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The wellbeing benefits of exposure to nature: The difference between environment types on different wellbeing types

Lily-Mae Petherick

Project Advisor: Dr Kayleigh Wyles, School of Psychology, University of Plymouth, Drake Circus, Plymouth, PL4 8AA.

Abstract
The world is facing a mental health crisis, thus implementing measures to improve wellbeing is a global priority. One way of combating this worldwide issue is through the well-known wellbeing benefits of nature. However, natural environments include more than just the well-known green spaces, and wellbeing encompasses multiple components. Consequently, this study compares the wellbeing outcomes of virtual exposure to a green space, blue space, and urban environment on both hedonic (pleasure) and eudaimonic wellbeing (meaningfulness). A factorial design was employed in which 96 University of Plymouth students watched one stressor video and then one of three environment videos (green, blue, or urban). To obtain the data, hedonic wellbeing was recorded before and after a stressor clip and after seeing an environmental video. Eudaimonic wellbeing was also measured after each video. Results from the wellbeing questionnaires revealed that exposure to natural environments led to an increase in hedonic and eudaimonic wellbeing, with no differences between green and blue spaces. Interestingly, the results also revealed that exposure to the urban environment had a detrimental effect on eudaimonic wellbeing, the wellbeing component associated with long-term and enduring wellbeing. As such, it is suggested that nature not only improves wellbeing, but may also provide a buffer against the harmful effects of urban environments. These results are supported by psycho-evolutionary theories which suggest that humans are innately drawn to nature, and that fulfilling this need leads to enhanced wellbeing. Consequently, this research highlights the ways in which wellbeing can be improved by virtual exposure to natural environments, as well as revealing the potential harmful psychological effects of exposure to urban environments. This has direct implications for the implementation of targeted nature-based policies and interventions designed to improve psychological wellbeing.

Keywords: nature, eudaimonic wellbeing, hedonic wellbeing, green spaces, blue spaces, virtual exposure.
Introduction

Investigating the wellbeing outcomes associated with exposure to natural environments is of global priority. Poor mental health is a primary cause of disability worldwide, with an estimated 30% of the global population suffering from a mental disorder (Steel et al., 2014). It is increasingly understood that complete mental health involves more than just the absence of illbeing; it is also the existence of wellbeing (World Health Organization, 2021), both hedonic (e.g., happiness) and eudaimonic (e.g., feelings of life satisfaction) (Lambert et al., 2015; Ryan et al., 2008). As such, there is increasing global interest in the different ways of enhancing and promoting positive wellbeing, highlighting the need to better understand the psychological paths and structures by which nature enhances wellbeing. However, despite the urgent need to combat poor wellbeing and the increasing literature on the connection between nature and mental wellbeing, little is known about the impact of different natural settings on different types of psychological wellbeing (Cleary et al., 2017).

An extensive body of research has gathered over the past 30 years that indicates a positive impact of green space exposure on human health and wellbeing. Green space encompasses both dedicated leisure spaces, like public parks, and various other types of green areas and vegetation, like street trees and green roofs (Hunter et al., 2019). Numerous systematic reviews have confirmed the association between green space and mental health. These show a correlation between green space exposure and lowered symptoms of stress, depression and anxiety, as well as increased wellbeing (Corazon et al., 2019; McDonald et al., 2018; Vanaken & Danckaerts 2018). This is consistent with foundational results from experimental studies which suggest that sights of nature, or closeness to nature and greenspace, is beneficial to wellbeing regardless of whether it is actually visited (Kaplan, 1985; Kaplan, 1992; Cordell et al., 1998). As such, research into green space has expanded significantly, notably in terms of its wellbeing benefits.

New perspectives on natural environments propose that these areas can be classified as green or blue spaces, with blue spaces being specified as outdoor environments that prominently feature water (McDougall et al., 2022). Recent studies investigating blue spaces and their impact on health and wellbeing separately remain scarce, although there is growing evidence highlighting the health potential of blue space in relation to physical, psychological, and social health. The relationship between health and large-scale blue spaces in the form of oceans was explored, revealing associations between coastal living and good health (Wheeler et al., 2012; White et al., 2013). Furthermore, by investigating the impact of water imagery in Amsterdam, White et al. (2010) discovered that scenes with water had higher preference, stronger positive affect, and higher perceived restoration than ones without water. However, despite widespread acknowledgement of these blue space benefits, research into them has been relatively limited in comparison to green spaces. Importantly, although green and blue spaces share many commonalities, there are also significant differences. According to research by White et al. (2020), blue spaces have their own unique benefits for health and wellbeing, despite sharing certain advantages with green areas. Therefore, it is crucial to address this gap in the literature and investigate the benefits of exposure to blue spaces separately from green spaces.

Numerous psycho-evolutionary theories converge in suggesting that nature is beneficial for humans. Grounded within these theories is the biophilia hypothesis, which proposes that humans are genetically predisposed to connect with nature. It
suggests that all humans are drawn to and require nature, and that satisfying this need results in wellbeing benefits (Wilson, 1984). Another key evolutionary theory in this domain is stress reduction theory, this argues that exposure to certain unthreatening natural environment that were evolutionary valuable for wellbeing and survival results in an automatic restorative effect (Ulrich et al., 1991). As such, it predicts that exposure to nature will result in decreased physiological and psychological stress reactions, resulting in enhanced wellbeing. This restoration process begins with a scene featuring natural elements, such as vegetation and water, which quickly generate interest and positive emotions. Subsequently, this displaces and confines negative feelings, thereby enabling heightened stress levels to drop. Restoration is characterised by higher positively toned emotions and lower levels of physiological markers, such as heart rate. Studies guided by this theory have demonstrated differences in psychological and physiological outcomes when viewing real or virtual natural and urban environments. Ulrich (1979, 1981) found that, compared to urban settings, nature can reduce arousal and perceived stress levels and foster psychophysiological stress recovery. Moreover, access to nature can act as a stress buffer, such as by lowering pulse rate and cortisol levels (Stigsdotter et al., 2010; Van Herzele & de Vries, 2012; Ulrich, 1981; Tsunetsugu et al., 2010; Bowler et al., 2010). As such, stress reduction theory proposes that exposure to a natural, unthreatening environment can promote recovery from stressful situations by redirecting attention and displacing negative emotions. According to Ulrich (1981), it is exposure to natural settings that enhances restoration, as opposed to exposure to urban environments.

A key emerging theory has recently been published which solely focuses on blue spaces and the benefits of this environment type. Grounded in cutting-edge neurobiology studies, cognitive psychology, economics, and medicine, Nichols (2015) introduced blue mind theory as tying together the critical importance of water to health and happiness. The term “blue mind” describes the mildly absorbed state that humans fall into when exposed to water and is the antidote to the anxious over-stimulated “red mind”. This theory states that water calms our brain, generating a drift state whereby mental attention is not forced or directed, but rather is involuntary and therefore more peaceful. This is supported by neurobiological studies revealing that water increases dopamine and serotonin, known as the feel-good hormones, and decreases cortisol, described as the stress hormone (Nichols, 2015). As such, this theory supports the position that exposure to blue spaces has a positive impact on wellbeing.

Wellbeing is a multifaceted measure of positive mental health, typically consisting of two dimensions in research: hedonia and eudaimonia (Ryan & Deci, 2001). Hedonia relates to instant pleasure and happiness, while eudaimonia refers to the outcomes of self-development and self-actualisation (Ryan & Deci, 2001; Ryff, 1989). Hedonic wellbeing is essentially the feeling good element of wellbeing (Keyes & Annas, 2009). Numerous studies have investigated the connection between hedonic wellbeing and exposure to nature, revealing that interactions with nature promotes positive emotions. For instance, moderately short walks in nature as opposed to urban settings significantly improved mood (Mayer et al., 2009; Nisbet & Zelenski, 2011). This is further supported by a meta-analysis of 32 randomised controlled studies involving more than 2,000 people, which revealed that nature exposure leads to significant increases in positive affect and a small but significant decline in negative affect (McMahan & Estes, 2015). Technologically mediated or virtual exposure to nature has also been associated with increased hedonic wellbeing.
(Velarde et al., 2007). On the other hand, eudaimonic wellbeing is referred to as the functioning well element of wellbeing and encompasses further components of mental health beyond simply feeling good (Keyes & Annas, 2009). Eudaimonic elements are characteristics of high-quality living, such as purpose in life and life satisfaction (Ryan & Frederick, 1997). Most research has focused on the association between nature and hedonic wellbeing; however, some work has begun exploring nature’s impact on eudaimonic wellbeing components. Nature contact and connection has been associated with several measures of eudaimonic wellbeing. For example, experiences in natural environments provide an influential source of meaning for adults of all ages (Fegg et al., 2008; Reker & Woo, 2011; Schnell, 2009), including clinical populations (Berger & McLeod, 2006; Granerud & Eriksson, 2014). After identifying that no reviews had focused on nature connection and eudaimonic wellbeing as a separate wellbeing component, Pritchard et al. (2020) conducted a meta-analysis to explore this relationship and found that individuals who are more connected to nature generally have enhanced eudaimonic wellbeing.

Altogether, research exploring the impacts of nature on eudaimonic wellbeing are relatively scarce, and this is particularly the case for blue spaces. One study explored the different wellbeing components associated with blue spaces, including eudaimonic wellbeing (Vert et al., 2020). It revealed that blue spaces led to significantly improved wellbeing, however only one question was asked looking at eudaimonic wellbeing, thus not providing a robust measure of eudaimonic wellbeing for blue spaces. Altogether, eudaimonic wellbeing is related to, but distinct from hedonic wellbeing (Ryan & Deci, 2001) and as such are important to investigate separately. This is especially important as there is limited research exploring the eudaimonic wellbeing impact of nature, particularly for blue spaces, despite McMahan and Estes (2011) finding that eudaimonia is more likely to create long-term and enduring wellbeing whereas hedonic wellbeing is more likely to dispel in the short-term. Therefore, this study looks specifically at comparing different environmental spaces for both hedonic and eudaimonic wellbeing.

With current developments in technology, virtual exposure is becoming more accessible and recent evidence suggests that both virtual and in-person exposure to natural surroundings can have restorative effects (Gao et al., 2019; Hedblom et al., 2019; White et al., 2018). A recent study investigated the restorative impacts of green and blue environments provided by flat-screen and virtual reality technology (Reece et al., 2022). The findings revealed that exposure to the environment clips were associated with lowered anxiety and enhanced mood. These findings provide several opportunities for public health improvements for demographic groups with limited outdoor access due to mobility problems or confinement to restricted places (Söderlund & Newman, 2017; Guo et al., 2019). This provides further support to research the wellbeing impact that virtual environments may provide. However, to date no research has been conducted investigating both the hedonic and eudaimonic wellbeing benefits of virtual exposure to green, blue, and urban spaces. As such, nature is well known to have psychological benefits (Kaplan, 1995), and work has been conducted on both green spaces (Van den Berg et al., 2015) and blue spaces (White et al., 2020) to support this. However, much research on the wellbeing benefits of nature have solely focused on green spaces and investigating hedonic wellbeing, leading to a constrained view of how to access these natural psychological benefits. To investigate this gap, the current study aimed to investigate the wellbeing benefits of virtual exposure to nature. It aimed to explore the differences between green, blue, and urban environments in regard to their impacts on two types of wellbeing: hedonic wellbeing and eudaimonic wellbeing. This is
particularly important as eudaimonia is more likely to be associated with enduring wellbeing (McMahan & Estes 2011). To address these aims, the following research questions were formulated:

RQ1: Are there wellbeing benefits of exposure to green and blue spaces?
RQ2: Are these benefits specific for natural spaces?
RQ3: Is there a difference between exposure to green and blue spaces for wellbeing?

Following these research questions, the following hypotheses were put forward. These were tested by using a factorial design in which participants watched one stressor video and then one of three environment videos (green, blue, or urban). To see whether wellbeing changed, the participants completed a hedonic wellbeing questionnaire before the stressor clip and the same hedonic wellbeing questionnaire as well as a eudaimonic wellbeing questionnaire after each video.

H1: Exposure to green and blue spaces will lead to increased hedonic and eudaimonic wellbeing.
H2: The wellbeing benefits will be specific for natural spaces and not be found for exposure with the urban space.
H3: There will be a larger increase in wellbeing after exposure to the blue space compared to the green space.

**Methodology**

**Participants**
This study took place at the University of Plymouth in England, United Kingdom. The participants consisted of a convenience sample who replied to the study advertisement via the university psychology participant pool, obtaining one point for participating. The recruitment process took place between February and March 2023. Participants eligible to take part were healthy volunteers with normal or corrected-to-normal vision.

In total, 96 participants took part in the study, of which 79 were female (82%) and 17 were male (18%). The participants' ages ranged from 18 to 31, with an average of 20 years ($SD = 2.63$). All participants were university students enrolled in an undergraduate psychology programme. The participants were randomly allocated to the urban condition, green space condition, or blue space condition using the Qualtrics software (Qualtrics, 2005). Demographics were similar across the three conditions.

**Design**
A mixed factorial design was employed, which had a within-subject component of time and a between-subject component of condition (environment type). This involved participants watching one stressor video and then one of three environment videos (green, blue, and urban). Participants were randomly assigned to either watch the green, blue, or urban environment video. Regardless of condition, the same stressor video was used, with the aim of establishing a similar baseline mood among the participants. Hedonic wellbeing was measured before and after the stressor. Both hedonic and eudaimonic wellbeing were measured before and after exposure to the environment clip. Further questions related to upbringing and environmental preference were also asked, however these were not used in this analysis.
Materials

The experiment took place in a room with six standard desktop computers on the Plymouth University campus. Each participant was separated by a screen and had their own desk and computer. The study was created using Qualtrics (Qualtrics, 2005), an online survey tool.

The stimuli used consisted of one stressor clip and three environment clips. The environment clips were employed from a previous study which assessed the restorative impacts of green, blue, and historic settings provided by flat screen technology (Reece et al., 2022). This involved a two-minute colour and sound display clip of a green space, blue space, and an urban environment. Typically, previous studies exploring different environment types have employed unattractive urban spaces, with researchers paying little attention to the potential health benefits of exposure to attractive urban environments (Bornioli et al., 2018). To address this limitation, this study used an attractive historic urban environment clip as employed in Reece et al. (2022) to determine the wellbeing outcomes of exposure to a more attractive urban setting.

The green space clip depicted an open field with expansive views of the Somerset countryside and sunny conditions (Figure 1A). The blue space clip exhibited a large lake (Chew Valley Lake, UK) with vegetation visible in the distance and a cloudy climate with some sunshine (Figure 1B). The urban environment clip depicted a built historic street from the 14th century (Vicars’ Close, Wells, UK) with cobblestoned paths and a largely sunny climate (Figure 1C). Some people are visible near the end of the video (there are no people visible in the green and blue space clips). Several studies have validated the use of displays such as colour photographs to simulate actual outdoor scenes (Shuttleworth, 1980). Research employing audio-visual simulation procedures (such as colour slides or photographs supplemented with audio segments) revealed significant similarities between real and laboratory ratings for natural and urban environments (Anderson et al, 1983; Zube et al.,1985). Given these results, it appears likely that the use of realistic colour and sound clips in the current study was a valid simulation approach.

The stressor clip involved a 30-second video of heavy traffic as also previously used as a valid stressor stimulus (Reece et al., 2022) (Figure 1D). This was displayed before exposure to the environmental clips, following similar approaches used in earlier research (Van den Berg et al. 2003; Reece et al., 2022). A hedonic questionnaire and eudaimonic questionnaire were administered. The hedonic questionnaire involved six items based on those of Russell’s (1980) circumplex model of affect. This model quantifies affect based on self-report of cognitive sensations coming from valence and arousal. The hedonic questions in this study involved three positive hedonic emotions (relaxed, excited, happy) and three negative hedonic emotions (stressed, bored, sad). The eudaimonic questionnaire adapted five of the six items from Waterman’s (1993) personally expressive activities questionnaire. This widely used questionnaire assesses feelings of personal emotion which distinguishes between eudaimonia and hedonia. The eudaimonic questions in this study related to feelings of being alive, feelings of identity and place meaning, feelings of a special fit between one’s current place and themselves, and feelings of fulfilment. Within both subscales the participants were asked to rate how each item applies to themselves using a 7-point Likert rating scale, ranging from strongly agree to strongly disagree.
Figure 1: Images example content from video sources, one stressor video and then one of three environment videos (blue, green, or urban) kindly provided with permission for reuse from Reece et al. (2022).

Procedure
To begin, participants entered the lab and sat at a desk with a computer. They were first asked to read the participant information sheet displayed on the screen and complete the consent form box to ensure that they gave informed consent (see Appendix A: Participant Forms). A sound check was then conducted for each participant to confirm that the headphones were operating correctly. The participants then completed a hedonic wellbeing questionnaire. After this they viewed a 30-second stressor clip as used in a previous study (Reece et al., 2022), and afterwards completed the hedonic wellbeing questionnaire again to ensure that the stressor clip was sufficient to place the participants in a similar baseline mood and to obtain the hedonic wellbeing scores at this point in the study. During this time, the participants also completed a eudaimonic wellbeing questionnaire (see Appendix B: Wellbeing Questionnaires).

The participants were then exposed to either a blue space, green space, or urban environment delivered by video presentation via random allocation. This video lasted for two minutes. After this a manipulation check was carried out, in which the participants were asked to briefly describe what they had watched, to ensure that they were paying attention to the clip. They were then immediately asked to complete the hedonic and eudaimonic wellbeing questionnaires again. Further questions were then asked relating to environmental preference and upbringing; however, this was not used in this study. Once completed, they were given a debrief
explaining that we were trying to see the impact of nature on wellbeing, particularly if there was a difference in green and blue spaces and whether it was specific for natural spaces by investigating both hedonic and eudaimonic wellbeing.

Analysis
Analysis first involved screening the data to check for normality and statistical outliers. The data was moderately distributed, with all data skewness between 0.5 and -0.5 (Byrne, 2010). After screening the data, preliminary checks were completed to check whether there were any undesirable differences between the three conditions (for example Welch’s t-test to check for the effect of age and ANOVA to check if the stressor successfully stressed and reduced participants’ mood). To examine both changes over time and difference between green and blue spaces, a 2 (time: before and after a video) x 2 (condition: green vs. blue) ANOVA was conducted. Additionally, to examine both changes over time and difference between natural and urban spaces, a 2 (time: before and after a video) x 2 (condition: natural vs. urban) ANOVA was conducted. To explore statistically significant main effects further, partial eta squared tests were conducted to further reveal the extent of the main effects of time and environment. For significant interactions, simple effects analyses were also performed, which involved breaking the interaction down and conducting two independent within-subject t-tests to examine whether both conditions changed over time.

Results
Preliminary results
First, the distribution of the data was checked and revealed that the data was moderately distributed, with all data skewness between 0.5 and -0.5 (Byrne, 2010). As the study involved three scales (positive hedonic wellbeing, negative hedonic wellbeing, and eudaimonic wellbeing) Cronbach’s Alpha Analysis was conducted to measure the scale reliability of each of the scales. This revealed that all scales had an acceptable to high level of reliability (α = .75 - .90), (Bland & Altman, 1997). Thus, for each respective time point, it was appropriate to make a single score for positive hedonic wellbeing, negative hedonic wellbeing, and eudaimonic wellbeing by averaging across the items.

The participants were randomly allocated to the urban condition, green space condition, or blue space condition using the Qualtrics software (Qualtrics, 2005). Demographics (age & gender) were similar across the three conditions, as seen in Table 1.
Table 1: Demographic Information for Each Condition.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Sample Size</th>
<th>Age Mean (S.D)</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Clip</td>
<td>32</td>
<td>19.71 (2.41)</td>
<td>Female Total = 28, Male Total = 4</td>
</tr>
<tr>
<td>Green Space Clip</td>
<td>32</td>
<td>20.03 (2.58)</td>
<td>Female Total = 22, Male Total = 10</td>
</tr>
<tr>
<td>Blue Space Clip</td>
<td>32</td>
<td>20.15 (2.93)</td>
<td>Female Total = 29, Male Total = 3</td>
</tr>
</tbody>
</table>

Furthermore, a Welch’s t-test revealed that there were no observed differences between males and females for all wellbeing outcomes (hedonic and eudaimonic wellbeing at T1, T2, and T3) across all environment conditions, $p > .05$. Therefore, there was no need for further analysis to control for gender differences. Additionally, Pearson’s Correlation tests revealed that there was no significant associations between age and each of the wellbeing scores (hedonic and eudaimonic wellbeing at T1, T2, and T3) across all environment conditions, $p > .05$. Therefore, there was also no need for further analysis to control for age differences.

Finally, we checked if there were any undesirable differences between the conditions. There was no main effect of condition for positive hedonic wellbeing ($p = .06$), and there was no main effect of condition for negative hedonic wellbeing ($p = .06$) at the point of viewing the stressor. This shows that there were no unintended differences between the conditions for both positive and negative hedonic wellbeing at this point in the study.

Descriptive Statistics
Table 2 displays descriptive statistics for the wellbeing scores measured before the stressor, before environment exposure, and after exposure to each environment. Hedonic wellbeing decreased after watching the stressor clip across all conditions and was then seen to improve after exposure to all environments. However, although eudaimonic wellbeing improved after exposure to green and blue spaces, there was a decrease in eudaimonic wellbeing after exposure to the urban environment.

Stressor Check
To check that the stressor clip was sufficient in placing the participants in a similar lower baseline mood, a 2 (time: pre- and post-stressor) x 3 (condition: urban, green, blue) ANOVA was conducted for positive hedonic wellbeing and negative hedonic wellbeing. There was a significant decrease in average positive hedonic wellbeing scores after exposure to the stressor across all conditions $F(1, 92) = 9.5, p = .02, \eta^2_p = .03$ (small effect), (Cohen, 1988), (Table 2). Positive hedonic wellbeing scores were similar across the conditions ($p = .37$), and there was no interaction between the effects of time and environment type ($p = .79$). Therefore, there were no unintended differences between the conditions for positive hedonic wellbeing at this point in the study and the stressor successfully reduced participants’ positive hedonic wellbeing.

There was also a significant increase in average negative hedonic wellbeing scores after exposure to the stressor across all conditions, $F(1, 92) = 8.4, p = .02, \eta^2_p = .03$ (small effect, see Table 2). Negative hedonic wellbeing scores were similar across the conditions ($p = .06$), and there was no interaction between the effects of time and
environment type ($p = .99$). Therefore, there were also no unintended differences between the conditions for negative hedonic wellbeing at this point in the study.

Table 2: The Means (and SD) for Wellbeing Scores Pre-stressor, Pre-environment, and Post-environment.

<table>
<thead>
<tr>
<th></th>
<th>Pre-stressor M (&amp;SD)</th>
<th>Pre-environment M (&amp;SD)</th>
<th>Post-environment M (&amp; SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hedonic Wellbeing - Positive Emotions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition 1 - Urban</td>
<td>4.63(0.82)</td>
<td>4.15(0.92)</td>
<td>4.30(0.93)</td>
</tr>
<tr>
<td>Condition 2 - Green</td>
<td>4.40(0.98)</td>
<td>4.16(0.90)</td>
<td>5.04(0.75)</td>
</tr>
<tr>
<td>Condition 3 - Blue</td>
<td>4.07(1.00)</td>
<td>3.73(1.22)</td>
<td>4.66(0.88)</td>
</tr>
<tr>
<td>Total</td>
<td>4.63 (0.96)</td>
<td>4.01(1.03)</td>
<td>4.67 (0.90)</td>
</tr>
<tr>
<td><strong>Hedonic Wellbeing – Negative Emotions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition 1 - Urban</td>
<td>3.32(1.07)</td>
<td>3.60(1.04)</td>
<td>3.50(1.16)</td>
</tr>
<tr>
<td>Condition 2 - Green</td>
<td>3.55(1.06)</td>
<td>3.82(1.02)</td>
<td>3.25(0.70)</td>
</tr>
<tr>
<td>Condition 3 - Blue</td>
<td>3.76(0.94)</td>
<td>4.03(1.01)</td>
<td>3.45(1.04)</td>
</tr>
<tr>
<td>Total</td>
<td>3.54(1.03)</td>
<td>3.82(1.03)</td>
<td>3.4(0.98)</td>
</tr>
<tr>
<td><strong>Eudiamonic Wellbeing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition 1 - Urban</td>
<td>-</td>
<td>4.08 (0.93)</td>
<td>3.33 (1.23)</td>
</tr>
<tr>
<td>Condition 2 - Green</td>
<td>-</td>
<td>4.30 (0.98)</td>
<td>4.94 (0.83)</td>
</tr>
<tr>
<td>Condition 3 - Blue</td>
<td>-</td>
<td>3.49 (1.27)</td>
<td>4.40 (1.30)</td>
</tr>
<tr>
<td>Total</td>
<td>-</td>
<td>3.95 (1.11)</td>
<td>4.22 (1.31)</td>
</tr>
</tbody>
</table>

*Note – on a scale from 1 = strongly disagree, to 7 = strongly agree*

Hedonic Wellbeing for Green and Blue Spaces

There was an increase in average positive hedonic wellbeing scores after exposure to green and blue spaces (Table 2, Figure 2), which was found to be statistically significant, $F(1, 62) = 69.06$, $p < .001$, $\eta^2_p = 0.19$ (large effect). This supports the hypothesis that exposure to green and blue spaces will lead to increased hedonic wellbeing. Positive hedonic wellbeing differed between the environments, $F(1, 62) = 3.67$, $p = .045$, $\eta^2_p = .19$ (medium effect), whereby green spaces had a statistically significant higher positive hedonic wellbeing score.

In contrast, there was a decrease in average negative hedonic wellbeing scores after exposure to green and blue spaces (Table 2, Figure 3), $F(1, 62) = 28.12$, $p < .001$, $\eta^2_p = 0.09$ (medium effect), whereby hedonic wellbeing improved after exposure to a natural environment clip. This also supports the hypothesis that exposure to green and blue spaces will lead to increased hedonic wellbeing. The negative hedonic wellbeing scores were similar between the environments ($p = .34$), and there was no interaction between the effects of time and environment ($p = .96$), whereby the change in negative hedonic wellbeing after exposure was not dependent on the environment type. Therefore, this also goes against the hypothesis that there will be a larger increase in wellbeing after exposure to the blue space compared to the green space, as there was no difference between the environments for negative hedonic wellbeing.
Note - on a scale from 1 = strongly disagree, to 7 = strongly agree

**Figure 2:** Positive Hedonic Wellbeing Pre-environment and Post-environment for Green and Blue Spaces.

Note - on a scale from 1 = strongly disagree, to 7 = strongly agree

**Figure 3:** Negative Hedonic Wellbeing Pre-environment and Post-environment for Green and Blue Spaces.
Eudaimonic Wellbeing for Green and Blue Spaces

There was an increase in average eudaimonic wellbeing scores after exposure to green and blue spaces (Table 2, Figure 4). Eudaimonic wellbeing changed over time, $F(1, 62) = 22.49, p < .001, \eta^2_{p} = .11$ (medium effect), whereby eudaimonic wellbeing improved after watching a natural environment video. This supports the hypothesis that exposure to green and blue spaces will lead to increased eudaimonic wellbeing. Eudaimonic wellbeing scores differed between the environments, $F(1, 62) = 9.08, p = .004, \eta^2_{p} = .09$ (medium effect), whereby green spaces had a statistically significant higher eudaimonic wellbeing score. However, there was no interaction between the effects of time and environment ($p = .40$), whereby the change in eudaimonic wellbeing after exposure was not dependent on the natural environment type. Thus, there was no difference between green and blue spaces for eudaimonic wellbeing, going against the hypothesis for a difference between green and blue spaces.

Hedonic Wellbeing for Natural and Urban Spaces

The natural scores involved combining the green and blue spaces scores. There was an increase in average positive hedonic wellbeing scores after exposure to natural spaces and the urban environment (Table 2, Figure 5). Positive hedonic wellbeing changed over time $F(1, 94) = 31.89, p < .001, \eta^2_{p} = .07$ (small effect), whereby hedonic wellbeing improved after watching the environment video. The positive hedonic wellbeing scores were similar between the environments ($p = .35$). There was a statistically significant interaction between the effects of time and environment.

Note - on a scale from 1 = strongly disagree, to 7 = strongly agree

Figure 4: Eudaimonic Wellbeing Pre-environment and Post-environment for Green and Blue Spaces.
type, $F(1, 94) = 15.89, p < .001, \eta^2_p = .03$ (small effect). Simple effects analysis revealed that there was only a statistically significant difference in positive hedonic wellbeing after viewing a natural environment clip, $t(63) = -8.38, p < .001, d = -1.05$ (large effect), (Lakens, 2013), whereby positive hedonic wellbeing improved. However, there was no difference in positive hedonic wellbeing after viewing the urban environment clip, $t(31) = -1.01, p = .32$. This supports the hypothesis that exposure to green and blue spaces will lead to increased hedonic wellbeing, and that the wellbeing benefits will be specific for natural spaces and not be found for the urban space.

Note - on a scale from 1 = strongly disagree, to 7 = strongly agree

**Figure 5:** Positive Hedonic Wellbeing Pre-environment and Post-environment for Natural and Urban Spaces.

There was a decrease in average negative hedonic wellbeing scores after exposure to the natural spaces and urban environment (Table 2, Figure 6). Negative hedonic wellbeing changed over time, $F(1, 94) = 14.40, p < .001, \eta^2_p = .03$ (small effect), whereby hedonic wellbeing improved after watching the video, thus supporting the hypothesis that exposure to natural spaces will increase hedonic wellbeing. The negative hedonic wellbeing scores were similar between the environments ($p = .67$), and there was no interaction between the effects of time and environment ($p = .10$) whereby the change in negative hedonic wellbeing after exposure was not dependent on the environment type. Thus, there was no difference between natural and urban spaces for negative hedonic wellbeing.
Eudaimonic Wellbeing for Natural and Urban Spaces

There was an increase in average eudaimonic wellbeing scores after exposure to the natural environment, and a decrease in average eudaimonic wellbeing scores after exposure to the urban environment (Table 2, Figure 7). The 2 x 2 ANOVA revealed no main effect of time ($p = .90$). The eudaimonic wellbeing scores differed between the environments, $F(1, 94) = 0.01$, $p = .91$, $\eta^2_p = .06$ (small effect), whereby natural spaces had higher eudaimonic wellbeing scores. And there was a statistically significant interaction between the effects of time and environment type, $F(1, 94) = 26.07$, $p < .001$, $\eta^2_p = .10$ (medium effect). Simple effects analysis showed that there was a statistically significant increase in eudaimonic wellbeing after viewing a natural space clip, $t(63) = -4.75$, $p < .001$, $d = -0.6$ (medium effect). However, it also revealed that there was a statistically significant decrease in eudaimonic wellbeing after viewing the urban environment clip, $t(31) = 2.80$, $p = .009$, $d = 0.5$ (medium effect). This supports the hypothesis that exposure to green and blue spaces will lead to increased eudaimonic wellbeing, and that the wellbeing benefits will be specific for natural spaces.

Note - on a scale from 1 = strongly disagree, to 7 = strongly agree

Figure 6: Negative Hedonic Wellbeing Pre-Environment and Post-Environment for Natural and Urban Spaces.
Note - on a scale from 1 = strongly disagree, to 7 = strongly agree

Figure 7: Eudaimonic Wellbeing Pre-environment and Post-environment for Natural and Urban Spaces.

Discussion

Poor wellbeing is a prominent global issue, one way of combating this is through the well-known psychological benefits of nature (Kaplan, 1995). However, much research on the wellbeing benefits of nature have solely focused on green spaces by investigating hedonic wellbeing, leading to a constrained view of why nature has psychological benefits and ways to access these benefits. Consequently, this study investigated both the hedonic and eudaimonic wellbeing outcomes of virtual exposure to green, blue, and urban environments. It revealed that natural environments increased wellbeing, with no differences between green and blue spaces, whereas urban environments had a detrimental effect on wellbeing. Results from the analysis showed that exposure to nature increased levels of hedonic wellbeing. This supports patterns in previous studies, in which exposure to green and blue spaces increased hedonic wellbeing scores (Corazon et al., 2019; Vanaken & Danckaerts 2018; Wheeler et al., 2012; White et al., 2013). In this study, this hedonic wellbeing improvement involved an increase in positive hedonic emotions and a decrease in negative hedonic emotions. In line with previous work, there was also an increase in eudaimonic wellbeing after exposure to green spaces (White et al., 2013; Cleary et al., 2017). Furthermore, due to investigating eudaimonic wellbeing separately for blue spaces, the results also revealed that eudaimonic wellbeing increased after blue space. These findings could relate to stress reduction theory, which maintains that exposure to certain unthreatening natural environments rapidly evokes interest and positive emotions, and thereby displaces or restricts negative emotions. (Ulrich et al., 1991). This would suggest why there was an increase in positive hedonic emotions and eudaimonic feelings, and a decrease in negative hedonic emotions after exposure to the natural environments. Furthermore, the additional findings that there was an increase in
hedonic and eudaimonic wellbeing after exposure to the blue space may relate to blue mind theory (Nichols, 2015). This is because it suggests that water displaces negative and stressful feelings leading to elevated and sustained feelings of happiness, as well as connectivity and satisfaction with one’s life. This would explain why there was a decrease in negative hedonic emotions, such as stress, and an increase in positive hedonic emotions and eudaimonic feelings, such as happiness and satisfaction, after blue space exposure. Altogether, this supports the hypothesis that exposure to green and blue spaces would lead to increased wellbeing. The results also showed that these wellbeing benefits were not found for urban environment exposure, supporting the hypothesis that the wellbeing benefits would be specific for natural environments. The results revealed that negative hedonic wellbeing improved after urban exposure, however positive hedonic wellbeing did not change. Stress reduction theory can also be applied to explain why there was not an increase in positive hedonic wellbeing, as it argues that urban settings do not enhance restoration (Ulrich, 1981). However, this also suggests that breaking down wellbeing into separate positive and negative components may be important to consider when investigating the impacts of urban spaces. The improvement in negative hedonic emotions may be explained due to the use of an attractive historical urban scene, which has been found to offer restorative potential (Brancato et al., 2022).

Interestingly, the results also revealed that exposure to the urban clip resulted in a decrease in eudaimonic wellbeing. This follows a similar pattern to previous research, in which urban spaces decreased levels of hedonic wellbeing (Ulrich, 1979). However, there has been limited research showing that exposure to urban environments leads to a decrease specifically in eudaimonic wellbeing as a separate wellbeing component. The biophilia hypothesis may be applied to explain this novel finding. This theory states that humans are innately drawn to and need nature, and that satisfaction of this need positively impacts wellbeing. As such, it proposes that humans have evolved to have a special fit to natural environments, involving a sense of meaningful connection (Wilson, 1984). These components relate most strongly to the eudaimonic aspects of wellbeing, such as feelings of belonging and feeling a special fit with one’s surroundings. Therefore, it is suggested that when humans are exposed to an unnatural environment in which they have not evolved to connect with, such as an urban space, this may initiate feelings of a misfit between themselves and the environment. Because a key measure of eudaimonic wellbeing involved feeling a special fit and meaning to the environment, this may explain why there was a decrease in eudaimonic wellbeing when exposed to the unnatural environment.

Despite the hypothesis that there would be a larger increase in wellbeing after exposure to the blue space, the analysis revealed that there were no differences found between exposure to green and blue spaces for wellbeing. An explanation for this may be due to the virtual approach of the environment exposure. Despite reports that both virtual and real nature produce similar levels of positive emotional states and restoration (Browning et al., 2019), delivering the environments virtually meant that the participants would not have been exposed to all elements of the natural space. Due to the lack of physical involvement, such as walking and contact with natural elements, the brain may have processed the information differently than reality, resulting in some environmental aspects being concealed or disregarded (Taube et al., 2013). This is particularly important for blue spaces, as White et al. (2020) suggested that a key pathway for the enhanced wellbeing effects of water is
through the physical environmental factors of aquatic environments. Elements such as less polluted air, sunlight, and negative ions are all significant factors in accessing the wellbeing benefits of blue spaces (Salmond et al., 2016; Grafstätter et al., 2017; Cherrie et al., 2015). As such, this would suggest why there was not a higher wellbeing outcome of blue spaces compared to green spaces, as gaining the full benefits of blue spaces may require a more immersed exposure.

Limitations, Future Work, and Implications
Following this, a key limitation of the virtual approach employed in this study was that exposure to the environments was essentially passive. The lack of physical involvement may have caused the brain to process information differently, leading to some environmental elements being masked or overlooked (Taube et al., 2013). However, wellbeing benefits were still identified using virtual exposure in this study. Nonetheless, a different approach would be to explore the potential interactive effects of exercise in different environments (e.g. Hartig et al., 2003; Pretty et al., 2005). A program of work that began to explore this scheme in aquatic environments is the “Blue Gym”, which promotes exercise in and around aquatic settings (Depledge & Bird, 2009). If the present findings extend to active interactions in natural environments it could provide significant policy implications for how best to enhance a population’s health and wellbeing (Maller et al., 2006). As such, this also provides evidence of a gap within existing literature, suggesting a need for further research to reveal whether in-person exposure to blue spaces will lead to a higher increase of hedonic and eudaimonic wellbeing compared to green spaces by being fully immersed to all sensations of real-world exposure to aquatic environments.

Research has revealed that urban life is associated with increases in mood and anxiety disorders compared to rural life (Gruebner et al., 2017; Peen et al., 2010). The world population is urbanising, with 66% of the global population predicted to live in cities by 2050. (United Nations, 2014). Therefore, it is crucial for research and practise to understand the wellbeing implications of built environments and develop strategies to enhance the psychological wellbeing of urban residents. This study supports the potential for developing virtual technology strategies to deliver these wellbeing benefits of nature to those who are not able to access such environments, such as those living in urban areas or those with limited mobility. Furthermore, this study suggests that nature may provide a buffer against poor eudaimonic wellbeing which may occur when individuals are exposed to urban environments. As such, this has direct implications for the implementation of nature-based policies and interventions within urban areas designed to combat the potential adverse wellbeing outcomes associated with them.

Conclusion
In conclusion, this study compared the wellbeing outcomes of virtual exposure to a green space, blue space, and urban environment on both hedonic (pleasure) and eudaimonic wellbeing (meaningfulness) from 96 university student participants. Results revealed that exposure to natural environments led to an increase in hedonic and eudaimonic wellbeing, with no differences between green and blue spaces. Interestingly, the results also revealed that exposure to the urban environment had a detrimental effect on eudaimonic wellbeing, the wellbeing component associated with long-term and enduring wellbeing. As such, it is suggested that nature not only improves wellbeing, but may also provide a buffer against the harmful effects of urban environments. Therefore, this research provides further evidence for the importance of natural environments in combating the prominent global wellbeing
issue and the implementation of targeted nature-based policies and interventions, potentially via virtual exposure.

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References


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