

Article

Differences of Restorative Effects While Viewing Urban Landscapes and Green Landscapes

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Abstract: Attention Restoration Theory argues that natural objects such as trees and flowers have psychological restoration effects. However, relevant studies have been mostly based on survey methods, and few of them suggest guidelines for restoration environments. This study, therefore, aims to verify the restorative effect of natural objects using eye-tracking methods and a survey regarding visual aesthetics, complexity, and the Perceived Restorativeness Scale, as well 25 various images divided into 4 types: natural scene and close view, natural scene and distant view, built scene and close view, and built scene and distant view. The analysis showed that natural scenes had a stronger positive restorative effect compared to built scenes regardless of differences in the distance. In terms of the overall landscape composition, visual characteristics such as visual aesthetics and complexity had a statistically significant relationship with restorative effect. Additionally, an eye-tracking method was found to be a valid and useful tool for studying the restorative environments by significant differences in the scan path length depending on the four types of landscape images. This study ultimately provides an overview regarding restorative design guidelines not only by using natural elements but also by considering landscape composition in terms of complexity, openness, and so on.

Keywords: landscape evaluation; restorative landscape; urban green areas; attention restorative theory; eye-tracking

1. Introduction

The World Health Organization (WHO) defines health as a “state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity”. Therefore, social interest and studies that reduce people’s diseases have been increasing in many ways. Mental disease, in particular, has become considerably more prevalent recently because of overwork, genetic effects, surrounding environment, and so on. Among these causes, surrounding environments such as built scenes mostly caused by urban development have been an important focus of space design research as many studies [1–9] have shown that green infrastructures such as natural elements have a positive effect on reducing human stress in city dwellers. These studies have found that natural landscapes rather than built landscapes not only function as city attractions themselves but also reduce workers’ and tourists’ stress in a populated city, using methods such as surveys [10], a meta-analysis based on a literature review [11], electrocardiograms [12], and so on. Since landscape can be interpreted as the interaction between human and their environments [13], it includes various senses such as auditory sense, sense of touch, etc. as well as the sense of sight presented above. Especially, a soundscape study [14] emphasizing the auditory sense in a landscape study has mainly accumulated the verification of the sound effect perceived in the natural landscape. [15–18]. The ultimate goal of

previous studies is not only to prove the restorative effect of natural elements but also to provide the design guidelines that can effectively reduce stress in the city.

However, these studies have mostly focused on the visual aspects in a limited space such as the presence, quantity, and so on of natural elements and have not evaluated other attributes such as openness or complexity level that could affect the restorative effect in a space. This means that existing studies have limited the direct design guidelines of green spaces to reduce people's stress. Therefore, in this study, we expand on prior studies by introducing and proving other aspects that can affect people's stress relief and compare the restorative effect through various urban spaces, ultimately suggesting a design guideline for restorative environments in a city. Additionally, by applying the eye-tracking method that can track people's unconscious eye movement to verify the restorative effect, we demonstrated the possibility of utilizing the eye-tracking method as a tool to evaluate the restorative effect.

1.1. Attention Restoration Theory

Attention restoration theory (ART) infers that directed attention is voluntary, central to maintain focus, controls distractions through inhibitory mechanisms, and requires effort [19]. According to ART, one would, therefore, expect natural stimuli to facilitate subsequent selective attention in that exposure to natural stimuli facilitates the restoration of the capacity for directed attention [20]. Directed attention was first proposed by James (1892) [21] and is an essential concept for us to perform productive activities. It refers to "attention that requires effort and is susceptible to fatigue" [22]. The concept of directed attention is becoming increasingly important in modern society and requires intensive work with a number of stimuli. The core of the ART concept is that exposure to a restorative environment is essential for the restoration of directed attention that can have production and stabilization functions. Soft fascination, which is moderate in intensity and generally focused on aesthetically pleasing stimuli, permits an opportunity for reflection that best promotes attention restoration [23]. Previous studies and theories [9,19,22–26] related to this theory have pointed out that exposure to soft fascination, such as in nature settings, plays a critical role in reducing stress from directed attention. These theories emphasize the relative standing of natural environments as aids in the restoration from undesirable states in which functional capabilities are compromised [8].

As interest in the restorative environment of ART has grown, the question of how to create an environment to restore directed attention has also been raised. As part of that question, Korpela and Hartig [26] developed the Perceived Restorativeness Scale (PRS), "which is based on four basic elements: being away, which implies a setting that is physically or conceptually different from one's everyday environment; extent, which implies a setting sufficiently rich and coherent that it can engage the mind and promote exploration; fascination (or effortless attention), which can derive from content (animals, people, water, fire) or process (storytelling, gambling, problem solving); and compatibility, which implies a setting that fits with and supports one's inclinations or purposes [27] for creating or evaluating a restorative environment [19,24]". The PRS has been reported relatively frequently in the literature, despite the psychometric and factorial properties of the scale not being well-established [28]. There is now a large body of studies applying the PRS, and these studies have compared restorative effects with variables such as soundscape, ecosystem diversity, familiarity, and experience, as well as the effect on visual natural elements [29–33]. The original version of the PRS by Reference [26] consisted of 29 items and measures perceptions of being away, fascination, coherence, scope, and compatibility based on the main concept of ART. Among the previous studies using PRS, Berto [29] applied a short version of the PRS to make the scale easier to understand. In addition to Reference [29], many studies [31,34–38] validated this scale as a tool to evaluate perceived restorative potential, and related studies [39–41] have applied Reference [29]'s short version of the PRS. Therefore, we applied it in this study as a tool to measure restorativeness in various environments.

1.2. Restorative Effect and the Natural Environment

In addition to ART, the proposition of having a restorative experience in a natural environment has been confirmed through a number of studies. Therefore, the efficacy of the natural environment needs to be emphasized and approached in various ways more than ever before. Reference [19] argued that the natural environment not only relieves stress but also enhances concentration and achievement. Rennit and Maikov [42] also said that enhancing concentration towards tasks could have benefits including improving performance and mood and reducing stress. Stemming from this study, Lee et al. [5] and Bratman et al. [43] confirmed this theory through their experiments. Lee et al. [5], in particular, verified the effect of exposure to natural elements by directing participants to perform specific tasks, such as “fast-frequency moment-to-moment on the task”, “slow-frequency gradual response variability”, “response errors”, and “response speed.” As a result of these studies, the effect of people being exposed to natural environments extends from simply reducing stress to concentration, improving productivity, and so on.

Less attention has been given to the relative importance of physical environmental components that contribute to the restorative potential of such environments [10]. That means we need to focus more on environments that can increase restorative effects compared to other types of environments. Hartig et al. [42] also insisted that the degree of restorativeness depends on environmental characteristics. Various environmental settings have been used as tools to evaluate restorative environments. Especially, water-based environments have been confirmed as representative for improving the restorative effect in existing studies [30,42,44,45]. Furthermore, other specific landscape setting such as “access to nature” [46], “a closed view” [35], “a balance between enclosed areas and open view” [47], “window view of nature” [46,48,49], “planting with flower cover” [33], “mixed built natural scene” [34], “private spaces” [37], and so on have been shown to be representative restorative environments within the conditions set by each study. In sum, various types of settings can affect the perceived degree of the restorative effect. In this study, therefore, various environmental settings composed of water, mountains, and flowers and various degrees of openness to nature were applied as experimental images to evaluate which settings would be suitable for forming and managing restorative environments.

1.3. Visual Characteristics Mediating Restorative Effects

A growing body of research has revealed that landscapes with a perceived restorative potential have a strong relationship with the landscape preference [24,29,33,34,38,50,51]. This means that the higher the visual aesthetics of the landscape, the higher the restorative effect. Although there have been many previous studies to prove the above, there are limitations in presenting the necessary influential factors or principles as well as specific design guidelines for future restorative environments. The current literature on restorative environments generally leads to the conclusion that urban environments are inherently deficient in stress-reducing and mood-enhancing capacities [52]. Therefore, we need a different approach by investigating various landscape characteristics such as visual aesthetics and complexity, which is consistent with Velarde et al.’s suggestion [53]. Related to this, previous studies have dealt with various landscape characteristics such as “familiarity, social context, and perceived security” [32], “place attachment” [54], “level of urbanity observed” [35], and “the role of prospect and refuge theory” [55] to suggest their effects on perceived restorative potential. In Reference [35]’s study, for example, they focused on which level of observed urbanity helped to improve the restoration perception in urban forest changes. The levels of urbanity were divided into “open,” “semi-closed,” and “closed” views, and they concluded that restoration perception was highest when the visibility of the urban matrix was closed. Gatersleben and Andrews’s study [55] was very interesting because it explored the positive relationship between restorative effects and natural environments low in prospect and high in refuge based on Appleton’s prospect and refuge theory.

Among the existing studies dealing with the various impact factors mediating restorative effects, those considering “complexity” are noteworthy. Supporting this, Ulrich et al. [56] mentioned that

proper complexity, including proper depth in space, focal point, and the whole structure, would be one of the main impact factors for the perceived restorative potential along with natural elements. Pazhouhanfar and Kamal [51] applied complexity as one of the visual characteristics to induce restoration and confirmed that it positively affects the restorative effect. Beyond this, many studies regarding complexity within the visual landscape have been carried out including entropy and fractal studies [57] that are highly related to complexity. This may indicate that people have been considering “complexity” as one of the main determinants that are most likely related to restoration. It is necessary to consider various visual characteristics such as complexity because simply comparing the presence of many versus few natural elements is insufficient to explain how people experience the restorative effect in a certain place. In this respect, Bell et al. [58] and Pitt [59] suggested that not only the natural elements but also the various forms surrounding the natural elements (e.g., abandoned or vacant plot, community garden, etc.) can act as valuable elements for increasing restoration.

1.4. Eye Tracking as a Tool for Evaluating Environmental Perception

To date, landscape preference and evaluation studies for landscape management implication have mainly relied on surveys using photographs and in-depth interviews. Several researchers [60,61] have shown the value of landscape evaluation using photographs and so on, but landscape preferences rated with questionnaires could be influenced by people’s subjective personality traits. To fill this gap, the eye-tracking technique has been applied in this field using eye movement measurements such as area of interests (AOIs), fixation duration, saccade duration, scan path length, etc. It has been acknowledged as an objective way to measure the movement of eyes, and there is the possibility that this method can be utilized for landscape evaluation. Moreover, eye-tracking technology has become cheaper, more mobile, and more accurate, heralding a new era of big data capture and analysis for landscape preferences [62]. Unlike traditional evaluation methods using questionnaire ratings, eye tracking is a powerful tool for analyzing people’s observations of the landscapes when represented by photographs [63]. This technique allows the recording of the velocity and direction of eye movements (saccades) and the position and duration of fixations while observing images, and it is well-known in the field of psychology [63].

Conniff and Craig [64] suggested that the use of eye tracking as a research method within studies looking at environmental preference and restoration is still relatively uncommon, but there are numerous attractions in using such a research tool in terms of interpreting environmental preference (e.g., capturing fatigue or emotional responses) more objectively. Previous environmental perception studies using eye tracking focused on the points where many people’s eyes fixated. Many researchers focused on the fixated areas where people’s eyes were unconsciously fixated in eye-tracking studies [65–68]. Nordh et al.’s study [69], in particular, found that “grass” was the area where people’s gaze was fixated a lot and discussed the preservation of grass for restoration likelihood. Based on this idea, people emphasize that the areas where many people fixate should be conserved, sustained, or managed well compared to other areas. Recently, Amati et al.’s study [62] proved that the fixated areas were significant not only in static images but also in dynamic walking videos in landscape evaluation studies. Sticking to these fixated areas in an eye-tracking study, however, has many shortcomings. Moreover, it remains unclear that the fixated areas refer to places most people find pleasant. Further studies are needed to apply other visual characteristics such as complexity, coherence, clearness, and so on or other eye movement measurements beyond previous studies that have focused on landscape preference in environmental perception research using eye-tracking methods. Berto et al. [25], in this context, took a new approach on the environmental perception research by linking the number of eye movement fixations to fatigue based on Kaplan’s soft fascination theory. Their study showed that there were a higher number of fixations and a greater exploration of images rated relatively low in fascination. This means, in turn, that images high in soft fascination require less directed attention; therefore, they would be effective for inducing restoration. This study adopts an eye-tracking method to expand the existing environmental perception studies, as well as to launch a new approach by analyzing correlations

between preference, complexity, and restoration perception using eye movement measurements. This would help the understanding of which compositions should be considered for landscape management in addition to simply acknowledging what objects or areas are favorable and restorative. Based on the results of previous studies, there is a need to diversify the means of evaluating landscapes. The eye-tracking technology, a possible method for evaluating landscape, is gradually expanding and becoming more convenient. However, in order to evaluate landscape design more accurately, it is necessary to systematically demonstrate the relationship between various landscape characteristics and eye-tracking measurements. Therefore, in this study, we aimed to measure the restorative effect depending on the landscape type and its components.

1.5. Research Hypotheses

In the present study, we expand on previous studies on restorative environments that have mainly focused on the effect of natural elements by applying perceived complexity as a factor mediating the restorative effects of various natural and built scenes. In other word, this is an exploratory study proving the relationship between perceived complexity, which is one of the determinants of environmental preference, and eye tracking. An additional aim of this study is to show that the eye-tracking technique could be utilized to evaluate restorative effects and environments. Therefore, this study was guided by the following four hypotheses:

H1: People's perceived level of visual aesthetics (preference), complexity, and restoration perception will vary depending on landscape type (natural scenes and built scenes).

H2: People's perceived visual aesthetics as well as restoration perception will be lower in built scenes than natural environment scenes, and complexity will be higher in built scenes.

H3: The extent of the restorative effect of looking away from the landscape and looking closely will vary (close and distant view).

H4: People's eye movements (fixation duration or scan path length) will be lower while viewing natural scenes than built scenes.

2. Methods

2.1. Research Process

The Virginia Tech Institution Review Board (IRB) approved the protocol (No. 12–435) for eliciting responses from human subjects in this study. This experimental study was carried out on the second floor of the School of Visual Arts Perception and Usability Testing Laboratory at Virginia Tech in Blacksburg, Virginia. As this laboratory is specially designed for visual evaluation, it has an enclosed setting with no windows and little noise. Since this study was a landscape evaluation study that verified the visual impact only, it excluded the influence of sound and maintained silence throughout each participant's experiment. Prior to the start of the experiment, participants performed a calibration test to obtain accurate results. Participants sat in front of a monitor with an eye-tracking device and infrared camera and were informed about the procedures and precautions of the experiment. The participants' work was divided into two major areas. The first was to look at twenty-five different images related to the restorative environment without any intention, and the second was to evaluate the degree of several visual characteristics and PRS of each image. It was set up to observe 25 landscape images by participant in turns, and the experiment time took about 30 min for each participant. The method of showing pictures was based on a slideshow that took 8 s per image [70], and the images appeared one at a time on the monitor. To prevent order effects, the order of the slideshow in this experiment was divided into two types in a random order. The participants were asked to rate their level of visual aesthetics (1 very unpleasing to 7 very pleasing), complexity (1 very uncomplicated to 7 very complicated), and PRS (1 very disagree to 7 very agree) on a 7-point scale, and a total of 7 questions

were asked for each image. Unlike the time limit for viewing each image, the participants were given as much time as they wanted in the photo evaluation area. After the photo evaluation, the space bar was pressed to automatically view the next image. Each participant filled out questions asking for demographic information such as gender, age, and ethnic background at the end of the experiment.

2.2. Study Design

Twenty-five color images of outdoor environment scenes (resolution = 1280×1024) were used to test the assumptions of this study. The premise of replacing these landscape scenes with photographs was that many existing studies [71,72] have proved the utility of landscape evaluation with photography experiments since the Scenic Beauty Estimation (SBE) development by Daniel and Boster [73]. The basic types of photographs set up in this study were classified into natural scenes and built scenes to prove the restorative effects of natural factors. Furthermore, we applied the distance differences on landscapes considering the existing studies [74,75], showed the significance of distance differences when evaluating landscapes. Therefore, the photographs represented four different environmental categories (five to seven images per category): natural scene and close view, natural scene and distant view, built scene and close view, and built scene and distant view, containing trees, lakes, buildings, roads, and squares. The experimental images used in this study were selected by collecting five experts' opinions. They were also instructed to distinguish between the four landscape types used in this study, depending on the landscape components and distance. Specifically, the experts who gave opinions on the final image selection were specialized in landscape architecture, architecture, and environmental design and had at least 10 years of experiences in their fields. To reduce seasonal and time effects, the final images were taken in the same season and at the same time around 2 to 3 pm at several spots in Europe. All the images used in this study are shown in Figure A1.

2.3. Eye-Tracking Apparatus

The study used a video-based, pupil/corneal reflection eye-tracking apparatus manufactured by SensoMotoric Instruments (SMI; version 3.2, Teltow, Germany) from Germany, which was equipped with an infrared camera and dual eye recording system (Red 250, Teltow, Germany) to measure eye movements (see Figure 1). The infrared sensor was located right beneath the monitor and was set up to allow the participant's eye movements to be identified. An operator controlled the software and hardware for eye movement, and the participant sat at a distance of 500 mm from the monitor. The size of each image shown to the participants in the lab was set to $375 \text{ mm} \times 300 \text{ mm}$ in a 17-inch monitor, and the resolution of image was set to 1280×1024 , which enabled participants to see each image in detail. This eye-tracking software (Begaze 2) supported various types of eye movement measurements such as fixation duration, saccade duration, pupil size, total viewing time, and so on. The peak velocity threshold of the eye tracker was set at 20% of the saccade length at start and 80% of the saccade length at end. Prior to the eye-tracking experiment, this eye-tracking system was calibrated by repeatedly to measure the participant's eyes.

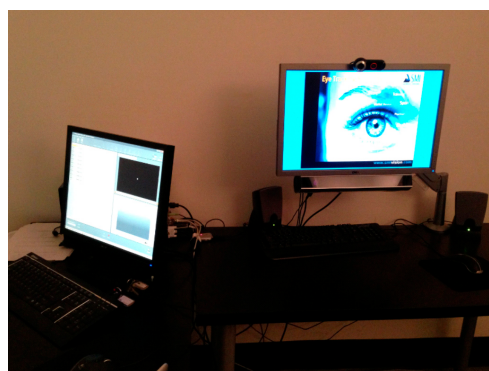


Figure 1. A photo of the eye-tracking equipment.

2.4. Participants

In order to minimize errors in the experiment, thirty-eight right-handed participants were recruited from a previous study [76]. Seven participants among them who were not suitable for the experiment were excluded from the calibration test, and the final thirty-one samples were analyzed as valid samples of this study. Related eye-tracking studies [77–79] used relatively small sample sizes compared to other studies. The sample pool contained students, professors, and university staff. All participants were informed of the purpose and the main procedure, compensation, and so on by an IRB consent document before the experiment. The participants' age ranged from 20 to 50 (mean = 32.2, std. = 9.4; 20s = 51.6%, 30s = 25.8%, 40s = 16.1%, 50s = 6.5%). Their ethnic backgrounds were Caucasian ($n = 16$, 51.6%), Asian ($n = 10$, 32.3%), and Middle Eastern ($n = 5$, 16.1%). The ratio of male to female was 6 ($n = 19$) to 4 ($n = 12$).

2.5. Measurement

The measurements in this study were divided into variables related to the visual characteristics of a restorative environment and two eye-tracking variables to measure participants' eye movements. Visual aesthetics [33,51], complexity [50,51,56,80], and PRS [28,32,36,64,81,82] were used for the visual characteristics related to the restorative environment. Especially, we used the five-item short version of the PRS by Reference [29] which was based on Korpela and Hartig's scale [26]. The PRS used the mean value of each of five variables as the final data. The details were as follows.

- That is a place which is away from everyday demands and where I would be able to relax and think about what interests me (being away);
- That place is fascinating; it is large enough for me to discover and be curious about things (fascination);
- That is a place where the activities and items are ordered and organized (coherence);
- That is a place which is very large, with no restrictions to movements; it is a world of its own (scope);
- In that place, it is easy to orient and move around so that I could do what I like (compatibility).

The eye-tracking variables used in this study were fixation duration [25,65,83–86] and scan path length [86–88] (see Table 1), which were used to determine whether people were using directed attention in viewing the image. Fixation duration can usually be used to measure how much attention people have paid to stimuli, but they are often associated with fatigue or levels of expertise in the processing of information on subject. According to Poole and Ball [89], a longer fixation duration indicates difficulty in extracting the information or that the object is more engaging in some way. Miyao et al. [89] also suggested that an increase in the fixation duration could be the result of readability difficulties, which could lead to visual fatigue. Dupont et al. [65] proved landscape experts recorded less fixations than laymen. They suggested that it could be a consequence of the lack of expertise or knowledge regarding landscapes, which caused a longer fixation on individual objects to resolve uncertainty or confusion about them and to understand their meaning. In this study, it was assumed that seeing a built scene in which more information needed to be deciphered would cause more fatigue than seeing a natural environment scene. This assumption was based on the studies of References [90,91] as well as the existing studies presented above. Yamada and Kobayashi [90] insisted that oculomotor-based metrics related to saccades and fixations could also develop a model for inferring mental fatigue in everyday situations, and Schleicher et al. [91] used fixation durations as one of measurements to assess the relationship between eye movement and fatigue. Therefore, fixation duration is one of the critical measures to determine the degree of restorative effect. In other words, we anticipated that a relatively less fixation duration would be recorded in natural environment scenes. Another measurement used in relation to eye movement is scan path length, which is used to compare PRS depending on various types of scenes. Here, scan path length was based on the contents obtained

from the whole image, not from object-by-object in the image. PRS that measures the degree of recovery obtained the representative score by image, using the average value from previous studies [29,31,36,38]. For Rebollar et al.'s study [87], the scan path was determined by the position and size when perceiving products, and this was sufficient to use as a tool for perceiving landscape.

Table 1. A summary of the terms used in this study.

Terms	Description
Fixation duration	Total time of all fixated area (no movement)
Scan path length (pixel)	Total length (pixel) of eye movements as the gaze travels from one point of fixation to another

A MANOVA (Multivariate analysis of variance) was used to verify statistically significant differences in each of the visual aesthetics, complexity, and PRS for different types and distances of the landscapes. Pearson's correlation, moreover, was carried out to check the relationships between ratings of visual aesthetics, complexity, and PRS. Finally, the correlations were additionally run between the fixation duration and PRS and the scan path length and complexity across the different environmental images to explore other ways of applying eye-tracking in landscape studies.

3. Results

3.1. Visual Characteristics of Landscapes with High Scores

The results showed that people preferred scenes composed of natural elements to built scenes generally. First, photographs with the highest visual aesthetics ratings among the 25 photographs tended to include many natural elements. Especially, the image with the highest preference is shown on the far left of Figure 2 and is mainly composed of water. This confirms the results of previous studies [32,44,45,92], suggesting a strong correlation between landscape beauty and waterfront elements. The image with the highest complexity included many artificial instead of natural elements, and the more artificial elements the picture had or the narrower the distance between buildings were, the higher the rating of complexity was. Finally, the landscape with the highest degree of PRS is shown in the far right of Figure 2, is surrounded by many natural elements, and shows a panoramic view from far away.



Figure 2. The highest scoring (mean) image for each visual characteristic: (a) visual aesthetics ($m = 6.7$), (b) complexity ($m = 6.5$), and (c) Perceived Restorativeness Scale (PRS) ($m = 5.6$).

3.2. Results Regarding Restorative Landscapes

To verify the restoration effect that varies depending on the specific characteristics of the landscape, we first divided the landscapes in this study into four basic types of natural scene and close view, natural scene of distant view, built scene and close view, and built scene and distant view. As shown in Figure 3, the average score of the landscape with the highest PRS was natural scene and distant view (4.7 out of 7.0) and the lowest average score was built scene and distant view (3.9 out of 7.0). In order

to prove the difference on visual aesthetics, complexity, and PRS depending on 4 landscape types, a MANOVA and a post hoc (Tukey) test were carried out due to statistically significant correlations among the three dependent variables. The suitability of this test was verified through homogeneity test (Box's test of equality of covariance matrices; $p = 0.484$) and Levene's test before analyzing the comparison among variables. The MANOVA result clearly showed a difference statistically (Wilks's $\lambda = 0.656$, $F = 8.640$, $p = 0.000$) in visual aesthetics ($F = 9.691$, $p = 0.000$, $\eta^2 = 0.145$), complexity ($F = 20.149$, $p = 0.000$, $\eta^2 = 0.261$), and PRS ($F = 6.812$, $p = 0.000$, $\eta^2 = 0.107$) between the four landscape types. Specifically, Table 2 showed the difference between landscape types by each of the three dependent variables (visual aesthetics, complexity, and PRS). We focused more on the PRS results depending on landscape types and found out that the values of natural scenes were higher than of built scenes. This shows that the natural element has a higher restorative effect, confirming previous studies [1,4,81,82] and supporting hypothesis 2 in this study. Further, to verify hypothesis 3, the statistical differences in restorative effect depending on the distance within the same type of landscape were compared. Even though the numerical values of close view in natural scenes (4.7) and distant view in built scenes (4.0) were relatively higher, hypothesis 3 was rejected due to statistical insignificance.

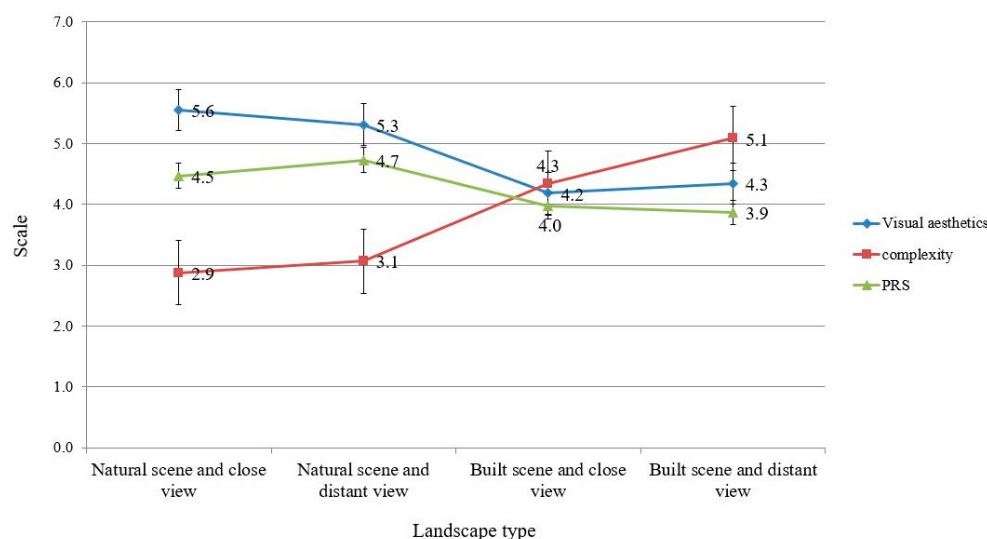


Figure 3. The basic statistics of various types of landscapes.

Pearson's correlations between visual aesthetics, complexity, and PRS were carried out; both visual aesthetics and complexity are some of the main mediating factors in restorative environments, and statistically significant results were obtained (Table 3). The relationship between visual aesthetics and PRS in this study was statistically significant, $r = 0.483$, $p < 0.01$. This means that the higher the aesthetics, the higher the PRS score, and it can be assumed that locating landscape preference elements or managing the landscape can help improve the restorative effect. On the other hand, there was a significant negative correlation between complexity and PRS score, $r = -0.168$, $p < 0.05$. Although complexity had an adverse effect on the restorativeness unconditionally from this result, it implies that efforts to improve visual aesthetics need to be encouraged but making the landscape complex excessively in restorative environment can bring negative effects. We further compared the statistical relationship between complexity and PRS within the natural landscape types (natural scene/close view and natural scene/distant view only) to suggest the potential of improving the recovery effect in natural landscape. The result showed that a negative correlation ($r = -0.210$, $p < 0.05$) between complexity and PRS was significant.

Table 2. The multiple comparison (Tukey HSD; honestly significant difference) in the rated visual aesthetics, complexity, and PRS depending on landscape type in this study (MANOVA Results).

Dependent Variable	(I) Landscape Type	(J) Landscape Type	Mean Difference (I – J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Visual aesthetics	Natural scene and close view	Natural scene and distant view	0.2415	0.31112	0.865	−0.5657	1.0487
		Built scene and close view	1.3673 *	0.29891	0.000	0.5918	2.1429
		Built scene and distant view	1.2082 *	0.32744	0.002	0.3586	2.0577
	Natural scene and distant view	Built scene and close view	1.1259 *	0.31112	0.002	0.3187	1.9330
		Built scene and distant view	0.9967 *	0.33862	0.025	0.0881	1.8452
		Built scene and distant view	−0.1592	0.32744	0.962	−1.0087	0.6904
Complexity	Natural scene and close view	Natural scene and distant view	−0.1939	0.31589	0.928	−1.0134	0.6257
		Built scene and close view	−1.4694 *	0.30350	0.000	−2.2568	−0.6820
		Built scene and distant view	−2.2082 *	0.33246	0.000	−3.0707	−1.3456
	Natural scene and distant view	Built scene and close view	−1.2755 *	0.31589	0.000	−2.0951	−0.4559
		Built scene and distant view	−2.0143 *	0.34381	0.000	−2.9063	−1.1223
		Built scene and distant view	−0.7388	0.33246	0.121	−1.6013	0.1238
PRS	Natural scene and close view	Natural scene and distant view	−0.25918	0.21918	0.614	−0.8094	0.2911
		Built scene and close view	0.49796	0.20376	0.073	−0.0307	1.0266
		Built scene and distant view	0.60082 *	0.22321	0.039	0.0217	1.1799
	Natural scene and distant view	Built scene and close view	0.75714 *	0.21208	0.003	0.2069	1.3074
		Built scene and distant view	0.86000 *	0.23083	0.001	0.2611	1.4589
		Built scene and distant view	0.10286	0.22321	0.967	−0.4763	0.6820

* $p < 0.05$.**Table 3.** The Pearson's correlation between visual aesthetics, complexity, and PRS.

		Visual Aesthetics	Complexity	PRS
Visual aesthetics	Pearson Correlation	1		
	Sig. (2-tailed)			
	N	775		
Complexity	Pearson Correlation	−0.435 **	1	
	Sig. (2-tailed)	0.000		
	N	775	775	
PRS	Pearson Correlation	0.483 **	−0.168 *	1
	Sig. (2-tailed)	0.000	0.026	
	N	775	775	775

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

3.3. Eye-Movement Analysis and Visualization

The average fixation duration (ms) and scan path length (px) for the four types are shown below (see Table 4). First, there were no significant differences between the four types of landscape in fixation duration. This contrasts with Berto et al.'s (2008) [25] study, which demonstrated that the fixation duration was lower when the directed attention decreased when seeing a natural landscape. On the other hand, the scan path length values showed different results through an ANOVA test for each of the four landscape types despite having the same time limit per image. The mean of the natural scene and distant view was 4502.0 (std. = 1334.6), which was the smallest scan path length recorded among the four types of landscape. The longest scan path length was for the built scene and close view (mean = 5179.4, std. = 1281.6). The statistical differences (ANOVA test) between the four types were found to be significant ($F = 7.329$, $p < 0.00$). In the post hoc test of ANOVA, significant differences between natural/close scenes and built/close scenes ($p = 0.001$), natural/distant scenes and built/close scenes ($p = 0.000$) were verified. Therefore, hypothesis 4, stating that eye movement (scan path length)

is lower while viewing natural scenes than built scenes, was partially accepted even though the fixation duration was not statistically significant.

Table 4. The eye-movement analysis results (mean).

Types	Fixation Duration Average (Millisecond)	Scan Path Length (Pixel)
Natural scene and close view	249.3	4596.8
Natural scene and distant view	241.0	4502.2
Built scene and close view	231.7	5179.4
Built scene and distant view	244.1	4855.0

The following Figure 4 shows 6 participants' scan path maps as a sample image. In the case of gazing at a natural landscape, as shown on the left, the figure indicates that the eyes remained in several places without moving too much compared to the built scene heat map on the right.

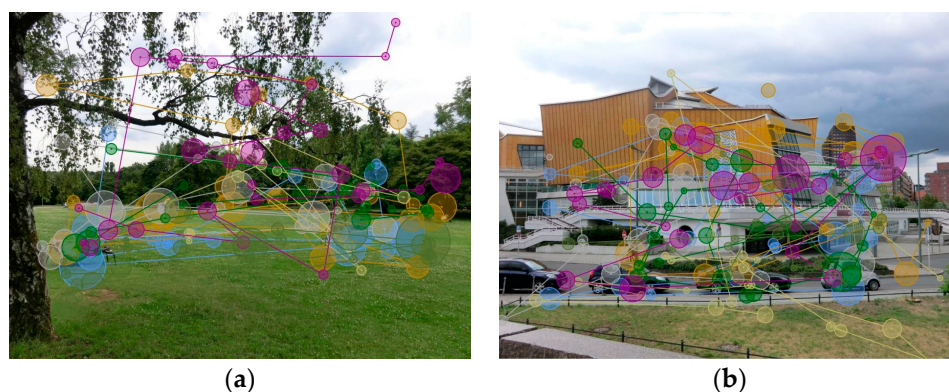


Figure 4. Scan path maps: (a) one of the natural scenes and distant views and (b) one of the built scenes and close views.

4. Discussion

4.1. Implications of Restorative Landscapes

Nature-based experiences have relaxing effects, and the therapeutic effect of nature has received increasing attention [93,94]. In this context, natural elements have been addressed predominantly as a major tool to enhance the restorative effect [1,3–5,8,9,50,51,95]. However, Velarde et al. [53] argued that it is not enough to just divide built and natural environments dichotomously as a design guideline for restorative landscapes. This study, therefore, tried to compare the differences in estimates of restorativeness depending on close and distant views in each natural and built scene. Further, we compared the differences in landscape characteristics such as visual aesthetics and complexity regarding natural and built environments. This study focused on how restorative landscapes should be created and managed especially in natural scenes. It is not just that the restorative effect is increased by natural elements, but the degree of restorative effect can be mediated by various visual characteristics. Although the differences in the restorative effects regarding close and distant views of landscapes shown were not statistically significant, this study suggests that complexity and visual aesthetics can affect the estimate of restorativeness. Among these, the correlations of visual aesthetics (preference) were consistent with the findings of Reference [96] of strong correlations between the PRS and preference. The results on complexity can be interpreted to mean that the higher the perceived complexity of the landscape, the lower the landscape's PRS regardless of landscape type ($r = -168$, $p < 0.05$). As we determined that this could be the result of complexity perceived in built scenes (referring to the MANOVA test of complexity depending on landscape types), the correlation between complexity and PRS was additionally conducted in natural scenes only. However, the result of

relationship was identical with previous test, and even the correlation coefficient was found to be higher ($r = -210$, $p < 0.05$) than the overall comparison. Therefore, complexity should be considered when it comes to restorative landscapes. Berlyne [80] insisted that a potential candidate for a special cue that triggers soft fascination with nature is visual complexity, but it was somewhat different from our finding. Ulrich et al. [56] also showed differences with our result by suggesting that appropriate complexity improves healing effects. We believe that further research regarding this issue is needed because we did not use the same landscape image or PRS scale as the existing studies. Therefore, future research subjects may subdivide the scale of complexity in landscape studies or demonstrate specific landscape elements that perceive complexity, etc. Especially, it is considered that subdividing the complexity scale is one of the necessary areas in landscape research, as it is judged that there is a large difference in the perceived complexity among people.

A limitation of this study is that there were not enough guidelines such as types, size, or location of flowers, trees, other structures to be presented, specifically like several existing studies [10,47]. A detailed simulation study on a change of the area or location of a specific landscape element could be performed to overcome this limitation, but it is more important to concentrate on landscape composition created by the sum of individual landscape elements than individual landscape elements themselves. In this context, future research should explore various other visual characteristics that can be used for specific design guidelines in addition to complexity and visual aesthetics.

4.2. Methodological Considerations (Eye-Tracking Methods)

Applying eye-tracking methods to restorative landscape research is very reasonable, as eye tracking has been used in a few notable environmental psychology studies [64,65,97], and its potential in landscape research has also been appreciated in recent years. In particular, the eye's influence is the dominant factor in perceiving visual information, so it is likely to be used in the future. Significant differences in the scan path length among eye-movement measurements between natural scenes and built scenes shown in this study are very indicative. Although the differences in the fixation duration in eye movement depending on landscape types shown in Berto et al.'s study [25] was not found in this study, the statistic differences of scan path length, which is one of the eye-movement measures, were proved depending on landscape types. This result suggests that eye tracking has a broad usability in landscape evaluation studies and further provides potentials to be used as a measure when evaluating restorativeness with previous PRS. Recently, Hartig's study [98] supported this suggestion by figuring out a significant correlation between eye movement (fixation count, fixation duration, and total eye travel distance) and restorative factors (Being away, Fascination, Coherence, and Compatibility). This can be discussed more in relation to skepticism on using PRS in previous studies. Velarde et al. [53] and Hartig [98] stated that the PRS needed to be revised and developed as much as possible. Therefore, the scan path length might be used as a tool to complement PRS or as a verification tool in the modification or development when an additional PRS should be considered, if many related studies are accumulated. In addition to the fixation duration and scan path length proposed in this study, various eye-movement measures such as pupil size, saccade duration, blinks, and so on are available as eye-tracking methods; accordingly, these can be used for various landscape evaluations in the future. Additionally, according to Reference [72], eye-tracking methods can be used to recognize which factors have a restorative potential by figuring out the components that show higher fixations or dwelling times on specific areas than other elements. In their study, components such as benches and bushes had a high affordance for restoration on the stimulus environment depicted. However, it is difficult to confirm this result because not enough studies have yet been conducted about what specific components obtain higher mean dwelling times. Moreover, this result means that spending much time on images may be associated with inducing directed attention. Therefore, Kang and Kim's method [85] of investigating the mean fixation areas on images by instructing participants to consciously look at the most beautiful or fearful spots could be one of the appropriate ways to understand restorative landscapes using eye-tracking methods. As such, analyzing landscapes using eye tracking has a great potential and can be used

as a guide for various landscape or environmental perception studies. Finally, in order to spread eye-tracking technologies in landscape research, further studies should be conducted by comparing eye-tracking results with conservative survey methods or expert evaluations as well as applying other eye-tracking measures on various types of landscape elements and types.

A limitation on the eye-tracking experiment of this study is that relatively low samples were reflected. Although previous related studies have used few samples, our further study will require more samples to enhance of the reliability.

5. Conclusions

This study explored various properties of landscapes to increase the restorative effects of urban landscape and to suggest the implications for landscape design. The main results and implications obtained from this study are as follows: natural scenes are perceived as more restorative than built scenes; not only visual aesthetics but also complexity affected the degree of restorativeness; and eye-tracking provides direct empirical support for the attention restoration theory. This study ultimately can play a critical role in providing an overview regarding restorative design guidelines not only by using natural elements but also by considering landscape compositions in terms of complexity, openness, and so on. Therefore, the results derived from this study can actually help landscape designs to improve the recovery effect in the future.

Author Contributions: All authors have contributed to the intellectual content of this paper. The first author, Y.K., developed the flow of this study and wrote most of the manuscript. She was also responsible for all statistical analyses and image data. E.K. contributed to the research design, wrote the discussion part that suggests urban green area design.

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

Appendix A



Figure A1. Cont.



Figure A1. Cont.

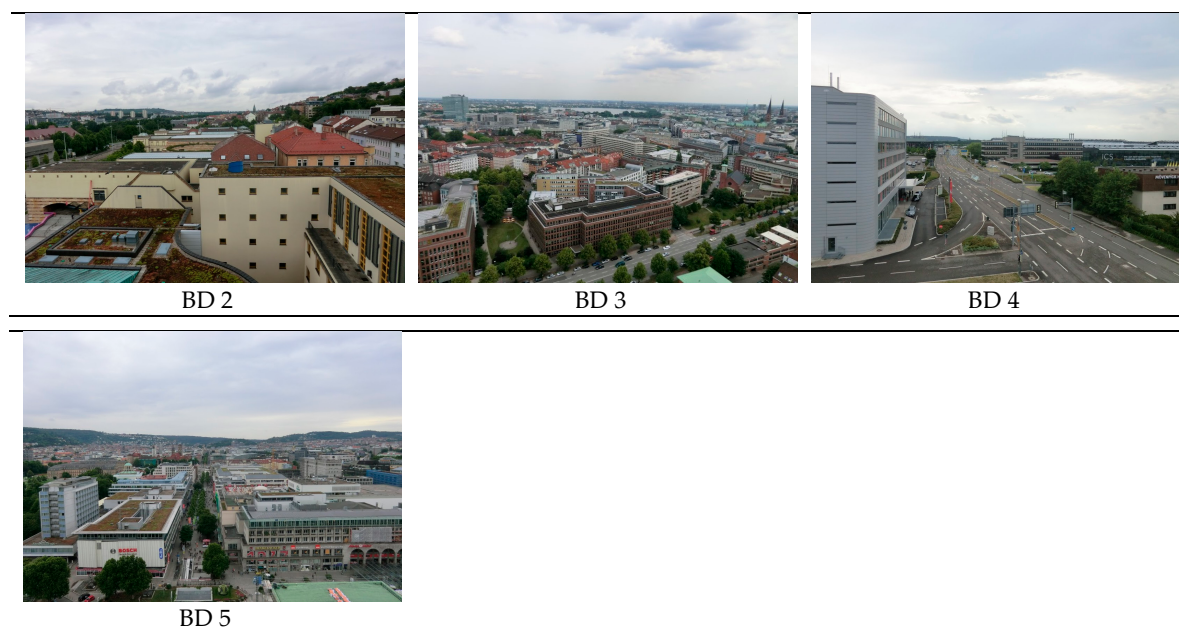


Figure A1. The images used in this study: natural scene and close view (NC), natural scene and distant view (ND), built environment scene and close view (BC), and built environment scene and distant view (BD).

References

1. Arnberger, A.; Eder, R. Are urban visitors' general preferences for green-spaces similar to their preferences when seeking stress relief? *Urban For. Urban Green.* **2015**, *14*, 872–882. [\[CrossRef\]](#)
2. Galea, S.; Udding, M.; Koenen, K. The urban environment and mental disorders. *Epigenetics* **2011**, *6*, 400–404. [\[CrossRef\]](#)
3. Grahn, P.; Stigsdotter, U.A. Landscape planning and stress. *Urban For. Urban Green.* **2003**, *2*, 1–18. [\[CrossRef\]](#)
4. Hartig, T.; Staats, H. The need for psychological restoration as a determinant of environmental preferences. *J. Environ. Psychol.* **2006**, *26*, 215–226. [\[CrossRef\]](#)
5. Lee, K.E.; Williams, K.J.H.; Sargent, L.D.; Williams, N.S.G.; Johnson, K.A. 40-s Green roof views sustain attention: The role of micro-breaks in attention restoration. *J. Environ. Psychol.* **2015**, *42*, 182–189. [\[CrossRef\]](#)
6. van den Berg, M.; Wendel-vos, W.; van Poppel, M.; Kemper, H.; van Mechelen, W.; Maas, J. Health benefits of green spaces in the living environment: A systematic review of epidemiological studies. *Urban For. Urban Green.* **2015**, *14*, 806–816. [\[CrossRef\]](#)
7. Srivastava, K. Urbanization and mental health. *Ind. Psychiatry J.* **2009**, *18*, 75–76. [\[CrossRef\]](#)
8. Staats, H.; Kieviet, A.; Hartig, T. Where to recover from attentional fatigue: An expectancy-value analysis of environmental preference. *J. Environ. Psychol.* **2003**, *23*, 147–157. [\[CrossRef\]](#)
9. Vujcic, M.; Tomicevic-dubljevic, J.; Grbic, M.; Lecic-tosevski, D. Nature based solution for improving mental health and well-being in urban areas. *Environ. Res.* **2017**, *158*, 385–392. [\[CrossRef\]](#)
10. Nordh, H.; Alalouch, C.; Hartig, T. Assessing restorative components of small urban parks using conjoint methodology. *Urban For. Urban Green.* **2011**, *10*, 95–103. [\[CrossRef\]](#)
11. Jiang, S. Therapeutic landscapes and healing gardens: A review of Chinese literature in relation to the studies in western countries. *Front. Archit. Res.* **2014**, *3*, 141–153. [\[CrossRef\]](#)
12. Tyrväinen, L.; Ojala, A.; Korpela, K.; Lanki, T.; Tsunetsugu, Y.; Kagawa, T. The influence of urban green environments on stress relief measures: A field experiment. *J. Environ. Psychol.* **2014**, *38*, 1–9. [\[CrossRef\]](#)
13. Cottet, M.; Vaudor, L.; Tronchere, H.; Roux-Michollet, D.; Augendre, M.; Brault, V. Using gaze behavior to gain insights into the impacts of naturalness on city dwellers' perceptions and valuation of a landscape. *J. Environ. Psychol.* **2018**, *60*, 9–20. [\[CrossRef\]](#)
14. Schafer, R.M. *The Soundscape: Our Sonic Environment and the Tuning of the World*; Destiny Books: Rochester, NY, USA, 1977.

15. Carles, J.; Barrio, I.; de Lucio, J. Sound influence on landscape values. *Landsc. Urban Plan.* **1999**, *43*, 191–200. [[CrossRef](#)]
16. Hong, X.; Liu, J.; Wang, G.; Jiang, Y.; Wu, S.; Lan, S. Factors influencing the harmonious degree of soundscape in urban forests: A comparison of broad-leaved and coniferous forests. *Urban For. Urban Green.* **2019**, *39*, 18–25. [[CrossRef](#)]
17. Jeon, J.Y.; Hong, J.Y. Classification of urban park soundscapes through perceptions of the acoustical environments. *Landsc. Urban Plan.* **2015**, *141*, 100–111. [[CrossRef](#)]
18. Ren, X.; Kang, J.; Zhu, P.; Wang, S. Effects of soundscape on rural landscape evaluations. *Environ. Impact Assess. Rev.* **2018**, *70*, 45–56. [[CrossRef](#)]
19. Kaplan, S. The restorative benefits of nature: Toward an integrative framework. *J. Environ. Psychol.* **1995**, *15*, 169–182. [[CrossRef](#)]
20. Laumann, K.; Gärling, T.; Stormark, M. Selective attention and heart rate responses to natural and urban environments. *J. Environ. Psychol.* **2003**, *23*, 125–134. [[CrossRef](#)]
21. James, W. *Psychology: The Briefer Course*; Holt: New York, NY, USA, 1892.
22. Berto, R.; Baroni, M.R.; Zainaghi, A.; Bettella, S. An exploratory study of the effect of high and low fascination environments on attentional fatigue. *J. Environ. Psychol.* **2010**, *30*, 494–500. [[CrossRef](#)]
23. Felsten, G. Where to take a study break on the college campus: An attention restoration theory perspective. *J. Environ. Psychol.* **2009**, *29*, 160–167. [[CrossRef](#)]
24. Kaplan, R. The nature of the view from home: Psychological benefits. *Environ. Behav.* **2001**, *33*, 507–542. [[CrossRef](#)]
25. Berto, R.; Massaccesi, S.; Pasini, M. Do eye movements measured across high and low fascination photographs differ? Addressing Kaplan’s fascination hypothesis. *J. Environ. Psychol.* **2008**, *28*, 185–191. [[CrossRef](#)]
26. Korpela, K.; Hartig, T. Restorative qualities of favorite places. *J. Environ. Psychol.* **1996**, *16*, 221–233. [[CrossRef](#)]
27. Herzog, T.R.; Maguire, P.; Nebel, M.B. Assessing the restorative components of environments. *J. Environ. Psychol.* **2003**, *23*, 159–170. [[CrossRef](#)]
28. Pasini, M.; Berto, R.; Brondino, M.; Hall, R.; Ortner, C. How to measure the restorative quality of environments: The PRS-11. *Procedia Soc. Behav. Sci.* **2014**, *159*, 293–297. [[CrossRef](#)]
29. Berto, R. Exposure to restorative environments helps restore attentional capacity. *J. Environ. Psychol.* **2005**, *25*, 249–259. [[CrossRef](#)]
30. White, M.; Smith, A.; Humphries, K.; Pahl, S.; Snelling, D.; Depledge, M. Blue space: The importance of water for preference, affect, and restorativeness ratings of natural and built scenes. *J. Environ. Psychol.* **2010**, *30*, 482–493. [[CrossRef](#)]
31. Payne, S.R. The production of a Perceived Restorativeness Soundscape Scale. *Appl. Acoust.* **2013**, *74*, 255–263. [[CrossRef](#)]
32. Collado, S.; Staats, H.; Sorrel, M.A. A relational model of perceived restorativeness: Intertwined effects of obligations, familiarity, security and parental supervision. *J. Environ. Psychol.* **2016**, *48*, 24–32. [[CrossRef](#)]
33. Hoyle, H.; Hitchmough, J.; Jorgensen, A. All about the “wow factor”? The relationships between aesthetics, restorative effect and perceived biodiversity in designed urban planting. *Landsc. Urban Plan.* **2017**, *164*, 109–123. [[CrossRef](#)]
34. Ivarsson, C.T.; Hagerhall, C.M. The perceived restorativeness of gardens: Assessing the restorativeness of a mixed built and natural scene type. *Urban For. Urban Green.* **2008**, *7*, 107–118. [[CrossRef](#)]
35. Hauru, K.; Lehvävirta, S.; Korpela, K.; Kotze, D.J. Closure of view to the urban matrix has positive effects on perceived restorativeness in urban forests in Helsinki, Finland. *Landsc. Urban Plan.* **2012**, *107*, 361–369. [[CrossRef](#)]
36. Peschardt, K.K.; Stigsdottir, U.K. Associations between park characteristics and perceived restorativeness of small public urban green spaces. *Landsc. Urban Plan.* **2013**, *112*, 26–39. [[CrossRef](#)]
37. Cervinka, R.; Schwab, M.; Schönbauer, R.; Hämmerle, I.; Pirgie, L.; Sudkamp, J. My garden—My mate? Perceived restorativeness of private gardens and its predictors. *Urban For. Urban Green.* **2016**, *16*, 182–187. [[CrossRef](#)]

38. Marselle, M.R.; Irvine, K.N.; Lorenzo-arribas, A.; Warber, S.L. Does perceived restorativeness mediate the effects of perceived biodiversity and perceived naturalness on emotional well-being following group walks in nature? *J. Environ. Psychol.* **2016**, *46*, 217–232. [[CrossRef](#)]
39. Hidalgo, M.C.; Berto, R.; Galindo, M.P.; Getrevi, A. Identifying attractive and unattractive urban places: Categories, restorativeness and aesthetic attributes. *Medio Ambiente Comportamiento Humano* **2006**, *7*, 115–133.
40. Lin, Y.; Tsai, C.; Sullivan, W.C.; Chang, P.; Chang, C. Does awareness effect the restorative function and perception of street trees? *Front. Psychol.* **2014**, *5*, 1–9. [[CrossRef](#)]
41. Rennit, P.; Maikov, K. Perceived restoration scale method turned into (used as the) evaluation tool for parks and open green spaces, using Tartu city parks as an example. *City Territory Archit.* **2015**, 2–6. [[CrossRef](#)]
42. Hartig, T.; Evans, G.W.; Jamner, L.D.; Davis, D.S.; Gärling, T. Tracking restoration in natural and urban field settings. *J. Environ. Psychol.* **2003**, *23*, 109–123. [[CrossRef](#)]
43. Bratman, G.N.; Daily, G.C.; Levy, B.J.; Gross, J.J. The benefits of nature experience: Improved affect and cognition. *Landsc. Urban Plan.* **2015**, *138*, 41–50. [[CrossRef](#)]
44. Pradhan, P. The Role of Water as a Restorative Component in Small Urban Spaces. Master's Thesis, Swedish University of Agricultural Science, Uppsala, Sweden, 2012.
45. Sato, I.; Conner, T.S. The quality of time in nature: How fascination explains and enhances the relationship between nature experiences and daily affect. *Ecopsychology* **2013**, *5*, 197–204. [[CrossRef](#)]
46. Nejati, A.; Rodiek, S.; Shepley, M. Using visual simulation to evaluate restorative qualities of access to nature in hospital staff break areas. *Landsc. Urban Plan.* **2016**, *148*, 132–138. [[CrossRef](#)]
47. Stigsdotter, U.K.; Corazon, S.S.; Sidenius, U.; Refshauge, A.D.; Grah, P. Forest design for mental health promotion: Using perceived sensory dimensions to elicit restorative responses. *Landsc. Urban Plan.* **2017**, *160*, 1–15. [[CrossRef](#)]
48. Tennessen, C.M.; Climpich, B. Views to nature: Effects on attention. *J. Environ. Psychol.* **1995**, *15*, 77–85. [[CrossRef](#)]
49. Gilchrist, K.; Brown, C.; Montarzino, A. Workplace settings and wellbeing: Greenspace use and views contribute to employee wellbeing at peri-urban business sites. *Landsc. Urban Plan.* **2015**, *138*, 32–40. [[CrossRef](#)]
50. van den Berg, A.E.; Koole, S.L.; van der Wulp, N.Y. Environmental preference and restoration: (How) are they related? *J. Environ. Psychol.* **2003**, *23*, 135–146. [[CrossRef](#)]
51. Pazhouhanfar, M.; Kamal, P. Effect of predictors of visual preference as characteristics of urban natural landscapes in increasing perceived restorative potential. *Urban For. Urban Green.* **2014**, *13*, 145–151. [[CrossRef](#)]
52. Karmanov, D.; Hamel, R. Assessing the restorative potential of contemporary urban environment(s): Beyond the nature versus urban dichotomy. *Landsc. Urban Plan.* **2008**, *86*, 115–125. [[CrossRef](#)]
53. Velarde, M.D.; Fry, G.; Tveit, M. Health effects of viewing landscapes: Landscape types in environmental psychology. *Urban For. Urban Green.* **2007**, *6*, 199–212. [[CrossRef](#)]
54. Ratcliffe, E.; Korpela, K.M. Memory and place attachment as predictors of imagined restorative perceptions of favourite places. *J. Environ. Psychol.* **2016**, *48*, 120–130. [[CrossRef](#)]
55. Gatersleben, B.; Andrews, M. When walking in nature is not restorative: The role of prospect and refuge. *Health Place* **2013**, *20*, 91–101. [[CrossRef](#)]
56. Ulrich, R.S.; Simons, R.F.; Losito, B.D.; Fiorito, E.; Miles, M.A.; Zelson, M. Stress recovery during exposure to natural and urban environments. *J. Environ. Psychol.* **1991**, *11*, 201–230. [[CrossRef](#)]
57. Kuper, R. Evaluations of landscape preference, complexity, and coherence for designed digital landscape models. *Landsc. Urban Plan.* **2017**, *157*, 407–421. [[CrossRef](#)]
58. Bell, S.; Foley, R.; Houghton, F.; Maddrell, A.; Williams, A.M. From therapeutic landscapes to healthy spaces, places and practices: A scoping review. *Soc. Sci. Med.* **2018**, *196*, 123–130. [[CrossRef](#)]
59. Pitt, H. Therapeutic experiences of community gardens: Putting flow in its place. *Health Place* **2014**, *27*, 84–91. [[CrossRef](#)]
60. Daniel, T.C. Whither scenic beauty? Visual landscape quality assessment in the 21st century. *Landsc. Urban Plan.* **2001**, *54*, 267–281. [[CrossRef](#)]
61. Ode, A.; Fry, G.; Tveit, M.S.; Messenger, P.; Miller, D. Indicators of perceived naturalness as drivers of landscape preference. *J. Environ. Manag.* **2009**, *90*, 375–383. [[CrossRef](#)]
62. Amati, M.; Parmehr, E.G.; McCarthy, C.; Sita, J. How eye-catching are natural features when walking through a park? Eye-tracking responses to videos of walks. *Urban For. Urban Green.* **2018**, *31*, 67–78. [[CrossRef](#)]

63. Dupont, L.; Antrop, M.; Eetvelde, V.V. Eye-tracking analysis in landscape perception research: Influence of photograph properties and landscape characteristics. *Landsc. Res.* **2014**, *39*, 417–432. [[CrossRef](#)]
64. Conniff, A.; Craig, T. A methodological approach to understanding the wellbeing and restorative benefits associated with greenspace. *Urban For. Urban Green.* **2016**, *19*, 103–109. [[CrossRef](#)]
65. Dupont, L.; Antrop, M.; Eetvelde, V.V. Does landscape related expertise influence the visual perception of landscape photographs? Implications for participatory landscape planning and management. *Landsc. Urban Plan.* **2015**, *141*, 68–77. [[CrossRef](#)]
66. van Schijndel, O.; Litschel, R.; Maal, T.J.J.; Berge, S.J.; Tasman, A.-J. Eye tracker based study: Perception of faces with a cleft lip and nose deformity. *J. Cranio-Maxillofac. Surg.* **2015**, *43*, 1620–1625. [[CrossRef](#)]
67. Li, Q.; Huang, Z.; Christianson, K. Visual attention toward tourism photographs with text: An eye-tracking study. *Tour. Manag.* **2016**, *54*, 243–258. [[CrossRef](#)]
68. Luan, J.; Yao, Z.; Zhao, F.; Liu, H. Search product and experience product online reviews: An eye-tracking study on consumers review search behavior. *Comput. Hum. Behav.* **2016**, *65*, 420–430. [[CrossRef](#)]
69. Nordh, H.; Hagerhall, C.M.; Holmqvist, K. Tracking restorative components: Patterns in eye movements as a consequence of a restorative rating task. *Landsc. Res.* **2013**, *38*, 101–116. [[CrossRef](#)]
70. Wedel, M.; Pieters, R. A Review of Eye-Tracking Research in Marketing. In *Review of Marketing Research*; Malhotra, N.K., Ed.; Emerald Group Publishing Limited: West Yorkshire, UK, 2008; Volume 4, pp. 123–147.
71. Franco, D.; Franco, D.; Mannino, I.; Zanetto, G. The impact of agroforestry networks on scenic beauty estimation: The role of a landscape ecological network on a socio-cultural process. *Landsc. Urban Plan.* **2003**, *62*, 119–138. [[CrossRef](#)]
72. Peng, S.; Han, K. Assessment of aesthetic quality on soil and water conservation engineering using the scenic beauty estimation method. *Water* **2018**, *10*, 407. [[CrossRef](#)]
73. Daniel, T.C.; Boster, R.S. *Measuring Landscape Aesthetics: The Scenic Beauty Estimation Method*; USDA Forest Service: Washington, DC, USA, 1976.
74. Lin, L.; Homma, R.; Iki, K. Preferences for a lake landscape: Effects of building height and lake width. *Environ. Impact Assess. Rev.* **2018**, *70*, 22–33. [[CrossRef](#)]
75. Zhou, T.; Koomen, E.; van Leeuwen, E.S. Residents' preferences for cultural services of the landscape along the urban-rural gradient. *Urban For. Urban Green.* **2018**, *29*, 131–141. [[CrossRef](#)]
76. Nicholls, M.E.R.; Thomas, N.A.; Loetscher, T.; Grimshaw, G.M. The Flinders handedness survey (Flanders): A brief measure of skilled hand preference. *Cortex* **2013**, *49*, 2914–2926. [[CrossRef](#)]
77. Riby, D.M.; Doherty, M.J. Tracking eye movements proves informative for the study of gaze direction detection in autism. *Res. Autism Spectr. Disord.* **2009**, *3*, 723–733. [[CrossRef](#)]
78. Kimble, M.O.; Fleming, K.; Bandy, C.; Kim, J.; Zambetti, A. Eye tracking and visual attention to threatening stimuli in veterans of the Iraq war. *J. Anxiety Disord.* **2010**, *24*, 293–299. [[CrossRef](#)]
79. Brunyé, T.T.; Gardony, A.L. Eye tracking measures of uncertainty during perceptual decision making. *Int. J. Psychophysiol.* **2017**, *120*, 60–68. [[CrossRef](#)]
80. Berlyne, D.E. *Aesthetics and Psychobiology*; Appleton-Century-Crofts: New York, NY, USA, 1971.
81. Hipp, J.A.; Ogunseit, O.A. Effect of environmental conditions on perceived psychological restorativeness of coastal parks. *J. Environ. Psychol.* **2011**, *31*, 421–429. [[CrossRef](#)]
82. Villagra-Islas, P.; Alves, S. Open space and their attributes, uses and restorative qualities in an earthquake emergency scenario: The case of Concepción, Chile. *Urban For. Urban Green.* **2016**, *19*, 56–67. [[CrossRef](#)]
83. Byrne, M.D.; Anderson, J.R.; Douglas, S.; Matessa, M. Eye Tracking the Visual Search of Click down Menus. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI'99, Pittsburgh, PA, USA, 15–20 May 1999; ACM Press: New York, NY, USA, 1999; pp. 402–409.
84. De Lucio, J.V.; Mohamadian, M.; Ruiz, J.P.; Banayas, J.; Bernaldez, F.G. Visual landscape exploration as revealed by eye movement tracking. *Landsc. Urban Plan.* **1996**, *34*, 135–142. [[CrossRef](#)]
85. Kang, Y.; Kim, M. Application strategies of eye-tracking method in nightscape evaluation. *Korean Inst. Landsc. Archit.* **2015**, *43*, 87–97. [[CrossRef](#)]
86. Kato, M.; Konishi, Y. Where and how infants look: The development of scan paths and fixations in face perception. *Infant Behav. Dev.* **2013**, *36*, 32–41. [[CrossRef](#)]
87. Rebollar, R.; Lidón, I.; Martín, J.; Puebla, M. The identification of viewing patterns of chocolate snack packages using eye-tracking techniques. *Food Qual. Preference* **2015**, *39*, 251–258. [[CrossRef](#)]

88. Poole, A.; Ball, L. Eye tracking in human-computer interaction and usability research: Current status and future prospects. In *The Encyclopedia of Human-Computer Interaction*; Ghaoui, C., Ed.; Idea Group Reference: London, UK, 2005; pp. 211–219.
89. Miyao, M.; Hacisalihzade, S.S.; Allen, J.S.; Stark, L.W. Effects of VDT resolution on visual fatigue and readability: An eye movement approach. *Ergonomics* **1989**, *32*, 603–614. [[CrossRef](#)]
90. Yamada, Y.; Kobayashi, M. Detecting mental fatigue from eye-tracking data gathered while watching video: Evaluation in younger and older adults. *Artif. Intell. Med.* **2018**, *91*, 39–48. [[CrossRef](#)]
91. Schleicher, R.; Galley, N.; Briest, S.; Galley, L. Blinks and saccades as indicators of fatigue in sleepiness warnings: Looking tired? *Ergonomics* **2008**, *51*, 982–1010. [[CrossRef](#)]
92. Völker, S.; Kistemann, T. The impact of blue space on human health and well-being – Salutogenetic health effects of inland surface waters: A review. *Int. J. Hyg. Environ. Health* **2011**, *214*, 449–460. [[CrossRef](#)]
93. van den Berg, A.E.; Joye, Y.; Koole, S.L. Why viewing nature is more fascinating and restorative than viewing buildings: A closer look at perceived complexity. *Urban For. Urban Green.* **2016**, *20*, 397–401. [[CrossRef](#)]
94. Song, C.; Ikei, H.; Park, B.; Lee, J.; Kagawa, T.; Miyazaki, Y. Psychological benefits of walking through forest areas. *Int. J. Environ. Res. Public Health* **2018**, *15*, 2804. [[CrossRef](#)]
95. Nordh, H.; Evensen, K.H.; Skår, M. A peaceful place in the city: A qualitative study of restorative components of the cemetery. *Landsc. Urban Plan.* **2017**, *167*, 108–117. [[CrossRef](#)]
96. Purcell, T.; Peron, E.; Berto, R. Why do preferences differ between scene types? *Environ. Behav.* **2001**, *33*, 423–437. [[CrossRef](#)]
97. Franek, M.; Sefara, D.; Petruzalek, J.; Cabal, J.; Myska, K. Differences in eye movements while viewing images with various levels of restorativeness. *J. Environ. Psychol.* **2018**, *57*, 10–16. [[CrossRef](#)]
98. Hartig, T. Restorative environments. In *Encyclopedia of Applied Psychology*; Spielberger, C., Ed.; Academic Press: Cambridge, MA, USA, 2004; Volume 3, pp. 273–279.



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