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Interactions between Brief Virtual Exposure to Natural Environments and Psychological Well-Being

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INTERACTIONS BETWEEN BRIEF VIRTUAL EXPOSURE TO NATURAL ENVIRONMENTS AND PSYCHOLOGICAL WELL-BEING

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Abstract

Interactions with nature have been associated with improved emotional well-being and attentional functioning. Nature, however, is a broad category, encompassing several ecosystems that are perceptually distinctive (e.g., forests versus countryside fields), making it unclear whether all nature environments improve well-being to similar degrees. Therefore, the current experiment assessed how viewing a brief video of different natural environments, compared to viewing a video of an urban environment, influenced subjective ratings of restoration and psychological well-being. Participants were randomly assigned to one of three video conditions, which depicted a simulated walk through a forest, a countryside field, or an urban city. Immediately before and after the videos, participants rated their current emotional states. Participants additionally rated the perceived restorativeness of the video. Taken together, the results suggest that not all nature environments contain the same restorative potential. First, the current study supports previous research in which virtual exposure to nature improves psychological well-being; specifically, the simulated forest walk significantly increased happiness relative to the countryside and urban walks. Second, results from the “Fascination” subscale of the Perceived Restorativeness Scale suggested that the forest walk elicited the greatest fascination, followed by the urban walk, and then the countryside walk. The differentiation of the forest and countryside walks, despite comparable green space in both environments, suggests that an environment's restorativeness cannot be entirely predicted based on whether it is considered natural.

Keywords: Nature, Well-Being, Restoration, Green space

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Introduction

Interactions with nature have been associated with improved emotional well-being and attentional functioning. Immersion into the natural world offers a salve for our mental resources, increasing positive affect and decreasing negative affect (Felsten, 2009). The perceptual features of nature, such as the melodic contours of birdsong, are thought to be "softly fascinating," allowing individuals to address lingering or unresolved thoughts that would otherwise become mentally draining (Basu, 2018). In contrast, urban environments tend to draw on mental and attentional resources, leaving little opportunity for these resources to replenish themselves. Without periods of reflection, cognitive resources become fatigued, contributing to an overall decrease of psychological well-being (Kaplan, 1995; Basu, 2018, McMahan et al., 2015; Wood, 2018). One promising solution for alleviating these negative effects of urban environments is to present the sights and sounds of nature virtually - for example, through a personal computer. However, studies assessing the benefits of virtual presentations of nature are often limited to a single modality (e.g., pictures) and do not factor in the ecological variability of natural environments. The current experiment was therefore designed to assess whether viewing a brief video of different natural environments, compared to an urban environment, is sufficient to temporarily increase psychological well-being.

There is a considerable body of research assessing the interactions between nature and psychological functioning. The evidence suggests contact with natural environments is an essential factor in promoting optimal human feelings (McMahan et al., 2015), such as happiness, and points to a buffering effect between exposure to nature and the adverse effects caused by mental fatigue. For example, Dadvand et al. (2015) assessed the associations between outdoor exposure to green space and cognitive development in primary schoolchildren. Children with a more greenery (e.g., planted trees, gardens) surrounding their home and school showed improved cognitive and attentional abilities such as better working memory and reduced inattentiveness over a 12-month period. In contrast, children whose homes and schools had less surrounding green space did not show these effects. Similarly, Benfield et al. (2015) explored how views of nature influenced performance in a first-year collegiate writing course. Using a quasi-experimental design, students were assigned to one of several sections of an introductory writing course, with some of the classrooms containing views of nature and other classrooms containing a view of a concrete retaining wall. Students in classrooms with natural views had significantly higher final grades and overall positive perceptions of their classroom experience relative to students with a view of the concrete wall.

Nature exposure research can highlight the existing connection between psychological and physical well-being. For example, in hospitals, patients with green space views, such as a field or a garden, reported lower pain perception after surgery and often recovered better and faster than those with no such view (Ulrich, 1991). Surprisingly, a leukemia patient, isolated due to a weakened immune system, preferred a room with a view of trees despite overlooking a cemetery in which the patient knew they were to be buried eventually (Baird & Bell, 1995). Moore (1981) observed that prison inmates with a view of green spaces, such as an open field, showed decreased irritability and aggression and thus were less likely to take part in physical fights, subsequently making fewer trips to the infirmary to treat physical injuries. In another study using satellite data of green space in Toronto, Kardan et al. (2015) reported an association between the number of planted trees in a neighbourhood and psychological and physical well-being measures, even after controlling for factors like socioeconomic status.

However, there are two primary concerns with these prior investigations of nature and well-being. First, these studies often operationalize nature in terms of "green space," defined as the ratio of greenery in a given area. Although green space is an effective way to quantify nature, there is a risk of treating diverse ecosystems as equivalent. For example, one cubic meter in a grassy field and one cubic meter in the Amazonian rainforest are both considered "green space," yet these environments are distinctive in both perceptual features and biodiversity. Consequently, research assessing the interactions between nature and well-being findings oversimplify the nuanced differences between natural environments. In parallel, meaningful constructs that may explain these positive psychological effects are ignored by using green space as a characterization of nature.

Second, these large-scale studies are largely correlational and, despite the attempts to control for potentially confounding variables, cannot be used to make any causal claims. Although smaller-scale experimental investigations of nature-related benefits exist (e.g., Berman et al., 2008; Van Hedger et al., 2019), there is considerable variability in terms of how nature is presented to participants. One of the most salient issues in experimental investigations of nature-related benefits is whether the exposure is *real* (e.g., taking a walk through a nature preserve) or *virtual* (e.g., viewing pictures of a nature preserve).

Real exposure is characterized in terms of physical access or proximity to nature, such as window views of nature or park walks. Real exposure to nature, moreover, can be direct or indirect. For example, full immersion into the natural world via a park walk would constitute direct real exposure, whereas observing nature through a window is an example of indirect real exposure. The idea of virtual exposure is beginning to be explored in response to advancing technology and limited access to green space for those immersed in urban environments.

Typically, virtual exposure is simulated in a laboratory setting by presenting computer displayed images of natural environments, sounds of nature played through headsets or paintings of natural landscapes. Real exposure to nature is associated with the most significant increases in positive affect, whereas virtual exposure is associated only with moderate improvement (McMahan et al., 2015). More importantly, studies have demonstrated that virtual exposure to nature is associated with decreases in negative affect comparable to real exposure. In contrast, no exposure, which is often equated with urban settings, was associated with no increase in positive affect (McMahan et al., 2015).

Some studies directly compared real and virtual exposure to nature. A study by Zieseniz et al. (2008) assessed whether the different media differed in psychologically restorative outcomes. Using a Necker cube pattern control test, Zieseniz et al. (2008) assigned participants to either walk through a park or watch a simulated computer recording of the park walk. Stress recovery was measured using salivary amylase, which showed no difference between the real or virtual exposure condition. Therefore, the authors concluded that both real and virtual exposure to nature have comparable contributions to mental restoration.

Moreover, McMahan et al. (2015) explored effects of real (15-minute nature walk) or virtual (series of nature landscape photographs) exposure on mental well-being. Their findings reveal that real exposure is more beneficial for mental well-being than virtual exposure, which showed only a moderate benefit relative to the real exposure condition. In a second study, McMahan et al. (2015) compared nature photographs of tamed (urban green space) vs wild (high vegetation preserves) landscapes. Virtual exposure to wild natural landscapes showed a more significant restorative effect than tamed virtual exposure, and surprisingly, the real exposure (nature walk) from Study 1 and wild virtual exposure had the same effect on well-being. This suggests virtual exposure that mimics a high level of natural resources such as water and vegetation may act as a replacement for real exposure, at least in therms of psychological restoration. In a similar and complementary study by Felston (2009), real exposure to urban green space landscapes showed no benefit in mental restoration. Taken together, it might be concluded that exposure to nature and its beneficial effect on psychological well-being requires a sufficient level of natural resources, such as water and vegetation, in order to yield positive effects.

The level of natural resources in a given area is an essential factor for life to thrive and thus the number of species in the area will be a function of the available natural resource. Quantifying nature using the degree of biodiversity in a given area may therefore act as an important complement to typical “green space” characterization of nature. When nature is characterized in terms of observable biodiversity, different kinds of nature experiences may be related to well-being in different ways. Measuring nature in terms of biodiversity would allow for a greater specificity for the study of various natural environments and their positive psychological effects. In practice, the number of trees should be studied in relation to well-being as well as the types (species) of trees. In support of this notion, Wood et al. (2018) assessed 12 parks with varying levels of biodiversity (e.g., number of plant and bird species, habitat diversity), yet all the parks were comparable in terms of their green space (i.e. percentage of tree cover). Participants walking through each of the 12 parks were asked to take part in a survey assessing the restorative benefits from their nature walk. The findings suggest that the restorative effects of nature exposure could be predicted by the level of biodiversity in the park, even after controlling for age, gender, and ethnic background. As a result, the literature quantifying nature using green space appears to be insufficient.

Several hypotheses have been put forth to explain why exposure to nature is positively associated with mental well-being; however, it remains unexplored how biodiversity may relate to changes in well-being Perhaps the most influential, the Biophilia Hypothesis (Wilson, 1984), offers a foundational explanation for the relationship between nature and our well-being. Rooted in an evolutionary perspective, the hypothesis suggests that humans have a strong affiliation with living things because throughout most of human history people existed outdoors as members of hunter-gatherer societies. The number of species in a given area, known as biodiversity, might signal the presence of significant survival resources, creating a positive association between biodiversity and thriving life (Wood, 2018). Thus, humans have a strong need to connect with living things, only satisfied by immersion in the natural world.

Similar to the Biophilia Hypothesis, Stress Reduction Theory (SRT; Ulrich, 1991) posits that exposure to nature will reduce stress and promote stress recovery. Ulrich (1991) suggests exposure to natural resources, such as water and vegetation, that contributed to human ancestors' survival shaped an unconscious autonomic response involving increased positive affect and decreased negative affect and physiological arousal. To this extent, immersion into the natural world continues to trigger this response today; however, the type of natural environment that would elicit this response is not clearly defined. Intuitively, the assumption can be made so that reductions in stress works as a function of the level of vegetation in an environment, such that greater levels of vegetation would elicit a more significant stress reduction. However, this has not been explored; therefore, exploring various levels of biodiversity as a measure for vegetation would help understand the specificity and extent to which nature can trigger this response.

An equally influential theory, Attention Restoration Theory (ART) (Kaplan, 1995), suggests time spent in nature allows for cognitive resources to become restored, resulting in temporarily improved attentional abilities when re-entering urban life. For cognitive resources to become restored, Kaplan outlined a set of conditions that need to be met: *being away, extent, fascination,* and *compatibility*. First, *being away* allows for a distance between oneself and mentally fatiguing situations. Notably, the theory points out this need not be a physical distance; for example, virtual exposure to the natural world can elicit mental distance between an individual and their stressors. Second, *extent* is the degree (extent) to which an environment is perceived as being away from sources of mental fatigue. Third, *compatibility* is described as the degree to which an individual's environment fits with their goals and provides the necessary information to meet those goals. Lastly, *fascination* refers to interesting or captivating situations that effortlessly capture attention.

Although fascinating situations captivate attention effortlessly, not all captivating situations are inherently restorative. A situation which forcefully grabs one's attention, such as walking through Times Square in New York City, is categorized as *hard fascination*. In this case, the setting fully encompasses the mind, making a mental activity such as reflection hard to accomplish. In contrast, situations of *soft fascination* also involuntarily capture attention but not in an all-encompassing way, as would a fire alarm; an example of *soft fascination* is the sounds of birds. In a situation of *soft fascination,* the mind is not entirely occupied and thus has an opportunity for reflection. However, situations can be classified as *soft fascination* without necessarily being restorative as the situations leave little room for reflection.

Nature is often prescribed by ART to optimally restore cognitive and mental facilities as the natural world sufficiently meets these four conditions; however, it is not clear whether all nature environments are optimal for restoring attention, and a significant portion of research exploring ART quantifies nature using green space. This would then equate environments that differ in their biodiversity, such as a grass field in a park and a rich pine forest are assumed to elicit similar feelings of, for example, being away. Consequently, in attempts to ensure the internal validity of nature and well-being studies, real and virtual exposure to sensory stimuli across multiple sensory modalities are studied in isolation. For example, McHahon and Estes (2015) and Wood et al. (2018) included only visual stimuli as their manipulation, whereas a study by Van Hedger et al. (2019) used only auditory stimuli. This poses a problem for ecological validity as real exposure to nature is a multimodal experience.

In this experiment, I am focused on exploring multi-modal, virtual exposure to nature and its relationship to perceived restoration and well-being, integrating visual and auditory sensory stimuli in the form of a simulated walk. The present experiment will address the question of how different natural environments, as compared to an urban environment, might be differentially associated with an attenuation of depleted mental resources and is the first experimental approach to determine the causal effects of biodiversity on psychological well-being. This is important as the results have the potential to offer insight into the causal conclusions for the interaction between nature and well-being, by specifically assessing how varying degrees of biodiversity might provide a more nuanced look at the effect of nature on well-being.

To better understand the restorative effects of varying biodiversity levels, the current experiment will include three conditions: a high biodiversity nature setting; a low biodiversity nature setting; and an urban setting. These conditions are represented by a forest nature walk, a countryside nature walk, and an urban walk, respectively. After the participant experiences a first-person simulated walk, the restorative effects of the intervention will be assessed using a battery of questionnaires: (1) the Positive Affect Negative Affect Schedule (PANAS; Watson et al., 1988); (2) the State-Trait Anxiety Inventory for Adults (Spielberger, 1983); (3) a pre-post

Visual Analogue Scale (VAS), (4) A Mental Bandwidth Scale (MBS) to evaluate the level of soft-fascination in each condition (Basu et al., 2019); (5) the Nature Relatedness Scale (NRS; Nisbet et al., 2009), to measure participants' inter-and intra-personal connection to nature; (6) the Short-Form UCLA Loneliness Scale (Hughes et al., 2014); (7) the Perceived Restorativeness Scale (PRS; Norling et al., 2008); and (8) the Ten-Item Personality Inventory (Gosling et al., 2003) to assess the Big Five personality traits.

I hypothesize that there will be a relationship between the *state* (in-the-moment) measures of psychological well-being and virtual walk condition, with biodiverse nature eliciting the greatest positive changes to well-being. Specifically, I predict that the forest nature walk will elicit the most significant improvements in psychological well-being, followed by the countryside field walk, followed by the urban walk. Second, I hypothesize the perceived restorativeness of each nature walk will differ for each condition such that the forest walk will elicit the greatest perceived restorativeness, followed by the countryside field walk followed by the urban walk. In order to answer this question, the PRS and MBS will provide insight into participants thoughts on restorative feelings for each walk. Lastly, I hypothesize that questionnaires assessing trait measures (such as the Ten-Item Personality Inventory) will not differ across the conditions but rather provide additional assurance that all participants across conditions are well-matched before the intervention.

Method

Participants

150 participants were recruited using Amazon Mechanical Turk, an online recruitment platform. CloudResearch (Litman et al., 2017) was also used to further constrain participant recruitment from Mechanical Turk. Specifically, only participants who had passed attention and

data quality checks implemented by CloudResearch were eligible to participate. In order to enrol in the study, participants were required to be fluent in English (to read and answer the survey questions) and had to have a high-speed internet connection (for loading the virtual walk video). Headphone use was encouraged but was not required. Participants were provided $5 compensation for their participation in the study.

Materials

The virtual walk videos (Treadmill TV, 2016; Nomadic Ambience, 2019; Tall Sky Walks, 2019) were found on YouTube using the following keywords: *first-person forest walk*, *first-person field walk*, and *first-person urban walk*. The videos were originally 60 minutes long; however, only the first 15 minutes of each video were shown to participants. The videos were downloaded, trimmed, and presented using jsPsych, an open-source JavaScript library for conducting psychological research in a web browser (de Leeuw, 2015). The rest of the study was administered using Qualtrics.

Three scales were “state” measures used to assess participant's emotions and anxiety in the present moment; two scales were administered specially asking about the virtual walk to help the researchers assess how restorative the participants perceived the experience. Lastly, four scales targeted participants' “trait” emotions and anxiety in general as trait measures were not expected to change as a brief intervention function.

State Measures

Participants filled out a visual analogue scale (VAS) immediately before and after watching the virtual walk video. The VAS asked participants to rate how they were feeling at that moment on five terms (happy, sad, calm, anxious, and lonely), on a 100-point slider scale (with higher ratings indicating a greater extent of feeling that term).

The state component of the State-Trait Anxiety Inventory for Adults (STAI-S; Spielberger, 1983), assessed participants' anxiety at the moment of scale administration. The STAI-S consisted of 20 items (e.g. “I feel calm”, “I feel nervous”). Participants were asked to rate each item on a four-point Likert scale from 1 (*not at all*) to 4 (*very much so*).

The third state-measure was the Positive Affect Negative Affect Schedule (PANAS; Watson et al., 1988). The PANAS contains 10 positive affect (e.g., “proud”) and 10 negative affect (e.g., “guilt”) words that participants are asked to rate, based on their current state, on a five-point Likert scale from 1 (*not at all*) to 5 (*extremely*).

Restorativeness Scales

The Perceived Restorativeness Scale (PRS; Norling et al., 2008) is a nine-item scale meant to assess the therapeutic potential of environments, explicitly focused on activities - in this case, the virtual walk. The scale consists of three subcomponents. First, “being away” focuses on capturing the extent to which participants feel removed from the taxing demands of day-to-day life (e.g., "this activity is an escape for me"). Second, “fascination” addresses the little attentional effort required for the task (e.g., "this activity has many fascinating qualities"). Third, “extent,” which is similar to fascination, aims at capturing the level of effort required to engage in the activity (e.g., "this activity sustains my interest"). Each item was rated by participants on a five-point item Likert scale from 1 (*not at all*) to 5 (*extremely*).

The Mental Bandwidth Scale (MBS; Basu et al., 2019) is a seven-item scale designed to assess mental activities such as reflection and self-awareness during activities - in this case, the virtual walk. Similar to the PRS, the MBS contains three subcomponents. First, “self-awareness” addresses participants’ awareness of their surroundings and internal thoughts (e.g., “during this video, I was able to take note of thought and feelings”). Second, “daydreaming” is meant to assess mind-wandering (e.g., "during this video, to what degree are you lost in thought?"). Third, “planning” assesses the extent to which, during the virtual walk, participants were lost in thought for events in the past or future (e.g., “during this video, to what degree were you making plans for the future?”). Participants rated each item on a five-point Likert scale from 1 (*not at all*) to 5 (*extremely*).

Trait Measures

The Ten Item Personality Inventory (TIPI; Gosling et al., 2003) was used to assess the Big Five personality traits: (1) openness to experience, (2) conscientiousness, (3) extraversion, (4) agreeableness, and (5) emotional stability. Each item consists of a word pair (e.g., “extroverted, enthusiastic”), and participants rated the extent to which the words generally described them using a seven-point Likert scale, from 1 (*disagree strongly*) to 7 (*agree strongly*).

The trait component of the State-Trait Anxiety Inventory for adults (STAI-T; Spielberger, 1983) was administered to assess participants’ trait levels of anxiety (i.e., independent of the virtual walk manipulation). Participants were instructed to rate 20 statements (e.g., “I lack confidence”) based on how they feel generally. The state and trait portions of the state-trait anxiety inventory for adults were administered as two separate questionnaires. The response scale was identical to the STAI-S

The Short-Form UCLA Loneliness Scale (ULS-8; Hughes et al., 2014) assessed participants' general feelings of loneliness independent of the virtual walk. Participants rated eight items (e.g., "I feel left out") on a 5-point Likert scale, ranging from 1 (*not at all*) to 5 (*extremely*).

Lastly, the Nature Relatedness Scale (NRS; Nisbet et al., 2009) assesses an individual's general level of connectedness to the natural world. Participants were asked to rate 21 items (e.g., "my relationship to nature is an important part of who I am") on a 5-point Likert scale, ranging from 1 (*not at all*) to 5 (*extremely*). Nisbet et al. (2009) reported that the Cronbach's alpha was .87 and the test-rest reliability was .85 for the NRS.

Procedure

Participants first read the letter of information, which specified the details of the study. After reading the letter of information, the participants were asked to either consent to participate or not. If not, they were directed to the end of the study and thanked for their interest in the study.

Those who consented were randomly assigned to one of three conditions. The three conditions can be conceptualized along one factor - virtual walk type (forest, countryside, urban). Immediately after providing consent, participants clicked to the next page where they were instructed to find a quiet place in which they felt comfortable to turn on computer sound or to use headphones; participants were also reminded to ensure their volume was at an appropriate level before continuing. Next, participants completed the VAS. Then, participants completed the virtual walk. At the end of the virtual walk, participants were given a unique code to input into the survey to confirm that they had watched the entire video. Immediately after entering their unique completion code, participants completed the same VAS that had been administered prior to the virtual walk.

Next, participants completed the state measures (PANAS and STAI-S) and the restorativeness scales (PRS and MBS) in a randomized order. Following the state measures and restorativeness scales, participants completed the trait-measures (NRS, TIPI, STAI-T, and ULS-8) in a randomized order. Relative to the trait measures, the state measures and restorativeness scales were always administered first as they are more likely to be influenced by the time since the intervention, as they ask about participants' feelings in the moment as well as about specific aspects of the virtual walk.

Following the trait measures, participants completed a short demographic questionnaire to record age and gender identity. Following the demographic questions, participants were asked to briefly describe what they saw and heard in the video. This was intended as an attention check to verify that participants has actually watched the video with their computer sound turned on.

Participants were then thanked for their participation, awarded compensation, and given a debriefing form that explained the study's purpose and hypotheses. Contacts of myself and thesis advisor were included in all forms; in any case, the participants had additional questions or concerns. **Figure 1** summarizes the experimental design.

Data analysis and Inclusion Criteria

In a preliminary analysis, participants were removed from the data analysis if they completed the survey in fewer than 20 minutes, were missing more than one answer on any survey, or did not pass the attention check. To pass the attention check, participants had to describe both visual and auditory elements of the simulated walk. Almost, all participants correctly described the visual details from their assigned video; however, data from 50 participants were removed as they did not report anything about the video's sounds. Although it might seem overly conservative to remove data from these 50 participants, the sounds were an important component of creating an immersive virtual environment and thus integral to the study's hypotheses. However, it should be noted that including the participants who only described one of the two modalities did not influence the main interpretation of the results.

A one-way analysis of variance (ANOVA) was used to assess differences in the scales as a function of walk type (forest, countryside, urban), with walk type being a between-participant factor. As the VAS was the only scale administered both before and after the intervention, the analysis of the VAS used a 2x3 ANOVA, with time (pre-intervention, post-intervention) as a within-participant factor and walk type (forest, countryside, urban) as a between-participant factor.

Results

Visual Analogue Scale

Table 1 summarizes results from all measures. VAS scores for happiness, $F(1, 92) = 26.1$, $p < 0.001$, sadness, $F(1, 92) = 7.0$, $p < 0.010$, calmness, $F(1, 92) = 10.1$, $p = 0.002$, anxiety, $F(1, 92) = 15.6$, $p < 0.001$, and loneliness, $F(1, 92) = 5.5$, $p = 0.021$ all showed significant main effects of time. Specifically, after the virtual walk, participants provided significantly higher happiness and calmness ratings, as well as significantly lower sadness, anxiety, and loneliness ratings. Additionally, the VAS happiness measure showed a significant interaction between time and virtual walk condition. Tukey's post-hoc tests indicated that participants in the forest nature walk condition showed a significantly greater increase in happiness compared to the other two conditions. The VAS scores for sadness, calmness, anxiety, and loneliness, did not interact with virtual walk condition.

Positive Affect Negative Affect Schedule

Positive affect was not significantly different across the virtual walk conditions. Negative affect was not significantly different across the virtual walk conditions.

Mental Bandwidth Scale

The “self-awareness” subscale of the MBS did not differ significantly across the virtual walk conditions. The “daydreaming” subscale of the MBS was not significantly different across the virtual walk conditions. The “planning” subscale of the MBS was not significantly different across the virtual walk conditions.

Perceived Restorativeness Scale

The means from the “Fascination” Subscale of the Perceived Restorativeness Scale had a significant main effect of the walk type. Tukey’s post-hoc tests indicated that those in the forest nature walk condition scored significantly higher than those in the countryside nature walk, $t = 2.64$, $p = .026$, but not those in the urban walk condition, $t = 0.93$, $p = 0.63$. Additionally, the countryside and urban walk did not significantly differ, $t = 1.55$, $p = 0.271$. The “away” subscale scores of the PRS was not significantly different across the virtual walk conditions. The “extent” subscale of the PRS was not significantly different across the virtual walk conditions. There was not a significant difference in fascination between the forest nature walk and the urban nature walk as well as between the countryside nature walk and the urban nature walk.

UCLA Loneliness 8-Item Scale

The UCLA loneliness 8-item scale was not significantly different across the virtual walk conditions.

Nature Relatedness Scale

The Nature Relatedness Scale was not significantly different across the virtual walk conditions.

State-Trait Anxiety Inventory

The State Anxiety Inventory for Adults showed no significant difference across the virtual walk conditions. The Trait Anxiety Inventory for Adults showed no significant difference across the virtual walk conditions.

Ten-Item Personality Inventory

The Ten-Item Personality Inventory showed no difference in openness, consciousness, extraversion, agreeableness, and neuroticism, across the virtual walk conditions.

Discussion

The current study was designed to assess whether a brief, simulated walk in different environments is sufficient to increase psychological well-being. Exposure to nature is often reported to promote feelings of restoration, both psychologically and physically (McMahan et al., 2015; Kaplan, 1995; Ulrich, 1991); the present study was designed to examine whether these feelings of restoration, along with changes in positive and negative affect, would differ as a function of exposure to biodiversity. Various levels of biodiversity were represented by a pine forest walk, characterized as having high amounts of observable biodiversity, a countryside walk, characterized as having relatively little observable biodiversity, and an urban walk, characterized as having relatively little observable biodiversity. The results suggest three main conclusions that, taken together, support the notion that *not all environments contain the same restorative potential and that not all green space is created equal.*

First, the current experiment is consistent with previous research in which virtual exposure to nature improves psychological well-being; specifically, a simulated nature walk in a pine forest increased happiness relative to the countryside and urban walks. Notably, the pine forest nature walk and the countryside nature walk were well matched on amount of green space. Thus the results suggest there might be a specific element in a highly biodiverse environment that will increase psychological well-being as predicted by the Biophilia Hypothesis and SRT; specifically environments high in perceptual biodiversity should signal the existence of resources and thriving life, and thus lead to the increase of happiness.

Another possibility is that environments varying in biodiversity also vary in perceptual features, and this is the primary factor for understanding nature-related benefits. Berman et al. (2014) investigated specific visual features of natural environments that, from perceptual point of view, can be classified natural. The results suggest low-level visual features — features that are processed relatively early in the visual pathway (e.g., primary visual cortex) — such as curved lines and colour saturation, were found to be related to the perception of naturalness. For example, a picture with more curved lines should be associated with a natural environment, whereas straight lines should be more associated with an urban setting. Furthermore, non-straight edges and less colour saturation were found to be vital in perceptually classifying a scene as natural.

I used a countryside nature walk to represent a low-biodiverse environment, which included many straight lines from surrounding fields and fences and may partly explain why there were such differences in the results of the pine forest versus countryside nature walk. Berman et al. (2014) noted these visual features might be key in eliciting the beneficial effects from interactions with natural environments. However, further research would have to be carried out systematically test this hypothesis. The pine forest environment in the present study, albeit virtually presented, contained the visual features described by Berman et al. (2014) that may be associated with soft fascination and reflection. Since virtual exposure can sufficiently meet low-level perceptual features, exposure to virtual environments potentially elicits comparable beneficial effects as real exposure.

Second, results from the “fascination” subscale of the Perceived Restorativeness Scale suggested that the pine forest walk elicited the greatest fascination. Tukey’s Post-Hoc test revealed the forest nature walk significantly differed from the countryside walk; however, there was no difference between the forest and urban walk, nor the urban and countryside walk. This is interesting for two reasons. First, this result suggests a pine forest and countryside, again comparable in terms of green space, significantly differ in their ability to capture attention softly and thus restore mental faculties, supporting the notion that not all green space is created equal. Second, the urban walk did not significantly differ from the countryside and forest condition. I remain cautious in drawing implications from non-significant results; however, the pattern of data suggests that urban environments (1) can have sufficient stimuli that offer restorative benefits and (2) can elicit soft fascination more than a low biodiverse green space environment. This is consistent with Berman et al.'s (2014) findings as there is nothing inherent about curved lines and nature. Thus, the low-level visual features such as curved lines can also be found in non-natural environments, such as the current study's urban walk condition.

Furthermore, elements of soft fascination are not limited to natural environments. The empirical study by Kaplan et al. (1993) showcases an example wherein an urban environment elicited restoration that met the conditions of Attention Restoration Theory (Kaplan, 1995). Kaplan et al. (1993) found museums, classified as an urban setting, to be a restorative environment. Museums are large and encourage exploration, thus meeting conditions of extent; the exhibits facilitate feelings of being away as displays often do not depict everyday 21st-century life; fascination requirements are met as the exhibits vary greatly; and, museums often fulfil one's purpose: to explore and learn about something new, thus meeting the requirements of compatibility. Lastly, the forest and countryside nature walk are well matched in terms of area of green space. This again suggests that not all natural environments will promote improved psychological well-being in the same way. More important, this suggests at least to types of nature (i.e. pine forest and countryside) do not have similar effects on restorative behaviour.

Third, caution should be exercised in concluding that all possible environments may be categorized as either fitting within a nature or an urban framework, as this kind of categorization can minimize important within-category differences. There seems to be an implicit assumption in the literature that all nature should have similar behavioural effects. For example, using simple area of green space as a measure of nature ignores the various degrees of biodiversity and the vastly different perceptual experience of one ecosystem to the next. To highlight this point, the dissociable findings between the pine forest and countryside walk would have otherwise been lost if both walks had been operationalized in terms of green space and treated as equivalent.

Contrasting the perceptual differences between natural environments such as a pine forest and a sand dune may be obvious; but less obvious are the perceptual differences between, for example, two different pine forests, which may offer quite different experiences and, therefore, elicit different restorative behaviours. In future, nature should be treated with more granularity than categorizing the world into natural and urban. Both natural and urban environments are highly variable in terms of their perceptual features. To boil down the world into two categories (nature-urban) consequently minimizes the within-category variability of these environments, contributing to the implicit assumptions that all nature (or all urban) is equal. Thus, it does not explain how different natural environments, equated in green space, affect psychological well-being in different ways. The results of the current study, consistent with the findings from Wood et al. (2018), point to the need to recharacterize nature beyond a single category.

Furthermore, future work exploring nature's effects on well-being should characterize nature as existing along a continuum. In this way, researchers could begin to include natural environments such as beaches or sand dunes, which might otherwise be ignored as natural environments. It can be hypothesized that even though a beach does not have green space, it might well be restorative, relaxing, and softly fascinating. Thus, a characterization of nature that includes non-green space environments and considerations for nature's multifaceted precepts should be considered if the goal is to understand the restorative effects of nature fully.

Under the premise that not all nature is created equal, the current study's empirical findings provide evidence for the theoretical frameworks mentioned at the beginning of this thesis. First, the Biophilia Hypothesis (Wilson, 1984) states that the number of species in a given area — the level of biodiversity — can signal the presence significant survival resources and thus evoke a positive association between biodiversity and thriving life. The results of the current experiment showcase this positive association, as participants in the high biodiverse condition (the pine forest nature walk) reported feeling happier after the brief exposure than the other two conditions (low and no biodiversity). Along these lines, Stress Reduction Theory (SRT; Ulrich, 1991) more specifically states that perceptual cues of natural resources such as vegetation and water will elicit this positive association between availability of resources and thriving life. In the pine forest nature walk condition, salient cues of a river and multiple different species of trees, bushes, and wildlife indicate natural resources, which may have contributed to overall increased feelings of happiness in the pine forest nature walk condition. Happiness reports for the countryside nature walk and the urban walk were not significantly different. This may be because the countryside nature walk's visual cues were only of grass rather than vegetation. Similarly, the urban conditions had no visual cues of vegetation, apart from occasional views of leaves on trees.

Perhaps the most interesting finding of the study came from the “fascination” component of the Perceived Restorativeness Scale, in which the countryside nature walk was significantly lower than the pine forest nature walk. These results are consistent with Attention Restoration Theory (Kaplan, 1995) as a pine forest nature walk softly captures attention and is consistent with prior associations between nature and ART. In contrast, the countryside walk was not able to capture participants attention which may be explained by the low perceptual biodiversity in this particular simulated walk.

This result suggests an environment's restorativeness cannot be entirely predicted based on whether it is considered natural and urban and that not all nature can softly capture attention in the way ART describes all nature can. To correctly identify an environment as restorative, the focus should shift to meeting ART’s criteria rather than assuming nature will offer an ideal restorative experience. In other words, the criterion for a restorative environment is not unique to all natural environments (Kaplan, 1993) and the characterization of nature as “green space” cannot be assumed to meet the criterion. This way researchers may begin to further distinguish the types of environments that will promote optimal psychological well-being.

Notably, the findings show some urban environments can also be restorative. An urban environment can be restorative as long as it meets the criterion of ART. Perhaps, nature readily meets the criterion for mental restoration due to some other factor that is not inherently a part of the natural world. Instead, identifying perceptual features (Berman, 2014) that can elicit a restorative experience may explain how we can optimally design urban environments. In this way, urban environments can be designed to create a restorative environment that can promote optimal human feelings and psychological well-being. This has important implications for furthering our understanding of what constitutes a restorative experience. Moreover, a restorative urban environment offers an option for individuals who seek a restorative experience but do not have access to a natural environment such as a rich pine forest and can instead seek a more accessible urban environment.

Similarly, further exploring how virtual exposure to nature, such as the approach used in the present experiment, can potentiate a restorative experience, is a promising solution for individuals who may not be able to physically access nature. However, virtual exposure has its limitations. Immersion into the natural world is a multi-sensory experience, while a virtual/simulated video, like the one used in the current study, could only offer visual and auditory input. Previous empirical research has focused on a single sensory modality (e.g. Images of landscapes or soundscapes), while the current study took virtual exposure a step further by integrating the two sensory modalities. A virtual walk via a computer device cannot simulate sensory experience in the same manner as real exposure. For example, peripheral vision cues and other sensory modalities, such as touch or smell, all contribute to the creation of an immersive experience. Therefore, the current study was not designed to assess the effects of a fully immersive experience and was limited in capturing critical perceptual features that may contribute to an optimally restorative experience.

A second limitation of the present experiment was that only two natural environments were assessed. Given the ecological and geographic diversity in the natural world, these results cannot be generalized to any environment outside of those assessed in the current study. Future studies could be destined to assess a greater variety of natural environments such as environments with and without green space (e.g. beaches, tropical jungles). Once researchers move beyond the characterization of nature "green space", a significant portion of the natural world opens up for investigation. Similarity, the current study was limited to conditions of high and low biodiversity; however, assessing biodiverse environments with more granularity and specificity (i.e. high, medium, low biodiversity) may help our understanding of how ART, SRT, and the Biophilia Hypothesis may differentially contribute to the relationship between nature and well-being. Systematically testing more-diverse natural environments might also begin to direct researchers. to develop a working definition of nature by specifying the perceptual features that contribute most strongly to individuals' judgment of an environment as natural. Berman et al. (2014) has already begun identifying low-level perceptual variables associated with nature, such as curved lines and colour saturation, while McMahan et al. (2015) found participants preferred wild over tamed nature landscapes.

A third limitation of the present experiment was that it was administered online, rather than in the laboratory. Although online research is not inherently limited relative to laboratory-based research, the present experiment required participants to watch a 15-minute video without any overt responses. Without controlling the participants' surrounding environment as they watched the video, the degree to which the simulated walk was "immersive" is unclear. Even though the participants were instructed to find a quiet place to complete the study, controlling the background environment is not possible in an online experiment, particularly compared to an in-lab experiment where all participants can complete the task in the same environment.

Conclusion

The current study was designed to assess the interaction between a simulated virtual walk and psychological well-being. A simulated pine forest nature walk increased happiness and was "fascinating" to participants' attention, in line with prior research. In contrast, the countryside walk, well matched in terms of amount green space to the pine forest walk, did not show these effects.

Interestingly, the simulated urban walk condition was also able to softest capture attention. Taken together, the results suggest that the green space is not an accurate characterization of nature, and urban environments have the potential to be mentally restorative. One significant challenge for future research would be to recharacterize nature in a way that encompasses the natural world and its profound diversity. This will most likely require a multidimensional approach and characterizing nature on a continuum. Once nature is properly conceptualized, researchers can begin to understand what perceptual features of the natural world can lead to improvements in psychological well-being and why these features are able to do so. This could, hopefully, increase appreciation for the natural world in all of its diversity and complexity.

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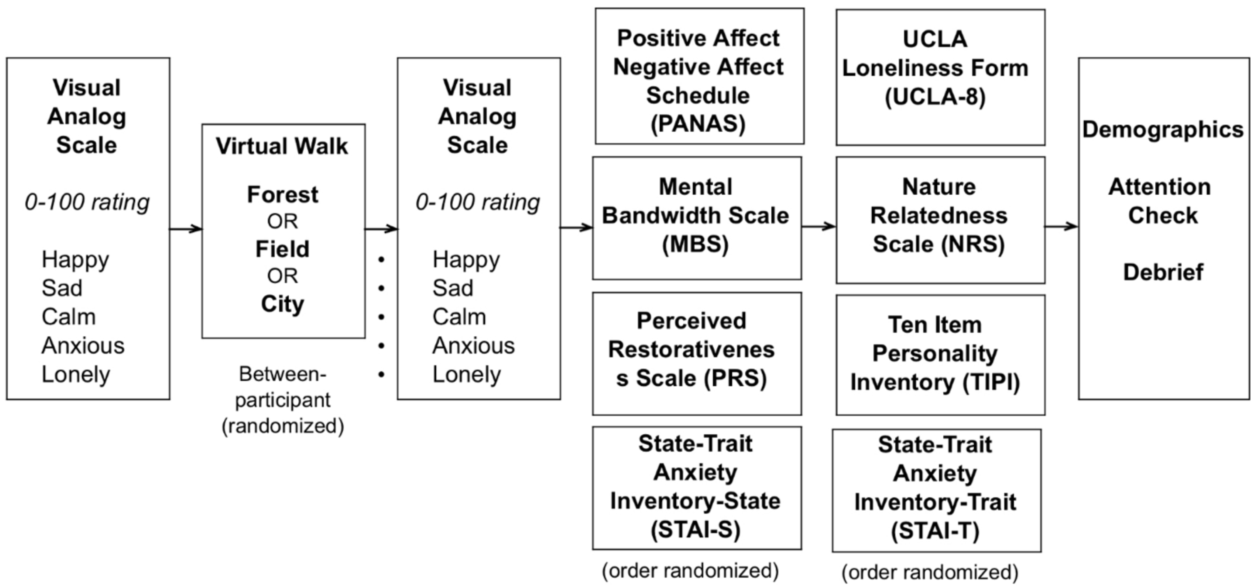
Appendix

Table 1: Summary of results

	Pine Forest (*M* ± *SD*)	Countryside (*M* ± *SD*)	Urban (*M* ± *SD*)	*F*-value
VAS – Happy	12.2 ± 6.51	5.7 ± 2.49	2.8 ± 4.33	4.49 *
VAS – Sad	-4.7 ± 5.66	-3.1 ± 3.93	-3.0 ± 8.62	0.18
VAS – Calm	7.3 ± -1.68	5.1 ± 1.61	4.0 ± 3.93	0.36
VAS – Anxious	-5.2 ± 5.89	-5.07 ± 6.20	-6.7 ± 7.70	0.12
VAS – Lonely	-3.7 ± 1.85	-4.5 ± 8.78	-5.1 ± 8.15	0.05
PANAS – P	30.1 ± 9.31	30.6 ± 7.54	28.5 ± 7.06	0.51
PANAS – N	13.0 ± 5.56	13.4 ± 6.55	11.0 ± 1.63	1.81
MBS - SA	6.0 ± 1.53	5.8 ± 1.30	5.6 ± 1.67	0.69
MBS - D	6.5 ± 2.02	6.2 ± 2.33	5.3 ± 2.25	2.18
MBS - P	5.2 ± 2.39	6.0 ± 3.03	4.7 ± 1.91	1.76
PRS - A	10.1 ± 3.79	9.4 ± 3.73	9.2 ± 3.93	0.59
PRS - E	10.9 ± 3.30	9.9 ± 3.44	10.1 ± 2.52	0.85
PRS - F	10.2 ± 3.49	8.0 ± 3.25	9.4 ± 3.20	3.51 *
ULS-8	17.4 ± 8.60	16.0 ± 7.11	8.26 ± 7.20	0.624
NRS	74.6 ± 16.08	78.9 ± 17.64	75.1 ± 16.48	0.63
STAI-S	32.3 ± 11.51	34.4 ± 13.07	29.9 ± 6.74	1.24
STAI-T	39.2 ± 16.50	40.9 ± 16.10	40.1 ± 13.38	0.10
Openness	9.6 ± 3.64	10.6 ± 2.43	10.8 ± 2.23	1.69
Conscientiousness	9.3 ± 2.27	8.8 ± 2.57	10.0 ± 2.33	1.72
Extraversion	6.5 ± 4.04	7.2 ± 4.02	5.5 ± 2.98	1.55
Agreeableness	10.8 ± 3.16	11.4 ± 2.46	11.0 ± 2.56	0.33
Neuroticism	10.1 ± 3.78	10.0 ± 3.73	9.7 ± 3.10	0.10

Note: The VAS was the only measure administered twice and therefore the table values represent post- minus pre-intervention difference scores. The F-value column represents the ANOVA that compares the three virtual walk conditions. * $p < .05$

Figure 1: Summary of Experimental Design



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