

# Nature Connectedness Moderates the Effect of Nature Exposure on Explicit and Implicit Measures of Emotion

Journal of Positive Psychology and Wellbeing  
2018, Volume 2(2): 128–148  
www.journalppw.com  
ISSN 2587-0130  
OPEN ACCESS

Ethan A. McMahan<sup>1</sup>, David Estes<sup>2</sup>,  
Jessica S. Murfin<sup>1</sup>, and Cruz M. Bryan<sup>1</sup>

## Abstract

Previous research indicates that both short-term and long-term exposure to natural environments is associated with higher levels of emotional well-being. However, less research has examined whether person-related factors may impact the salutogenic effects of nature. In the current study, we examined whether trait-level nature connectedness moderates the effect of exposure to nature on explicit and implicit measures of affect. Participants ( $n = 89$ ) completed baseline measurements of trait nature connectedness and affective state. Approximately two weeks later, participants viewed a lab-based immersive simulation of either a natural or built environment and then again completed measures of affective state. Findings indicated that trait nature connectedness moderated the effect of nature on affect, with more positive outcomes of nature exposure observed among those high in nature connectedness. These findings suggest that interacting with nature may be especially beneficial for those who already feel a strong sense of connectedness to the natural environment.

## Keywords

Connectedness to nature, natural environments, emotion, and well-being.

---

<sup>1</sup>Department of Psychological Sciences, Western Oregon University, United States of America.

<sup>2</sup>Department of Psychology, University of Wyoming, United States of America.

*Corresponding Author:* Ethan A. McMahan, Department of Psychological Sciences, Western Oregon University, 345 N. Monmouth Ave. Monmouth, OR 97361, United States of America. Phone: 503.838.8634

Email: mcmahane@mail.wou.edu

*Article History:* Received: 18 January 2018 | Accepted: 04 April 2018 | Published Online: 10 April 2018

Natural environments are a class of environments that are relatively unaltered by humans and typically contain a high concentration of living systems, including flora and fauna (Johnson et al., 1997). A large and growing body of empirical research now indicates that exposure to and contact with natural environments is associated with a host of positive outcomes (for reviews see Collado, Staats, Corraliza & Hartig, 2017; Hartig et al., 2011; Mantler & Logan, 2015). For example, even brief contact with natural environments has been found to improve cognition (Berman, Jonides, & Kaplan, 2008), decrease stress (Cole & Hall, 2010; Gidlow et al., 2015), decrease blood pressure (Lee, Park, Tsunetsugu, Kagawa, & Miyazaki, 2009), enhance emotion (Nisbet & Zelenski, 2011), and increase self-esteem (Barton & Pretty, 2010). However, we still know relatively little about how individual differences in personal experiences, dispositions, and preferences may influence these salutogenic effects on well-being. To address this limitation, we examined whether one person-level factor, namely trait-level nature connectedness, moderates the effect of nature exposure on explicit and implicit measures of emotion.

### **Emotional Responses to Nature**

Theories concerning human responses to nature posit that humans evolved to respond positively to natural environments (e.g., Kellert & Wilson, 1995). In particular, Ulrich's (1983) psycho-evolutionary stress reduction theory (SRT) states that individuals will experience less stress and increased positive affect when in contact with environments that contain the resources that were necessary for survival during our evolutionary history (e.g., those with expansive views, water sources, vegetation). According to this approach, people respond positively to nature because the vast majority of human history took place in natural environments, and these environments are particularly rich in these survival-related resources. Attention restoration theory (ART; Kaplan, 1995) focuses primarily on cognition and proposes that modern urban environments tax directed attentional systems, which leads to cognitive fatigue and higher levels of stress and irritability. In contrast, natural environments contain a high concentration of elements that are inherently fascinating, draw on directed attentional systems only modestly, reducing cognitive load and thus allowing for both cognitive and affective restoration (see also Kaplan, 2001). Importantly, ART also draws from evolutionary accounts of behavior and proposes that the well-documented human preference for natural over built environments (e.g., Beute & de Kort, 2013; Hartig & Evans, 1993; Kaplan & Kaplan, 1989; Ulrich, 1993; van den Berg, Koole, & van der Wulp, 2003) is the result of nature's ability to reduce attentional fatigue, a process which would presumably aid in survival (Joye & van den Berg, 2011).

Although SRT and ART differ in several respects, they converge on the notion that humans have evolved to respond more positively to natural versus built environments, and a large body of supporting empirical evidence indicates that people do show increased positive emotion and, to lesser extent, decreased negative emotion following exposure to natural environments (see Capaldi, Passmore, Nisbet, Zelenski, & Dopko, 2015; Collado et al., 2017; Hartig et al., 2011; Howell & Passmore, 2013; Russell et al., 2013). Moreover, the positive effects of nature on emotional state have been observed under a variety of experimental conditions. For instance, higher levels of positive affect have been observed following contact with both real natural environments (e.g.,

Berman et al., 2012; Passmore & Holder, 2016) and laboratory simulations of natural environments (e.g., Valtchanov, Barton, & Ellard, 2010; Valtchanov & Ellard, 2010; van den Berg, Koole, van der Wulp, 2003); after both short-term (e.g., Nisbet & Zelenski, 2011) and longer-term exposure to natural environments (e.g., Passmore & Howell, 2014); and in response to highly-managed natural environments (e.g., urban green spaces; Berman, et al., 2008; Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009) and relatively unmanaged natural environments (e.g., wilderness areas; Hartig, Evans, Jamner, Davis, & Garling, 2003; Lee, Park, Tsunetsugu, Ohira, Kagawa, & Miyazaki, 2011). Exposure to nature thus seems to improve emotional state across a wide variety of environmental contexts and circumstances.

### **Nature Connectedness**

Less research has addressed the extent to which person factors impact responses to natural environments. This is possibly due to the assumption that, according to SRT and ART, these responses evolved in our species through a process of natural selection and should therefore be present in all individuals. However, individuals vary in their responses to nature, with individual differences in physical and psychological connection to nature likely impacting how people respond, emotionally or otherwise, to nature exposure. Concerning physical connection to natural environments, people differ with respect to their level of experience in nature, and because affective responses to an object/entity are influenced by previous exposure and familiarity (see Monahan, Murphy, & Zajonc, 2000; Zajonc, 1968), those with greater experience in natural environments should respond more positively when exposed to nature. In support, existing empirical evidence shows that individuals tend to prefer those environments that they have more experience with (Balling & Falk, 1982; Falk & Balling, 2010), and more frequent exposure to natural areas during childhood is associated with more positive affective responses to nature during adulthood (Hinds & Sparks, 2011; Ward Thompson, Aspinall, & Montarino, 2008).

Beyond personal experience in natural environments, psychological connection to the natural world in the form of nature connectedness likely also impacts how individuals respond to nature exposure. Nature connectedness is a trait-level construct reflecting the degree to which one feels a subjective connection to the natural environment and natural entities (Capaldi, Dopko, & Zelenski, 2014). Nature connectedness is relatively stable across time and situations (Mayer & Frantz, 2004) and consistently predicts pro-environmental attitudes and engagement in pro-environmental behaviors (Mayer & Frantz, 2004; Nisbet, Zelenski, & Murphy, 2009; Tam, 2013). Additionally, there is reason to suspect that nature connectedness impacts affective response to natural environments. First, nature connectedness is positively associated with previous experience in nature (e.g., Hinds & Sparks, 2008, 2009; Ward Thompson et al., 2008), as well as frequency of visits to natural environments (e.g., Mayer & Frantz, 2004), and highly connected people may respond more positively to natural environments, relative to low-nature connected individuals, by virtue of their increased familiarity with these environments. Second, research indicates that several constructs related to nature connectedness moderate the effects of nature exposure on emotional state. For example, those who self-identify as ‘country people,’ an aspect of place identity (see Droseltis & Vignoles, 2010), respond more positively to nature scenes than those who

self-identify as ‘city people’ (Wilkie & Clouston, 2015; Wilkie & Stavridou, 2013). Taken together, the above indicates that exposure to nature does not affect everyone in the same way or to the same degree, and moreover, these findings strongly suggest that people who feel more connected to nature may be particularly responsive to nature exposure.

Given the above, in the current study we examined whether trait-level connectedness to nature moderates affective responses to nature exposure. We note here that Passmore and Howell (2014, 2016) found that nature connectedness did not moderate the effects of a two-week nature intervention on emotional state. However, they only assessed nature connectedness *after* the intervention. This is problematic because, although nature connectedness is a trait-level construct, subjective reports of connection to nature can temporarily fluctuate in response to nature exposure, with higher levels observed among those who have recently spent time in nature (Schultz, 2002; Nisbet & Zelenski, 2011). Post-intervention assessments of nature connectedness alone are thus unlikely to accurately reflect baseline levels of this construct, and whether pre-existing individual differences in nature connectedness influence how individuals respond to natural environments remains an open question.

### **The Present Study**

The primary objective of the current study was to examine whether trait-level nature connectedness moderates the effect of nature exposure on emotional state. Participants viewed immersive simulations of either a natural or built environment. Nature connectedness and emotional state were assessed using validated self-report instruments, and in addition to using explicit measures of emotional state, implicit measures of emotion were included to reduce experimental demand. A two-phase study design was used, whereby participants first completed baseline measures of nature connectedness and explicit positive and negative affect (Time 1). Later, participants viewed an immersive simulation of either a natural or built environment and completed post-simulation assessments (Time 2).

The following hypotheses were tested:

H<sub>1</sub>: Consistent with previous literature regarding the general effects of nature on emotional state, we predicted a main effect of environment type (natural versus built), such that those exposed to nature simulations would show increased positive affect and decreased negative affect relative to those exposed to simulations of built environments.

H<sub>2</sub>: We further predicted, based on the rationale presented above, that environment type and nature connectedness would interact, such that the effect of environment type on affect would be more pronounced among those high in nature connectedness. More specifically:

- H<sub>2A</sub>: Those high in nature connectedness will show more positive affective responses to natural environmental simulations versus built environment simulations.
- H<sub>2B</sub>: Individuals higher in nature connectedness will show more positive affective responses to natural environment simulations when compared to those lower in nature connectedness.

## Method

### Participants

Participants were 89 students (62 female,  $M_{\text{age}} = 24.22$ ,  $SD_{\text{age}} = 7.43$ ) sampled from the undergraduate population of a mid-sized university in the northwestern United States. The majority of the sample identified as being in their first or second year at university (57%), while a large minority indicated being in their third, fourth, or fifth year of undergraduate training or as having graduate status (43%). A large proportion of the sample reported being Caucasian (69%), with fewer participants identifying as Hispanic (17%), African American (6%), Asian American (5%), and other ethnicities (3%). All participants self-reported uncorrected or corrected 20/20 vision and normal hearing. The simulation equipment used in the current study accommodates those with corrected vision (e.g., those wearing eye glasses), and thus no participants were excluded due to visual acuity related concerns. Participants received partial course credit for participation.

### Measures and Procedure

The current study used a between-subjects two-phase design, with phases occurring approximately two weeks apart ( $M = 12$  days,  $SD = 5.73$  days, range = 1-45 days). Baseline assessments of trait connectedness to nature and explicit positive and negative affect were conducted at Time 1. At Time 2, participants viewed simulations of either a natural or built environment and completed post-simulation assessments of both explicit and implicit affect. All self-report instruments were administered online via the survey administration program Qualtrics, and order of administration was randomized at both Time 1 and Time 2. Participants completed Time 1 assessments at a place of their convenience. Time 2 assessments were completed on-site immediately following the environmental simulations.

Nature connectedness was measured using the Connectedness to Nature Scale (CNS; Mayer & Frantz, 2004), a 14-item self-report instrument assessing the degree to which respondents feel a subjective connection to the natural environment (e.g., "I often feel a sense of oneness with the natural world around me,"). Participants indicated their agreement with each item using 5-point Likert-type scale (1 = *Strongly disagree* to 5 = *Strongly agree*). In the current study, negatively worded items (e.g., "I often feel disconnected from nature,") were reverse-coded, and a single composite CNS variable was created by averaging across all items.

The Positive and Negative Affective Schedule (PANAS; Watson, Clark, & Tellegen, 1988) was used to measure explicit emotional state. This widely used 20-item scale asks participants to report the degree to which they are experiencing both positive (e.g., interested, proud, alert) and negative (e.g., disinterested, upset, irritable) affect on a 5-point Likert-type scale (1 = *very slightly or not at all* through 5 = *extremely*). Composite positive and negative affect scores were computed, with higher scores indicating greater affective responses.

Participants completed two different instruments assessing implicit affect. The Polygon Test of Implicit Affect (PTIA; Mauss, Tamir, Anderson, & Savino, 2011) asks participants to rate how much they like each of two randomly-ordered abstract polygons on a 7-point Likert-type scale (1 = *Don't like at all* to 7 = *Like very much*). Positive feelings tend to be associated with more positive judgments (see Mayer & Hanson, 1995), and thus greater liking of the polygons indicates a more

positive mood. Ratings of each polygon were averaged to yield a single composite variable, with higher scores on this variable indicating a more positive affective state.

The Implicit Positive and Negative Affect Test (IPANAT; Quirin, Kazen, & Kuhl, 2009) was also used as an implicit measure of emotion.<sup>1</sup> This scale asks participants to rate the degree to which six neutral artificial words (e.g., “Safme,” “Talep,” etc.) express three positive and three negative affectively charged adjectives (e.g., “Happy,” “Tense,” “Cheerful,” etc.) on a 4-point Likert-type scale (1 = *Doesn't fit at all* to 4 = *Fits very well*). To maintain consistency with the scoring format of the PTIA, responses to the negative adjectives on the IPANAT were reverse-coded, and a single composite variable was created by averaging across all items. Higher scores on this measure thus indicate a more positive affective state.

**Environmental Simulations.** Previous research indicates that exposure to real natural environments impacts concurrent affect to a greater extent than laboratory simulations of natural environments, which typically involve showing participants photographs of nature (see McMahan & Estes, 2015). However, using real nature also tends to lead to a loss of experimental control and presents a number of formidable logistical challenges. To address these issues, the current study exposed participants to more realistic, immersive simulations of nature that allowed the maintenance of strict experimental control.

In the interest of providing a more realistic environmental experience, simulations included both visual and auditory stimuli. Visually, the simulations involved viewing a series of equirectangular images (dimensions = 5,376 x 2,688 pixels) displayed in 360° spherical range on an Oculus Rift Development Kit 2 head-mounted display (HMD). Images were taken by the research staff specifically for use in this study (see Figure 1 for example images displayed in rectangular format). Natural environments were defined as those that did not include obvious evidence of human impact (e.g., trails) or artifacts (e.g., buildings), and built environments were defined as those that included human artifacts. To ensure comparability of images across environment types, research staff reviewed images with respect to several characteristics (e.g., image complexity, weather), and a subset of comparable images was selected for use. In a separate pilot ( $n = 41$ ), the environments depicted in all images were rated for “naturalness,” and as expected, environments designated as natural by the research staff were rated by participants as more natural than those designated as built environments ( $M_s = 5.36$  versus 2.98 on a 7-point Likert-type scale,  $t(39) = 4.02$ ,  $p < .001$ ).

Prior to initiating the environmental simulations, participants received a set instructions that addressed how the simulation equipment functioned and the content of their assigned simulation. Participants were told that they would be viewing a series of images and that they were free to look around the images as their interest dictated. The simulations included a series of five images, with each image displayed for 1m 20s (total time of exposure to images = 6m), and the full simulation (inclusive of pre-image and post-image instructions) lasting 8m. Participants' view of each of the images was controlled by their own head movements, such that a particular range within the image was viewed by orienting one's body towards that range. For example, to view objects on the left, participants rotated their head/body to the left. To view objects on the right, participants rotated their head/body to the right, and so on. Participants' position within the simulation was fixed, in

that they were not able to move around the scene and could only look around the environment from their fixed vantage point. Brightness and contrast levels for each image were balanced, and mean brightness levels were similar across all images.

Each image was paired with an audio sample recorded on-site at the same time images were being taken. These samples thus captured the ambient sounds associated with each environment. The content of the audio samples was not edited in order to provide a more realistic simulation of the experience of being in each environment. Participants listened to the audio samples on a set of Sony MDRZX100 stereo headphones, with the volume held constant across all images and conditions.

## Results

Means, standard deviations, skewness, kurtosis, internal consistency coefficients, and bivariate correlations between each of the variables measured in the current study are displayed in Table 1. As shown, internal consistency was acceptable for each variable, with the exception of the PTIA. Skewness and kurtosis were also within acceptable ranges for each variable.

**Table 1.** Descriptive statistics and intercorrelations for each measured variable ( $n = 89$ )

Variable	<i>M</i>	<i>SD</i>	Skew.	Kurt.	$\alpha$	1	2	3	4	5	6	7
1. CNS	3.49	.48	-.12	.22	.79	1						
2. PA – Time 1	3.22	.78	-.47	-.41	.90	.12	1					
3. PA – Time 2	3.36	.75	-.72	.90	.88	.02	.60**	1				
4. NA – Time 1	1.61	.50	.87	.48	.78	-.10	.20†	.19†	1			
5. NA – Time 2	1.43	.40	1.25	1.54	.70	-.09	.08	-.05	.52**	1		
6. IPANAT	2.61	.24	.42	.17	.71	.12	.06	.25*	-.01	.04	1	
7. PTIA	3.30	1.23	.12	-.22	.56	.13	.08	.23*	-.20†	-.10	.06	1

Note. CNS = Connectedness to Nature. PA = Explicit Positive Affect. NA = Explicit Negative Affect. IPANAT = Implicit Positive and Negative Affect Test. PTIA = Polygon Test of Implicit Affect. Higher scores on the CNS and each measure of affect indicate, respectively, greater connecteness and affective experience.

† $p < .10$ . \* $p < .05$ . \*\* $p < .01$ .

Two-step regression analysis on each criterion variable was used to test the hypothesis that there would be a main effect of environment type ( $H_1$ ) and to test the environment type  $\times$  CNS interaction hypothesis ( $H_2$ ). In all models, environment type (-1 = built, 1 = natural) and CNS scores were mean-centered and entered in Step 1. For analyses involving explicit positive and negative affect, Time 1 explicit affect scores were also entered in Step 1 in order to control for baseline affect levels. The environment type  $\times$  CNS interaction term was then entered in Step 2. For clarity, we focus on only those analyses that are directly relevant to the current study's hypotheses. As shown in Table 2, these analyses failed to support  $H_1$ , finding no main effect of environment type on explicit positive affect, explicit negative affect, and IPANAT scores. There was a marginally significant main effect of environment type on PTIA scores. However, results

were largely supportive of H<sub>2</sub>, as the hypothesized interaction between environment type and CNS scores was significant for explicit positive affect and PTIA scores and marginally significant for IPANAT scores. The interaction of environment type and CNS scores on explicit negative affect was nonsignificant.

**Table 2.** Regression coefficients for associations between environment type, CNS scores, and each outcome variable (*n* = 89)

	Positive Affect – Time 2			Negative Affect – Time 2			IPANAT			PTIA		
	<i>β</i>	<i>t</i>	<i>p</i>	<i>β</i>	<i>t</i>	<i>p</i>	<i>β</i>	<i>t</i>	<i>p</i>	<i>β</i>	<i>t</i>	<i>p</i>
Step 1												
Covariate <sup>1</sup>	.61	6.92	<.001	.53	5.77	<.001	-	-	-	-	-	-
Environment Type	.07	.86	.39	-.04	-.42	.67	-.05	-.46	.65	.18	1.71	.09
CNS	-.06	-.67	.50	-.02	-.24	.81	.10	.97	.34	.13	1.25	.22
Step 2												
Environment Type × CNS	.30	3.62	.001	-.05	-.53	.60	.19	1.82	.07	.24	2.31	.02

Note. *β* = Standardized Regression Coefficient. CNS = Connectedness to Nature. PA = Explicit Positive Affect. NA = Explicit Negative Affect. IPANAT = Implicit Positive and Negative Affect Test. PTIA = Polygon Test of Implicit Affect.

<sup>1</sup>Time 1 Positive Affect was entered as a covariate in Step 1 of the model with the criterion = Positive Affect – Time 2, and Time 1 Negative Affect was entered as a covariate in Step 1 of the model with criterion = Negative Affect – Time 2.

To interpret significant and marginally significant interactions and address our more specific hypotheses regarding the nature of the environment type × CNS interaction (H<sub>2A</sub> and H<sub>2B</sub>), we then conducted a series of floodlight analyses and simple slopes analyses. Floodlight analyses were used to address the hypothesis that those high in nature connectedness, relative to those lower in nature connectedness, would respond more positively to natural versus built environmental simulations (H<sub>2A</sub>) by testing the simple effect of environment type across the CNS scores continuum. Floodlight analyses were used in favor of the more familiar spotlight analyses because (1) they test for regions of significance along the entirety of the proposed moderator rather than at arbitrarily determined points along its continuum (e.g., at ± 1 standard deviation about the mean), and (2) these analyses allow for the detection of regions of significance that may not be detected by spotlight analyses (see Spiller, Fitzsimons, Lynch, & McClelland, 2013). Conventional simple slopes analyses were used to address the hypothesis that individuals higher in nature connectedness will respond more positively to natural environmental simulations when compared to those lower in nature connectedness (H<sub>2B</sub>).

Results of floodlight analyses addressing H<sub>2A</sub> are shown in Figure 2. Shaded regions indicate the range of values over which the effect of environment type is significant. Consistent with our hypothesis, analyses indicated that those with high CNS scores (i.e., CNS scores ≥ 3.64) indicated higher levels of positive affect when exposed to the natural environmental simulation versus the built environmental simulation. Additionally, and unexpectedly, those with low CNS scores (i.e., CNS scores ≤ 2.99) indicated lower levels of positive affect following exposure to the natural environmental simulation versus the built environmental simulation. For IPANAT scores, analyses indicated no significant differences between those exposed to the natural environmental simulation and those exposed to the built environmental simulation at any point along the CNS score

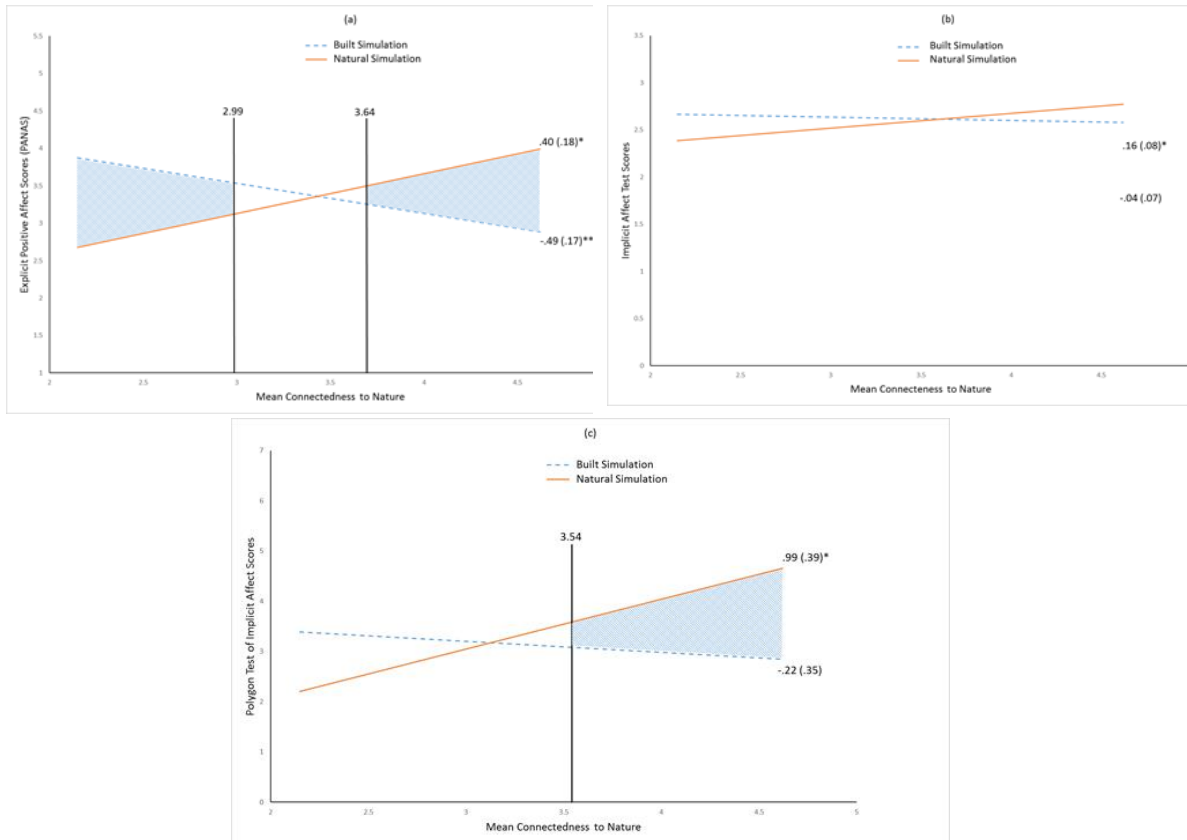


continuum. However, results for the PTIA were consistent with  $H_{2A}$ , with those with high CNS scores (i.e., CNS scores  $\geq 3.54$ ) indicating more positive implicit affect following exposure to the natural environment versus the built environment.



**Figure 1.** Example images for built (a) and natural (b) environmental simulations, displayed in rectangular format.

Also shown in Figure 2 are the results of the simple slopes analyses addressing whether those higher in nature connectedness respond more positively to natural environmental simulations than those lower in nature connectedness ( $H_{2B}$ ). Regression coefficients for each simple slope are displayed next to the regression line for each treatment group (standard errors included in parentheses). As shown, results were supportive of  $H_{2B}$ . A significant positive association was observed between CNS scores and explicit positive affect for those exposed to the natural environmental simulation. Additionally, a significant negative association between CNS scores and positive affect was observed for those exposed to the built environmental simulation. Together, these findings indicate that those higher in nature connectedness responded more positively to the natural environment and less positively to the built environment. Among those exposed to the natural environment simulations, significant positive associations between CNS scores and both the IPANAT and the PTIA were observed, indicating that those higher in nature connectedness showed more positive implicit affect in response to nature exposure than those lower in nature connectedness. No significant associations were observed between CNS scores and IPANAT or PTIA scores for those exposed to build environmental simulations.



**Figure 2.** Environment type  $\times$  Connectedness to Nature interactions with floodlight and simple slopes analyses for (a) explicit positive affect scores, (b) implicit affect test scores (higher scores indicate a more positive affective state), and (c) the polygon test of implicit affect scores. Higher scores indicate higher values for all variables. Environment type is significant ( $p < .05$ ) within the shaded (Johnson-Neyman) regions. Simple slope coefficients (standard errors in parentheses) are located next to each regression line.

\* $p < .05$ . \*\* $p < .01$ .

## Discussion

As noted previously, a great deal of empirical research indicates that exposure to natural environments is associated with a host of positive outcomes, but a relative dearth of research exists addressing whether relevant person-level factors influence the degree to which nature is beneficial. The primary objective of the current study was therefore to examine whether one potentially important person factor, trait-level nature connectedness, influences the effect of nature exposure on emotional state. Consistent with previous literature regarding the effects of nature on emotion (see McMahan & Estes, 2015), we first forwarded the general prediction that those exposed to natural environments would indicate more positive affect and less negative affect than those exposed to built environments. Second, we then focused on the current study's primary objective and further predicted that nature connectedness would moderate the effects of nature exposure on affect, such that more positive affective responses would be observed among those higher in nature

connectedness, compared to those lower in nature connectedness, when exposed to natural versus built environments.

We found limited support for the prediction that exposure to nature would be associated with more positive affective responses when compared to exposure to the built environment. However, this lack of significant findings was qualified by several significant interactions between environment type and nature connectedness, where nature connectedness moderated the effect of environment type on outcomes, as predicted. Specifically, those high in nature connectedness displayed higher levels of explicit positive affect and a more positive implicit affective state, as measured by the PTIA, to the natural versus built environmental simulations. However, these findings were not replicated for negative affect nor implicit affect measured using the IPANAT. Also, those high in nature connectedness indicated higher levels of explicit positive affect and a more positive implicit affective state (as measured by both the PTIA and the IPANAT) in response to nature exposure than those lower in nature connectedness. Again, this finding was not replicated for negative affect. Thus, although the current results were somewhat mixed, significant findings were in the predicted direction and provide initial evidence that the effects of nature exposure depend on the degree to which one already feels a connection to the natural environment.

Surprisingly, we did not find a main effect of environment type, and participants in general did not differ in affect based on whether they viewed a natural or built environment. This is inconsistent with the previous literature on nature exposure, and we are uncertain as to why this effect did not emerge in the current study. One possibility concerns the novelty of using immersive environmental simulations. Across both experimental conditions, many participants indicated interest and excitement when told they were going to use the technology, and perhaps this interest and excitement effectively minimized general affective differences between the groups. Future research should address whether this is the case by habituating participants to the experimental apparatus prior to initiating environmental simulations.

Also unexpectedly, nature exposure had little effect on negative affect. We believe this null finding is due to a floor effect. Baseline negative affect levels were quite low in the current study (1.61 on a 1 to 5 scale), thus making it difficult to detect any decreases in negative affect resulting from nature exposure. Indeed, although unanticipated, the aforementioned novelty of the environmental simulations may have contributed to this null finding by temporarily decreasing negative affect in both groups. Notably, previous research indicates that the effect of nature exposure on positive affect is more robust than its effect on negative affect (see McMahan & Estes, 2015), and consistent with the current results, several studies have found a significant effect for positive affect while not observing an effect for negative affect (e.g., Berman et al., 2012; Mayer et al., 2009; Nisbet & Zelenski, 2011). When an effect on negative affect has been observed, researchers have typically employed various techniques to temporarily increase negative affect prior to nature exposure, finding that nature effectively decreases elevated negative affect levels (e.g., van den Berg et al., 2003). Since participants in the current study did not have elevated negative affect levels, there was little room for improvement on this outcome indicator.

### Individual Responses to Nature

At first glance, the current findings may seem inconsistent with propositions made by SRT and ART, theories which suggest that the human preference for natural environments is biologically-based, rooted in our evolutionary history, and should therefore be present in all members of our species. From these perspectives, how do we account for individual variation in affective responses to natural environments and, even more puzzling, individuals who indicate more positive affective responses to built environments (see Figure 2a)? In our view, this seeming inconsistency is reconciled when taking into account contemporary approaches to environmental preferences that focus on how individual experience and familiarity modify biological predispositions towards natural environments (see Falk & Balling, 2010). In line with these approaches, we submit that humans possess an innate preference for natural over built environments, which may then be modified through individual experience and familiarity, such that greater experience in certain environments leads to a stronger preference for and more positive responses to those environments. As stated previously, nature connectedness is associated with experience and time spent in nature (Mayer & Frantz, 2004; Nisbet et al., 2009), and those higher in nature connectedness typically report higher levels of interaction with the natural world than their low nature-connected counterparts. This suggests that those higher in nature connectedness may be more familiar with natural environments and, due to this familiarity, respond more positively to these environments, a suggestion that is consistent with the current study's findings.

A biding question concerns the mechanisms through which nature connectedness and environmental familiarity impact affective responses to natural environments. One possible mechanism involves the allocation of attentional resources towards potentially significant features of the environment. Specifically, those higher in nature connectedness may more motivated to attend to significant features of natural environments and, due to their higher level of familiarity, better able to locate those features within the environment, thus leading to more positive affective outcomes. In result, when exposed to natural environments, they may be more likely than those low in nature connectedness to notice the evolutionarily significant and affectively beneficial resources identified by SRT (e.g., water features, expansive views, etc.). Or, they may be more likely to notice the inherently fascinating stimuli that, according to ART, promote cognitive and affective restoration. Future research should address this possibility by examining how individual differences in nature connectedness affect attention to natural scenes using techniques specifically designed to examine attentional processes (e.g., eye-tracking; see Berto, Massaccesi, & Pasini, 2008; Valtchanov & Ellard, 2015).

The proposition that innate environmental preferences are modified through experience with particular environments at once explains the existence of individual differences in nature connectedness, as well as the existence of individuals who more closely identify with the built environment while feeling less connected to the natural world. This raises the question as to whether exposure to built environments provides affective benefits to those who feel a strong connection to the built world, and if so, is that benefit comparable to that observed among those high in nature connectedness when exposed to nature. In the current study, we found indirect evidence that exposure to built environments may be more beneficial for some, where individuals

low in nature connectedness showed higher levels of explicit positive affect in response to the built environmental simulation compared to the natural environmental simulation. Further, these findings make salient the provocative possibility that because individuals differ in the degree to which they respond positively to built versus natural environments as a function of nature connectedness, this variable may serve as a useful predictor of behavior aimed at either expansion and development of the built world on one hand, or conservation and preservation of natural environments on the other. Previous research provides initial evidence in support of this possibility, finding that feeling a subjective connection to nature predicts support for and engagement in pro-environmental behavior (e.g., Nisbet et al., 2009).

There is reason to suspect that while the built environment may provide relatively greater psychological benefit for certain groups of individuals (i.e., those lower in nature connectedness), in addition to other benefits such as increased resource efficiency, accessibility, and economic viability (Jenks, Burton, & Williams, 1996), natural environments may be uniquely capable of improving psychological well-being. Natural environments contain those elements identified by SRT and ART as contributing to positive human feeling and functioning (e.g., water features, expansive views), while built environments typically contain lower concentrations of these elements and may therefore be less able to promote well-being. Indeed, lay people seem to recognize this, as natural environments are consistently viewed as more restorative than built environments (e.g., Berto, 2005; Herzog, Maquire, & Nebel, 2003; Korpela, Ylen, Tyrvaenen, & Silvenninen, 2010).

But despite the general perception that natural environments are more restorative than built environments, evidence indicates that individuals are spending less time interacting with nature (Soga & Gaston, 2016). In recent decades, there has been an increase in the proportion of people living in urban areas without easy access to nature (Turner, Nakamura, & Dinetti, 2004), increases in engagement in sedentary indoor activities (e.g., playing computer games; Ballouard, Brischoux, & Bonnet, 2011; Pergams & Zaradic, 2006), and corresponding decreases in engagement in outdoor activities (Clements, 2004). In result, individuals are becoming less connected to the natural world and often underestimate the psychological benefits of frequent interaction with nature (Nisbet & Zelenski, 2011). This lack of interaction with nature in combination with greater relative accessibility of indoor activities may lead to further decreases in time spent in nature and increased disconnection from the natural world. If these trends continue, it is believed that this loss of physical contact with nature will likely lead, through the decreased valuation and destruction of natural environments, to corresponding decreases in human well-being, broadly conceived (see Soga & Gaston, 2016). The current findings further suggest that those who are disconnected from the natural environment may not experience the same affective benefits of interaction with nature, even when given the opportunity for interaction. Thus, not only may well-being suffer as a result of decreased exposure to nature, but also as a result of decreased affective responsiveness to nature.

Although not a primary objective of the current research, our findings provide evidence that environmental simulations like the ones deployed here may be of use in future research examining the effects of nature on well-being. As noted previously, the utilization of simulations allows for a

level of experimental control that is not possible in real environments, and these simulations may be used to answer more specific and targeted questions regarding the benefits of nature. For example, through careful specification and design, environmental simulations may be able to isolate potentially important variables within natural environments that significantly impact emotional state. Additionally, the use of such simulations reduces or eliminates logistical demands associated with testing in certain environments, thus allowing access to a greater breadth of environments in future research. For example, although wilderness areas are, by definition, difficult to access, and examining the effects of real, wild nature is thus logistically challenging, if not impossible, our findings suggest that simulated wilderness areas may be an effective substitute in research that is, for whatever reason, unable to use the real thing. Moreover, the current findings suggest that environmental simulations may be one avenue by which connection to and benefit from nature may be encouraged among those without ready access to the natural world. As urban populations grow and easy access to nature wanes, the use of nature simulations to expose increasingly nature-disconnected populations to natural environments may be an effective strategy towards increasing public health.

### **Limitations and Future Directions**

The current study is not without limitations. First, this study was conducted using a student sample that was quite homogenous in demographic characteristics. Future research should attempt to corroborate the current findings in more diverse samples. It is noteworthy that the majority of nature research has utilized convenience samples of students, so little is known about how older adults respond to natural environments. A recent meta-analysis indicated larger effects of nature exposure among older samples, but the mean ages of the samples included in the meta-analysis captured only a small section of the human lifespan (*M*s ranging from 20 to 28.5 years; McMahan & Estes, 2015). Moreover, no previous study has addressed whether nature connectedness moderates the effects of nature exposure in older adults, and a priority for future research is thus to replicate the current findings in samples drawn from this population. Similarly, future studies should also attempt a cross-cultural replication of the current findings. Cultures differ in mean-level nature connectedness (Tam, 2013), and they also differ in access to nature. For example, people in more traditional societies typically have greater access and exposure to nature than those in post-industrial societies. Examining the interaction of nature connectedness and nature exposure in cultures that vary on each of these constructs should be informative. Finally, the current study used only a single measure of nature connectedness (the CNS) and a single method of nature exposure (immersive simulation). Several other measures of nature connectedness exist (e.g., the Nature Relatedness Scale; Nisbet et al., 2009), and numerous methods for exposing participants to nature have been used (e.g., in-person exposure to real nature; Berman et al., 2012). Future research should utilize these alternative measures and methods to address the consistency of the current findings.

## **Conclusion**

There is now a robust body of literature indicating that nature exposure improves well-being. The current findings indicate that person-level factors, in particular nature connectedness, impact how individuals respond to natural environments. Although additional research should attempt to replicate the current study in other populations and using alternative methods, there are several potentially important implications of our findings. Notably, in light of research indicating that individuals are spending less time in nature (e.g., Clements, 2004; Hofferth, 2009; Soga & Gaston, 2016), our findings highlight the potential importance of reversing this trend and encouraging a strong connection to the natural world, as individuals who experience this connection seem to benefit more from nature exposure. Additionally, mental health practitioners are becoming increasingly aware of the potential clinical importance of natural environments, and applied research focusing on the promotion of mental health via exposure to nature is therefore likely to be in increasing demand (e.g., Mantler & Logan, 2015). Although such research will no doubt inform efforts to enhance well-being in both clinical and non-clinical populations, the current findings suggest that relevant person factors will need to be taken into account when examining the beneficial effects of nature exposure. As demonstrated here, the degree to which nature enhances positive emotions depends on particular individual dispositions, with exposure to nature being especially beneficial for those who already feel a strong connection to the natural world.

**Declaration of Conflicting Interests**

The author(s) declared no conflicts of interest with respect to the research, authorship, and/or publication of this article.

**Funding**

The author(s) received no financial support for the research, authorship, and/or publication of this article.

**Notes**

<sup>1</sup>The IPANAT was included as a second measure of implicit affect because there were concerns that the PTIA, which despite regular use in previous literature, includes only two items and may produce a high level of variability in responses. The IPANAT, although used less frequently than measures similar to the PTIA, is lengthier and tends to produce lower levels of response variability. These two instruments together thus provide converging information regarding the affective state of the individual, measured via implicit means.



## References

- Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Thousand Oaks, CA, US: Sage Publications, Inc.
- Balling, J. D., & Falk, J. H. (1982). Development of visual preference for natural environments. *Environment and Behavior*, *14*(1), 5-28. doi:10.1177/0013916582141001
- Ballouard, J. M., Brischoux, F., & Bonnet, X. (2011). Children prioritize virtual exotic biodiversity over local biodiversity. *PLoS ONE*, *6*, e23152. <https://doi.org/10.1371/journal.pone.0023152>
- Barton, J., & Pretty, J. (2010). What is the best dose of nature and green exercise for improving mental health? A multi-study analysis. *Environmental Science and Technology*, *44*(10), 3947-3955. doi:10.1021/es903183r
- Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological Science*, *19*(12), 1207-1212. doi:10.1111/j.1467-9280.2008.02225.x
- Berman, M. G., Kross, E., Krpan, K. M., Askren, M. K., Burson, A., Deldin, P. J., & ... Jonides, J. (2012). Interacting with nature improves cognition and affect for individuals with depression. *Journal of Affective Disorders*, *140*(3), 300-305. doi:10.1016/j.jad.2012.03.012
- Berryman, J. C. (1984). Interest and liking: Further sequential effects. *Current Psychological Research & Reviews*, *3*(4), 39-42. doi:10.1007/BF02686556
- Berto, R. (2005). Exposure to restorative environments helps restore attentional capacity. *Journal of Environmental Psychology*, *25*(3), 249-259. doi:10.1016/j.jenvp.2005.07.001
- Berto, R., Massaccesi, S., & Pasini, M. (2008). Do eye movements measured across high and low fascination photographs differ? Addressing Kaplan's fascination hypothesis. *Journal of Environmental Psychology*, *28*(2), 185-191. doi:10.1016/j.jenvp.2007.11.004
- Beute, F., & de Kort, Y. W. (2013). Let the sun shine! Measuring explicit and implicit preference for environments differing in naturalness, weather type and brightness. *Journal of Environmental Psychology*, *36*162-178. doi:10.1016/j.jenvp.2013.07.016
- Bornstein, R. F. (1989). Exposure and affect: Overview and meta-analysis of research, 1968-1987. *Psychological Bulletin*, *106*(2), 265-289. doi:10.1037/0033-2909.106.2.265
- Capaldi, C. A., Dopko, R. L., & Zelenski, J. M. (2014). The relationship between nature connectedness and happiness: A meta-analysis. *Frontiers in Psychology*, *5*, 976. DOI:10.3389/fpsyg.2014.009762524999210.3389/fpsyg.2014.00976
- Capaldi, C.A., Passmore, H., Nisbet, E.K., Zelenski, J.M., & Dopko, R.L. (2015). Flourishing in nature: A review of the benefits of connecting with nature and its application as a wellbeing intervention. *International Journal of Wellbeing*, *5*(4), 1- 16. DOI: <http://dx.doi.org/10.5502/ijw.v5i4.449>
- Clements, R. (2004). An investigation into the status of outdoor play. *Contemporary Issues in Early Childhood*, *5*, 68-80. doi: 10.2304/ciec.2004.5.1.10
- Cole, D. N., & Hall, T. E. (2010). Experiencing the restorative components of wilderness environments: Does congestion interfere and does length of exposure matter?. *Environment and Behavior*, *42*(6), 806-823. doi:10.1177/0013916509347248

- Collado, S., Staats, H., Corraliza, J.A., & Hartig, T. (2017). Restorative environments and health. In O. Navarro, G. Fleury-Bahi, & E. Pol (Eds.), *Handbook of environmental psychology and quality of life research*. New York, NY: Springer.
- Droseltis, O., & Vignoles, V. (2010). Towards and integrative model of place identification: Dimensionality and predictors of intrapersonal-levels place preferences. *Journal of Environmental Psychology*, *30*, 23-34. <https://doi.org/10.1016/j.jenvp.2009.05.006>
- Falk, J. H., & Balling, J. D. (2010). Evolutionary influence on human landscape preference. *Environment and Behavior*, *42*(4), 479-493. doi:10.1177/0013916509341244
- Gidlow, C. J., Jones, M. V., Hurst, G., Masterson, D., Clark-Carter, D., Tarvainen, M. P., & ... Nieuwenhuijsen, M. (2016). Where to put your best foot forward: Psycho-physiological responses to walking in natural and urban environments. *Journal of Environmental Psychology*, *45*, 22-29. doi:10.1016/j.jenvp.2015.11.003
- Hartig, T., & Evans, G. W. (1993). Psychological foundations of nature experience. In T. Gärling, R. G. Golledge, T. Gärling, R. G. Golledge (Eds.), *Behavior and environment: Psychological and geographical approaches* (pp. 427-457). Oxford, England: North-Holland. doi:10.1016/S0166-4115(08)60053-9
- Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S., & Gärling, T. (2003). Tracking restoration in natural and urban field settings. *Journal of Environmental Psychology*, *23*(2), 109-123. doi:10.1016/S0272-4944(02)00109-3
- Hartig, T., van den Berg, A. E., Hagerhall, C. M., Tomalak, M., Bauer, N., Hansmann, R., Ojala, A., et al. (2011). Health benefits of nature experience: Psychological, social, and cultural processes. In K. Nilsson et al. (Eds.), *Forest, trees, and human health* (pp. 127-168). New York, NY: Springer. DOI 10.1007/978-90-481-9806-1\_5
- Herzog, T. R., Maguire, C. P., & Nebel, M. B. (2003). Assessing the restorative components of environments. *Journal of Environmental Psychology*, *23*(2), 159-170. doi:10.1016/S0272-4944(02)00113-5
- Hinds, J., & Sparks, P. (2008). Engaging with the natural environment: The role of affective connection and identity. *Journal of Environmental Psychology*, *28*(2), 109-120. doi:10.1016/j.jenvp.2007.11.001
- Hinds, J., & Sparks, P. (2009). Investigating environmental identity, well-being, and meaning. *Ecopsychology*, *1*(4), 181-186. doi:10.1089/eco.2009.0026
- Hinds, J., & Sparks, P. (2011). The affective quality of human-natural environment relationships. *Evolutionary Psychology*, *9*(3), 451-469. doi:10.1177/147470491100900314
- Hofferth, S. L. (2009). Changes in American children's time – 1997 to 2003. *Electronic International Journal of Time Use Research*, *6*, 26-47. doi: 10.1016/S1040-2608(01)80011-3
- Howell, A. J., & Passmore, H.A-. (2013). The nature of happiness: Nature affiliation and mental well-being. In C. M. Keyes, C. M. Keyes (Eds.), *Mental well-being: International contributions to the study of positive mental health* (pp. 231-257). New York, NY: Springer. doi:10.1007/978-94-007-5195-8\_11

- Jenks, M., Burton, E., & Williams, K. (1996). *The compact city: A sustainable urban form?* London, UK: Taylor and Francis. doi:10.4324/9780203362372
- Johnson, D. L., Ambrose, S. H., Bassett, T. J., Bowen, M. L., Crummy, D. E., Isaacson, J. S., & Johnson, D. N. (1997). Meanings of environmental terms. *Journal of Environmental Quality*, 26, 581-589.
- Joye, Y., & van den Berg, A. (2011). Is love for green in our genes? A critical analysis of evolutionary assumptions in restorative environments research. *Urban Forestry and Urban Greening*, 10, 261-268. <https://doi.org/10.1016/j.ufug.2011.07.004>
- Kaplan, R. (2001). The nature of the view from home: Psychological benefits. *Environment and Behavior*, 33(4), 507-542. doi:10.1177/00139160121973115
- Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. New York, NY, US: Cambridge University Press.
- Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, 15(3), 169-182. doi:10.1016/0272-4944(95)90001-2
- Kellert, S. R., & Wilson, E. O. (Eds.) (1995). *The biophilia hypothesis*. Washington, DC: Island Press.
- Korpela, K. M., Ylen, M., Tyrvaïnen, L., & Silvänninen, H. (2010). Favorite green, waterside, and urban environments, restorative experiences and perceived health in Finland. *Health Promotion International*, 25, 200-209. <https://doi.org/10.1093/heapro/daq007>
- Lee, J., Park, B., Tsunetsugu, Y., Kagawa, T., & Miyazaki, Y. (2009). Restorative effects of viewing real forest landscapes, based on a comparison with urban landscapes. *Scandinavian Journal of Forest Research*, 24, 227-234. doi:10.1080/02827580902903341
- Lee, J. J., Park, B. J., Tsunetsugu, Y. Y., Ohira, T. T., Kagawa, T. T., & Miyazaki, Y. Y. (2011). Effect of forest bathing on physiological and psychological responses in young Japanese male subjects. *Public Health*, 125(2), 93-100. doi:10.1016/j.puhe.2010.09.005
- Mantler, A., & Logan, A. C. (2015). Natural environments and mental health. *Advances in Integrative Medicine*, 2, 5-12. <http://dx.doi.org/10.1016/j.aimed.2015.03.002>
- Mauss, I. B., Tamir, M., Anderson, C. L., & Savino, N. S. (2011). Can seeking happiness make people unhappy? Paradoxical effects of valuing happiness. *Emotion*, 11(4), 807-815. doi:10.1037/a0022010
- Mayer, F. S., & Frantz, C. M. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of Environmental Psychology*, 24(4), 503-515. doi:10.1016/j.jenvp.2004.10.001
- Mayer, F., Frantz, C., Bruehlman-Senecal, E., & Dolliver, K. (2009). Why is nature beneficial?: The role of connectedness to nature. *Environment and Behavior*, 41(5), 607-643. doi:10.1177/0013916508319745
- Mayer, J. D., & Hanson, E. (1995). Mood-congruent judgment over time. *Personality and Social Psychology Bulletin*, 21(3), 237-244. doi:10.1177/0146167295213005
- McMahan, E. A., & Estes, D. (2015). The effect of contact with natural environments on positive and negative affect: A meta-analysis. *The Journal of Positive Psychology*, 10(6), 507-519. doi:10.1080/17439760.2014.994224

- Monahan, J. L., Murphy, S. T., & Zajonc, R. B. (2000). Subliminal mere exposure: Specific, general, and diffuse effects. *Psychological Science, 11*(6), 462-466. doi:10.1111/1467-9280.00289
- Nisbet, E. K., & Zelenski, J. M. (2011). Underestimating nearby nature: Affective forecasting errors obscure the happy path to sustainability. *Psychological Science, 22*(9), 1101-1106. doi:10.1177/0956797611418527
- Nisbet, E. K., Zelenski, J. M., & Murphy, S. A. (2009). The Nature Relatedness Scale: Linking individuals' connection with nature to environmental concern and behavior. *Environment and Behavior, 41*(5), 715-740. doi:10.1177/0013916508318748
- Passmore, H.-A., & Holder, M. D. (2016). Noticing nature: Individual and social benefits of a two-week intervention. *Journal of Positive Psychology*. Advance online publication. <http://dx.doi.org/10.1080/17439760.2016.1221126>
- Passmore, H.-A., & Howell, A. J. (2014). Nature involvement increases hedonic and eudaimonic well-being: A two-week experimental study. *Ecopsychology, 6*(3), 148-154.
- Pergams, O. R., & Zaradic, P. A. (2006). Is love of nature in the US becoming love of electronic media? 16-year downtrend in national park visits explained by watching movies, playing video games, internet use, and oil prices. *Journal of Environmental Management, 80*, 387-393. <https://doi.org/10.1016/j.jenvman.2006.02.001>
- Quirin, M., Kazén, M., & Kuhl, J. (2009). When nonsense sounds happy or helpless: The Implicit Positive and Negative Affect Test (IPANAT). *Journal of Personality and Social Psychology, 97*(3), 500-516. doi:10.1037/a0016063
- Russell, R., Guerry, A. D., Balvanera, P., Gould, R. K., Basurto, X., Chan, K. M. A. ... Tam, J. (2013). Humans and Nature: How knowing and experiencing nature affect well-being. *Annual Review of Environment and Resources, 38*, 473-502. DOI: 10.1146/annurev-environ-012312-110838
- Schultz, P. W. (2002). Inclusion with nature: The psychology of human-nature relations. In P. Schmuck & P. W. Schultz (Eds.), *Psychology of Sustainable Development* (pp. 61-78). New York, NY: Springer.
- Soga, M., & Gaston, K. J. (2016). Extinction of experience: The loss of human-nature interactions. *Frontiers in Ecology and the Environment, 14*, 94-101. doi:10.1002/fee.1225
- Spiller, S. A., Fitzsimons, G. J., Lynch, J. G., & McClelland, G. H. (2013). Spotlights, floodlights, and the magic number zero: Simple effects tests in moderated regression. *Journal of Marketing Research, 50*, 277-288. <https://doi.org/10.1509/jmr.12.0420>
- Tam, K. (2013). Concepts and measures related to connection to nature: Similarities and differences. *Journal of Environmental Psychology, 34*, 64-78. doi:10.1016/j.jenvp.2013.01.004
- Turner, W. R., Nakamura, T., & Dinetti, M. (2004). Global urbanization and the separation of humans from nature. *BioScience, 54*, 585-590. [https://doi.org/10.1641/0006-3568\(2004\)054\[0585:GUATSO\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2004)054[0585:GUATSO]2.0.CO;2)

- Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. In I. Altman, & J. Wohlwill (Eds.), *Behavior and the natural environment* (pp. 85-125). New York, NY: Plenum Press.
- Ulrich, R. S. (1993). Biophilia, biophobia, and natural landscapes. In S. R. Kellert & E. O. Wilson (Eds.), *The biophilia hypothesis* (pp. 73–137). Washington, D.C.: Island Press.
- Valtchanov, D., Barton, K. R., & Ellard, C. (2010). Restorative effects of virtual nature settings. *Cyberpsychology, Behavior, and Social Networking*, *13*(5), 503-512. doi:10.1089/cyber.2009.0308
- Valtchanov, D., & Ellard, C. (2010). Physiological and affective responses to immersion in virtual reality: Effects of nature and urban settings. *Journal of Cybertherapy and Rehabilitation*, *3*(4), 359-374.
- Valtchanov, D., & Ellard, C. G. (2015). Cognitive and affective responses to natural scenes: Effects of low level visual properties on preference, cognitive load and eye-movements. *Journal of Environmental Psychology*, *43*, 184-195. doi:10.1016/j.jenvp.2015.07.001
- van den Berg, A. E., Koole, S. L., & van der Wulp, N. Y. (2003). Environment preference and restoration: (How) are they related?. *Journal of Environmental Psychology*, *23*(2), 135-146. doi:10.1016/S0272-4944(02)00111-1
- Ward Thompson, C., Aspinall, P., & Montarino, A. (2008). The childhood factor: Adult visits to green places and the significance of childhood experience. *Environment and Behavior*, *40*(1), 111-143. doi:10.1177/0013916507300119
- Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063-1070. doi:10.1037/0022-3514.54.6.1063
- Wilkie, S., & Clouston L. (2015). Environment preference and environment type congruence: Effects on perceived restoration potential and restoration outcomes. *Urban Forestry and Urban Greening*, *14*, 368-376. <https://doi.org/10.1016/j.ufug.2015.03.002>
- Wilkie, S., & Stavridou, A. (2013). Influence of environmental preference and environment type congruence on judgments of restoration potential. *Urban Forestry and Urban Greening*, *12*, 163-170. <https://doi.org/10.1016/j.ufug.2013.01.004>
- Zajonc, R. B. (1968). Attitudinal effects of mere exposure. *Journal of Personality and Social Psychology*, *9*(2, Pt.2), 1-27. doi:10.1037/h0025848