

---

# Restorativeness in Natural and Urban Environments: A Meta-Analysis

Psychological Reports

0(0) 1–21

© The Author(s) 2019

Article reuse guidelines:

[sagepub.com/journals-permissions](https://sagepub.com/journals-permissions)

DOI: 10.1177/0033294119884063

[journals.sagepub.com/home/prx](https://journals.sagepub.com/home/prx)

**Elisa Menardo**  and  
**Margherita Brondino**

Department of Human Sciences, University of Verona,  
Verona, Italy

**Rob Hall**

Environmetrics Ltd, Pymble, Australia

**Margherita Pasini**

Department of Human Sciences, University of Verona,  
Verona, Italy

## Abstract

In recent decades, there has been an increasing volume of research aimed at quantifying the extent to which the natural environment can assist in restoring mental, emotional, and physical well-being. It is commonly assumed that natural environments are more restorative than urban environments. However, studies addressing this issue use a variety of methods for data collection making it difficult to compare the findings of different studies. The research reported here uses a meta-analysis aimed at estimating how much natural environments are perceived as being more restorative than urban environments. We investigated the role of moderator variables such as research design, kind of natural environment, participants, measurement instruments used or the context in which the data were collected. PsycINFO, PsycARTICLES, Scopus, SpringerLINK, Web of Science online databases were used to identify all peer-review articles on restorativeness published

---

## Corresponding Author:

Elisa Menardo, Department of Human Sciences, University of Verona, Lungadige Porta Vittoria, 17, 37129 Verona, Italy.

Email: [elisa.menardo@univr.it](mailto:elisa.menardo@univr.it)

to date ( $k = 167$ ). Reference sections of obtained papers were examined for additional studies. Only 22 studies met inclusion criteria (direct exposure to environment, comparison between one outdoor environment with natural element and one without natural element, and restorativeness measured by self-report scale) and were included in meta-analysis. Results show that natural environments are perceived to be more restorative than urban environments (Cohen's  $d$  (confidence interval) = 1.99 (1.38–2.61)). Significant heterogeneity between the study was found ( $Q(19) = 503.16$ ,  $p < .001$ ) and variability within studies was very high ( $I^2 = 97\%$ ). However, subsequent univariate moderator analyses were not significant. Other methodological differences (e.g., lighting conditions) could explain this variability. We concluded that the variability in studies is more likely to be due to individual differences (e.g., age, connections to nature, and environmental attitude) than the methodological differences.

### **Keywords**

Meta-analysis, nature environment, urban environment, restorativeness, environmental psychology

### **Introduction**

Restorative environments, that is, environments that facilitate the recovery of resources (biological, cognitive, psychological, and social) in an individual (Hartig, 2004), have become an important research field in environmental psychology (Staats, 2012). An increasing number of studies from different areas (e.g., environmental psychology, consumer psychology, health psychology, organizational psychology, and sports psychology) indicate that exposure to natural environments can influence people's well-being (e.g., Berto, 2014; Bodin & Hartig, 2003; Bowler, Buyung-Ali, Knight, & Pullin, 2010; Hartig, Mitchell, de Vries, & Frumkin, 2014; Mitchell, 2013; Mitchell & Popham, 2008). In the past 30 years, empirical research has been driven by two main theories proposed to explain why human beings benefit from exposure to certain types of environments: the stress recovery theory (SRT; Ulrich, 1983; Ulrich et al., 1991) and the attention restoration theory (ART; Kaplan, 1995; Kaplan & Kaplan, 1989). The SRT (or psycho-evolutionary theory) focuses on the immediate and unconscious emotional response elicited by an environment (Korpela, Klemetilä, & Hietanen, 2002). It suggests that contact with nature can promote mild to moderate feelings of interest, calm, and pleasantness (Hartig et al., 2011) and, consequently, allow recovery from a stress condition (Ulrich, 1979). The empirical support to Ulrich's theory was recently strengthened by a meta-analysis (McMahan & Estes, 2015) of the effect of contact with natural

environments on positive affect and negative affect. As expected, exposure to nature was positively correlated with positive emotions ( $r = .31$ ) and negatively correlated with negative emotions ( $r = -.12$ ; McMahan & Estes, 2015).

The ART focuses on cognitive responses and suggests that contact with nature allows people to restore resources consumed in facilitating directed (voluntary) attention and, consequently, to recover from a situation of cognitive fatigue (Kaplan, 1995). This theory assumes that the ability to direct voluntary attention decreases with use, as it requires an effort to inhibit distractions.

Being in a situation that does not require voluntary attention reduces the effect of the inhibitory mechanism thus freeing mental resources (Staats, 2012). According to the literature (e.g., Kaplan, 1995; Korpela & Hartig, 1996; Pasini, Berto, Brondino, Hall, & Ortner, 2014), a number of characteristics of an environment have been shown to promote the quality of restoration in individuals. These are the following:

- *Fascination*, a term that refers to the way an environment might attract the involuntary attention of an individual;
- *being away*, a term that refers to the extent to which an environment causes a person to feel freed from everyday cares and obligations;
- *extent*, a quality that comprise two elements: (1) *coherence* that refers to whether an environment is perceived as structured or not and (2) *scope* that refers to the way an environment affords opportunities for exploration;
- *compatibility* that refers to the correspondence between the expectations of a person and the observed qualities of the environment.

The restorativeness of an environment, or its ability to restore cognitive resources, can be investigated not only directly, through physiological (e.g., Chen, He, & Yu, 2016; Tang et al., 2017) or behavioral measures (e.g., Berto, 2005; Lin, Tsai, Sullivan, Chang, & Chang, 2014), but also indirectly, through self-report measures. The latter assess the perceived restorativeness of an environment (e.g., Berto, 2014; Hartig, Korpela, Evans, & Gärling, 1997; Pasini et al., 2014). That is the estimation of the restorative potential of the environments (Staats, 2012). Whereby people are asked to evaluate the five restorative qualities of given environments based on the assumption that the meta-cognitive abilities of individuals allow them to understand their cognitive processes and to estimate how they are influenced by different environments (Pearson & Craig, 2014).

A recent systematic review (Ohly et al., 2016) focusing on ART confirmed the positive effect of exposure to natural environments on attention performance.

However, ART and SRT theories are not mutually exclusive, and both are based on the concept of biophilia (Wilson, 1984). Human beings, it is argued, would have developed an innate tendency to focus on living things and thus to affiliate with nature (Berto, Barbiero, Barbiero, & Senes, 2018). The natural environment would exhibit characteristics (e.g., vegetation, water, and caves)

or qualities (e.g., spatial configuration such as smooth ground texture or trees that help define the depth of the scene) which, during evolution, proved to be favorable for survival and which could explain why humans obtain affective and cognitive benefits from natural environments (Berto, 2014; Kaplan & Kaplan, 1989; Wilson, 1984). For example, the spatial configuration of a forest or savannah can make these natural environments favorable for survival because immediate information is available to judge where one can explore safely and what might occur in particular context (Kaplan & Kaplan, 1989).

In sum, many empirical studies suggest that nature is the most potent restorative environment with respect to both affective and cognitive domains. However, as highlighted in some reviews and meta-analysis (Berto, 2014; Hartig et al., 2014; McMahan & Estes, 2015; Ohly et al., 2016), there is substantial diversity across studies, in terms of method and study design that makes it difficult to compare studies and draw conclusions.

For example, the effect of environmental exposure on positive emotion seems to be stronger in real environments than laboratory simulations, whereas no difference was found between manicured and wild nature (McMahan & Estes, 2015). Moreover, the observed difference in people's emotions and cognitive ability after exposure to different environments (nature vs. urban) could be biased by the measurement instruments used. Indeed, the estimated effect of exposure to nature on mood and cognitive ability is higher in studies using positive and negative affect schedule (PANAS) or the trail making test versus Zuckerman Inventory of Personal Reactions (ZIPERS) or Sustained Attention to Response Test (SART) (for details see McMahan & Estes, 2015; Ohly et al., 2016).

Some studies suggested that "water" environments (i.e., lake, seaside, and river) and wild nature are perceived as more restorative than "no water" (i.e., mountains and forest) environment or urban nature, respectively (e.g., Carrus et al., 2015; Laumann, Gärling, & Stormark, 2001; McAllister, Bhullar, & Schutte, 2017; Tang et al., 2017; Tyrväinen et al., 2014).

Given that perceived restorativeness is a concept now widely used in the literature (Staats, 2012), we suggest that a meta-analysis to summarize this literature could be useful. Moreover, through moderator analysis it should be possible to investigate whether methodological differences could explain the variability in findings across studies.

## **Overview of the Meta-analysis**

The main aim of this study was to estimate the effect size and direction of the difference between the perceived restorativeness in natural and urban environments. Based on the literature (e.g., Berto, 2014; Hartig, Korpela, Evans, & Gärling, 1997), we expected that exposure to natural environments was associated with a greater perception of restorative quality than exposure to urban

environments. Since meta-analysis also allows for the study of moderator variables that could explain the variability between studies, the second objective of this study was to test whether differences in research design or method can explain the differences in effect size observed between studies. Such information could be useful for highlighting possible systematic bias due to the methods used in estimating the effect of exposure to nature on people's cognitive resources.

Specifically, in this study, we considered the following potential moderator variables:

1. *Research design.* Studies investigating the perceived restorativeness of environments have been conducted using both between-subject (e.g., Korpela, 2013; Wilkie & Clouston, 2015) and within-subject designs (e.g., Stigsdotter, Corazon, Sidenius, Kristiansen, & Grahn, 2017; Tyrväinen et al., 2014). Given that within-subject studies tend to have higher effect sizes, we first checked whether research design is responsible for the variability between studies of the estimated effect size.
2. *Exposure to test environments.* Most of the research was conducted in the laboratory using photos (e.g., Wilkie & Stavridou, 2013), videos (e.g., Wang, Rodiek, Wu, Chen, & Li, 2016), or virtual reality devices (e.g., Schutte, Bhullar, Stilinović, & Richardson, 2017) based on the implicit assumption that exposure to simulated environments produces the same effects as exposure to real environments (de Kort, Meijnders, Sponselee, & IJsselsteijn, 2006; Valtchanov, Barton, & Ellard, 2010; Valtchanov & Ellard, 2010). However, some psychologists have shown that the technical characteristics of the simulated environments such as the dynamic (or static) characteristics of the stimulus (Heft & Nasar, 2000; Kroh & Gimblett, 1992) critically influence the perception of the environments. For moderation analysis, this variable has been coded in two levels: in laboratory and in situ.
3. *Environment.* The type of natural and urban environments investigated varies across studies (e.g., forest, mountains, lake, park, and boulevard). Furthermore, some studies have suggested that even a few urban or built elements in a natural setting could be enough to decrease the potential power of the natural environment to restore people's resources (e.g., Beil & Hanes, 2013; Hauru, Lehvävirta, Korpela, & Kotze, 2012; Pals, Steg, Dontje, Siero, & van der Zee, 2014). So, we classified natural environments into three categories, wild nature, urban nature (i.e., nature with a built element), and mixed (wild and urban nature) to verify whether the type of environment moderates a difference between nature and urban restorativeness.
4. *Measuring instruments.* The most used self-report questionnaire for investigating the cognitive qualities of environments (i.e., perceived restorativeness) is the Perceived Restorativeness Scale (Hartig et al., 1997) or variants of it. Other questionnaires that have been used are the Restorativeness Outcome Scale (Korpela, Ylén, Tyrväinen, & Silvennoinen, 2008; Takayama et al., 2014;

Tyrväinen et al., 2014), the Restorativeness State Scale (Van den Berg, Jorgensen, & Wilson, 2014), Environmental Restoration Perception (Martínez-Soto, Gonzales-Santos, Barrios, & Lena, 2014), and the Restorative Components Scale (Laumann et al., 2001; Stevens, 2014). When the total score of a scale was not available (e.g., Chen et al., 2016), the fascination dimension was used for meta-analysis purposes. Fascination is a central element in Kaplan's theory (Kaplan & Kaplan, 1989) because it links to the attentional system. In particular, it refers to the form of attention that does not require effort (involuntary attention) and, consequently it allows a fatigued attentional system to be restored (Kaplan, 1995). For moderation analyses, this variable has been codified in three levels: Perceived Restorativeness Scale (PRS), fascination, and other.

5. *Participants.* One of the main sources of variation between psychological studies is the type of participants that are used in surveys (Arnett, 2008; Henrich, Heine, & Norenzayan, 2010). Moreover, the extensive use of university students has often been criticized (e.g., Hanel & Vione, 2016). For this reason, we wanted to include the type of participants (student or general adults) used as a possible influence on the calculated effect sizes.

## Method

### *Literature Analysis and Inclusion Criteria*

Studies for inclusion in the analysis were selected using two different research strategies. Peer-reviewed articles were searched in different databases (PsycINFO, PsycARTICLES, SpringerLINK, and Web of Science) using combinations of the following keywords: restoration, restorativ\*, "restorative qualit\*\*", "perceived restorativeness scale", "restorative outcome\*\*", and "environment\* psychology". Then, the references list of the selected studies was examined to identify further studies. A total of 168 studies were selected.

First, we excluded studies that did not report primary data (e.g., theoretical papers or meta-analytic studies) and instrument validation papers ( $n = 23$ ). To be included in this meta-analysis, the remaining studies had to meet the following inclusion criteria:

- The restorativeness was investigated following direct visual exposure to real or simulated environments (photographs, video, or virtual reality). Studies that required the participants to evaluate an environment after imagining it (e.g., Korpela & Hartig, 1996; Korpela et al., 2008) or to evaluate personal experience (e.g., Kelz, Evans, & Röderer, 2015) were excluded.
- The restorativeness was investigated in at least two outdoor environments, one with natural elements (wild nature, city parks, or avenues) and one without natural elements (roads and buildings). Studies that required to the

participants to evaluate an indoor environment such as home interiors (e.g., Meagher, 2016), offices (e.g., Evensen, Raanaas, Hagerhall, Johansson, & Patil, 2015), or an undefined place such as the participants' "favorite place" (e.g., Ratcliffe & Korpela, 2016) were excluded.

- The restorativeness was investigated through a self-report questionnaire. Studies that investigated the effect of exposure to nature on memory (e.g., Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009) attention (e.g., Berto, 2005), other cognitive tests (e.g., Newman & Brucks, 2016), or on emotional resources (e.g., Lee et al., 2011; Ulrich, 1979) alone were excluded.

In total, 22 peer-reviewed studies met the inclusion criteria (Table 1). Most of them are within-subject research designs (60%) conducted in the laboratory (76%) with students (67%) using the Perceived Restorativeness Scale (67%).

### Data Analysis

To estimate effect size of the difference between restorativeness perceived in natural or urban environments, we used Cohen's  $d$  (1988). In almost all cases, the latter was calculated using the descriptive statistics and the following formulas: Cohen's  $d = \frac{\bar{z}_1 - \bar{z}_2}{s}$ ,  $s = \sqrt{\frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1 + n_2}}$ ; where  $\bar{x}$  = mean,  $s$  = standard deviation;  $n$  = sample size (Dunst, Hamby, & Trivette, 2004). We used the same Cohen's  $d$  formula for between-subject and within-subject studies because we did not have information about the correlation between the perceived restorativeness of natural and urban environments required in the formula for within-subject designs (Dunst et al., 2004). However, through personal communication we retrieved some, but not all, correlational data (R. Berto, personal communication, October 18, 2017; T. Hartig, personal communication, October 25, 2017; K. M. Korpela, personal communication, November 2, 2017; J. Martínez-Soto, personal communication, October 27, 2017; N. Takayama, personal communication, October 26, 2017). Data suggested low or zero correlation between perceived restorativeness scores in natural and urban environment (range = .00–.31). Consequently, the use of the between-subject formula was an appropriate alternative (Dunst et al., 2004). In two cases (Chen et al., 2016; Lee, Williams, Sargent, Williams, & Johnson, 2015), the descriptive statistics were not available and, therefore, the Cohen's  $d$  was calculated starting from the student  $t$ -statistic using the following formula: Cohen's  $d = t \sqrt{\frac{n_1 + n_2}{n_1 n_2}}$ .

When information regarding the sample size of groups compared (in the case of between-subject studies) was not available, we assigned equal numbers to the groups by dividing the participants in half.

The software *r* (metaphor package, version 2.0–0) was used for all analyzes. A random-effects model (estimation method: restricted maximum-likelihood) was used to estimate the medium effect size. In random effects models, each

**Table 1.** Characteristics and estimated effect size (Cohen's  $d$ ) for each of the 22 selected studies.

Author (Year)	No.	Research design	Exposition	Instrument	Participants	Environment	Cohen's $d$
Berto (2007)	20	Between	Laboratory	Perceived Restorativeness Scale	General adults	Wild	2.76
Berto et al. (2008)	40	Within	Laboratory	Perceived Restorativeness Scale	Students	Wild	6.68
Bodin & Hartig (2003)	12	Within	Situ	Fascination	General adults	Urban	3.03
Chen et al. (2016)	32	Between	Situ	Fascination	Students	Urban	1.14
Franek (2013)	70	Within	Situ	Fascination	Students	Urban	3.53
Hernandez (2005)	76	Between	Laboratory	Perceived Restorativeness Scale	Students	Urban	0.60
Herzog et al. (2003)	144	Within	Laboratory	Fascination	Students	Wild	0.49
Hietanen et al. (2007)	33	Within	Laboratory	Perceived Restorativeness Scale	Students	Urban	3.00
Hietanen et al. (2004)	20	Within	Laboratory	Perceived Restorativeness Scale	General adults	Wild	2.71
Korpela (2013)	81	Within	Laboratory	Perceived Restorativeness Scale	Students	Mixed	3.39
Lee et al. (2015)	150	Between	Laboratory	Perceived Restorativeness Scale	Students	Urban	0.41
Martinez-Soto et al. (2014)	96	Within	Laboratory	Other	Students	Wild	4.15
Schutte et al. (2017)	26	Between	Laboratory	Perceived Restorativeness Scale	Students	Wild	1.73
Stevens (2014)	69	Within	Laboratory	Other	General adults	Wild	1.86
Stigsdottir et al. (2017)	46	Within	Situ	Perceived Restorativeness Scale	Students	Wild	2.26
Takayama et al. (2014)	45	Within	Situ	Other	Students	Wild	0.89
Tang et al. (2017)	31	Within	Laboratory	Perceived Restorativeness Scale	General adults	Wild	4.36
Tyrväinen et al. (2014)	77	Within	Situ	Other	General adults	Urban	1.07
Van den berg et al. (2014)	50	Between	Laboratory	Other	Students	Wild	0.46
Wang et al. (2016)	40	Between	Laboratory	Perceived Restorativeness Scale	Students	Urban	4.15
Wilkie & Stavridou (2013)	113	Between	Laboratory	Perceived Restorativeness Scale	Students	Mixed	7.46
Wilkie & Clouston (2015)	100	Between	Laboratory	Perceived Restorativeness Scale	Students	Wild	0.40

study is weighted by the inverse of its variance, which includes both the variance between-subjects and the variance within-subjects (Borenstein, Hedges, Rothstein, & Higgins, 2009). This model was chosen instead of a fixed factor model because the studies included in the meta-analysis were conducted independently and using different methods in different populations, so we did not expect a common effect size. Heterogeneity was investigated through the Cochran's heterogeneity statistic ( $Q$ ) which tests the null hypothesis according to which the effect sizes of the individual studies are similar enough to share a common effect size (Cochran, 1954). A significant value for  $Q$  means heterogeneity between the effects. Because of the limited power of  $Q$  in identifying heterogeneity in the meta-analysis (Higgins, Thompson, Deeks, & Altman, 2003),  $p < .10$  are considered significant. The level of heterogeneity was investigated using the  $I^2$  statistic, which measures the proportion of total variance due to the variability between studies (i.e., the heterogeneity that is explained by the random effect). High values (75–100) correspond to high levels of heterogeneity, medium values (50–74) correspond to moderate heterogeneity, low values (1–49) correspond to low heterogeneity, and zero indicates the absence of heterogeneity (Higgins et al., 2003). To verify the presence of abnormal studies we checked the distribution of effect size (funnel plot) and the influence of individual studies on heterogeneity ( $Q$  statistic) and on the general model (Cook's distance).

Meta-analysis results can be influenced by bias due to publication process (e.g., scientific studies without significant results are not published). This phenomenon is commonly called "publication bias" (Rosenthal, 1995; Rothstein, Sutton, & Borenstein, 2005) and can be controlled through different strategies (Borenstein et al., 2009). We used the trim and fill approach of Duval and Tweedie (2000), a non-parametric method that estimates the number of studies missing from the meta-analysis by suppressing the studies that generate patterns of asymmetry and generating new data based on the initial sample to obtain a symmetrical effect size distribution.

Univariate moderation analyses were conducted to verify whether methodological differences between studies moderate the effect size estimated. In other words, we investigated whether the difference in restorativeness between environments changes depending, for example, on the instrument used or on the type of exposure. In particular, using univariate mixed effects models, we investigated the potential moderation effect of each of the variables coded: research design (between-subject or within-subject), location (laboratory or in situ), environment (wild nature or urban nature), instrument (PRS, fascination, or other tools), and participants (students or general adults). In addition to the indices previously described for the random effects model, the  $R^2$  statistic that quantifies the amount of heterogeneity explained by the moderator variables is also reported.

## Results

The effect sizes calculated for the individual studies included in the meta-analysis are listed in Table 1. All the estimated effect sizes were in the expected direction (median = 2.43) and had a normal distribution (asymmetry = 0.98, kurtosis = 0.72).

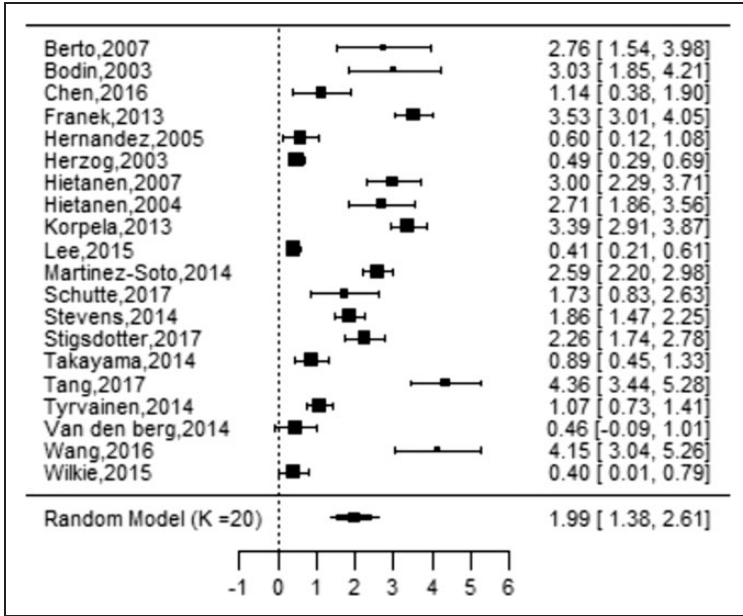
The random effects model ( $k = 22$ ,  $n = 1677$ ) estimated a medium effect size very large (Cohen's  $d$  (confidence interval, CI) = 2.46 (1.61–3.31); standard error (SE) = .41). The studies were heterogeneous ( $Q(21) = 731.97$ ,  $p < .001$ ) and the proportion of total variance due to the variability between studies was very high ( $I^2$  (CI) = 98.49% (97.42–99.29)). Trim and fill test was not significant suggesting no publication bias. Two studies, Wilkie & Stavridou (2013) and Berto (2008) had an effect size very far from the medium effect size estimated and from the confidence intervals ( $\pm 1.96$  SE), Cohen's  $d = 7.46$ , and Cohen's  $d = 6.68$ , respectively. Moreover, both had high Cook's distance values indicating a huge influence on the medium effect size estimated. Wilkie's study had also a large influence on the studies' heterogeneity. For this reason, a second random model was run after exclusion of the Wilkie et al. (2013) and Berto (2008) studies.

The effect size estimated by this second model was still large (Cohen's  $d$  (CI) = 1.99 (1.38–2.61), SE = .29), although lower but more accurate than those estimated by first random model (Figure 1). The heterogeneity of the studies was still very high ( $Q(19) = 503.19$ ,  $p < .001$ ;  $I^2$  (CI) = 96.97% (94.61–98.62)) and trim and fill approach was not significant.

Univariate mixed effect models were run to verify whether moderator variable could explain the high heterogeneity. As shown in Table 2, only research design and the kind of participants involved explained a small amount of heterogeneity (13% and 3%, respectively) but their influence was not significant. None of the other moderators considered explained the different effect sizes found in single studies. Even so, the differences in effect sizes were in the expected direction: (1) in within-subject studies, the difference between nature and urban environment was higher (Cohen's  $d = 2.39$ ) than in between studies (Cohen's  $d = 1.36$ ), (2) studies conducted in laboratory (Cohen's  $d = 2.32$ ) than in situ (Cohen's  $d = 1.97$ ), (3) studies comparing urban environment to urban nature (Cohen's  $d = 2.06$ ) than to wild nature (Cohen's  $d = 1.82$ ). The "mixed" category for the type of environment was excluded in the moderation analysis because only one study (Korpela, 2013) fell into this category.

## Discussion and Conclusion

The aim of this study was to conduct a meta-analysis on studies comparing perceived restorativeness resulting from direct exposure to natural or urban environments (simulated or real). In particular, this meta-analysis sought to



**Figure 1.** Forest plot: *Cohen's d* computed for each studies and medium effect size computed by the random effect model ( $k = 20$ ; in brackets confidence interval of *Cohen's d*).

estimate how much nature is perceived as more restorative than urban environments. Results pointed to nature being perceived as more restorative than urban environments, confirming from an empirical point of view what is typically now considered a given in environmental psychology (Gifford, 2014; Staats, 2012). The relevant indicator was the magnitude of the estimated medium effect size, which was particularly large ( $Cohen's d = 1.99$ ) compared with those that are usually observed in psychology (Brand & Bradley, 2016). These results suggest that self-report questionnaires reliably discriminate between natural and urban environments with respect to perceived restorativeness. Moreover, moderator analysis indicated: (1) no real difference between instruments used in the literature and (2) no difference between global scales or fascination subscale supporting the use of fascination items alone when other subscales were not available.

However, although this meta-analysis suggests that nature is perceived to be much more restorative than urban environments, its real benefits on people's cognitive resources may not be substantially greater than those offered by urban environments.

Indeed, if as claimed by the ART (Kaplan & Kaplan, 1989), the recovery of cognitive resources is the result of an interaction between direct attention and

**Table 2.** Results of univariate mixed effect model.

	Test of moderator		Model results		
	QM ( <i>F</i> (1,18))	<i>p</i>	<i>R</i> <sup>2</sup> (%)	Cohen's <i>d</i>	95% CI
Research design	3.32	.085	13.40		
Between				1.36	0.44–2.29
Within				2.39	1.65–3.13
Exposition	0.01	.940	0.00		
Laboratory				2.32	1.43–3.21
In situ				1.97	0.57–3.37
Environment	0.14 <sup>a</sup>	.7118	0.00		
Wild nature				1.82	0.98–2.67
Urban nature				2.05	1.06–3.05
Instrument	0.84 <sup>b</sup>	.449	0.00		
PRS				2.29	1.44–3.13
Fascination				2.01	0.61–3.40
Other				1.38	0.16–2.60
Participant	1.68	.211	3.15		
Student				1.76	1.04–2.47
General adults				2.58	1.45–3.71

CI: confidence interval.

<sup>a</sup>*df* = 1, 17. Mixed environments were excluded from this analysis because it was represented by only one study (Korpela, 2013).

<sup>b</sup>*df* = 2, 18.

intrinsic properties of the environments, this recovery should occur regardless of what is perceived (Pearson & Craig, 2014). Environments can be assessed as more restorative even if cognitive performance is not influenced by the quality of the environment (Evensen et al., 2015). Consequently, measuring the perceived restorativeness without directly measuring the effects on cognitive functions could lead to misleading results (Pearson & Craig, 2014).

The second aim of this study was to investigate whether methodological differences could explain variability across studies.

First, moderation analyses highlighted that, as expected, research design partly explained the variability between studies, with higher effect sizes observed in within-subject studies than those observed in between-subject studies. This depended on the better inter-individual variability control in the first kind of research design than in the second. Indeed, obtaining two different measurements from the same subject makes it possible to exclude the influence of between-subject differences on the construct under investigation. So, people's personal characteristics (i.e., age, gender, educational level, or personality) could play a significant role in determining the perceived restorativeness of certain

environments. For example, age does not seem to influence the perception of the restorative qualities of the environments (Berto, 2007), however, natural and urban environments could have different restorative potential in relation to the stage of life (Scopelliti & Giuliani, 2004). McMahan found higher correlation between positive mood and nature exposure in older people (McMahan & Estes, 2015). There seemed not to be any studies that have verified the effect of gender or educational level on the perception of restorativeness. There were gaps in the demographic details across the studies we used for analysis and so it was not possible to check the extent of moderating effects of these variables. Future studies that are able to take these variables into account identify their possible effects on the perception of restorativeness perceived in a given environment. Personality characteristics could also play a role in determining the perceived restorativeness of environments. For example, it has been suggested that neuroticism influences the perceived restorativeness of home environments (Meagher, 2016). Furthermore, people with high neuroticism scores might obtain greater benefits following exposure to urban environments than people who score lower on neuroticism (Newman & Brucks, 2016). It has also been suggested that the ability to perceive the restorative potential of an environment depends on the level of affinity with natural elements. Empirical evidence shows that a high degree of perceived naturalness (Carrus et al., 2013; Hartig et al., 1997; Hipp, Gulwadi, Alves, & Sequeira, 2016), and connection with nature (Berto et al., 2018) could increase the perceived restorativeness of the environment.

Our results also highlight that nature is perceived as more restorative than urban environments regardless of the context of exposure (in the laboratory or in situ), the kind of natural environment being considered (wild or urban nature), the measurement instrument being used, or the kinds of people making the judgments. Consequently, these findings suggest that reproduced (virtual) environments are valid representations of real environments, confirming the implicit assumption that exposure to simulated environments produces the same effects as exposure to real environments (Stamps, 1990; Valtchanov et al., 2010; Valtchanov & Ellard, 2010). Moreover, students can be considered a good representative sample of the general population when the aim is to investigate the perception of restorativeness in different environments.

We found that all of the measurement instruments used to assess the perceived restorativeness of environments had the same ability to detect differences between environments. As a result, after appropriately transforming scales, plausible comparisons can be made between studies using different tools.

Finally, these findings suggest that urban nature could be a valid substitute for wild nature when planning restorative environments (McMahan & Estes, 2015). However, even if the presence of human alteration (e.g., street, buildings, etc.) seems not to influence perception of the restorative qualities of an environment, other environmental characteristics could influence it. Indeed, the

literature reports different restorative potential in respect of level of greenery (Beil & Hanes, 2013; de Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003; Hauru et al., 2012; Pals et al., 2014), biodiversity (Carrus et al., 2015; Hartig et al., 2014; Marselle, Irvine, Lorenzo-Arribas, & Warber, 2016), and percentage (de Vries et al., 2003; White, Pahl, Ashbullby, Herbert, & Depledge, 2013; White et al., 2010) and kinds of water surface (Wilkie & Stavridou, 2013). High levels of greenery (e.g., Beil & Hanes, 2013; Hauru et al., 2012) or the presence of a water surface (e.g., river, lake, and sea; Tang et al., 2017; White et al., 2010, 2013) increase the perceived restorativeness of the environment. Urban environments with water elements could have the same restorative potential as nature without water (White et al., 2010). Conversely, environments with unpleasant water elements could be less restorative than environments without water (Wilkie & Stavridou, 2013). Moreover, empirical evidence suggested that the characteristics of light (e.g., brightness, evenness, extensiveness, color quality, and glare) influence the perception of restorativeness qualities (e.g., Nikunen & Korpela, 2009; Nikunen, Puolakka, Rantakallio, Korpela, & Halonen, 2014). For example, natural light (fire and sunset) enhance the fascination of an environment (Kaplan & Kaplan, 1989), brightness promotes its exploration (scope), and color quality facilitates relaxation and feelings of being away (Nikunen et al., 2014).

In sum, the critical aspect in determining the levels of perceived restorativeness is probably not the presence of human alteration (e.g., street, buildings, etc.) but particular (objective of subjective) features of the environment. So, investigations of different kinds of urban natural environments and on elements that discriminate each other are needed.

The principal limitation of this study is linked with the computation of effect sizes. We considered within-subject studies as between-subject studies because we did not have relevant correlational data from some studies. This approach is conservative (e.g., Elbourne et al., 2002) and consequently effect size of within studies could be underestimated. So, it is plausible to hypothesize that in within-subject studies compared with between-subject studies, the difference between the perceived levels of restorativeness across nature and urban environments is potentially higher.

Second, we included only peer-reviewed studies and we did not include articles from the so-called grey literature. However, we controlled for the presence of publication bias and the result was negative.

In conclusion, this meta-analysis supports the view that nature environments are perceived as much more restorative than urban environments, independently of mode of presentation, participants making the judgments, and the instruments used to assess the judgments. Consequently, we suggest that researchers should shift the focus from the comparison between nature and urban environments or between real and simulated environments and from the development of

measurement tools to the identification of environmental or individual variables that influence the perception of restorativeness.

### Declaration of Conflicting Interests

The author(s) declared no potential 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.

### ORCID iD

Elisa Menardo  <https://orcid.org/0000-0002-4813-2980>

### References

- Arnett, J. J. (2008). The neglected 95%: Why American psychology needs to become less American. *American Psychologist*, *63*(7), 602–614. doi:10.1037/0003-066X.63.7.602
- Beil, K., & Hanes, D. (2013). The influence of urban natural and built environments on physiological and psychological measures of stress—A pilot study. *International Journal of Environmental Research and Public Health*, *10*(4), 1250–1267. doi:10.3390/ijerph10041250
- 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. (2007). Assessing the restorative value of the environment: A study on the elderly in comparison with young adults and adolescents. *International journal of psychology*, *42*(5), 331–341.
- Berto, R. (2014). The role of nature in coping with psycho-physiological stress: A literature review on restorativeness. *Behavioral Sciences*, *4*(4), 394–409. doi:10.3390/bs4040394
- 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.
- Berto, R., Barbiero, G., Barbiero, P., & Senes, G. (2018). An individual's connection to nature can affect perceived restorativeness of natural environments. Some observations about biophilia. *Behavioral Sciences*, *8*(3), 34. doi:10.3390/bs8030034
- Bodin, M., & Hartig, T. (2003). Does the outdoor environment matter for psychological restoration gained through running? *Psychology of Sport and Exercise*, *4*(2), 141–153. doi:10.1016/S1469-0292(01)00038-3
- Borenstein, M., Hedges, L. V., Rothstein, H. R., & Higgins, J. P. T. (2009). *Introduction to meta-analysis*. Chichester, England: John Wiley & Sons.
- Bowler, D. E., Buyung-Ali, L. M., Knight, T. M., & Pullin, A. S. (2010). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health*, *10*(1), 456. doi:10.1186/1471-2458-10-456

- Brand, A., & Bradley, M. T. (2016). The precision of effect size estimation from published psychological research: Surveying confidence intervals. *Psychological Reports*, *118*(1), 154–170. doi:10.1177/0033294115625265
- Carrus, G., Laforteza, R., Colangelo, G., Dentamaro, I., Scopelliti, M., & Sanesi, G. (2013). Relations between naturalness and perceived restorativeness of different urban green spaces. *Psychology*, *4*(3), 227–244. doi:10.1174/217119713807749869
- Carrus, G., Scopelliti, M., Laforteza, R., Colangelo, G., Ferrini, F., Salbitano, F., . . . Sanesi, G. (2015). Go greener, feel better? The positive effects of biodiversity on the well-being of individuals visiting urban and peri-urban green areas. *Landscape and Urban Planning*, *134*, 221–228. doi:10.1016/j.landurbplan.2014.10.022
- Chen, Z., He, Y., & Yu, Y. (2016). Enhanced functional connectivity properties of human brains during in-situ nature experience. *PeerJ*, *4*, e2210. doi:10.7717/peerj.2210
- Cochran, W. G. (1954). The combination of estimates from different experiments. *Biometrics*, *10*(1), 101. doi:10.2307/3001666
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.
- de Kort, Y. A. W., Meijnders, A. L., Sponselee, A. A. G., & IJsselsteijn, W. A. (2006). What's wrong with virtual trees? Restoring from stress in a mediated environment. *Journal of Environmental Psychology*, *26*(4), 309–320. doi:10.1016/j.jenvp.2006.09.001
- de Vries, S., Verheij, R. A., Groenewegen, P. P., & Spreeuwenberg, P. (2003). Natural environments—Healthy environments? An exploratory analysis of the relationship between greenspace and health. *Environment and Planning A: Economy and Space*, *35*(10), 1717–1731. doi:10.1068/a35111
- Dunst, C. J., Hamby, D. W., & Trivette, C. M. (2004). Guidelines for calculating effect sizes for practice-based research syntheses. *Centerscope* *3*(1), 10.
- Duval, S., & Tweedie, R. (2000). Trim and fill: A simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics*, *56*(2), 455–463. doi:10.1111/j.0006-341X.2000.00455.x
- Elbourne, D. R., Altman, D. G., Higgins, J. P., Curtin, F., Worthington, H. V., & Vail, A. (2002). Meta-analyses involving cross-over trials: Methodological issues. *International Journal of Epidemiology*, *31*, 140–149.
- Evensen, K. H., Raanaas, R. K., Hagerhall, C. M., Johansson, M., & Patil, G. G. (2015). Restorative elements at the computer workstation: A comparison of live plants and inanimate objects with and without window view. *Environment and Behavior*, *47*(3), 288–303. doi:10.1177/0013916513499584
- Franěk, M. (2013). Environmental factors influencing pedestrian walking speed. *Perceptual and motor skills*, *116*(3), 992–1019.
- Gifford, R. (2014). Environmental psychology matters. *Annual Review of Psychology*, *65*(1), 541–579. doi:10.1146/annurev-psych-010213-115048
- Hanel, P. H. P., & Vione, K. C. (2016). Do student samples provide an accurate estimate of the general public? *PLoS One*, *11*(12), e0168354. doi:10.1371/journal.pone.0168354
- Hartig, T. (2004). Restorative environments. In C. Spielberger (Ed.), *Encyclopedia of applied psychology* (pp. 273–279). Amsterdam, the Netherlands: Elsevier. doi:10.1016/B0-12-657410-3/00821-7

- Hartig, T., Korpela, K., Evans, G. W., & Gärling, T. (1997). A measure of restorative quality in environments. *Scandinavian Housing and Planning Research*, *14*(4), 175–194. doi:10.1080/02815739708730435
- Hartig, T., Mitchell, R., de Vries, S., & Frumkin, H. (2014). Nature and health. *Annual Review of Public Health*, *35*, 207–228. doi:10.1146/annurev-publhealth-032013-182443
- Hartig, T., van der Berg, A. E., Hagerhall, C. M., Tomalak, M., Bauer, N., Hansmann, R., . . . Waaseth, G. (2011). Health benefits of nature experience: Psychological, social and cultural processes. In K. Nilsson, M. Sangster, C. Gallis, T. Hartig, S. de Vries, K. Seeland, & J. Schipperijn (Eds.), *Forests, trees and human health* (pp. 127–168). Dordrecht, the Netherlands: Springer. doi:10.1007/978-90-481-9806-1\_5
- Hauru, K., Lehvävirta, S., Korpela, K., & Kotze, D. J. (2012). Closure of view to the urban matrix has positive effects on perceived restorativeness in urban forests in Helsinki, Finland. *Landscape and Urban Planning*, *107*(4), 361–369. doi:10.1016/j.landurbplan.2012.07.002
- Heft, H., & Nasar, J. L. (2000). Evaluating environmental scenes using dynamic versus static displays. *Environment and Behavior*, *32*(3), 301–322.
- Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences*, *33*(2–3), 61–83. doi:10.1017/S0140525X0999152X
- Hernández, B., & Hidalgo, M. C. (2005). Effect of urban vegetation on psychological restorativeness. *Psychological reports*, *96*(3\_suppl), 1025–1028.
- Herzog, T. R., Maguire, P., & Nebel, M. B. (2003). Assessing the restorative components of environments. *Journal of Environmental Psychology*, *23*(2), 159–170.
- Hietanen, J. K., & Korpela, K. M. (2004). Do both negative and positive environmental scenes elicit rapid affective processing?. *Environment and behavior*, *36*(4), 558–577.
- Hietanen, J. K., Klemetilä, T., Kettunen, J. E., & Korpela, K. M. (2007). What is a nice smile like that doing in a place like this? Automatic affective responses to environments influence the recognition of facial expressions. *Psychological Research*, *71*(5), 539–552.
- Higgins, J. P. T., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *British Medical Journal*, *327*(7414), 557–560. doi:10.1136/bmj.327.7414.557
- Hipp, J. A., Gulwadi, G. B., Alves, S., & Sequeira, S. (2016). The relationship between perceived greenness and perceived restorativeness of university campuses and student-reported quality of life. *Environment and Behavior*, *48*(10), 1292–1308. doi:10.1177/0013916515598200
- Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. Cambridge, England: CUP Archive.
- 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
- Kelz, C., Evans, G. W., & Röderer, K. (2015). The restorative effects of redesigning the schoolyard: A multi-methodological, quasi-experimental study in rural Austrian middle schools. *Environment and Behavior*, *47*(2), 119–139. doi:10.1177/0013916513510528
- Korpela, K., & Hartig, T. (1996). Restorative qualities of favorite places. *Journal of Environmental Psychology*, *16*(3), 221–233. doi:10.1006/jevp.1996.0018

- Korpela, K. M. (2013). Perceived restorativeness of urban and natural scenes—Photographic illustrations. *Journal of Architectural and Planning Research*, 30(1), 23–38.
- Korpela, K. M., Klemettilä, T., & Hietanen, J. K. (2002). Evidence for rapid affective evaluation of environmental scenes. *Environment and Behavior*, 34(5), 634–650. doi:10.1177/0013916502034005004
- Korpela, K. M., Ylén, M., Tyrväinen, L., & Silvennoinen, H. (2008). Determinants of restorative experiences in everyday favorite places. *Health & Place*, 14(4), 636–652. doi:10.1016/j.healthplace.2007.10.008
- Kroh, D. P., & Gimblett, R. H. (1992). Comparing live experience with pictures in articulating landscape preference. *Landscape Research*, 17(2), 58–69. doi:10.1080/01426399208706362
- Laumann, K., Gärling, T., & Stormark, K. M. (2001). Rating scale measures of restorative components of environments. *Journal of Environmental Psychology*, 21(1), 31–44. doi:10.1006/jenvp.2000.0179
- Lee, J., Park, B.-J., Tsunetsugu, Y., Ohira, T., Kagawa, T., & Miyazaki, 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
- Lee, K. E., Williams, K. J. H., Sargent, L. D., Williams, N. S. G., & Johnson, K. A. (2015). 40-second green roof views sustain attention: The role of micro-breaks in attention restoration. *Journal of Environmental Psychology*, 42, 182–189. doi:10.1016/j.jenvp.2015.04.003
- Lin, Y.-H., Tsai, C.-C., Sullivan, W. C., Chang, P.-J., & Chang, C.-Y. (2014). Does awareness effect the restorative function and perception of street trees? *Frontiers in Psychology*, 5, doi:10.3389/fpsyg.2014.00906
- Marselle, M. R., Irvine, K. N., Lorenzo-Arribas, A., & Warber, S. L. (2016). Does perceived restorativeness mediate the effects of perceived biodiversity and perceived naturalness on emotional well-being following group walks in nature? *Journal of Environmental Psychology*, 46, 217–232. doi:10.1016/j.jenvp.2016.04.008
- Martínez-Soto, J., Gonzales-Santos, L., Barrios, F. A., & Lena, M. E. M.-L. (2014). Affective and restorative valences for three environmental categories. *Perceptual and Motor Skills*, 119(3), 901–923. doi:10.2466/24.50.PMS.119c29z4
- Mayer, F. S., Frantz, C. M., 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
- McAllister, E., Bhullar, N., & Schutte, N. S. (2017). Into the woods or a stroll in the park: How virtual contact with nature impacts positive and negative affect. *International Journal of Environmental Research and Public Health*, 14(7), 786. doi:10.3390/ijerph14070786
- 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
- Meagher, B. R. (2016). There's no place like a neurotic's home: Neuroticism moderates the prioritization of restorative properties in home environments. *Journal of Individual Differences*, 37(4), 260–267. doi:10.1027/1614-0001/a000213

- Mitchell, R. (2013). Is physical activity in natural environments better for mental health than physical activity in other environments? *Social Science & Medicine*, *91*, 130–134. doi:10.1016/j.socscimed.2012.04.012
- Mitchell, R., & Popham, F. (2008). Effect of exposure to natural environment on health inequalities: An observational population study. *Lancet (London, England)*, *372*(9650), 1655–1660. doi:10.1016/S0140-6736(08)61689-X
- Newman, K. P., & Brucks, M. (2016). When are natural and urban environments restorative? The impact of environmental compatibility on self-control restoration. *Journal of Consumer Psychology*, *26*(4), 535–541. doi:10.1016/j.jcps.2016.02.005
- Nikunen, H. J., & Korpela, K. M. (2009). Restorative lighting environments—does the focus of light have an effect on restorative experiences? *Journal of Light & Visual Environment*, *33*(1), 37–45. doi:10.2150/jlve.33.37
- Nikunen, H., Puolakka, M., Rantakallio, A., Korpela, K., & Halonen, L. (2014). Perceived restorativeness and walkway lighting in near-home environments. *Lighting Research & Technology*, *46*(3), 308–328. doi:10.1177/1477153512468745
- Ohly, H., White, M. P., Wheeler, B. W., Bethel, A., Ukoumunne, O. C., Nikolaou, V., . . . Garside, R. (2016). Attention restoration theory: A systematic review of the attention restoration potential of exposure to natural environments. *Journal of Toxicology and Environmental Health, Part B*, *19*(7), 305–343. doi:10.1080/10937404.2016.1196155
- Pals, R., Steg, L., Dontje, J., Siero, F. W., & van der Zee, K. I. (2014). Physical features, coherence and positive outcomes of person–environment interactions: A virtual reality study. *Journal of Environmental Psychology*, *40*, 108–116. doi:10.1016/j.jenvp.2014.05.004
- Pasini, M., Berto, R., Brondino, M., Hall, R., & Ortner, C. (2014). How to measure the restorative quality of environments: The PRS-11. *Procedia-Social and Behavioral Sciences*, *159*, 293–297. doi:10.1016/j.sbspro.2014.12.375
- Pearson, D. G., & Craig, T. (2014). The great outdoors? Exploring the mental health benefits of natural environments. *Frontiers in Psychology*, *5*, doi:10.3389/fpsyg.2014.01178
- Ratcliffe, E., & Korpela, K. M. (2016). Memory and place attachment as predictors of imagined restorative perceptions of favourite places. *Journal of Environmental Psychology*, *48*, 120–130.
- Rosenthal, R. (1995). Writing meta-analytic reviews. *Psychological Bulletin*, *118*(2), 183–192. doi:10.1037/0033-2909.118.2.183
- Rothstein, H. R., Sutton, A. J., & Borenstein, M. (2005). *Publication bias in meta-analysis*. Chichester, England: Wiley.
- Schutte, N. S., Bhullar, N., Stilić, E. J., & Richardson, K. (2017). The impact of virtual environments on restorativeness and affect. *Ecopsychology*, *9*(1), 1–7. doi:10.1089/eco.2016.0042
- Scopelliti, M., & Giuliani, M. V. (2004). Choosing restorative environments across the lifespan: A matter of place experience. *Journal of Environmental Psychology*, *24*(4), 423–437. doi:10.1016/j.jenvp.2004.11.002
- Staats, H. (2012). *Restorative environments*. Oxford, England: Oxford University Press. doi:10.1093/oxfordhb/9780199733026.013.0024
- Stamps, A. E. (1990). Use of photographs to simulate environments: A meta-analysis. *Perceptual and Motor Skills*, *71*, 907–913.

- Stevens, P. (2014). Affective priming of perceived environmental restorativeness: Affect and perceived restorativeness. *International Journal of Psychology, 49*(1), 51–55. doi:10.1002/ijop.12016
- Stigsdotter, U. K., Corazon, S. S., Sidenius, U., Kristiansen, J., & Grahn, P. (2017). It is not all bad for the grey city—A crossover study on physiological and psychological restoration in a forest and an urban environment. *Health & Place, 46*, 145–154. doi:10.1016/j.healthplace.2017.05.007
- Takayama, N., Korpela, K., Lee, J., Morikawa, T., Tsunetsugu, Y., Park, B.-J., ... Kagawa, T. (2014). Emotional, restorative and vitalizing effects of forest and urban environments at four sites in Japan. *International Journal of Environmental Research and Public Health, 11*(7), 7207–7230. doi:10.3390/ijerph110707207
- Tang, I.-C., Tsai, Y.-P., Lin, Y.-J., Chen, J.-H., Hsieh, C.-H., Hung, S.-H., ... Chang, C.-Y. (2017). Using functional Magnetic Resonance Imaging (fMRI) to analyze brain region activity when viewing landscapes. *Landscape and Urban Planning, 162*, 137–144. doi:10.1016/j.landurbplan.2017.02.007
- Tyrväinen, L., Ojala, A., Korpela, K., Lanki, T., Tsunetsugu, Y., & Kagawa, T. (2014). The influence of urban green environments on stress relief measures: A field experiment. *Journal of Environmental Psychology, 38*, 1–9. doi:10.1016/j.jenvp.2013.12.005
- Ulrich, R. S. (1979). Visual landscapes and psychological well-being. *Landscape Research, 4*(1), 17–23. doi:10.1080/01426397908705892
- Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. In I. Altman & J. F. Wohlwill (Eds.), *Behavior and the natural environment* (pp. 85–125). Boston, MA: Springer US. doi:10.1007/978-1-4613-3539-9\_4
- Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology, 11*(3), 201–230. doi:10.1016/S0272-4944(05)80184-7
- 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 Cyber Therapy and Rehabilitation, 3*(4), 359–373.
- Van den Berg, A. E., Jorgensen, A., & Wilson, E. R. (2014). Evaluating restoration in urban green spaces: Does setting type make a difference? *Landscape and Urban Planning, 127*, 173–181. doi:10.1016/j.landurbplan.2014.04.012
- Wang, X., Rodiek, S., Wu, C., Chen, Y., & Li, Y. (2016). Stress recovery and restorative effects of viewing different urban park scenes in Shanghai, China. *Urban Forestry & Urban Greening, 15*, 112–122. doi:10.1016/j.ufug.2015.12.003
- White, M., Smith, A., Humphries, K., Pahl, S., Snelling, D., & Depledge, M. (2010). Blue space: The importance of water for preference, affect, and restorativeness ratings of natural and built scenes. *Journal of Environmental Psychology, 30*(4), 482–493. doi:10.1016/j.jenvp.2010.04.004
- White, M. P., Pahl, S., Ashbullby, K., Herbert, S., & Depledge, M. H. (2013). Feelings of restoration from recent nature visits. *Journal of Environmental Psychology, 35*, 40–51. doi:10.1016/j.jenvp.2013.04.002

- Wilkie, S., & Clouston, L. (2015). Environment preference and environment type congruence: Effects on perceived restoration potential and restoration outcomes. *Urban Forestry & Urban Greening*, *14*(2), 368–376. doi: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 & Urban Greening*, *12*(2), 163–170. doi:10.1016/j.ufug.2013.01.004
- Wilson, E. O. (1984). *Biophilia*. Cambridge, MA: Harvard University Press.

### Author Biographies

**Elisa Menardo**, completed her master degree in Health and Clinical Psychology at the University of Pisa. She is now a PhD student in Human Sciences at the University of Verona. Her current research interests include data analysis, environmental psychology, personality psychology, sport psychology.

**Margherita Brondino**, completed her graduate studies (PhD) in Organizational Psychology at the University of Verona. She is research assistant in Psychometrics at the University of Verona, Department of Human Science. Her current research interests include organizational psychology, wellbeing and safety at work, work related stress, psychometrics and data analysis in psychology, environmental psychology.

**Rob Hall** is director of Environmetrics, research center in Sydney, Australia. He holds a PhD in psychology from Macquarie University. He is a member of a number of professional organizations including the Australian Psychological Society, the American Psychological Association, the Australian Social and Market Research Society and the Statistical Society of Australia. He combines academic expertise with the practical knowledge gained from his work with range of public and private organizations, assisting them to develop appropriate policies to meet their strategic goals.

**Margherita Pasini** is associate professor in psychometrics at the University of Verona, at the Department of Human Science. She is director of “Applied Psychology Measurement Lab” (APsyM Lab) at University of Verona, a research lab which aims to investigate the theoretical aspects related to measurement, research design, and data analysis in psychology, mainly in the research areas like organizational psychology, environmental psychology, cognitive processes in connection with Information and Communication Technology, emotions in learning contexts.