were screened to ensure that their features were as similar as possible.

Forests: Tree species may affect restorative effects, as the cultural meanings behind different tree species may differ. In order to avoid such differences, all forest sites were selected from the prevalent fir forest in the Wuhan area (fir accounts for about 90%). The height and density of trees may affect the restorative benefits of nature. People may perceive inaccessibility or unsafety as a result of dense vegetation [78]. Thus, we chose forests with moderate tree densities. Tree height and tree density were similar (all sites were selected from urban parks, so tree density had similar planting criteria).

Lawns: All sites' scale ranged from 0.24 to 0.6 hectares (the distance between the photography point and the edge of the scene is about 31 to 39 m), so the difference in visual perception of area and depth was acceptable.

Street: All street sites were selected from straight roads within the second and third ring roads of Wuhan. The trees beside the roads were camphor and magnolia trees. The traffic and people flow were moderate.

Watersides: The visual depth of the lake sites were 100~200 m, and the trees in the distance were mostly pine, camphor, and metasequoia.

Plazas: All sites were circular squares with a radius of 14–17 m, surrounded by seating for rest. Camphor trees and French plane trees, which are very common in Wuhan, accounted for 90% of the trees.

We developed a standardized observation procedure—simulated viewing—inspired by simulated walking (which is commonly used in restoration studies [24,37,41,79–81]). Simulated viewing is the simulation of a human observing an environment by swinging a virtual camera around, displaying approximately 270° of a panoramic image. The horizon line was always in the screen center while recording, and the camera swung at a steady speed (4.5°/S) to minimize the risk of dizziness. Each panoramic image was captured as a 2-min video with a resolution of 1920 × 1080 at 60 feet per second. The initial camera position was aimed at the main point of interest in the panoramic image; for example, in the waterside treatment, the main point of interest was facing the lake. First, the camera panned 90° to the left at a constant speed (20 s) and displayed the left landscape for 10 s. The camera then panned back to the central perspective at the same speed and remained there for 10 s. Next, the camera repeated this movement pattern to the right. This standardized observation procedure was employed to ensure that all participants viewed the environment the same way and avoided boredom generated by static images [82].

2.4. Participants

We calculated that a partial eta square of 0.06 (small = 0.01, medium = 0.06, large = 0.14) where α = 0.05, power = 0.95 would require 125 samples with five groups and three measures using a two-way repeated-measures analysis of variance (RM-ANOVA) (Gpower software 3.1.9.6 [83]). We recruited 125 subjects (62 males and 63 females) through online platforms (WeChat and WeChat Moments). In order to evenly allocate males and females to each treatment group, we assigned a corresponding random number to each subject. We then sorted the random number from smallest to largest. The corresponding number of samples was selected in random numerical order and allocated to different treatment groups. All participants (N = 125; 62 men and 63 women) were physically non-disabled native Chinese-speaking college students. Their ages ranged from 18 to 32 (Mean = 22, SD = 2.3). We collected demographic and basic health information from each participant. The recruitment ended in June since high-stress events are common for Chinese college students at this time (e.g., job search, dissertation defense, and final exams). Despite being physically well, these people may have developed subclinical depressive symptoms as a result of the high-stress experiences. We also provided a panoramic picture to determine whether the participant felt dizzy while watching, and this possibility was double-checked when they arrived at the laboratory. Those who reported dizziness and those who smoked, drank alcohol, drank coffee, drank tea, or exercised intensely in the 6 h before the trial were excluded from this experiment. This study was conducted following the Declaration of Helsinki and was approved by the review board of the Landscape Architecture Research Center, School of Urban Design, Wuhan University. All potential participants were informed about experimental procedures, associated risks, and confidentiality issues and provided written informed consent before the experiment.

2.5. Procedure

Figure 2 depicts the experimental procedure. First, we briefly informed participants about the experiment and obtained their consent. We thoroughly explained the questionnaire and scale to ensure that all items were comprehended. Before the experiment began, participants completed questionnaires regarding demographic information and health status in a separate room, and they were then taken to a 24 °C constant temperature laboratory. First, the respondents relaxed for 5 min, before filling out the SAM scale to assess their emotional state at baseline (T0: baseline). We did not measure attention function at baseline because the BDS task might have caused the subjects to become tired. Participants were then asked to complete an English interview and a mental arithmetic task to cause negative emotions and induce attention fatigue, followed by finishing the SAM scale and BDS task

(T1: pre-video). Finally, participants viewed a 10-min video before completing the SAM scale and BDS task (T2: post-video). The experiment was carried out individually for each respondent.

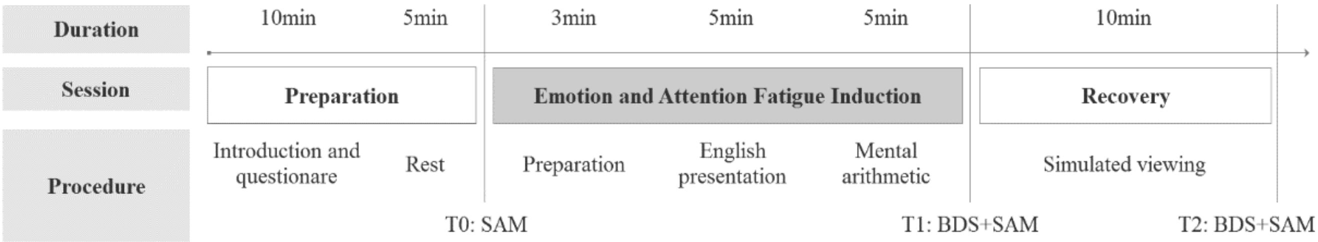


Figure 2. Experimental procedure.

2.6. Data Analysis

All statistical analyses were performed using SPSS 24. Analysis of Variance (ANOVA) was used to determine differences between groups at baseline in chronic attention fatigue, emotion (valence and arousal), and physical-psychological health status (depression and stress). A paired t-test was performed to determine whether the induction task successfully caused negative emotions. RM-ANOVA was used to investigate changes over time within groups. Post hoc comparisons were performed using the Bonferroni correction. We used regression analysis to determine whether individual depressive and stress symptoms modulated emotion and attention function change after environment viewing. All predictor variables were centered according to guidelines for regression analysis [84]. The hierarchical regression analysis included post-video(T2) measurements (BDS score, valence, and arousal) as dependent variables. Pre-video (T1) measures were added to correct for differences in attention function and emotion before simulated viewing. In the subsequent block, the treatment was entered as the independent variable. The depressive symptom (PHQ-9 sum score) was then added. Finally, the interaction item between treatment and depressive symptoms was added. For stress symptoms (PSS-10 sum score), we performed the same procedure as for the depressive symptoms. We used an alpha of 0.05 as the threshold for determining statistical significance.

3. Results

3.1. Randomization and Manipulation Checks

We found that 29.6% of the participants showed moderate-or-above (≥10) depressive symptoms in the previous month (0–4 minimal, 5–9 mild, 10–14 moderate, 15–19 moderately severe, 20–27 severe), 22.4% of the participants thought their physical health level (1 = very unhealthy 7 = very healthy) was below normal (<4), and 39.2% believed their chronic attention fatigue (1 = not at all, 7 = severe) was more than moderate (>4).

We used an ANOVA to investigate any between-group differences in chronic attention fatigue, emotion, and physical-psychological health status at baseline(T0). There were no significant between-group differences for arousal (F = 1.85, $p = 0.122$), valence (F = 0.61, $p = 0.651$), chronic attention fatigue (F = 0.50, $p = 0.732$), perceived physical health (F = 2.04, $p = 0.092$), depressive symptoms (F = 0.54, $p = 0.703$), or stress symptoms (F = 0.33, $p = 0.856$). See Table S1 in the Supplementary Materials for a more detailed overview.

We performed a paired t-test on the measured variables at baseline (T0) and pre-video (T1) and found significant differences in valence ($t = -12.41, p < 0.001$) and arousal ($t = -15.87$, $p < 0.001$), suggesting that the induction task successfully induced negative emotions in participants.

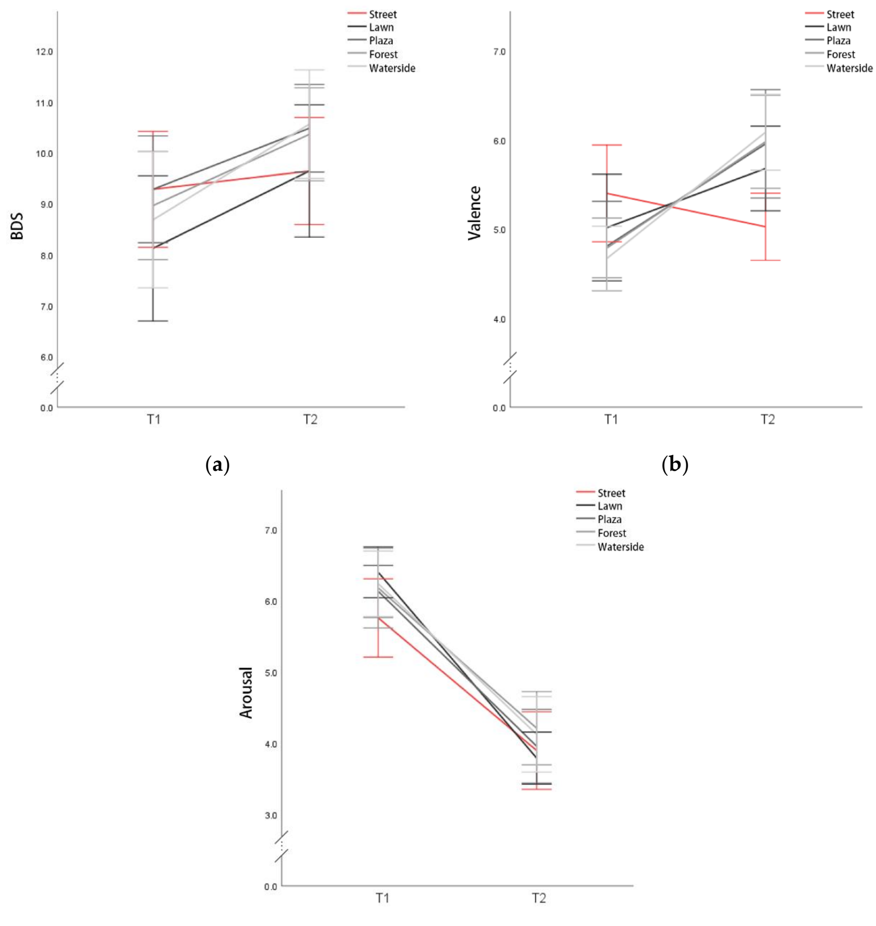
3.2. Attention Function

We ran a mixed-model 5 × 2 RM-ANOVA for attention function, in which treatment (green streets, lawns, forests, watersides, and plazas) was the between-subjects variable and time (T1: pre-video and T2: post-video) was the within-subjects variable. Table 1 shows the results of the RM-ANOVA. The results of the RM-ANOVA revealed no significant treatment effect. The subjects' attention function changed significantly at the end of recovery. Time has a significant main effect ($F(1, 120) = 64.44$, $p < 0.001$, $\eta_p^2 = 0.349$). In addition, a significant interaction effect on attention function ($F(4, 120) = 2.56$, $p = 0.042$, $\eta_p^2 = 0.079$) was detected between time and treatment (Figure 3a). In order to compare the attention function of subjects at different time points, we performed paired t-tests to examine time effects in each environment. The results showed that after the recovery period, only the subjects in the street environment showed no significant recovery in attention function, while the subjects in the four park environments showed a significant recovery in attention function ($ps < 0.002$) (Figure 4a). Means are presented in Table S2 of the Supplementary Materials. This result suggests that viewing park environments is beneficial for attention recovery.

Table 1. Results of RM-ANOVA for attention function (BDS score), valence, and arousal.

Variable	BDS			Valence			Arousal		
	F	p	η_p^2	F	p	η_p^2	F	p	η_p^2
Time (T)	64.44	<0.001 ***	0.349	82.37	<0.001 ***	0.407	194.73	<0.001 ***	0.619
Setting (S)	0.53	0.716	0.017	0.22	0.929	0.007	1.17	0.328	0.037
T × S	2.56	0.042 *	0.079	5.55	<0.001 ***	0.156	0.97	0.456	0.031

* $p < 0.05$, *** $p < 0.001$.



(**a**) (**b**) (**c**)

Figure 3. BDS (**a**), valence (**b**), and arousal (**c**) before and after viewing environment videos. The type of environment is represented by the five lines on two time-points. Note: T1 = pre-video, T2 = post-video.

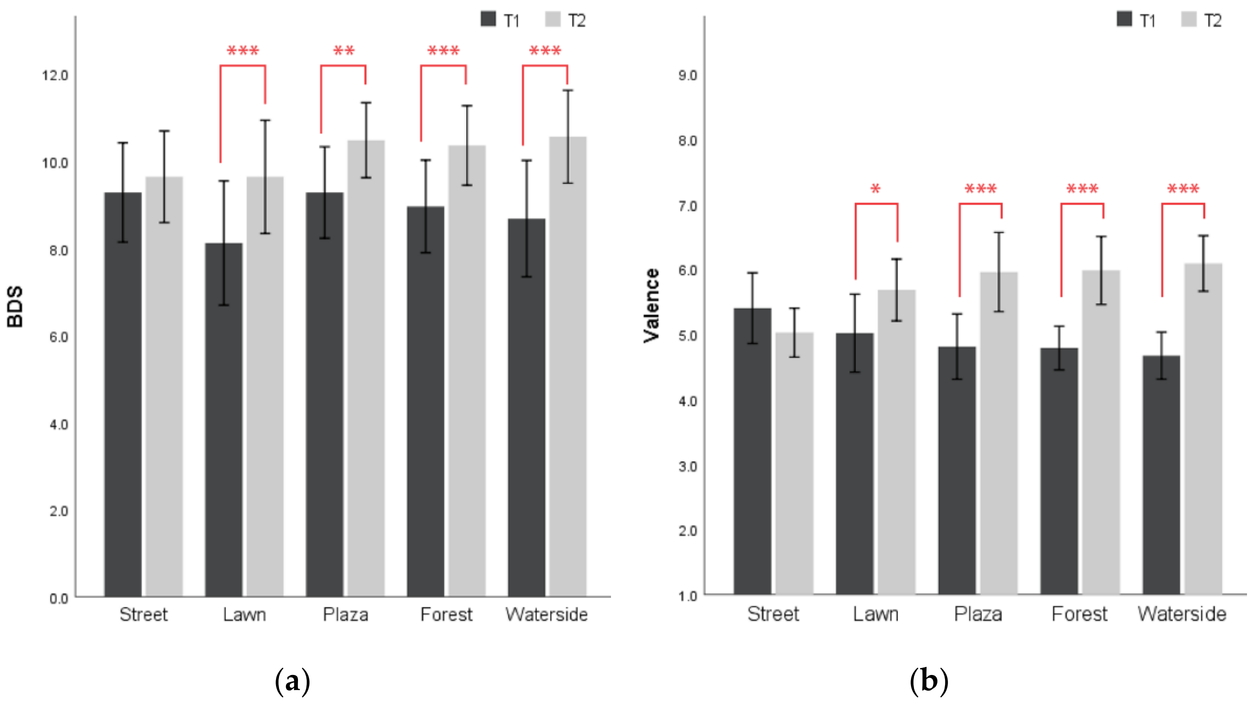


Figure 4. Changes in mean BDS score (**a**) and valence (**b**) in different environments during the experiment. Pairwise comparisons between pre-video (T1) and post-video (T2) in each environmental treatment are marked. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

3.3. Emotion

3.3.1. Valence

We ran a mixed-model 5 × 3 RM-ANOVA for valence and arousal, in which treatment (green streets, lawns, forests, watersides, and plazas) was the between-subjects variable and time (T0: baseline, T1: pre-video, and T2: post-video) was the within-subjects variable. Table 1 shows the results of the RM-ANOVA. For valence, the results of the RM-ANOVA revealed no significant treatment effect. The subjects' valence changed significantly over time ($F(2, 240) = 82.37$, $p < 0.001$, $\eta_p^2 = 0.407$). In addition, a significant interaction effect on valence ($F(8, 240) = 5.56$, $p < 0.001$, $\eta_p^2 = 0.156$) was detected between time and treatment (Figure 3b). To compare participants' valence at different time points, we examined the time effect of each environment individually. The results showed that after the recovery period, only the subjects exposed to the four park environments had displayed significantly improved valence (ps < 0.05) (Figure 4b). Regarding the post-video (T2) valence, only the participants in the waterside environment had significantly higher positive emotions than those in the street environment ($p = 0.019$). These results indicate that viewing the park environments improved emotions, especially the waterside environment, which brought people the most significant degree of positive emotions.

3.3.2. Arousal

For arousal, the results of the RM-ANOVA revealed a significant time effect ($F(2, 240) = 194.73$, $p < 0.001$, $\eta_p^2 = 0.619$) but no significant treatment effect, nor a time*treatment interaction effect (Figure 3c). Subjects' arousal seemed to change only over time.

In general, we discovered that after the induction event (T1), participants generally exhibited high arousal and low valence emotions (Figure 5b). People's arousal decreased after viewing the different environment videos (T2), but there was no difference between exposure to the five environments (Figure 5c). Valence changes revealed that the park environment improved people's moods more than the street with greening.

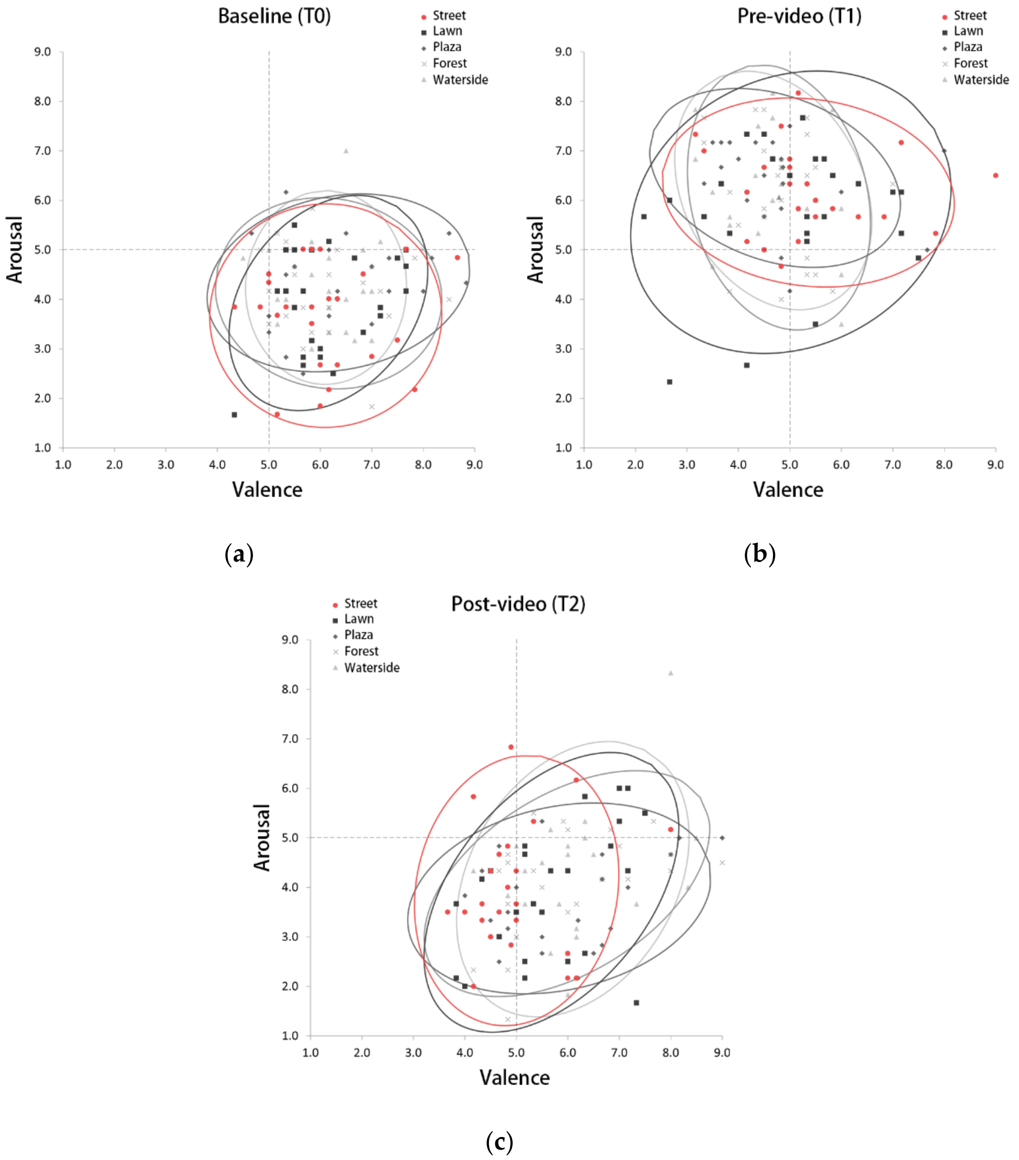


Figure 5. Scatter plots of total emotion (Valence-Arousal) for different groups at baseline (**a**), pre-video (**b**), and post-video (**c**).

3.4. The Effect of Stress and Depressive Symptoms on Restorative Benefits

A regression analysis was conducted to predict post-video (T2) measurements (BDS, valence); the analysis included treatment, moderator (PHQ-9, PSS-10), and the interaction between moderator and treatment as predictors, while controlling for pre-video (T1) corresponding measurement. Because the main effect of treatment on arousal was not significant, no additional hierarchical regression analysis was conducted. Since depressive (PHQ-10 sum score) and stress symptoms (PSS-10 sum score) were highly correlated (Pearson correlation coefficient = 0.592, $p < 0.001$), they were included individually in the hierarchical regression analysis. However, the moderator and treatment interaction terms in all models did not significantly improve the models, so all interaction terms were excluded from the model in the final analysis. See Tables S3–S6 in the Supplementary Materials for a more detailed overview. Our results suggest that the effects of depressive and stress symptoms on environmental restorative benefits do not change with the type of environment.

When stress symptoms were a moderator (Table 2), attention function and valence showed similar patterns, with significant treatments' effect indicating higher BDS and valence scores after viewing one of the four park videos compared to the street. In other words, for the same recovery time, the park environment's attention and emotion improvement effects were better than the street. However, stress symptoms did not significantly improve in the model. This result suggests that stress experienced in the last month does not affect the attentional and emotional improvement benefits people derive from the environment.

Table 2. Results of regression models testing stress symptoms (PSS-10 sum score) on BDS score and valence.

Variable	BDS (Post-Video)		Valence (Post-Video)	
	B	SE	B	SE
Constant	9.326 ***	0.304	4.786 ***	0.205
Measure pre-video (centered)	0.705 ***	0.048	0.532 ***	0.080
Treatment (street as reference)				
Lawn	0.802 +	0.432	0.865 **	0.286
Plaza	0.896 *	0.430	1.225 ***	0.289
Forest	0.986 *	0.430	1.266 ***	0.289
Lake	1.367 **	0.430	1.441 ***	0.290
PSS score (centered)	0.050 +	0.028	−0.018	0.018

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

When depressive symptoms are a moderator (Table 3), for attention functions, the significant treatment effect indicated that subjects who watched one of the four park videos had higher BDS scores than those who watched the streets. In other words, for the same recovery time, the attention recovery effect of a park environment was better than the street. However, depressive symptoms were not significantly improved in the model. This result suggests that depressive symptoms in the last month do not affect the attentional restorative benefits people derive from the environment. For valence, the significant treatment main effect showed that participants were happier after watching one of the four park videos than the street. Depressive symptoms significantly improved the model (coefficient $= -0.038$, $p = 0.044$). These results suggest that the greater the depressive symptoms in the last month, the worse the emotional recovery induced by the park environment and green street. The moderator (PHQ-9) and treatment interaction term did not significantly improve the model. This result suggests that the effect of depressive symptoms on environmental restorative benefits does not change with the type of environment.

Table 3. Results of regression models testing depressive symptoms (PHQ-9 sum score) on BDS score and valence.

Variable	BDS (Post-Video)		Valence (Post-Video)	
	B	SE	B	SE
Constant	9.339 ***	0.308	4.808 ***	0.202
Measure pre-video (centered)	0.697 ***	0.048	0.517 ***	0.079
Treatment (street as reference)				
Lawn	0.802 +	0.438	0.867 **	0.282
Plaza	0.859 +	0.435	1.198 ***	0.285
Forest	0.969 *	0.436	1.218 ***	0.286
Lake	1.354 **	0.436	1.407 ***	0.287
PHQ score (centered)	0.019	0.029	−0.038 *	0.019

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

4. Discussion

4.1. Effects of Different Setting Types on Attention Function

We observed that only the subjects in the street environment showed no significant recovery of attention function after the recovery period. In contrast, the subjects exposed to the four park environments (lawn, plaza, forest, and waterside) benefitted from significant recovery of attention function. Our findings support previous research that natural environments profoundly benefit attention recovery [23,58,85], and imply that street planting alone is insufficient to offer a quality restorative environment for urban residents. This result may be due to the fact that street environments inevitably contain bottom-up stimuli that attract attention. People need to consume directed attention resources to overcome such stimuli (e.g., avoiding traffic, ignoring advertisements, etc.). Conversely, park environments contain fewer bottom-up stimuli, which reduces the consumption of directed attention resources [21]. Park environments have more "fractal" characteristics, require less cognitive processing resources, and process more smoothly [35,86]. Smooth processing is often correlated with positive emotions [87].

Our research found no differences in the restorative benefits of different park landscape types (lawns, plazas, watersides, forests). This may be due to the fact that the restorative effects are universally inherent to all kinds of natural settings, so even hardscapes (which contain fewer natural elements) can offer the same restorative benefits as natural environments like woods or watersides. This research is consistent with recent studies that visiting an urban open space with a few trees improved attention function performance and reduced negative effects (depression and stress) [88,89].

4.2. Effects of Different Setting Types on Emotion

Our study further clarifies the impact of restorative environments on mood. In particular, the circumplex model of affect helped us distinguish the effects of different environments on the arousal and valence dimensions of emotion, which had been overlooked in previous studies [47,90–92]. We discovered that participants showed high-arousal and low-valence emotions after the negative emotion and attention fatigue induction event. Arousal generally decreased after the recovery period (no difference was found between environments), but the park environments were preferable to the street environment for raising people's valence. Previous research has found that highly attractive objects or vegetation in a scene (e.g., flowers) are likely to cause high-arousal and high-valence emotions [65], such as "excitement." All of the scenes in our study were ordinary urban greenspace landscapes, which therefore tended to elicit low-arousal and high-valence emotions, such as "relaxation" and "calm." While containing some bottom-up stimuli, the street environment is still a prevalent urban environment, resulting in low-arousal and low-valence emotions.

4.3. Do Psychological Symptoms Affect Restorative Benefits?

Our study adds to previous work by demonstrating that the mood improvement benefits of natural environments may gradually decrease as depressive symptoms worsen. This result could be due to depressive symptoms suppressing the emotional improvement benefits that people derive from the natural environment. One characteristic of depression is anhedonia, a reduced motivation or ability to experience pleasure [39]. Supporting this, a meta-analysis of 19 laboratory studies revealed that clinically depressed patients tended to show blunted emotional responses compared to non-clinically depressed patients [53]. Although evidence has documented the benefits of nature in improving attention function and mood in clinically depressed patients [93–95], our results further suggest that individuals exhibiting subclinical depressive symptoms may derive restorative benefits from natural environments. However, these restorative benefits may decrease until they disappear for those with worse psychological status. Depressed individuals may be in a worsening cycle of negative self-perception, revisiting negative episodes even in natural settings, and thus derive fewer natural restorative benefits. Studies have shown that individuals with severe depressive symptoms do not derive attentional [54] or emotional benefits [55,56] from natural environments.

However, it should be noted that some studies are contrary to our findings. These findings indicate that individuals with negative psychological states recover better in natural settings because they are more in need of recovery and hence more adapted to natural settings that provide restorative benefits [45–47]. However, two caveats should be mentioned here. First, the psychological status of our subjects may have been affected by the COVID-19 pandemic, thereby limiting the restorative benefits of greenspace. Second, it may seem puzzling that our study did not find significant effects of chronic stress symptoms on attention and mood. Previous research has found that cortisol has a negative effect on working memory [96–98]. However, three studies found no significant differences in BDS scores and n-back task scores among participants with different stress levels [99–101]. Those results might imply that the effect of stress on working memory is stronger when physiological measurements are utilized rather than questionnaires. Therefore, the absence of an effect of chronic stress on attention and mood in our study may be because we measured stress through self-report rather than physiological measures.

4.4. Limitations and Future Research

Our study may have the following limitations: First, individual characteristics and cultural backgrounds may limit the applicability of research conclusions. Participants were all from China and had the same cultural background, so the applicability of the current research conclusions may be limited by race and culture. Ethnic and cultural backgrounds may influence people's environmental preferences [102,103]. Preferences are correlated with recovery effects [104,105]. Future research should consider the cultural background as a possible moderating factor for natural environments' physical and psychological restorative benefits. In addition, we did not consider individuals who did not want to participate in the experiment, which may have caused a selection bias. Our participants were college students, and we should be cautious about extending our conclusions to the general population.

Second, the environmental samples we chose might restrict the results' application. The characteristics of the scenarios we chose may prevent our conclusions from extending to other environments. We did not find differences in the restorative effects (attentional and emotional recovery) in these different park environments, but this may have been due to differences in the environment, for example, different tree types, heights, and densities in different conditions, or the visual scale of the place. This study investigated ordinary streets and park landscapes in Wuhan, China, and we used only one type of environment for each experimental treatment. However, there are various restorative environments in urban settings. Future research should try to extend the conclusions to other types of urban settings. In addition, to reduce sources of variation that might influence the results, we did not consider natural features (e.g., vegetation color or form) or spatial features (e.g., enclosure). Future research should explore these factors that we did not mention, such as the complexity of natural elements, the cultural meaning of plants, or the cultural/social qualities of the location. Understanding the restoration mechanism is conducive to balancing the restorative effect and construction cost.

Finally, our study used simulated natural environments instead of real ones. It should be noted that there is an experience difference between the simulated environment (viewing nature through video, picture, panoramic video, or virtual reality) and walking in a real natural environment. People's experience in the real natural environment is multi-dimensional. For example, when people walk in the real forest park, in addition to seeing the green everywhere, they will also hear the rustling of leaves and the song of birds, smell the fragrance of plants and flowers, feel the wind on their cheeks and feel the soft soil on their feet. However, most simulated environments fail to provide multi-sensory stimulation. Several studies have suggested that simulated and real natural environments can provide the same restorative benefits, improving recovery quality scores [106], attention task scores [107], psychophysiological responses [108], and mood changes [109]. Following this literature, scholars further suggest that while virtual nature can provide restorative benefits, real nature may have even more benefits, including increased psychological restorative benefits [110], enhancing attention-restoring effects [111], and a more significant impact on positive emotions [17]. Indeed, virtual nature may not replace real nature. However, at a time when the COVID-19 pandemic is becoming a regular occurrence, those who cannot go outside may benefit from simulating nature [110]. When people do not have the opportunity to access real natural environments, they can use nature substitutes (potted plants) or simulations (nature pictures, videos, or virtual reality) to obtain restorative effects [81,90]. In particular, immersion in a virtual natural environment has been found to be an effective aid in treating anxiety disorders and a tool for stress management and relaxation [112,113]. In addition, the advantage of using simulated nature is that it is easy to control other uncontrollable disturbance factors in the environment, such as pedestrians, vehicles, and weather. These distractions may interfere with the process of physical or psychological data collection. We should be cautious about extending our results to real-world settings. Future research incorporating multi-dimensional senses to make laboratory simulations more realistic could help end this discussion.

5. Conclusions

In general, our study supports previous research showing that the natural environment has powerful benefits for attention recovery and mood improvement. Our study shows that street planting alone will not provide citizens with a sufficiently high-quality restorative environment. We also discovered that hardscape (which contain fewer natural elements) could provide the same attentional and emotional restorative benefit as natural landscapes. Park environments mainly provide low-arousal, high-valence emotions (e.g., relaxation, calm), while green streets provide low-arousal, low-valence emotions (e.g., boredom). We also found that the mood-improving benefits of natural environments may gradually decrease as depressive symptoms deepen. Visiting urban greenspaces may be a primary self-intervention to improve people's emotional and mental health. Because people with milder negative psychological symptoms do not require specialized mental health services, providing self-management strategies or low-intensity interventions in primary care is sufficient to alleviate negative mental health [114]. However, other medical interventions are still needed for individuals with severe negative mental health conditions.

Our results suggest some implications on planning and park design. Firstly, increasing vegetation in a high-density urban setting is unrealistic due to the lack of space. The urban environment can be improved by enhancing existing spaces, such as by adding vegetation to the perimeter of plazas to insulate from street stimuli or by building pocket parks in the fragmented spaces. Secondly, we should improve the greenspaces around places more prone to stress, such as hospitals, school buildings, or office buildings. People can promptly improve emotions and restore attention by visiting greenspaces or enjoying the green or natural scenery from a window. Thirdly, we can encourage people quarantined at home to view the green scenery daily in different ways (e.g., enjoying the view out the window, watch natural scenery videos on smartphones, taking a walk in the community (xiao qu) where they live, or spending time with houseplants), which will help alleviate the negative psychological symptoms caused by the quarantine.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/f13122001/s1, Table S1: Descriptive Statistics and randomization checks; Table S2: Descriptive Statistics of the Outcome Variables; Table S3: Results of regression models testing the interaction between environmental treatment and stress symptoms (PSS-10 sum score) on BDS score; Table S4: Results of regression models testing the interaction between environmental treatment and depressive symptoms (PHQ-9 sum score) on BDS score; Table S5: Results of regression models testing the interaction between environmental treatment and stress symptoms (PSS-10 sum score) on valence; Table S6: Results of regression models testing the interaction between environmental treatment and depressive symptoms (PHQ-9 sum score) on valence.

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