J Multidisciplinary Scientific Journal

Article

The Impact of Nature Imagery and Mystery on Attention Restoration

Trina Yap [1], Denise Dillon [2,*] and Peter K. H. Chew [2]

[1] College of Healthcare Sciences, James Cook University, Townsville 4811, Australia
[2] School of Social & Health Sciences, JCU Singapore, Singapore 387380, Singapore
* Correspondence: denise.dillon@jcu.edu.au

Abstract: The factors contributing to urbanization, such as population growth and the development of mega-cities, have increased environmental stressors on top of everyday stressors, resulting in information overload. This has led to the increasing incidence of direct attentional fatigue, which causes stress and mental fatigue. The attention restoration theory centres on the environment's capacity to restore attentional deficits and suggests that there are certain qualities in the environment that restore attention, which leads to improvements in our physical, mental, and social well-being. An environment can be restorative through the activation of involuntary attention, which limits the need for directed attention. This study explored for effects of natural, built, and mixed environment types and levels of mystery on attention restoration in university undergraduates. Perceived and actual levels of attention restoration were measured using a perceived restoration scale (PRS) and the digit symbol substitution task (DSST), respectively. A total of 101 participants viewed a restorative image followed by the completion of the DSST and the PRS for each of the 18 images depicting different environments. Actual attention restoration was measured by latency values in the DSST instead of through both speed and error rates due to some operational issues with the DSST which interfered with the full achievement of the study's aims. There was an effect of different environments and mystery on perceived attention restoration. However, there appeared to be no effect on actual attention restoration, indicating a disconnect between perceived and actual restoration. Further research is required to confirm the specific effects of natural and built environments and mystery on attention restoration.

Keywords: attention restoration; environment settings; mystery

Citation: Yap, T.; Dillon, D.; Chew, P.K.H. The Impact of Nature Imagery and Mystery on Attention Restoration. *J* **2022**, *5*, 478–499. https://doi.org/10.3390/j5040033

Academic Editor: Prashant Kumar

Received: 23 August 2022
Accepted: 6 November 2022
Published: 8 November 2022

1. Introduction

Environmental psychology is the study of interrelationships between people and their physical environments, including how people perceive and respond to the physical environment [1]. Understanding the physical environment has important implications on how we react to the world around us. People's physical, mental, and social well-being can be affected by the surrounding environments and landscapes [2]. Understanding how the different environments and landscape elements can contribute to health improvement is essential to provide new landscape designs beneficial to human health.

The factors contributing to urbanization, such as population growth and the development of mega-cities, have increased environmental stressors on top of everyday stressors, resulting in information overload. This has led to the increasing incidence of direct attentional fatigue, which causes stress and mental fatigue among urban residents [1]. Natural environments can help reduce stress and promote the recovery of mental fatigue [3–5]. Restoration "proceeds in tandem with other processes that also affect the resources that people use to meet everyday demands" [6] (p. 2). According to the attention restoration theory (ART), full restoration does not amount to a mere recovery of directed attention capacity, because part of the restorative experience is for individuals to reflect on unsolved life issues [3].

The investigation of the beneficial effects of nature and urban settings departs from two theoretical perspectives. According to the ART, nature exposure experiences allow for either improvements in mood states accompanied by physiological changes [7] or the restoration of attention deficit [3,4]. Roger Ulrich's [5] stress reduction theory centres on the environments' capacity to influence affective states. In this model, affective responses towards the environment are mediated by changes in mood states, which may result from exposure to different environments that have varying stress-reducing capacities. The rapid, automatic, and unconscious process through which individuals respond to the environment can be attributed to the important subcortical areas in the brain, especially the amygdala, which is involved in modulating stress-related hormones [8]. This explains why different types of environments can have a different influence on autonomic stress responses. For instance, there is evidence which suggests a much stronger stress-reducing capacity of nature as compared to urban environments [9,10]. Exposure to nature can lead to greater psychological well-being, fewer negative mood states, stronger positive affect, and other physiological symptoms such as lower heart rates and reduced muscle tension as compared to urban environments [11].

This contrasts with the framework of Kaplan's attention restoration theory (ART), which centres on the environment's capacity to restore attention deficits. The ART holds that intensive or prolonged use of directed attention, which is a limited resource, leads to the fatigue of the mechanisms that serve it [4,12,13]. Directed attention fatigue has negative consequences that include negative emotions, irritability, impulsivity, decreased sensitivity to interpersonal cues, reduced ability to plan, and decrements on tasks requiring directed attention [14]. Thus, overworking the mind can result in the depletion of resources and a reduction in the ability to utilize higher-order executive functions used in cognition. In contrast, switching over to involuntary attention allows for the attentional system to rest and recover, since it is effortless. This provides an opportunity for the individual to restore and be recharged through clearing away unwanted thoughts, ultimately enabling a contemplative state of mind.

Specifically, an environment can be restorative by attracting the activation of involuntary attention and limiting the need for directed attention [15]. Such settings are known as restorative settings. Natural environments (e.g., preserved parks, nature trails, forests) have been demonstrated to be inherently restorative by freeing up directed attention resources through involuntary attention. In contrast, the array of stimuli in urban environments requiring directed attention is distracting rather than restorative [13]. Cognitive benefits for children with attentional deficits [16] and normal adults [12,14,17] have been demonstrated outcomes of interaction with nature, as have been improvements in short-term memory [18] and school success [19]. However, natural environments are not all equal in the level of restoration afforded to people who are mentally fatigued. The ART asserts that there are four properties of restorative settings: being away, extent, compatibility, and fascination.

Being away involves distancing oneself from usual activities that are taxing on directed attention, leading to attentional fatigue [20]. Being away can either be physical, such as leaving the office for a walk or a beach vacation, or conceptual, where well-worn mental content is avoided [12]. For example, a sense of "being away" can be induced by watching a favourite television programme or reading a favourite book. Scopelliti and Giuliani [21] highlighted that it is often more restorative to be conceptually distinct from the everyday environment as compared to a physical change.

Extent is generated by environments that have sufficiently rich content and a coherent structure, which allows one to feel connected and engaged in a "whole other world" [4] (p. 173). Extent is defined by the experience of two components: scope and connectedness. Scope refers to the scale of the domain (e.g., conceptual, perceptual) in which the activity occurs, wherein there is more than the immediate environment available, either physically just out of sight or even within the imagination [3]. On the other hand, connectedness is defined by the series of relationships between immediately perceived environmental features that relate to each other and to a larger environment [22]. Such environments engage the mind for a sufficient duration so that directed attention rests while supporting extended exploration. Extent, via scope and connectedness, can be experienced not only in physical environments, but also in psychological processes [22].

Compatibility requires that a setting be well-suited both to the individual's purpose and to the types of activity anticipated in the setting [23]. The potential for engaging an individual is dependent on the available information in supporting the individual's intentions or what the individual is trying to achieve. Natural settings can be compatible with a wide range of activities (e.g., biking, observing wildlife, kite flying, etc.) that align with the desires or interests of visitors [23]. These types of activities create familiarity and ease, thus creating opportunities for individuals to withdraw their voluntarily directed attention and gain restoration through engagement with the environment. Kaplan and Berman [13] argue that compatibility between the environment and the person is needed to restore directed attention, a common resource used in executive functioning and self-regulation tasks.

Fascination is a crucial component of the ART because inherently interesting stimuli capture attention without requiring effort, and thereby allows for the restoration of directed attentional capacity [4,23]. Fascination is elicited when the individual is engaged in inherently interesting stimuli that capture one's attention effortlessly, without having to use directed attention [3].

Settings can range along a spectrum from soft fascination to hard fascination. Soft fascination is usually a response to gentle stimuli which are moderate in intensity (e.g., the changing shape of cloud formations, or rain drops glistening on leaves), whereas hard fascination is usually high in intensity and rivets one's attention (e.g., tracking the action in a sports game, or engaging in gambling activities) [4]. Both soft and hard fascination share the aspect of captured attention but have different restorative effects. Soft fascination is common in natural settings (e.g., viewing a sunset) and best promotes attention restoration as it allows one to think freely [24].

Many studies have shown that fascination can be triggered by the attention-drawing qualities of natural settings (e.g., forests, beaches). Berto [25] has shown that attention restoration can occur in less than 10 min through exposure to images of natural environments rated as being high on perceived fascination. Similarly, photographs of environments rated as displaying content high in fascination that engage involuntary attention generate fewer eye fixations as compared to low-fascination photographs [26]. This suggests that less capacity of directed attention and focus is required for images high in fascination, thereby allowing for greater attention restoration.

However, fascination is not only engaged in the processes of landscape perception (i.e., exploring and making sense of the environment). It can also be activated by particular content (e.g., animals, people, water, nature), events (e.g., story-telling, watching competitive sports, gambling) and processes in which there is an element of uncertainty involved (i.e., reading a book that is unresolved until the end) [4]. It is important to consider the pleasantness, intensity, and functionality dimensions of fascination, which may differ for each individual [22]. While soft fascination appears to be advantageous for restoration, restoration might be advanced by more intense fascination, especially if it contributes to a sense of extent. The proposed three other components—being away, extent, and compatibility—are likely to enhance and contribute to attentional recovery and, together with fascination, their combined effect is what makes an environment restorative [4].

1.1. The Impact of Restorative Environments

A vast amount of literature has been devoted to examining the applied utility of the ART in terms of the cognitive benefits of nature exposure. In addition to improved attentional capacity, direct exposure to nature has also been associated with increased connectedness to nature, positive emotions, and improved ability to reflect on life problems [27]. Most research has examined the restorative effects of participants being physically immersed in the natural environment as compared to urban environments, but these benefits also carry over when simulated forms or visual representations of nature are used. Simply observing natural scenes has been shown to improve executive attention in young adults, as compared to viewing pictures of urban scenes [28]. Similarly, Berto [25] reported improved attentional capacity from measures of accuracy, reaction time, and target detection after viewing restorative nature images on a sustained attention test. Large dramatic nature murals, especially those containing elements of water, were also perceived by students as being more restorative places to study than settings of real mundane natural environments with built structures present [20]. This suggests that large nature murals used in indoor settings for study breaks may provide attentionally fatigued students with opportunities for attention restoration. This is especially advantageous in urban cities where views of nature are unavailable or limited in resource.

1.2. The Role of Mystery in ART

Natural settings are not all equal in their ability to enable mental restoration. It appears that high-mystery natural settings may enable restoration more so than low-mystery settings, and mystery can be used to predict environmental preference [29–31]. Kaplan and Kaplan [3] proposed that dual needs to understand and to explore an environment determine one's visual preference for a landscape. These two dimensions were utilized to produce a preference matrix containing four variables. Mystery is a scenic quality and is one of the informational variables proposed in the Kaplans' environmental preference matrix. Mystery refers to features that draw one's curiosity or attention through indications that the landscape has more to offer [29]. Other variables such as coherence, legibility, and complexity play an equally important role in influencing an individual's preference for an environment [30]. These four visual preference predictors provide information to further our understanding of the preference and perceived comfort of such environments. Therefore, it is possible to manage and design natural and urban environments based on these informational needs [32].

In the case of mystery, physical attributes (e.g., depth of field, spatial definition) that often contribute to a person's perception of mystery may enhance the perception of the level of complexity [31]. Examples include partially concealed views (e.g., sinuous paths or views obscured by tall grasses or shrubs) which draw the viewer's attention through the impression that there is more to be found. Thus, these kinds of settings contain the element of fascination as they increase the potential to learn something new and thereby prompt interest. Szolosi et al. [31] also suggest how mystery is a component of fascination from the tests of mediation which showed that mystery affects recognition performance as a consequence of such perceptions. Hence, images depicting settings high in mystery usually include soft fascination. Through a novel oculometric methodology to explore engagement with environments depicted in images, Marois et al. [33] proposed that it is the voluntary engagement with mystery and soft-fascination components of nature that helps bring about restoration by reducing cognitive demand.

Among the four predictors of visual landscape preference, only mystery was significant in explaining the perceived restoration potential in nature and urban environments [32]. However, there is no general consensus on this line of argument. No significant correlations were found between mystery and preference in natural and built environments [34,35].

1.3. Perceived vs. Actual Attention Restoration

Perceived restorative potential is defined as the individual's judgement of the degree to which an environment can aid in the recovery of mental resources [36]. For example, an individual's perception of a setting with high restorative potential will lead to the expectation of psychological, emotional, or physiological recovery after spending time in that perceived restorative space. However, perceived restoration differs from actual psychological restoration, which is an improvement to an individual's well-being (e.g., recovery of cognitive resources, reduced stress).

Most recently, studies have begun to discuss the ART in the context of the different cognitive processes that attention may require [9,17,25,28]. Natural environments capture involuntary attention, which requires little top-down processing, and thereby tends to have a positive effect on cognitive performance [37]. In contrast, urban or city-like environments capture dramatic attention and require directed attention and show no improvement on cognitive performance. Kaplan [4] linked the ART to the attention theory through a specific reference to processes such as selection, problem solving, and inhibition, amongst others. An individual would need to hold and replay visual and auditory stimuli and manipulate them according to the rules stored in short-term memory, while suppressing distracting alternative attentional cues in order to perform well on such measures [18]. As such, the higher demands on executive functions of attention such as working memory can be used as a measure of actual restoration.

With the assumption that nature affords opportunities for effortless attention, it is generally expected that participants perform better on cognitive tasks when exposed to natural scenes as opposed to urban scenes. Research has shown improved performance after exposure to natural settings, directly or through images, on the Necker cube pattern control task [9,38], the attention network task (ANT) [28], the digit span task [28,38], the sustained attention to response task (SART) [39], and the digit symbol substitution test (DSST) [40]. Berman et al. [28] reported substantially more correct trials on a digit span task after a walk in nature compared to a walk in city streets. A similar pattern has also been observed as performance on the digit span task and the executive portion of the ANT also increased by nearly 30% during exposure to natural pictures when compared to viewing urban pictures [28]. Likewise, this trend is observed on the DSST in individuals when walking alone or with a friend in natural settings [40] as well as on the digit span task in individuals diagnosed with depression [41] and in children with attention deficits [16].

A distinction needs to be made between the properties of objects (e.g., images, videos, actual environments) that affect perceived restoration and objectively measured attention restoration following exposure to such properties. In fact, the extent to which perceived restoration predicts actual attention restoration appears to be overestimated [42]. While it is often assumed that individuals are aware of their own cognitive processes and are able to accurately predict and estimate how different environments will affect them, such an assumption is not well evidenced [43].

Most studies have either investigated the effect of attention restoration using self-reported questionnaires similar to the PRS (e.g., [20]) or performance task measures alone [25,28]. Furthermore, restoration should occur regardless of whether it is perceived if there is an interaction between directed attention and the object's properties. Thus, the true restorative effect of natural environments may be overrepresented, and the restorative effect of built environments misrepresented, since there is no concrete evidence that perceived restoration has an impact on related cognitive effects.

1.4. The Current Study: Aims and Hypotheses

A vast amount of literature has covered the restorative potential of nature and urban settings. However, there is little evidence on the effect of urban nature (or mixed environments) on attention restoration. Research on the relationship between mystery and preference is also inconclusive, even though previous research has found mystery to be a strong predictor for environmental preference [29,30,44]. Furthermore, most of the studies have only examined the impact of mystery on attention restoration between scenes of nature and scenes of buildings [30] or of nature scenes alone [31]. Thus, understanding the influence of mystery in the domain of urban natural (or mixed) environments in addition to urban and built environments could prove useful from a future design perspective.

The aim of the current study was to examine the effect of visual exposure to built, urban nature (or mixed), and natural settings on attention restoration. The current study also aimed to examine the influence of mystery in the domains of built, urban nature (or mixed), and natural environments on attention restoration.

However, given the discussed limitations of previous attention restoration measures, the present research employed the use of Felsten's [20] single-item scale of PRS as well as a performance task, the digit symbol substitution task (DSST), in order to more accurately access the actual restorative potential of the visual exposure on a person's cognitive and attentional capacity. One of the major assumptions of the ART is that recovery from directed attention fatigue depends on resource restoration [4]. Thus, having the PRS together with the DSST as measures of perceived and actual attention restoration, respectively, will increase the reliability of accessing the mental workload that images of different settings will have on a person's cognitive capacity. Consideration of the discussed literature led to the framing of the following hypotheses:

Hypothesis 1A. *Participants will display a higher level of perceived attention restoration after being presented with natural scenes, followed by mixed and built scenes, respectively.*

Hypothesis 1B. *Participants will have the highest accuracy level on the DSST after being presented with natural scenes, followed by mixed and built scenes, respectively.*

Hypothesis 1C. *Participants will have the fastest reaction time on the DSST after being presented with natural scenes, followed by mixed and built scenes comparatively.*

Given the research suggesting greater improvements in performance for images perceived high in mystery when compared to images perceived low in mystery [31], the following hypotheses were also proposed:

Hypothesis 2A. *Participants will have a higher level of perceived attention restoration after being presented with images high in mystery than with images low in mystery.*

Hypothesis 2B. *Participants will have a higher accuracy level on the DSST after being presented with images high in mystery than with images low in mystery.*

Hypothesis 2C. *Participants will have a faster reaction time on the DSST after being presented with images high in mystery than with images low in mystery.*

Hypothesis 3. *There will be an interaction effect between the type of environmental settings and mystery on overall attention restoration.*

2. Materials and Methods

2.1. Participants

One hundred and one undergraduates from a private university in Singapore were recruited for the purposes of this study. PRS data from two participants (1.98%) were removed due to errors in task completion or missing data. Accordingly, RT data of these 2 participants, along with other repeated trials in the RT data, were also removed (7.62%). The final sample consisted of 99 participants (60.60% females). Their ages ranged from 17 to 34 years ($M = 22.48$, $SD = 2.64$). Participants were mostly recruited through convenience sampling via the university's research recruitment noticeboard and the research management system, while the remaining participants were recruited through snowball sampling. Eligible students were allocated credit points for their participation in the study while the remaining participants received neither incentive nor reward. The only specific inclusion criterion was that participants needed to have met the minimum level of English competence required for university entry.

2.2. Design

This study employed a 3 × 2 within-subjects experimental design with environment type (built, natural, or mixed) and mystery (high or low) as the independent variables (IVs). The dependent variable (DV) was attention restoration, which was operationalized in three different ways: (1) Perceived attention restoration measured by participants' scores on the PRS; (2) mean accuracy of participants' scores on the DSST measured by number of correct responses identified; and (3) mean speed of responses on the DSST. The study was designed to examine the effects of environment type and mystery on attention restoration in cognitively fatigued individuals. Cognitive fatigue was generated through performance of the DSST.

The different types of environments were operationalised as such: (1) Built environments are human-made surroundings such as those with architectural features ranging from buildings and roads to parks; (2) natural environments are landscapes usually untouched or conserved by humankind, usually characterised by an abundance of plants and other elements of natural ecosystems; and (3) mixed environments are a 50/50 combination of built and natural elements [45]. Images should be at least 75% natural or built to be classified as natural or built environments, respectively.

Mystery refers to settings that easily capture an individual's attention, providing the prospect to acquire additional information and enhance one's sense of involvement. High mystery settings usually contain partially concealed views, enticing a person to look further [3]. Examples include a bend in the trail, meandering streams, or winding city streets or staircases. Kaplan and Kaplan [3] emphasized that, even when defined, viewers tend to draw on "implicit interpretations of the opportunities and constraints afforded by the space" (p. 28) for the categorization of environments. We therefore employed a set of viewer ratings to determine a suitable set of stimuli to represent each of our pre-defined categories.

2.3. Materials

The materials include an information sheet detailing the nature of the study and outlining the terms of consent to participate, a set of images sourced specifically to represent environmental categories as visual stimuli, a self-report questionnaire (PRS), and a performance task (DSST) that also contributed to cognitive fatigue. Qualtrics survey software [46] and Inquisit experimental software version 4 [47] were employed for various parts of the study.

2.4. Stimulus Selection

A stimulus selection exercise involving seven participants was conducted to rate a set of images to be used in the experiment. In selecting the original set of images, we aimed for photographs that reflected environments that would likely be seen in (or similar to) real-life settings in Singapore, and we did not select images on the basis of colour or fractality. Joye et al. [48] have argued that selecting on such a basis would likely negate the effects of restoration if using such properties to differentiate between urban and natural settings, for example. Twenty-two photographic images reflecting low and high mystery in natural and mixed environments were used as stimuli with permission from Szolosi, Watson, and Ruddell [31]. According to the environmental type (built, mixed, or nature) and mystery levels (high or low), additional images were either drawn from the research supervisor's own photographic collection or sourced from Google. In total, 71 images were collated for stimulus selection. Participants were three males (42.9%) and four females (57.1%) aged between 22 and 26 years old (M = 23.4, SD = 1.40). All participants were fourth-year undergraduates whose involvement in the stimulus selection exercise excluded them from taking part in the experiment.

Within a Qualtrics survey created for the stimulus selection exercise, participants were provided with information about the task requirements and asked to provide informed consent by clicking on the "agree" button. Following this, they were provided with the definitions of 'built', 'mixed', 'nature', and 'mystery' before evaluating the stimuli. Participants were instructed to rate 71 images sequentially based on the type of environment and level of mystery which best represented the setting in each image. Two categorical questions were presented for each image, (1) "Which category do you think the above image best represents? (Built/Mixed/Nature)" and (2) "How mysterious do you think the above image is? (High Mystery/Low Mystery)".

Images from each category were selected based on a cut-off point of 5 out of 7 participants, reflecting a minimum consensus rating of 71.4%. Based on the collated results, 36 images met the criteria and, of those, three images with the highest consensus rating in each category were selected. In total, a final set of 18 images was selected across all 6 conditions (3 images per condition). Sample images for each of the 6 conditions are displayed in Figure 1.

Figure 1. Sample images for the 6 conditions (**a** = high mystery built, **b** = high mystery mixed, **c** = high mystery natural, **d** = low mystery built, **e** = low mystery mixed, and **f** = low mystery natural).

2.5. Measures

Perceived Restoration Scale (PRS) Short Version. The version of the PRS used in this study is based on the version used by Felsten [20], which comprises five items reflecting the characteristics of restorative experiences. Felsten used one item for each of the four properties of restorative environments together with one additional item. Four items assess the constructs of being away, extent, fascination, and compatibility, whereas the last item measures an overall perceived restorativeness: "Overall, how much do you agree that this setting would be excellent for taking a break and restoring your ability to study for an exam or work effectively on a demanding project?".

For each statement, participants respond on a seven-point Likert scale to assess the restorative potential of each setting (1 = "Not at all", 7 = "Very Much"). Higher scores on the PRS indicate a higher level of perceived attention restoration after viewing the respective restorative images. The minimum and maximum scores are 5 and 35, respectively.

According to Felsten [20], the internal consistency for the four items measuring components of perceived restorativeness for 30 settings ranged from 0.85 to 0.97, with a mean of 0.95. The four items measuring restorativeness also correlated with the one item measuring overall restorativeness for the same 30 settings, ranging from 0.61 to 0.92, with a mean of 0.82.

Automated Digit Symbol Substitution Task (DSST). The DSST is a component of the Wechsler adult intelligence scale [49] and is a test of coding performed at speed. It is a modification of the symbol digit modalities test (SDMT). Unlike the SDMT which has combined written and oral tests, the automated DSST only requires a computerized test. Given the complexity of the task, the DSST assesses several perception, attention, and executive function processes such as incidental memory, perceptual organization, visuomotor coordination, and selective attention [45,50]. The DSST is relatively free from cultural bias in college students [51] and gender, age, or education bias in younger adults [52]. While many of the attentional tests might be affected by mood, the DSST taps into cognitive function over and above any mood effects [53].

The test is structured in such a way that a key is provided at the top of the computer screen, with nine different symbols each paired with a number from 1 to 9. Beneath the key is another array of randomised symbols paired with an array of blank squares beneath. Participants complete the task by filling in the corresponding number for an appropriate symbol–number match. A practice response sequence is provided whereby a few of the numbers corresponding to symbols are shown as examples. Participants are asked to fill in the empty boxes of the practice sequence correctly before they proceed to the actual task. The test itself constitutes 8 rows of 18 symbols, with each row followed by a corresponding row of squares for responses. Of the total of 144 squares, nine have been filled up from the practice test. Participants are instructed to fill in as many blanks as possible in a 90 s timeframe.

This version of the DSST is run on Inquisit computer software [47], which allows for millisecond accuracy in timing. Unlike traditional paper-and-pen tests, participants are not given the opportunity to correct responses once they have been made. Both the number of correct and incorrect responses are recorded and the total score equals the sum of all correct symbols completed within 90 s. Lower error rates would indicate higher accuracy and better performance levels. The mean speed of responses reflecting an individual's perceptual processing speed is recorded as well. The DSST demonstrates good test–retest reliability of repeated measures at one day evaluated by the coefficient of correlation ($r = 0.93$), correlation of repeatability (7 items), and the coefficient of variation (13%) [54]. Typical mean number of items filled in per 90 s for individuals aged 18 to 35 with >13 years of education (tertiary undergraduate students) is 32 to 42 symbols [54].

2.6. Procedure

This study was approved by a Human Research Ethics Committee. This study was conducted in one of the testing rooms within the cognitive psychology research lab. There were ten cubicles in the room. Each participant was provided with a desktop computer, a table and chair at each cubicle such that there were no noise interferences or other distractions.

First, participants were directed to the computer screen on Qualtrics [46], where the information sheet detailing the nature of the experiment was presented. They were given time to read and clarify doubts before providing informed consent by clicking on the 'agree' button, thereby proceeding with the experiment. Participants were then directed to complete demographic information such as their age and gender. Following this, they were directed to an alternative webpage to complete the first DSST on Inquisit, to help familiarise themselves with the task and to initiate cognitive fatigue.

Prior to each DSST task, participants were instructed to enter their eight-digit student identification number followed by a dash and the image number (e.g., 123XXXXX-image number) to link performance on the DSST to the environmental image stimuli provided on Qualtrics. Since there was no image prior to the first task, participants were instructed to enter their student identification number followed by the number zero (e.g., 123XXXXX-0).

Participants were seated approximately 60 cm from the computer screen, where they were instructed to pay attention to the key provided at the top of the screen and to proceed with the practice trial followed by the first experimental trial. After completion of the first DSST (fatiguing task), participants were redirected to Qualtrics where the first image stimulus was shown on the screen. Images were randomized so that each participant viewed them in a different order. Each image was shown for 10 s before it disappeared. This duration of exposure to the stimulus was deemed sufficient as there was a significant relationship found between scene and recognition performance scores at 10 s durations [31,33]. Following the stimulus exposure, participants were redirected to Inquisit to complete the DSST following the first image. As such, the DSST performed a dual function as pre-exposure cognitive fatigue task and as a post-exposure measure of cognitive restoration.

After completion of the DSST measuring cognitive restoration, participants were directed back to Qualtrics to complete the PRS as a measure of perceived restoration. A smaller version of the image was provided at the top of the screen to prompt their memory and to ensure responses referred to the correct image. This sequence was followed for each of the 18 images. On completion of these tasks, participants were debriefed, thanked for their participation, and dismissed. The sequence of the procedure can be found in Table 1.

Table 1. Participation Sequence for the Study.

Sequence	Action in Qualtrics	Action in Inquisit
Step 1	Information about the study presented, informed consent implied upon proceeding to the study	
Step 2	Demographics data collected	
Step 3		First DSST for initial fatigue
Step 4	Stimulus/Measurement sequence	
	a. Restorative image in random order	
		b. DSST (DV and renewed fatigue)
	c. PRS	
Step 5	Repeat Step 4 a–c sequence x 17 for the remaining images	
Step 6	Verbal debrief	

3. Results

All analyses were conducted using the Statistical Package for the Social Sciences (SPSS) version 23 (IBM Corp., Armonk, NY, USA) with the alpha level set at 0.05.

3.1. Assumption Testing

Given that the study followed a within-subjects design, a sample of 99 exceeds the recommended sample size for repeated measures multivariate analysis of variance (MANOVA), which suggests to have 20 participants per DV (i.e., $N = 20 \times 3 = 60$) [55]. Post hoc power analysis (G*Power, Universität Düsseldorf, Düsseldorf, Germany) also revealed that a sample size of 99 was sufficient to obtain statistical power ($1 - \beta = 0.97$) at an alpha level of $p < 0.05$ and moderate effect size ($f\,2 = 0.25$).

Through visual inspection of the boxplots, four outliers were removed due to extreme scores of PRS scores, latency, and error rate beyond two standard deviations from the mean. An examination of skewness and kurtosis values indicated that the assumption of normality was violated for latency values and error rate in the DSST. However, distributions of reaction time data are often positively skewed, violating the normality assumption underlying the general linear model [56].

In order to address the violation of normality, a logarithmic transformation was conducted on latency and error rate data to normalise the distributions and impact of outliers [57]. As an outcome of this procedure, statistical assumptions regarding outliers and normality for latency values in the DSST were met. Unfortunately, error rates for the DSST were still too skewed beyond acceptable violations of normality and, thus, were removed from analysis. Pre- and post-transformation statistics pertaining to normality can be found in Table 2.

Table 2. Pre- and Post-Transformation Normality for Scores on Latency Values and Error Rates on the DSST.

	Pre-Transformation				Post-Transformation			
	Skewness	**Kurtosis**	***M***	***SD***	**Skewness**	**Kurtosis**	***M***	***SD***
Latency	1.37	4.53	1032.00	347.00	0.19	−0.06	2.99	0.14
Error Rate	3.93	25.82	0.02	0.03	3.21	17.03	0.01	0.01

Note: Values for skewness between −2 and +2 and values for kurtosis between −7 and +7 are considered acceptable indications of normality when assessing multivariate normality in MANOVA, which is assumed as it is robust against violations of normality [58,59].

3.2. Hypothesis Testing

Following the transformation of the data, the skewness and kurtosis for latency values were reduced and considered acceptable indications of normality [59]. A 2 (Mystery: high vs. low) × 3 (Environment setting: built vs. mixed vs. natural) repeated measures MANOVA was carried out on the DVs (PRS and latency on the DTTS) for hypothesis testing. The descriptive statistics for the data from 95 participants across six conditions are reported in Tables 3 and 4.

Table 3. Post-Transformation Descriptive Statistics for the Effects of Mystery and Environment Settings on the PRS.

Level of		Type of Environment Setting			
Mystery		**Built**	**Natural**	**Mixed**	**Mystery Totals**
High	M	17.53	25.87	28.02	23.81
	SD	(5.33)	(6.34)	(4.41)	(5.42)
Low	M	17.09	24.75	23.14	21.66
	SD	(6.54)	(5.60)	(5.74)	(5.97)
Setting totals	M	11.54	16.87	17.05	
	SD	(5.97)	(5.98)	(5.12)	

Table 4. Post-Transformation Descriptive Statistics for the Effect of Mystery and Environment Settings on Latency Values in the DSST.

Level of		Type of Environment Setting			
Mystery		**Built**	**Natural**	**Mixed**	**Mystery Totals**
High	M	1033	1042	1034	1036
	SD	(286)	(297)	(238)	(275)
Low	M	1045	1047	1025	1039
	SD	(288)	(314)	(292)	(298)
Setting totals	M	1039	1044	1029	
	SD	(287)	(306)	(266)	

Note: Response latencies reported in whole numbers because Inquisit accuracy is only to the millisecond.

The combined PRS scores and latency values in the DSST were used to assess attention restoration. There was a statistically significant interaction effect between mystery and the type of environment setting on the combined dependent variables measuring attention restoration, $F(4, 91) = 10.91$, $p < 0.001$, Wilks' $\Lambda = 0.675$, partial $\eta^2 = 0.325$.

A series of univariate ANOVA analyses was conducted to determine the effects of mystery and type of environmental setting on the DVs separately. The alpha level was corrected for, using the Bonferroni correction by dividing the current level of statistical significance by the number of tests (i.e., 0.05/6 = 0.008) for the analysis of multiple simple main effects. Therefore, the simple main effect is only statistically significant if $p < 0.008$.

Mystery**.** Mauchly's test of sphericity indicated that the assumption of sphericity had been exactly met for PRS scores and latency values in the DSST, χ^2 (0) = 1. Therefore, the degrees of freedom were corrected using Huynh–Feldt estimates of sphericity ($\varepsilon = 1$). The results show that the PRS scores were significantly affected by the level of mystery, $F(1, 94) = 32.27$, $p < 0.001$, partial $\eta^2 = 0.256$, with PRS values higher for images high in mystery than images low in mystery (Table 3). However, latency in the DSST was not significantly affected by the level of mystery, $F(1, 94) = 0.000$, $p > 0.008$, partial $\eta^2 < 0.001$, which indicates that the reaction time in the DSST did not differ significantly between images high and low in mystery (Table 4).

Environmental Setting. Mauchly's test of sphericity indicated that the assumption of sphericity had been violated for latency values in the DSST but not for PRS scores. Therefore, the degrees of freedom were corrected using Huynh–Feldt estimates of sphericity for latency ($\varepsilon = 0.98$). The results show that the PRS scores were significantly affected by the type of environmental setting, $F(2, 188) = 116.26$, $p < 0.001$, partial $\eta^2 = 0.553$. However, contrary to the hypotheses, the PRS scores were higher for images depicting mixed environments than for natural and built environments (Table 3). However, latency values in the DSST were not significantly affected by the type of environmental settings, $F(2, 188) = 0.307$, $p > 0.008$, partial $\eta^2 = 0.003$, which indicates that the reaction times in the DSST did not differ among built, natural, and mixed environments (Table 4).

Mystery × Environmental setting. Mauchly's test of sphericity indicated that the assumption of sphericity had been violated for latency values in the DSST but not for PRS scores. Thus, the degrees of freedom were corrected using Huynh–Feldt estimates of sphericity for latency values in the DSST ($\varepsilon = 1$). The results show that there was a statistically significant interaction effect between mystery and the type of environmental setting on the PRS scores, $F(2, 188) = 22.38$, $p < 0.001$, partial $\eta^2 = 0.192$. The PRS scores were the highest for mixed environments high in mystery. However, there was no statistically significant interaction effect between mystery and the type of environmental setting for latency values in the DSST, $F(2, 188) = 0.235$, $p > 0.008$, partial $\eta^2 = 0.002$, which indicates that the reaction times in the DSST did not differ between the levels of mystery and among different environment types. Graphical illustrations of the interactions can be found in Figures 2 and 3.

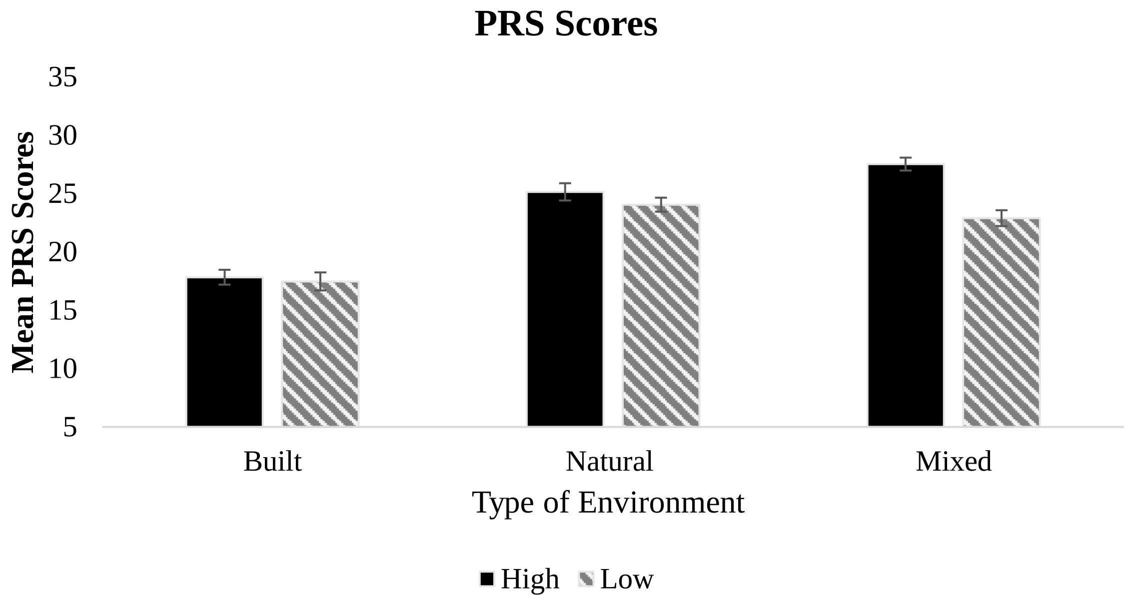

Figure 2. Effect of environmental settings (built/natural/mixed) and level of mystery (high/low) on PRS scores. Error bars represent the standard error of the mean PRS scores.

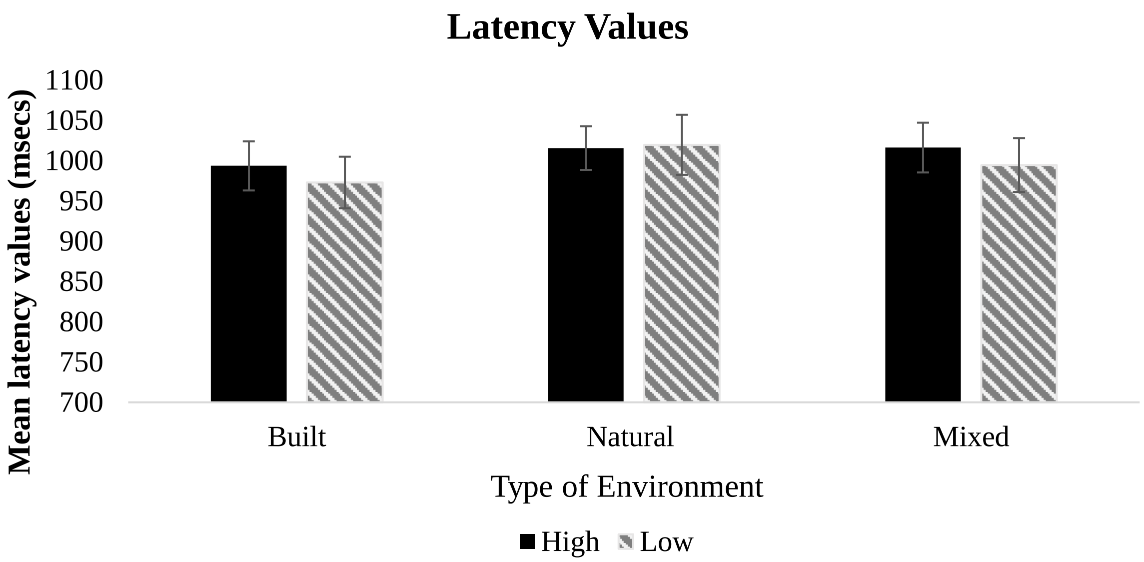

Figure 3. Effect of environmental settings (built/natural/mixed) and level of mystery (high/low) on latency values in the DSST. Error bars represent the standard error of the mean latency values.

4. Discussion

This study drew upon and advances previous research examining the cognitive benefits of nature [4,20,28] and mystery [3,29,31] on attention restoration. Given the previous gaps in research, the aims of this study were to examine the effect of visual exposure to built, urban nature (or mixed), and natural settings as well as the influence of mystery in the domains of built, urban nature (or mixed), and natural environments on perceived and actual attention restoration. In doing so, this study also sought to explore the possible interaction effect of environmental settings and mystery on perceived and actual attention restoration, respectively.

4.1. Adjusted Hypotheses

Some operational issues with the DSST interfered with the full achievement of the study's aims. The DSST was initially chosen as it is a direct measure of the rate of information processing of visual figures and because it is reportedly not affected by mood unlike other attentional tests [53]. Exposure and contact with greenery have been found to enhance cognitive performance [60], mood, and office productivity, amongst other benefits [61].

There are two versions of the DSST—automated and pen-and-paper. The automated version was chosen to allow for measures of both speed and accuracy. However, due to limitations in coding ability and despite substantial efforts to resolve the issue, only one version of the test was presented to participants throughout instead of the original plan to use equivalent versions of the test for repeated testing. The rationale for computing speed–accuracy trade-off functions despite practice effects provides the means to record reaction time on top of accuracy rate which is impractical to attempt with the pen-and-paper version.

Even by alternating the forms of the test, visual search and digit response patterns are held constant in digit symbol forms and, thus, practice effects may still be evident at brief retest intervals [62]. Alternating forms also does not necessarily prevent participants from developing strategies for approaching the task and thereby improving performance [63]. Therefore, for the current study we continued with the use of the DSST as an attentional task. The balancing of fatigue and practice effects over the course of the experiment was made easier by randomizing the sequence of restorative images from trial to trial across different conditions.

Unfortunately, it appears from the highly skewed error data (almost no errors) that practice effects were present and represent potential confounds for the analysis of intra-individual variability in performance among the six conditions. The errors in the DSST were low in frequency across all conditions and were extremely skewed despite logarithmic transformation of values, hence the decision to exclude error data from the analyses. Fortunately, latency values from the DSST were still suitable for analyses because simple motor speed in the DSST does not typically show sustained improvement with practice [64]. Instead, the executive function of strategizing and consciously exerting effort to learn the pairings is most likely to be at play. Thus, actual attention restoration was measured by latency values in the DSST instead of through both speed and accuracy (error rate). As such, some of the originally proposed hypotheses concerning accuracy levels could not be tested. These include hypotheses 1B and 2B. Furthermore, hypothesis 3 concerned 'overall attention restoration', including both perceived and actual (speed and accuracy), and so the testing of this hypothesis was also affected in such a way that overall restoration included only PRS and DSST latency data.

Consistent with previous research, the results indicate that there were significant differences in perceived attention restoration among the different environmental settings. Interestingly, however, the hypothesis that exposure to natural environments would result in a higher level of perceived attention restoration for natural environments, followed by mixed and, subsequently, built environments was not supported. Instead, the PRS scores were the highest for mixed environments, followed by natural and built environments, which means that hypothesis 1A is not supported.

The results confirm hypothesis 2A, according to which there would be higher levels of perceived attention restoration for images high in mystery than for images low in mystery, as there were higher PRS scores for the former. Contrary to expectations, the results indicate no significant differences in latency values in the DSST among natural, mixed, and built environments as well as between images high and low in mystery, which suggests that there was no actual restoration benefit from any one condition. Hypotheses 1C and 2C are therefore not supported by the current study data. The hypothesis concerning an interaction effect between the type of environmental stimuli and mystery was supported for perceived restoration but not for actual restoration.

4.2. Perceived Attention Restoration

The results of this study are somewhat consistent with previous evidence indicating the higher perceived restoration potential of natural environments as compared to built environments [4,16,26,28]. Interestingly, although it has been hypothesized that natural environments are the most restorative, contributing to attentional recovery and reducing mental fatigue [3], mixed environments (50% built, 50% natural) turned out to have the highest PRS scores. This suggests that for the current sample and for the range of environments used to represent the different categories, mixed environments were perceived to be the most restorative out of the three types of environments.

A possible explanation for higher PRS scores on mixed environments as compared to natural environments is that the evaluations of environmental scenes may be highly influenced by the associations the individual has with that environment. Given that we did not measure either familiarity with the environments or how much time participants may have spent in recreation activities in each type of environment, we acknowledge that this explanation is speculative. When Beute and de Kort [65] examined associations with the environment, they found that a large cluster of leisure activities was more frequently mentioned for highly natural scenes (e.g., picnic, swimming, hiking) and generally scored high on positive valence. Restorative environments such as urban parks, which are a combination of natural and built elements, were also highly related to leisure [66]. This highlights the importance of compatibility, which is the ability of the environment to support restorative activities [4]. As such, it is possible that mixed environments aligned better with the participants' goals and inclinations and, thereby, had higher compatibility compared to natural and built environments. Though urban elements in mixed environments can be very stimulating and require directed attention, there is evidence to suggest that exposure to nature incorporated into urban settings can contribute to attentional recovery and improve cognitive function and performance [28,67]. Kaplan and Berman [13] argued that compatibility between an individual and an environment is essential to restore directed attention. This ties well with previous research highlighting how preference and restorative potential of an environment are related [68,69].

In line with previous research, the results of this study confirm the notion that images high in mystery have a greater restorative potential than images low in mystery within nature or forest settings alone [29,31], as well as between natural and urban environments [25]. As predicted, images high in mystery had higher PRS scores, and therefore a greater perceived restorative potential than images low in mystery in mixed environments as well, which is consistent with the findings of Pazhouhanfar et al. [32].

Mystery, as a component of fascination, is a key element in facilitating attention restoration [31]. With their inherent promise of satisfying an individual's needs to understand and explore the environment, high-mystery settings have a higher potential to evoke involuntary attention [4]. Thus, images high in mystery possibly had higher PRS scores because they had sufficient strength to draw attention away from taxing cognitive content and were potential sources of directed attention fatigue stemming from the completion of each DSST. When stimuli are novel, complex, and unpredictable, the process of attracting attention is made easier and automatic, being relatively low on cognitive resources [70]. Reflective episodes stemming from encounters with high mystery settings containing soft fascination allow in turn for relaxation and an easing of negative moods engendered by the stressors of the repetition of the DSST.

However, our understanding of the restorative potential of environments has so far mainly relied on self-reported measures. Many concepts associated with the natural world are also typically associated with positive semantic associations (e.g., pristine, pure, clear) [71]. Though self-report measures of attention restoration like the PRS show that individuals experience mixed and natural environments as pleasant compared to built environments, this may be due to cultural beliefs ingrained from a young age instead of people's own personal experiences of nature.

4.3. Actual Attention Restoration

In order to address the potential shortcomings of self-reports, the current study employed the use of a cognitively fatiguing task, the DSST, aimed to more objectively verify the experience of whether images high in mystery indeed enhanced effortlessness as compared to images low in mystery. Similarly, this study also aimed to objectively verify the difference between exposure to natural, mixed, and built environments. However, in contrast to expectations, exposure to high mystery images did not significantly improve the reaction time taken to associate and match symbols and digits as compared to low mystery images. Similarly, reaction time taken for the association of symbols and digits did not differ among natural, mixed, and built environments. This is not entirely surprising given the learning effect of taking the cognitive test repeatedly [25].

While a contradiction to expectations, it still is consistent with some of the previous literature. Specifically, Bodin and Hartig [72] found no significant attentional benefits from running in a large nature reserve versus running on urban sidewalks and streets despite constructing four versions of the DSST (pen-and-paper version) and using a different test on each occasion. While the participants showed slight improvements in digit-capacity post-test, Emfield and Neider [37] found that performance was independent of the type of environment experienced, suggesting that performance was due to increased familiarity with the task after completing it for a second time. Similarly, there was also no significant effect of scene type (high and low mystery) on performance in the recognition memory task [31]. As such, it appears that there was no actual restoration regardless of the type of environment or the level of mystery involved.

It was hypothesized that there would be an interaction effect of mystery and environmental type on both perceived and actual restoration. However, the results only show a significant interaction effect on perceived restoration. As such, there seems to be a disconnect between perceived and actual attention restoration.

One reason for the differences between the levels of perceived and actual attention restoration may be affective forecasting. Affective forecasting suggests that people have difficulty predicting the intensity and duration of their feelings, and predictions are often distorted [73]. This overestimation of how much experiences affect feelings, a phenomenon termed as impact bias, can lead to frequent errors in decision-making [74]. This is particularly true when individuals make quick judgements about their environments, as in the present study, in which participants were only given 10 s to view each image. In such situations, participants often focus on one aspect of the environment (e.g., lighting, trees) and ignore other aspects of the image (e.g., depth). This results in focalism, which interferes with prediction accuracy regarding the effect of different environments on life satisfaction [73]. In the current study, some participants also reported being unable to differentiate between similar images. While previous research has shown how different scene types and mystery levels are able to predict actual attention restoration at 5 s and 10 s [31], 10 s may not be sufficient for all individuals to take in all elements of the image. Future research should consider increasing the time limit to allow participants to absorb and take in the entire image.

Another plausible reason for the disconnect between perceived and actual attention restoration may be the possibility that the images were not immersive enough to elicit attention restoration. Based on the definition of mystery, the current study design incorporated mystery elements in different environmental settings for attention restoration. However, not all images high in mystery may be equally suited to reach the stage of full restoration. Mystery is a component of fascination, so images high in mystery tend to include soft fascination. The ART posits that soft fascination settings enable involuntary attention, thereby freeing up directed attention capacity [3]. Unfortunately, the optimal combination of elements to induce soft fascination and thereby to provide a full restorative experience has not been clarified in the ART. This leaves us to speculate about the attributes that constitute a setting of soft fascination and, thereby, high in mystery (e.g., size, intensity, duration of the stimulus) rather than hard fascination which is low in mystery [75]. Moreover, it may be difficult to clearly identify at which point soft fascination turns into hard fascination and vice versa, but many stimuli could potentially be considered as engendering soft fascination when optimal softness in environments is not specified. Thus, these unknown attributes in mystery may have affected actual restoration since the restorative potential of the image perceived as high in mystery could vary in actual restorative potentials needed to reach 'full' restoration.

4.4. Limitations and Future Research

All research studies have limitations that affect the generalisability of the results due to the methods used. Since there were some operational issues in relation to the DSST for the current study, the measure of the participants' accuracy rate was removed from the analyses. A baseline performance measure was excluded from the study as a covariate since the participants were learning throughout the experiment due to the repeated presentation of a single DSST task instead of the originally planned presentation of 18 different but equivalent versions. Future research on actual restoration may consider implementing a control group tested at identical intervals instead of taking a single measure of baseline for better control over possible practice effects [63].

A recurrent concern in this type of study is the matter of attentional depletion prior to the experiment, which could potentially be the reason behind the lack of cognitive restoration for any condition in the current study. According to ART, restoration is achieved when attentional resources are depleted, but then replenished through exposure to inherently restorative natural environments [4]. However, in previous studies, measures that were considered cognitively fatiguing, such as the DSST, were used to induce fatigue, and in the current study the participants were all exposed to this fatiguing task prior to each new exposure to a restorative environment. However, it is difficult to predict and discern whether the tasks are taxing enough to induce directed attention fatigue. Therefore, the results of the study may not contribute to restorative environment research, which heavily focuses on attentional recovery from the depletion of resources. Future research may consider using a manipulation check aimed to confirm fatigue and attention depletion. Future research could also consider employing measures specifically aimed to induce fatigue as well.

A limitation of the current study relates to the fact that, despite the best efforts to create reasonably matched sets across all conditions, the images used in the experiment differed on a number of visual dimensions. First, the nature images depicted colourful scenes, whereas urban scenes had relatively dull colouring. This raises the question of whether the effect of environment type and mystery on attention restoration may be merely an artefact of these visual differences. Though the images may differ on several visual dimensions, images similar to those in our stimulus set are commonly used in such studies (and several were purposely drawn from previous research of a similar nature). Joye et al. [48] argued that qualities such as colour are what differentiates the restorative dimension of fascination between natural and urban scenes [48]. Hence, the use of these stimuli sets reflects an individual's actual experience of natural, mixed, and urban environments.

Additionally, the current study did not measure the participants' familiarity with the stimuli set. Since some of the images depict local settings, the novelty of certain images may have been a helpful predictor towards perceived restoration for some participants. Sometimes, individuals prefer familiar things over novel ones because we have extensive experience with them [76] and vice versa, where novel visual objects or places are preferred [77]. Individuals may have come to associate the places shown in the stimuli set with meanings over time and through cultural, familial, or even personal learning. As such, individuals may have already formed meaning-based associations with familiar places as they encounter them more frequently than the environments in novel images. However, experience does affect our preference in a variety of different yet contradictory ways for different individuals. Few participants in this study were nature experts and, regardless of familiarity, reported that they could not differentiate or point out the location of the images in the stimuli set. Moreover, according to the ART, restoration results from an interaction between directed attention and the intrinsic properties of an environment [3]. As such, restoration should occur regardless of whether it has been previously perceived [42]. Future research may wish to explore whether interactions with familiarity are more pronounced amongst nature lovers who may have stronger prior associations with the environments, which may in turn affect their perceived restorative potential of the environments.

Finally, the sample in this study consisted largely of undergraduate students who were all in the same age group, which makes it likely that they are unique from populations which are varying in factors such as age, lifestyle, and attention span. It is thus important to note that generalising these results to other populations and other age groups should be done with caution. However, given the imbalance of the studies conducted in Western countries, the current study goes some small way to address the imbalance by providing data obtained from a southeast Asian sample of participants in the highly urbanized setting of Singapore.

4.5. Implications

Despite these limitations, this study successfully relied on the theoretical foundations of the ART to further examine (1) the effect of natural, mixed, and natural environments and (2) the level of mystery on perceived and actual attention restoration. In doing so, this study provided the means to access the depth of the effect of mystery on the restoration potential of different types of environments, especially for mixed environments, which previous studies did not examine. Consequently, the findings of the study have both theoretical and practical implications.

First, some of the findings from this study support previous research in emphasizing the utility of integrating natural elements in an environment to increase perceived restoration, but the current findings also go beyond the nature and built dichotomy of the environments [78]. This is essential due to the trends of increasing population growth and the development of mega-cities, leading to concerns that people will have fewer opportunities for exposure to natural environments. If the postulated relationship between mixed environments and restoration is true, as evidenced here in our results showing this is so at least for perceived restoration, accessibility to well-maintained greenspace within urban environments could be imperative for future city planning. We acknowledge that our current findings have not clearly established this to be so but offer this as a potential direction for future research.

On the other hand, the current study revealed the role of mystery in increasing the perceived restorative potential of natural, mixed, and urban environments, in line with Kaplan and Kaplan [3]. This revealed that predictors of visual preference can also influence the evaluation of the person–environment interaction, which could potentially influence the perceptions of restorative environments. Given the evidence indicating the role of mystery in attention restoration, the continual exploration of its paradigms might allow us to venture beyond the relationship between perceived restorative properties of an environment and objective measures of cognitive restoration to the more specific realms of how the ART components operate [42].

However, it is still unclear whether perceived restoration is directly translational into actual restoration. Given the inconsistent findings in this study between perceived and actual restoration, it appears that there is more scope to find ways to see whether they are closely related or quite different. The findings from this study speak to the risk of mistaking perceived restoration as a reasonable proxy for actual cognitive effects. Thus, future studies must take caution to not assume actual restoration, especially when the mechanisms underlying nature's actual restorative effects are still not well understood.

5. Conclusions

To summarize, attention restoration research represents a particularly valuable approach to generating insight on the benefits towards an individual's health and well-being. This study examined the interaction between the types of environment and elements of mystery that influence the perceptions of different types of environment. Although the ART has been invaluable in drawing attention to the importance of natural environments in restoring human well-being and cognitive functioning, this study has revealed the potential for a restorative role of urban nature (mixed environments), which is particularly salient with respect to the current rate of urbanization and in the context of the current study location in Singapore. Additionally, this study has also highlighted the essential role of mystery in drawing effortless attention, which may prove to be valuable for the continued research on the restorative properties of the environment. However, given the inconsistent findings between perceived and actual restoration, greater conceptual and methodological clarity is still required to reliably conclude whether nature imagery and mystery could directly affect restoration in individuals. As such, the matter of restoration for effortful performance is not clearly resolved with respect to how the fascination dimension may be affected or influenced through brief exposures to images of nature, and as such warrants further research attention.

Author Contributions: Conceptualization, D.D. and T.Y.; methodology, D.D., T.Y. and P.K.H.C.; software, T.Y.; formal analysis, T.Y. and P.K.H.C.; investigation, T.Y.; resources, D.D.; data curation, D.D.; writing—original draft preparation, T.Y.; writing—review and editing, T.Y. and D.D.; visualization, T.Y. and D.D.; supervision, D.D. and P.K.H.C.; project administration, T.Y. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of James Cook University (protocol code H7286, 11 March 2018).

Informed Consent Statement: Informed consent was obtained from all the subjects involved in the study.

Data Availability Statement: The data presented in this study are openly available in Research Data JCU at (https://doi.org/10.25903/pt77-gr17).

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

References

1. 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. https://doi.org/10.1016/j.ufug.2007.07.001.
2. Menatti, L.; Casado da Rocha, A. Landscape and health: Connecting psychology, aesthetics, and philosophy through the concept of affordance. *Front. Psychol.* **2016**, *7*, 571. https://doi.org/10.3389/fpsyg.2016.00571.
3. Kaplan, R.; Kaplan, S. *The Experience of Nature: A Psychological Perspective*; Cambridge University Press: New York, NY, USA, 1989.
4. Kaplan, S. The restorative benefits of nature: Toward an integrative framework. *J. Environ. Psychol.* **1995**, *15*, 169–182.
5. Ulrich, R. Aesthetic and affective response to natural environment. In *Human Behaviour and Environment: Behaviour and the Natural Environment*; Altman, I., Wohlwill, J., Eds. Plenum Press: New York, NY, USA, 1983; pp. 85–125.
6. Hartig, T. Psychological restoration: One set of processes joining landscape and health. In *Open Space: People Space 2. Innovative Approaches to Research Excellence in Landscape and Health*; Aspinall, P., Bell, S., Thompson, C.W., Orme, A., Rees, A., Ribchester, L., Eds.; Pollock Halls: Edinburgh, UK, 19–21 September 2007.
7. 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. https://doi.org/10.1016/S0272-4944(05)80184-7.
8. Joye, Y. Architectural lessons from environmental psychology: The case of biophilic architecture. *Rev. Gen. Psychol.* **2007**, *11*, 305–328. https://doi.org/10.1037/1089-2680.11.4.305.
9. 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.
10. Ulrich, R.S.; Simons, R.F.; Miles, M.A. Effects of environmental simulations and television on blood donor stress. *J. Archit. Plan. Res.* **2003**, *20*, 38-47.

11. Laumann, K.; Gärling, T.; Stormark, K.M. Selective attention and heart rate responses to natural and urban environments. *J. Environ. Psychol.* **2003**, *23*, 125–134. https://doi.org/10.1016/S0272-4944(02)00110-X.
12. Kaplan, R. The nature of the view from home: Psychological benefits. *Environ. Behav.* **2001**, *33*, 507–542. https://doi.org/10.1177/00139160121973115.
13. Kaplan, S.; Berman, M.G. Directed attention as a common resource for executive functioning and self-regulation. *Perspect. Psychol. Sci.* **2010**, *5*, 43–57. https://doi.org/10.1177/1745691609356784.
14. Korpela, K.M.; Hartig, T.; Kaiser, F.G.; Fuhrer, U. Restorative experience and self-regulation in favorite places. *Environ. Behav.* **2001**, *33*, 572–589. https://doi.org/10.1177/00139160121973133.
15. Berto, R.; Baroni, M.R.; Zainaghi, A. An exploratory study of the effect of high and low fascination environments on attentional fatigue. *J. Environ. Psychol.* **2010**, *30*, 494–500. https://doi.org/10.1016/j.jenvp.2009.12.002.
16. Taylor, A.F.; Kuo, F.E. Children with attention deficits concentrate better after walk in the park. *J. Atten. Disord.* **2009**, *12*, 402–409. https://doi.org/10.1177/1087054708323000.
17. Kuo, F.E.; Sullivan, W.C. Environment and crime in the inner city: Does vegetation reduce crime? *Environ. Behav.* **2001**, *33*, 343–367. https://doi.org/10.1177/0013916501333002.
18. Jonides, J.; Lewis, R.L.; Nee, D.E.; Lustig, C.A.; Berman, M.G.; Sledge Moore, K. The mind and brain of short-term memory. *Annu. Rev. Psychol.* **2008**, *59*, 193. https://doi.org/10.1146/annurev.psych.59.103006.093615.
19. Diamond, A.; Barnett, W.S.; Thomas, J.; Munro, S. Preschool program improves cognitive control. *Science* **2007**, *318*, 1387–1388. https://doi.org/10.1126/science.11511.
20. Felsten, G. Where to take a study break on the college campus: An attention restoration theory perspective. *J. Environ. Psychol.* **2009**, *29*, 160–167. https://doi.org/10.1016/j.jenvp.2008.11.006.
21. Scopelliti, M.; Guiuliani, M.V. Choosing restorative environments across the lifespan: A matter of place experience. *J. Environ. Psychol.* **2004**, *24*, 423–437. https://doi.org/10.1016/j.jenvp.2004.11.002.
22. Hartig, T.; Kaiser, F.G.; Bowler, P.A. *Further Development of a Measure of Perceived Environmental Restorativeness*; Institution for Housing Research, Uppsala Universitet: Uppsala, Sweden, 1997.
23. Herzog, T.R.; Maguire, P.; Nebel, M.B. Assessing the restorative components of environments. *J. Environ. Psychol.* **2003**, *23*, 159–170. https://doi.org/10.1016/S0272-4944(02)00113-5.
24. Herzog, T.R.; Black, A.M.; Fountaine, K.A.; Knotts, D.J. Reflection and attentional recovery as distinctive benefits of restorative environments. *J. Environ. Psychol.* **1997**, *17*, 165–170. https://doi.org/10.1006/jevp.1997.0051.
25. Berto, R. Exposure to restorative environments helps restore attentional capacity. *J. Environ. Psychol.* **2005**, *25*, 249–259.
26. 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. https://doi.org/10.1016/j.jenvp.2007.11.004.
27. Mayer, F.S.; Frantz, C.M.; Bruehlman-Senecal, E.; Dolliver, K. Why is nature beneficial? The role of connectedness to nature. *Environ. Behav.* **2009**, *41*, 607–643. https://doi.org/10.1177/0013916508319745.
28. Berman, M.; Jonides, J.; Kaplan, S. The cognitive benefits of interacting with nature. *Physiol. Sci.* **2008**, *19*, 1207–1212.
29. Herzog, T.R.; Kropscott, L.S. Legibility, mystery, and visual access as predictors of preference and perceived danger in forest settings without pathways. *Environ. Behav.* **2004**, *36*, 659–677. https://doi.org/10.1177/0013916504264138.
30. Stamps, A.E., III. Mystery, complexity, legibility and coherence: A meta-analysis. *J. Environ. Psychol.* **2004**, *24*, 1–16. https://doi.org/10.1016/S0272-4944(03)00023-9.
31. Szolosi, A.M.; Watson, J.M.; Ruddell, E.J. The benefits of mystery in nature on attention: Assessing the impacts of presentation duration. *Front. Psychol.* **2014**, *5*, 1360. https://doi.org/10.3389/fpsyg.2014.01360.
32. Pazhouhanfar, M.; Kamal, M. 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. https://doi.org/10.1016/j.ufug.2013.08.005.
33. Marois, A.; Charbonneau, B.; Szolosi, A.M.; Watson, J.M. The differential impact of mystery in nature on attention: An occulometric study. *Front. Psychol.* **2021**, *12*, 759616. https://doi.org/10.3389/fpsyg.2021.759616.
34. Dosen, A.S.; Ostwald, M.J. Evidence for prospect-refuge theory: A meta-analysis of the findings of environmental preference research. *City Territ. Archit.* **2016**, *3*, 1–14. https://doi.org/10.1186/s40410-016-0033-1.
35. Herzog, T.R.; Kutzli, G. Preference and perceived danger in field/forest settings. *Environ. Behav.* **2002**, *34*, 819–835. https://doi.org/10.1177/001391602237250.
36. Twedt, E.; Rainey, R.M.; Proffitt, D.R. Designed natural spaces: Informal gardens are perceived to be more restorative than formal gardens. *Front. Psychol.* **2016**, *7*, 88. https://doi.org/10.3389/fpsyg.2016.00088.
37. Emfield, A.G.; Neider, M.B. Evaluating visual and auditory contributions to the cognitive restoration effect. *Front. Psychol.* **2014**, *5*, 548. https://doi.org/10.3389/fpsyg.2014.00548.
38. Taylor, A.F.; Kuo, F.E.; Sullivan, W.C. Views of nature and self-discipline: Evidence from inner city children. *J. Environ. Psychol.* **2002**, *22*, 49–63. https://doi.org/10.1006/jevp.2001.0241.
39. Lee, K.E.; Williams, K.J.; Sargent, L.D.; Williams, N.S.; Johnson, K.A. 40-second green roof views sustain attention: The role of micro-breaks in attention restoration. *J. Environ. Psychol.* **2015**, *42*, 182–189. https://doi.org/10.1016/j.jenvp.2015.04.003.
40. Johansson, M.; Hartig, T.; Staats, H. Psychological benefits of walking: Moderation by company and outdoor environment. *Appl. Psychol. Health Well-Being* **2011**, *3*, 261–280. https://doi.org/10.1111/j.1758-0854.2011.01051.x.
41. Berman, M.G.; Kross, E.; Krpan, K.M.; Askren, M.K.; Burson, A.; Deldin, P.J.; Jonides, J. Interacting with nature improves cognition and affect for individuals with depression. *J. Affect. Disord.* **2012**, *140*, 300–305.

42. Pearson, D.G.; Craig, T. The great outdoors? Exploring the mental health benefits of natural environments. *Front. Psychol.* **2014**, *5*, 1178. https://doi.org/10.3389/fpsyg.2014.01178.
43. Bona, S.; Silvanto, J. Accuracy and confidence of visual short-term memory do not go hand-in-hand: Behavioral and neural dissociations. *PLoS ONE* **2014**, *9*, e90808. https://doi.org/10.1371/journal.pone.0090808.
44. Herzog, T.R.; Bryce, A.G. Mystery and preference in within-forest settings. *Environ. Behav.* **2007**, *39*, 779–796. https://doi.org/10.1177/0013916506298796.
45. Ohly, H.; White, M.P.; Wheeler, B.W.; Bethel, A.; Ukoumunne, O.C.; Nikolaou, V.; Garside, R. Attention Restoration Theory: A systematic review of the attention restoration potential of exposure to natural environments. *J. Toxicol. Environ. Health Part B* **2016**, *19*, 305–343. https://doi.org/10.1080/10937404.2016.1196155.
46. Qualtrics. *Qualtrics*; Qualtrics: Provo, UT, USA, 2020.
47. Inquisit 4. [Computer Software]. 2015. Availabe online: https://www.millisecond.com (accessed on 5 November 2022).
48. Joye, Y.; Pals, R.; Steg, L.; Lewis-Evans, B. New methods for assessing the fascinating nature of nature experiences. *PLoS ONE* **2013**, *8*, e65332. https://doi.org/10.1371/journal.pone.0065332.
49. Wechsler, D. The psychometric tradition: Developing the Wechsler Adult Intelligence Scale. *Contemp. Educ. Psychol.* **1981**, *6*, 82–85. https://doi.org/10.1016/0361-476X(81)90035-7.
50. Rosano, C.; Newman, A.B.; Katz, R.; Hirsch, C.H.; Kuller, L.H. Association between lower digit symbol substitution test score and slower gait and greater risk of mortality and of developing incident disability in well-functioning older adults. *J. Am. Geriatr. Soc.* **2008**, *56*, 1618–1652. https://doi.org/10.1111/j.1532-5415.2008.01856.x.
51. O'Bryant, S.E.; Humphreys, J.D.; Bauer, L.; McCaffrey, R.J.; Hilsabeck, R.C. The influence of ethnicity on Symbol Digit Modalities Test performance: An analysis of a multi-ethnic college and hepatitis C patient sample. *Appl. Neuropsychol.* **2007**, *14*, 183–188. https://doi.org/10.1080/09084280701508986.
52. Sheridan, L.K.; Fitzgerald, H.E.; Adams, K.M.; Nigg, J.T.; Martel, M.M.; Puttler, L.I.; Wong, M.M.; Zucker, R.A. Normative Symbol Digit Modalities Test performance in a community-based sample. *Arch. Clin. Neuropsychol.* **2006**, *21*, 23–28. https://doi.org/10.1016/j.acn.2005.07.003.
53. Pfeffer, R.I.; Kurosaki, T.T.; Harrah Jr, C.H.; Chance, J.M.; Bates, D.; Detels, R.; Butzke, C. A survey diagnostic tool for senile dementia. *Am. J. Epidemiol.* **1981**, *114*, 515–527.
54. Amodio, P.; Wenin, H.; Del Piccolo, F.; Mapelli, D.; Montagnese, S.; Pellegrini, A.; Musto, C.; Gatta, A.; Umiltà, C. Variability of trail making test, symbol digit test and line trait test in normal people. A normative study taking into account age-dependent decline and sociobiological variables. *Aging Clin. Exp. Res.* **2002**, *14*, 117–131. https://doi.org/10.1007/BF03324425.
55. Tabachnick, B.G.; Fidell, L.S. *Using Multivariate Statistics*, 4th ed.; Allyn and Bacon: Sydney, Australia, 2001.
56. Baayen, R.H.; Milin, P. Analyzing reaction times. *Int. J. Psychol. Res.* **2010**, *3*, 12–28.
57. Ratcliff, R. Methods for dealing with reaction time outliers. *Psychol. Bull.* **1993**, *114*, 510. https://doi.org/10.1037/0033-2909.114.3.510.
58. Curran, P.J.; West, S.G.; Finch, J.F. The robustness of test statistics to nonnormality and specification error in confirmatory factor analysis. *Psychol. Methods* **1996**, *1*, 16.
59. George, D.; Mallery, P. *SPSS for Windows Step by Step. A Simple Study Guide and Reference (10. Baskı)*; Pearson Education: Boston, MA, USA, 2010.
60. Shibata, S.; Suzuki, N. Effects of the foliage plant on task performance and mood. *J. Environ. Psychol.* **2002**, *22*, 265–272. https://doi.org/10.1006/jevp.2002.0232.
61. Korpela, K.M.; De Bloom, J.; Kinnunen, U. From restorative environments to restoration in work. *Intell. Build. Int.* **2015**, *7*, 215–223. https://doi.org/10.1080/17508975.2014.959461.
62. Hinton-Bayre, A.; Geffen, G. Comparability, reliability, and practice effects on alternate forms of the Digit Symbol Substitution and Symbol Digit Modalities tests. *Psychol. Assess.* **2005**, *17*, 237. https://doi.org/10.1037/1040-3590.17.2.237.
63. Salinsky, M.C.; Storzbach, D.; Dodrill, C.B. Test–retest bias, reliability, and regression equations for neuropsychological measures repeated over a 12–16-week period. *J. Int. Neuropsychol. Soc.* **2001**, *7*, 597–605. https://doi.org/10.1017/S1355617701755075.
64. Jaeger, J.; Domingo, S.Z. The digit symbol substitution test (DSST): Psychometric properties and clinical utility in major depressive disorder. *Eur. Neuropsychopharmacol.* **2016**, *2*, S341. https://doi.org/10.1016/S0924-977X(16)31265-2.
65. Beaute, F.; de Kort, Y.A.W. Thinking of nature: Associations with natural versus urban environments and their relation to preference. *Landsc. Res.* **2018**, *44*, 374-392. https://doi.org/10.1080/01426397.2018.1457144.
66. Tyrväinen, L.; Ojala, A.; Korpela, K.M.; 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. https://doi.org/10.1016/j.jenvp.2013.12.005.
67. Hartig, T.; Mang, M.; Evans, G.W. Restorative effects of natural environment experiences. *Environ. Behav.* **1991**, *23*, 3–26. https://doi.org/10.1177/0013916591231001.
68. 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. https://doi.org/10.1016/S0272-4944(02)00112-3.
69. 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. https://doi.org/10.1016/S0272-4944(02)00111-1.
70. Silvia, P. Interest—The curious emotion. *Curr. Dir. Psychol. Sci.* **2008**, *17*, 57–60. https://doi.org/10.1111/j.1467-8721.2008.00548.x.

71. Rozin, P.; Fischler, C.; Shields-Argelès, C. European and American perspectives on the meaning of natural. *Appetite* **2012**, *59*, 448–455. https://doi.org/10.1016/j.appet.2012.06.001.
72. Bodin, M.; Hartig, T. Does the outdoor environment matter for psychological restoration gained through running? *Psychol. Sport Exerc.* **2003**, *4*, 141–153. https://doi.org/10.1016/S1469-0292(01)00038-3.
73. Wilson, T.D.; Gilbert, D.T. Affective forecasting. In *Advances in Experimental Social Psychology*; Zanna, M.P., Ed.; Elsevier Academic Press: Amsterdam, The Netherlands, 2003; Volume 35, pp. 345–411.
74. Wilson, T.D.; Wheatley, T.; Meyers, J.M.; Gilbert, D.T.; Axsom, D. Focalism: A source of durability bias in affective forecasting. *J. Personal. Soc. Psychol.* **2000**, *78*, 821.
75. Joye, Y.; Dewitte, S. Nature's broken path to restoration. A critical look at Attention Restoration Theory. *J. Environ. Psychol.* **2018**, *59*, 1–8. https://doi.org/10.1016/j.jenvp.2018.08.006.
76. Houston-Price, C.; Nakai, S. Distinguishing novelty and familiarity effects in infant preference procedures. *Infant Child Dev. Int. J. Res. Pract.* **2004**, *13*, 341–348. https://doi.org/10.1002/icd.364.
77. Park, J.; Shimojo, E.; Shimojo, S. Roles of familiarity and novelty in visual preference judgments are segregated across object categories. *Proc. Natl. Acad. Sci. USA* **2010**, *107*, 14552–14555. https://doi.org/10.1073/pnas.1004374107.
78. 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. https://doi.org/10.1016/j.landurbplan.2008.01.004.