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„Linking implicit biodiversity preferences in forests to biospheric concern and nature connectedness"

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Abstract

Undeniably, one of the biggest challenges the earth's population is currently facing is the global loss of biological biodiversity and its immense negative impacts on fundamental ecosystem services, which makes the need for conservation an important area of study. The positive effects of biodiverse ecosystems on human health have been widely studied. Biodiverse landscapes have been shown to be preferred over less biodiverse ones. Additionally, these landscape preferences are associated with environmental values. However, most of this research uses explicit rather than implicit measurement approaches. Aiming for full human support of biodiversity conservation, understanding implicit landscape preferences, too, proves to be a key factor. Drawing on the Preference Matrix the implicit landscape preferences in biodiversity were examined here using the Implicit Association Test. The main research interest was to investigate the interrelations between implicit biodiversity preferences, biospheric concern and nature connectedness. In total, 105 people participated in the online study (M_{age} = 28.2 years, SD_{age} = 9.77 years; 67 female, 38 male). Results revealed a strong implicit positive association with biodiversity. However, no significant relationship between this association and biospheric concern or nature connectedness was demonstrated. Thus, it could be shown that preference for biodiversity can also be measured implicitly. The analyses are reproducible and can be accessed at https://osf.io/wh2vu/.

Keywords: biodiversity, landscape preference, biospheric concern, nature connectedness

Zusammenfassung

Eine der größten Herausforderungen, mit denen die Weltbevölkerung derzeit konfrontiert ist, ist sicherlich der weltweite Verlust der biologischen Vielfalt und seine immensen negativen Auswirkungen auf die grundlegenden Ökosystemleistungen, was die Notwendigkeit der Erhaltung zu einem wichtigen Thema macht. Die positiven Auswirkungen von biodiversen Ökosystemen auf die menschliche Gesundheit sind umfassend untersucht worden. Es hat sich auch gezeigt, dass biodiverse Landschaften gegenüber weniger biodiversen Landschaften bevorzugt werden. Zudem werden diese Landschaftspräferenzen mit Umweltwerten in Verbindung gebracht. Die meisten dieser Forschungsarbeiten verwenden jedoch explizite Messansätze. Im Hinblick auf eine umfassende Unterstützung der Erhaltung der biologischen Vielfalt durch den Menschen erweist sich auch das Verständnis impliziter Landschafts-präferenzen als ein Schlüsselfaktor. Auf der Grundlage der Präferenzmatrix wurden hier die impliziten Landschaftspräferenzen in Bezug auf die biologische Vielfalt mit Hilfe des Impliziten Assoziationstests untersucht. Das Hauptforschungsinteresse bestand darin, die Zusammenhänge zwischen impliziten Biodiversitätspräferenzen, biosphärischer Besorgnis und Naturverbundenheit zu untersuchen. Insgesamt nahmen 105 Personen an der Online-Studie teil (M_{age} = 28,2 Jahre, SD_{age} = 9,77 Jahre; 67 weiblich, 38 männlich). Die Ergebnisse zeigten eine starke implizite positive Assoziation mit biologischer Vielfalt. Es konnte jedoch kein signifikanter Zusammenhang zwischen dieser Assoziation und der Sorge um die Biosphäre oder der Naturverbundenheit nachgewiesen werden. Es konnte also gezeigt werden, dass die Präferenz für Biodiversität auch implizit gemessen werden kann. Die Analysen sind reproduzierbar und können unter https://osf.io/wh2vu/ abgerufen werden.

Stichworte: Biodiversität, Landschaftspräferenz, biosphärische Besorgnis, Naturverbundenheit

Linking implicit biodiversity preferences in forests to biospheric concern and nature connectedness

The global issues of biodiversity loss and its huge negative impacts on fundamental ecosystem services for humans is one of the biggest challenges the world population is currently facing (Aerts et al., 2018; Brockerhoff et al., 2017; Cardinale et al., 2012; Hooper et al., 2012). Functioning ecosystems are necessary for human survival, as they ensure food supplies and water reserves (Secretariat of the Convention on Biological Diversity, 2005). Additionally, heat mitigation as well as reduction in noise and air pollution constitute important ecosystem services that promote positive effects on human health (Aerts et al., 2018). In addition, nature, especially forests, act as important recreational areas for humans (Marselle et al., 2021; Röhrig et al., 2020). It may be noted, however, that anthropogenic nature such as parks or planted forests are less valuable ecosystems in contrast to those of natural green spaces and forests high in biodiversity (Baral et al., 2016; Sandifer et al., 2015). Biodiversity can be defined as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems" (United Nations Convention on Biological Diversity, 1992, p. 3). The resilience of ecosystems, i.e. the biodiversity especially the genetic diversity, is additionally crucial for the upcoming adaptation to climate change and thus an increasingly important metric that should be continuously studied in an interdisciplinary manner. From this it can be inferred that preserving the nature that surrounds us, especially its biodiversity, is one of the most important tasks of today's society. Dwindling biodiversity currently occurs not only in fields and agriculture (Dudley & Alexander, 2017), but particularly in forests as the prevalence of monocultures is rapidly increasing (Liu et al., 2018). To combat this, it is critical to increase the resilience of the forest through the habitation of mixed species in order to make it less vulnerable to natural disturbances, and allow it to continue providing the essential ecosystem services for the human population (Jactel et al., 2017).

Ecosystems and Health

Ecosystem services seem to have positive effects on human health in both the short term (Kabisch et al., 2021) and the long term (Astell-Burt et al., 2014; Frumkin et al., 2017; Zhang et al., 2020). For example, green spaces have been linked to overall improved psychological well-being (Cleary et al., 2019), reduced stress (Berto, 2014; Ward Thompson et al., 2016), depression, anxiety (Beyer et al., 2014), and aggression (Younan et al., 2016), as well as improved sleep quality (Grigsby-Toussaint et al., 2015). Of studied greenspaces, natural woodlands appeared to create the most healthy environments of all (Betts et al., 2017; Doimo et al., 2020; Simkin et al., 2020). Because of this the need for effectively restorative forests is even more apparent in the wake of the current forest dieback caused by advancing climate change (Betts et al., 2017; Deuffic et al., 2020).

Biodiversity and Health

It was investigated whether the specific type of green environment affects the aforementioned health benefits, since the nature found in cities is primarily “managed nature” as opposed to “unmanaged nature” (Kabisch et al., 2021; Wyles et al., 2019). For instance, landscapes which are perceived as more natural are considered to have a stronger impact on mitigating depression in adolescents (Mavoa, Lucassen et al., 2019). Simkin’s (2020) research team examined the perceived restorative effects of different forests and their associated explicit positive and negative emotions on the individuals they were surrounding. The scientists concluded that natural forests and old commercial forests had the greatest restorative effects, while urban forests followed by young commercial forests had the least. This effect may be due to human influence resulting in reduced naturalness and an overall decrease in biodiversity due to highly managed green areas and forests. Positive perception of naturalness has been observed in woodlands and is mainly characterized by the lack of anthropogenic changes, i.e. presence of wildlife, undergrowth density and deadwood (Dandy & Van Der Wal, 2011; Ode et al., 2009; Purcell & Lamb, 1998). Biodiversity additionally refers to the different species, such as bird species richness, but also plant diversity (Cameron et al., 2020; Methorst et al., 2021). Comparatively, there are indications that the biodiversity of the nature humans spend time in plays a major role regarding the mentioned health buffers (Aerts et al., 2018; Mavoa, Davern et al., 2019; Schebella et al., 2019; Wood et al., 2018). For example, Fuller et al. (2007) have been able to show that psychological benefits derived from urban nature increase with the species richness. Additionally, perceived restorativeness may act as a mediator of biodiversity and naturalness on well-being (Carrus et al., 2015; Marselle et al., 2016). Monocultures can be used as an extreme example here, as they have very low plant biodiversity. Monocultures, or “pure stands” as they were originally called in forestry, are stands in which only one plant species occupies more than 90% of the area and in which there is no ecologically significant mixture in the understory. Little biodiversity in the forest is thus characterized by monocultures, as well as the absence of habitat trees and deadwood (Röhrig et al., 2020).

Landscape Preferences

One possible explanation for the additional health effects of biodiversity might be individual environmental or landscape preference, which can be defined as “the degree to which a landscape is liked” by the observer (Tveit et al., 2019, p. 53). There is evidence that the positive effects of nature on our well-being and health are linked to individual environmental preferences (Hartig et al., 2011). Researchers have found that the perceived degree of human influence in an area plays a fundamental role in explicit landscape preferences and equally, that people tend to explicitly prefer mixed forests over pure stands (Van den Berg et al., 2006). Findings also suggest that natural, sunny, and bright environments are preferred (Beute & de Kort, 2013). Furthermore, respective landscape preferences may correlate with personal support of conservation or lack thereof (Marselle, 2019). Therefore, in order to promote human support for conservation, it is important to create a deeper understanding of landscape preference.

The Preference Matrix

Landscape preference can be explained by the so-called Preference Matrix (Kaplan & Kaplan, 1989). In this matrix exploration of the surrounding immediate environment relies on information that is provided. The perceived complexity of the stimuli also plays a role within the Preference Matrix and was originally defined as “the amount of various visual features in a scene; how complicated the scene is; its richness” (Kaplan & Kaplan, 1989, p. 53). Complexity in this regard refers to how much there is to observe and consider; too much complexity and the environment cannot be understood and is confusing, but too little complexity and the individual is left bored and unmotivated to explore. Diversity is an important component in assessing the complexity of an environment (Kaplan & Kaplan, 1989). This indicates that less complexity in nature, as is often the case with managed environments like ordered monocultures, is evaluated more negatively than complex biodiverse scenes. Supportingly, research suggests that more complex nature is viewed for longer and likewise rated to have a greater restorative effect compared to less complex natural scenes (Van den Berg et al., 2016). In theory, biodiverse complex landscapes should be preferred due to their vital impacts on human beings. Thus, the current increasing loss of biodiversity is a threat to human beings - now and in the long term.

Explicit and implicit Approaches

Paradoxically, research findings indicate that people prefer nature with more biodiversity, even though they often do not explicitly recognize that this nature is more biodiverse (Pett et al., 2016). This people-biodiversity paradox suggests that unconscious processing of our environment also plays a role in landscape preference. This unconscious and implicit perception of nature as well as its biodiversity has not yet been fully elucidated although it might play a major role in human support of nature conservation. In general, the coexistence and interaction of explicit and implicit attitudes determine an individual's final behavior, and sometimes each level can motivate different courses of action (Olson & Fazio, 2009; Strack & Deutsch, 2004). Thus, to observe why people care about nature and its biodiversity, both levels must be understood. Comprehending public concern is considered to be a key prerequisite to mitigate an ongoing biological biodiversity loss through policy (Williams & Cary, 2002). Drawing on the Preference Matrix this study investigates to what extent implicit attitudes shape environmental preferences.

In their 2013 study, Beute and de Kort examined implicit preferences of natural environments with an affective priming task, finding no significant effects. In their experiment, prime stimuli were briefly shown, which were nature images that differed with respect to the three dimensions: naturalness, brightness, and weather. Subsequently, a target stimulus was shown, which was to be categorized as quickly as possible. The target stimuli used were pictures with happy and angry or sad facial expressions.

Biospheric Concern and Nature Connectedness

In addition, environmental value orientations have been observed to significantly influence landscape preferences (Howley, 2001; Kaltenborn & Bjerke, 2002). Environmental values can be defined as the individual concern about environmental justice and includes egoistic, altruistic and biospheric concern (Schultz, 2001; Stern & Dietz, 1994). The latter describes people’s concern about the environment and is constituted out of judgements about costs and benefits for the biosphere. Van den Berg and her research team (2006) investigated if environmental values may influence the rated beauty of images with managed and unmanaged natural landscapes. Participants with more environmental values presented higher preferences for unmanaged compared to managed natural landscapes (Van den Berg et al., 2006). Moreover, higher biospheric concerns have been associated with stronger implicit nature connectedness

(Bruni & Schultz, 2010). Connectedness with nature represents “an individual's beliefs about the degree to which he or she is part of the natural environment” (Schultz et al., 2004). Greater connectedness to nature has been linked to higher support in biodiversity protection (Sato et al., 2021) and could thus interact with the unconscious processing of biodiversity in forest scenes. As described, biospheric concerns and nature connectedness may correlate with implicit landscape preferences and therefore are variables in this investigation.

Implicit Association Test

A version of the Implicit Association Test (IAT) functions as an implicit measurement method in this study (Carpenter et al., 2019; Greenwald et al., 1998). To date the IAT has been used frequently to measure environmental attitudes and behavior (Venhoeven et al., 2020; Wilson & Smith, 2017). For instance, to elicit connectedness to nature or preferences for natural versus built environments, though to date it has not been used to investigate implicit biodiversity preferences (Tosi et al., 2019). The IAT is a response time-based task that assesses the degree of association between two attribute categories, for example, *good* versus *bad*, and two target categories. For instance, Sánchez-Miranda et al. (2016) assessed implicit attitudes towards natural environments compared to urban environments by using the target categories *city* versus *nature*. Importantly, it has been shown to be a more robust measure regarding social desirability bias than traditional techniques (Greenwald et al., 2009), and has shown superior psychometric properties in relation to other indirect tests (Bar-Anan & Nosek, 2014).

The present Study

The main research interest in the present paper is to investigate the interrelations between implicit biodiversity preferences, biospheric concern and nature connectedness. Categories used in the IAT are *positive* versus *negative* words and *biodiversity* versus *non-biodiversity* pictures. An association between *positive* terms and the *biodiversity* category in the IAT would imply that biodiversity is implicitly preferred over monocultures. This result would be reflected by a positive improved D-score (Greenwald et al., 2003).

Hypothesis 1*:* There is a positive implicit association with biodiversity, indicated by an average improved D-score greater than zero.

Furthermore, on the basis of the materials used, the following research question is to be answered: How are biospheric concern and nature connectedness linked to implicit biodiversity preference in forests?

Hypothesis 2: Biospheric concern is positively correlated with the implicit association.

Hypothesis 3a: Nature connectedness is positively correlated with the implicit association.

Hypothesis 3b: Nature connectedness explains a significant amount of variation in the effect on top of biospheric concern.

Methodology

Sample

Based on G*Power (Faul et al., 2007) and assuming a small effect size (d = 0.3), an alpha of .05, a power of .90, and a small buffer for dropouts for an analysis of the difference from a constant in a one sample case, an ad hoc sample of 100 participants was targeted. Data collection was stopped after two days, having reached more than this number of subjects. Ultimately, 130 people were recruited for the study and in return participated in a raffle. Twenty-five participants had to be completely excluded due to error rate above 30% in at least one of the IAT conditions or because they had filled in the questionnaire incompletely (N = 105; 67 female, 38 male; M_{age} = 28.2 years, SD_{age} = 9.77). The entire study was conducted in German.

Materials

Implicit Association Test

Adapted from the research of Beute and de Kort (2013), this study used a different implicit method, i.e. the IAT, and, as mentioned, the focus is placed only on the naturalness of the plants by using images. The attribute categories used in this investigation were *positive* versus *negative* words and the target categories are *biodiversity* versus *non-biodiversity* presented in pictures selected in a pilot study (both category items are shown in Appendix A). Biodiversity in the present investigation refers to high plant species richness and the opposite is monocultures due to extremely low plant species diversity. Candidates have to classify these stimuli as fast as possible to one of two categories that are displayed at the top of the screen by using the two response keys *E* and *I*. This results in two opposite conditions called compatible and incompatible blocks. For example, in one compatible condition, key *E* should be used to respond to *biodiversity* images as well as *positive* words and key *I* to respond to *non-biodiversity* images as well as *negative* words (see Figure 1). Most importantly, it was systematically diversified over the blocks whether the category *biodiversity* was to be responded to with the same key as the category *positive* (congruent trial) or as the category *negative* (incongruent trial).

Figure 1

Example Congruent Trial of the IAT

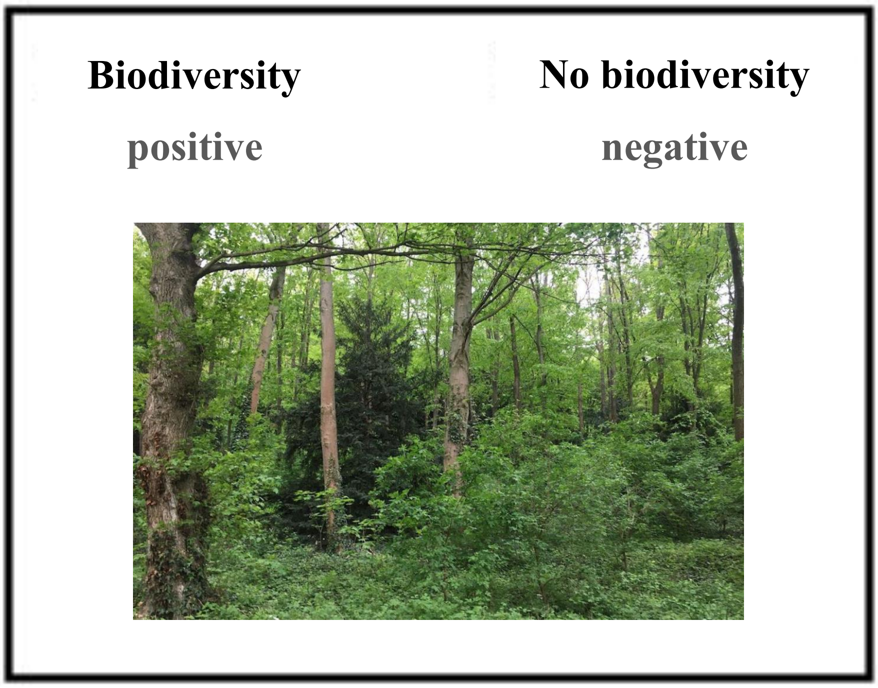


Table 1 shows the precise block sequence based on previous application from the literature (Greenwald et al., 1998). If, as hypothesized, participants implicitly associate biodiverse forests with positive rather than negative terms, the assignment of images with *biodiversity* to the matching category would be cognitively easier and therefore faster if *biodiversity* is presented in combination with the category *positive* (congruent trial) rather than with the category *negative* (*biodiversity*/*negative*; incongruent trial). All trials result in a D-score, which arises from the mean difference in response latencies in these two conditions and which depicts the intensity of the implicit association between the attribute categories and the target (Greenwald et al., 2003). Participants could familiarize themselves with the task during practice rounds before the start of the experimental trials. Moreover, each time a stimulus is incorrectly categorized, a red cross appears and participants are requested to adjust their response in order to move on with the test.

Environmental Concern Scale

A questionnaire including a German version of the Environmental Concern Scale to measure the individual biospheric values (Dornhoff et al., 2019; Schultz, 2001) is part of the investigation. The Environmental Concern Scale, originally developed by Schultz (2001), is a

Table 1

Sequence of the IAT Blocks

Block	Response key *E*	Response key *I*	Function	Number of trials
1	Biodiversity	Non-biodiversity	Practice	20
2	Positive	Negative	Practice	20
3	Biodiversity + positive	Non-biodiversity + negative	Practice	20
4	Biodiversity + positive	Non-biodiversity + negative	Test	40
5	Non-biodiversity	Biodiversity	Practice	20
6	Non-biodiversity + positive	Biodiversity + negative	Practice	20
7	Non-biodiversity + positive	Biodiversity + negative	Test	40

well-established instrument for assessing concern about environmental problems caused by human behavior. An excerpt of interest from the German version by Dornhoff et al. (2019) is used here which assesses participants' concern about the consequences of environmental problems on the biospheric environment (see Appendix A). Originally, the entire scale additionally considered egoistic and altruistic concern which are not relevant here and were accordingly omitted. On a 5-point Likert scale respondents have to score each of the four items from 1 (*not important*) to 5 (*important*).

Nature Relatedness Scale

Additionally, the German short version of the 6-item Nature Relatedness Scale (NR-6; Nisbet et al., 2009; Nisbet & Zelenski, 2013; Weber et al., 2020) which is increasingly used in sustainability research is included in the questionnaire (Nisbet & Zelenski, 2013). Based on a 5-point Likert scale, participants rate their relatedness to nature from 1 (*strongly disagree*) to 5 (*strongly agree*; e.g., I always think about how my actions affect the environment). The entire scale is shown in the language used, German, in Appendix A.

Design

The online questionnaire was implemented and provided to participants using SoSci Survey (Leiner, 2019). After informed consent and demographic variables were obtained from all participants, they first took part in the Implicit Association Test to measure implicit preferences in forest plant biodiversity. Next, participants completed the questionnaire including the NR-6 (Nisbet et al., 2009; Nisbet & Zelenski, 2013; Weber et al., 2020) to examine the trait nature connectedness as well as the Environmental Concern Scale to measure biospheric concern (Dornhoff et al., 2019; Schultz, 2001).

Results

Analytical Approach

The improved D-score of Greenwald et al. (2003) is primarily used for the evaluation of reaction times. It is based on the reaction times of all runs including the practice units. According to the improved D-score, if in more than 10% of the responses, the reaction time is faster than 300ms, the subject is excluded. Likewise, if a single response takes more than 10 seconds, that response is removed from the evaluation. Neither occurred in this survey. Furthermore, each error latency is replaced with the block mean + 600ms. For the improved D-score, the reaction times are not log transformed as is usually recommended for the analysis of reaction times (Whelan, 2008; for the exact calculation of the improved D-score, see Greenwald et al., 2003). The value range of the improved D-Score is in principle not limited. The results can be smaller than -1 and larger than +1 if the response times in blocks 3 and 6 or blocks 4 and 7 differ greatly. In terms of the present study, a positive improved D-Score implies an implicit positive association with biodiversity i.e. an implicit preference for forest pictures high in biodiversity.

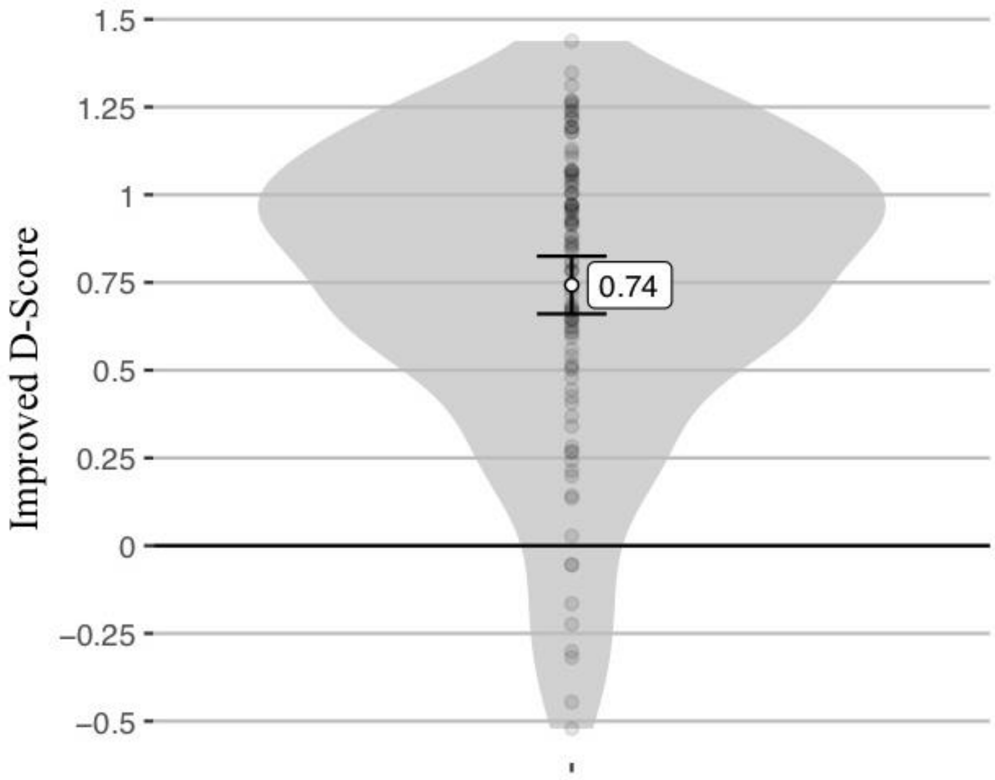
According to a Shapiro-Wilk normality test, the requirement of a normal distribution is not met. Nevertheless, a t-test is performed. Since the sample size is relatively large, it is assumed that the procedure is robust anyway. The plausibility of the results is evaluated, keeping in mind that not all prerequisites for the test are fulfilled. A Grubbs test for outliers was performed with the R package *outliers* (Komsta, 2011; R Core Team, 2021) and there were none.

Implicit Preferences – Hypothesis 1

Data analysis was done in R (Version 2021.09.1; R Core Team, 2021) using the packages *data.table* (Dowle & Srinivasan, 2021) and *tidyverse* (Wickham et al., 2019), as well as *lsr* (Navarro, 2015), *MBESS* (Kelley, 2020), *lme4* (Bates et al., 2015), *emmeans* (Lenth, 2019) and *broom* (Robinson et al., 2021). All R code and data are available at https://osf.io/wh2vu/. Results revealed that the average improved D-Score was significantly greater than zero, $M = 0.743$, 95% CI [0.66, 0.82], $SD = 0.425$, $t(104) = 17.92$, $p < .001$, $d_{unb} = 1.74$ [1.44, 2.05], Figure 2. d_{unb} (*unb* stands for unbiased) is the effect relative to the standard deviation adjusted using the

Figure 2

Violin Plot of the Distribution of the Improved D-Scores

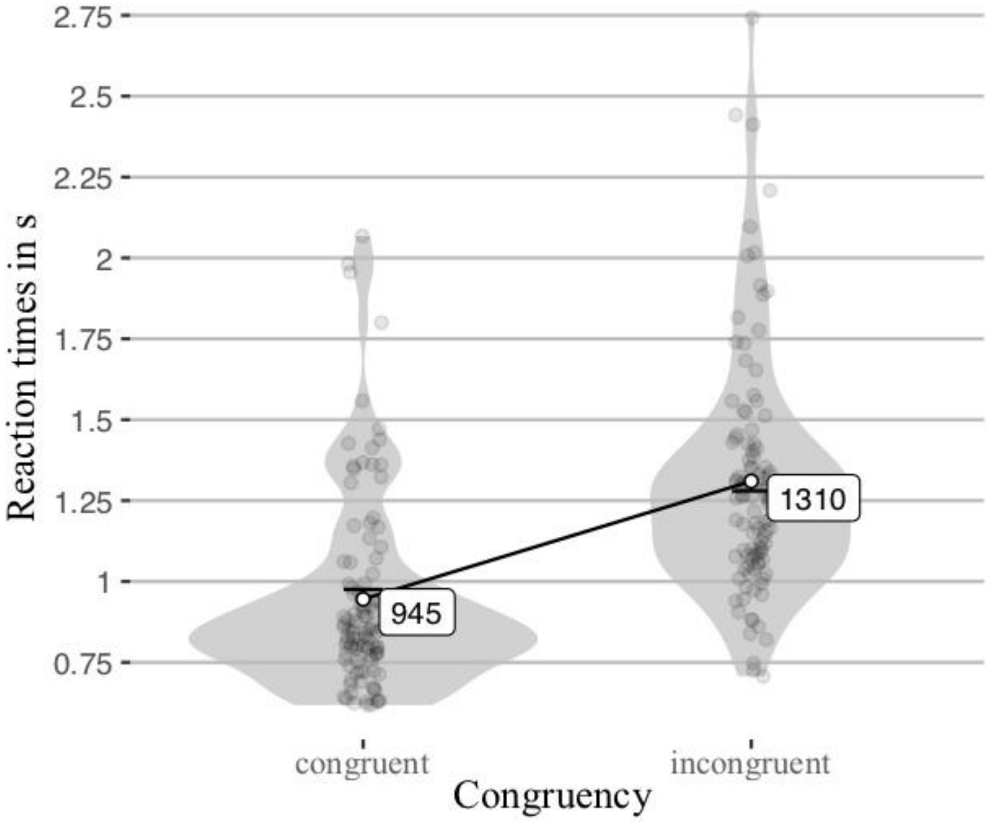


Note. Each dot represents an individual participant. Error bar shows standard error. Created with the R packages *ggplot2* (Wickham, 2016), *ggrepel* (Slowikowski, 2021), *ggthemes* (Arnold, 2021) and *extrafont* (Chang, 2014).

correction factor described by Hedges (1981). And as simplified depicted in Figure 3, during congruent trials (*biodiversity* and *positive, non-biodiversity* and *negative*), participants responded faster ($M = 945.13$ ms, $SD = 299.13$) than during incongruent trials (*biodiversity* and *negative, non-biodiversity* and *positive*; $M = 1310$ ms, $SD = 367.41$). To determine the split-half reliability of the IAT, the Spearman's rank correlation for the training and test sessions were calculated, $r_s(103) = .47$, $p < .001$. Significance for both the t-tests and the correlations was considered at the

Figure 3

Violin Plots for Reaction Times per Condition



Note. Each dot represents an individual participant. Error bar shows standard error. Created with the R packages *ggplot2* (Wickham, 2016), *ggrepel* (Slowikowski, 2021), *ggthemes* (Arnold, 2021) and *extrafont* (Chang, 2014).

$\alpha < 0.05$ level. Thus, in favor of hypothesis 1, it seems to be cognitively easier for participants to associate biodiversity with positive words than with negative words. Moreover, it is easier to associate *non-biodiversity* with *negative* terms. The evaluations suggest that images of biodiverse forests are implicitly valued more positively than pictured monocultures. These results are consistent with the Preference Matrix as well as previous research on explicit landscape preference (Kaplan & Kaplan, 1989; Pett et al., 2016; Van den Berg et al., 2006, 2016). The results complement prior research to the extent that landscape preference could be implicitly demonstrated.

Correlations – Hypothesis 2 & 3

Additionally, Spearman's rank correlation was computed to assess the relationship between the implicit associations with biodiverse forests and biospheric concern. No significant relationship between the two variables (H2) could be demonstrated, $r_s(103) = -.02$, p = .831 (see Appendix B). At the same time, it is tested if the implicit associations with biodiverse forests would be more positive for people with higher nature connectedness. Again, no significant Spearman's rank correlation (H3a) could be shown $r_s(103) = .04$, $p = .666$ (see Appendix B). Distributions of the measured biospheric concern ($M = 4.51$, $SD = 0.54$) and nature connectedness ($M = 3.58$, $SD = 0.83$) are also shown in Appendix B. Originally, in the further course a stepwise linear regression with forward selection was planned to make inferences about whether the regressors, *biospheric concern* and *nature connectedness,* significantly explain the variance of the dependent variable *implicit biodiversity preference*. Since no significant correlations could be shown, no regression analysis is performed (H3b).

Previous evidence has shown that respective landscape preferences correlate with personal support for conservation or lack thereof (Marselle, 2019). Furthermore, biospheric concern and nature connectedness have been shown to be predictors of pro-environmental behavior (Bruni & Schultz, 2010; Sato et al., 2021; Snelgar, 2006). Therefore, it was hypothesized here that biospheric concern and nature connectedness are related to implicit biodiversity preference. However, in this study, no significant relationship was found between biospheric concern or nature connectedness and implicit biodiversity preferences, although the coexistence and interaction of explicit and implicit attitudes seems to determine a person's final behavior (Olson & Fazio, 2009; Strack & Deutsch, 2004).

Discussion and Limitations

The advancing climate change as well as biodiversity loss make questions around the conservation of our ecosystems an important area of research (Brockerhoff et al., 2017; Cardinale et al., 2012; Hooper et al., 2012). The positive effects of ecosystems on human health have already been extensively studied (Berto, 2014; Frumkin et al., 2017; Zhang et al., 2020). In addition, the positive effects of environmental biodiversity have also been investigated (Aerts et al., 2018; Simkin et al., 2020; Wyles et al., 2019). Previously, it was shown that biodiverse landscapes are explicitly preferred by humans over less biodiverse landscapes (Beute & de Kort, 2013; Van den Berg et al., 2006). Based on the preference matrix, the implicit landscape preferences regarding biodiversity were investigated in the present study (Kaplan & Kaplan, 1989). The main research interest of the study was to investigate the relationships between implicit biodiversity preferences, biospheric concerns and nature connectedness. Using the IAT, it was possible to show that participants implicitly associated biodiversity positively and not negatively and therefore, pictures of biodiverse forests were preferred over monocultures. Furthermore, however, there was no correlation between biospheric concern or nature connectedness and this implicit landscape preference. To interpret the results, it is important to discuss the limitations of this study.

In previous research it has been shown that high levels of bird species richness are associated with increased life-satisfaction (Cameron et al., 2020; Methorst et al., 2021). This indicates that the existing diversity of birds plays a major role in perceived biodiversity. For this study however, it is important to note that a complete multisensory experience may evoke higher restorativeness and emotion compared to a visual-only perception (Schebella et al., 2020). In further studies, other components of the perception of nature should be implicitly investigated, such as bird diversity or existing deadwood in forests in order to be able to make statements about which components play which role in preferences. Moreover, some evidence indicates that responses to photographs of woodlands differ from reactions stimulated by a visit of those woodlands (Dandy & Van Der Wal, 2011). This brings to attention the possibility that images of forests in the IAT are not sufficient enough to represent the forest and further investigation would require a real-life setting. This discrepancy has the potential to slightly weaken the conclusions able to be drawn from the gathered results, however it does not invalidate the insights found from this proposed study.

Although biodiversity plays a major role in the emotional health of the individuals it surrounds, some research indicates that less biodiversity as opposed to more, causes higher restorative feelings and therefore elicits more positive feelings (Bielinis et al., 2020; Schebella et al., 2020). One explanation could be a human subconscious preference for landscapes like savannas (Schebella et al., 2020). These results may suggest that too much biodiversity in forest scenes could elicit feelings of insecurity, hence, negative emotions (Bielinis et al., 2020).

Measurement using the IAT has been criticized several times (Blanton et al., 2009). For example, the results of the IAT strongly depend on the stimuli presented (Bluemke & Friese, 2006). Thus, the research results obtained here should be validated by alternative measurement methods in subsequent studies. In addition, the order of the experimental blocks was not varied in this experiment to ensure comparability. This may have created a bias, as all participants always start with the same block of trials, which here is biodiversity and positive. In further experiments, the sequence should be varied. Furthermore, an alternative interpretation that was not ruled out is greater familiarity with the target category, which is the type of forest with which respondents are more familiar (Dasgupta et al., 2000). Although the images were carefully selected with a pilot study, it cannot be ruled out that certain properties of the images, such as sunlight, influence the reactions. Moreover, the way the sample is drawn here may influence the survey. In addition, the measured biospheric concern generally seems to be very high in the sample (M = 4.51, SD = 0.54), which possibly limits the generalizability of the results. A further general limitation is that the study was conducted individually online and thus possible confounding variables could not be held constant.

Conclusions

However, in the study it was demonstrated that participants had implicit preferences for images with biodiverse plants in forests. This supports previous research findings that showed an explicit preference for biodiversity. However, currently there is no knowledge about where the implicit preference comes from, especially whether it is innate or socially learned. Moreover, in this study, no significant relationship was found between biospheric concern or nature connectedness and implicit biodiversity preferences, although the coexistence and interaction of explicit and implicit attitudes seems to determine a person's final behavior, i.e. conservation (Olson & Fazio, 2009; Strack & Deutsch, 2004). These results do not support prior research on explicit landscape preference (Howley, 2001; Kaltenborn & Bjerke, 2002; Van den Berg, 2006). Previously, environmental value orientations have been observed to significantly influence explicit landscape preferences (Howley, 2001; Kaltenborn & Bjerke, 2002). However, in this case environmental value orientations could not be linked to implicit preferences. A significant relationship was suspected because biospheric concerns and nature connectedness have been shown to be predictors of pro-environmental behaviors (Bruni & Schultz, 2010; Sato et al., 2021; Snelgar, 2006) and because landscape preferences correlated with personal support for conservation or lack thereof (Marselle, 2019). Deeper research is needed to understand the relationships between biospheric concern, nature connectedness, explicit and implicit landscape preferences.

References

Aerts, R., Honnay, O., & Van Nieuwenhuyse, A. (2018). Biodiversity and human health: Mechanisms and evidence of the positive health effects of diversity in nature and green spaces. *British Medical Bulletin*, *127*(1), 5-22. https://doi.org/10.1093/bmb/ldy021

Arnold, J. B. (2021). ggthemes: Extra themes, scales and geoms for 'ggplot2'. R package version 4.2.4. https://CRAN.R-project.org/package=ggthemes

Astell-Burt, T., Mitchell, R., & Hartig, T. (2014). The association between green space and mental health varies across the lifecourse. A longitudinal study. *Journal of Epidemiology & Community Health*, *68*(6), 578-583. http://doi.org/10.1136/jech-2013-203767

Baral, H., Guariguata, M. R., & Keenan, R. J. (2016). A proposed framework for assessing ecosystem goods and services from planted forests. *Ecosystem Services, 22*, 260-268. https://doi.org/10.1016/j.ecoser.2016.10.002

Bar-Anan, Y., & Nosek, B. A. (2014). A comparative investigation of seven indirect attitude measures. *Behavior Research Methods, 46*, 668-688. https://doi.org/10.3758/s13428-013-0410-6

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software, 67*(1), 1-48. https://doi.org/10.18637/jss.v067.i01.

Berto, R. (2014). The role of nature in coping with psycho-physiological stress: a literature review on restorativeness. *Behavioral Sciences*, *4*(4), 394-409. https://doi.org/10.3390/bs4040394

Betts, M. G., Wolf, C., Ripple, W. J., Phalan, B., Millers, K. A., Duarte, A., Butchart, S. H. M., & Levi, T. (2017). Global forest loss disproportionately erodes biodiversity in intact landscapes. *Nature*, *547*(7664), 441-444. https://doi.org/10.1038/nature23285

Beute, F., & de Kort, Y. A. (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. https://doi.org/10.1016/j.jenvp.2013.07.016

Beyer, K. M., Kaltenbach, A., Szabo, A., Bogar, S., Nieto, F. J., & Malecki, K. M. (2014). Exposure to neighborhood green space and mental health: evidence from the survey of the health of Wisconsin. *International Journal of Environmental Research and Public Health*, *11*(3), 3453-3472. https://doi.org/10.3390/ijerph110303453

Bielinis, E., Xu, J., & Omelan, A. A. (2020). A novel anti-environmental forest experience scale to predict preferred pleasantness associated with forest environments. *International Journal of Environmental Research and Public Health*, *17*(18), 6731. https://doi.org/10.3390/ijerph17186731

Blanton, H., Jaccard, J., Klick, J., Mellers, B., Mitchell, G., & Tetlock, P. E. (2009). Strong claims and weak evidence: Reassessing the predictive validity of the IAT. *Journal of Applied Psychology, 94*(3), 567–582. https://doi.org/10.1037/a0014665

Bluemke, M., & Friese, M. (2006). Do features of stimuli influence IAT effects? *Journal of Experimental Social Psychology*, *42*(2), 163-176. https://doi.org/10.1016/j.jesp.2005.03.004

Brockerhoff, E. G., Barbaro, L., Castagneyrol, B., Forrester, D. I., Gardiner, B., González-Olabarria, J. R., Lyver, P. O. B., Meurisse, N., Oxbrough, A., Taki, H., Thompson, I. D., van der Plas, F., & Jactel, H. (2017). Forest biodiversity, ecosystem functioning and the provision of ecosystem services. *Biodiversity and Conservation, 26*, 3005–3035. https://doi.org/10.1007/s10531-017-1453-2

Bruni, C. M., & Schultz, P. W. (2010). Implicit beliefs about self and nature: Evidence from an IAT game. *Journal of Environmental Psychology*, *30*(1), 95-102. https://doi.org/10.1016/j.jenvp.2009.10.004

Cameron, R. W., Brindley, P., Mears, M., McEwan, K., Ferguson, F., Sheffield, D., Jorgensen, A., Riley, J., Goodrick, J.,Ballard, L., & Richardson, M. (2020). Where the wild things are! Do urban green spaces with greater avian biodiversity promote more positive emotions in humans? *Urban Ecosystems*, *23*(2), 301-317. https//doi.org/ 10.1007/s11252-020-00929-z

Cardinale, B. J., Duffy, J. E., Gonzalez, A., Hooper, D. U., Perrings, C., Venail, P., Narwani, A., Mace, G. M., Tilman, D., Wardle, D. A., Kinzig, A. P., Daily, G. C., Loreau, M., Grace, J. B., Larigauderie, A., Srivastava, D. S., & Naeem, S. (2012). Biodiversity loss and its impact on humanity. *Nature, 486*(7401), 59-67. https://doi.org/10.1038/nature11148

Carpenter, T. P., Pogacar, R., Pullig, C., Kouril, M., Aguilar, S., LaBouff, J., Isenberg, N., & Chakroff, A. (2019). Survey-software implicit association tests: A methodological and empirical analysis. *Behavior Research Methods*, *51*(5), 2194-2208. https://doi.org/10.3758/s13428-019-01293-3

Carrus, G., Scopelliti, M., Lafortezza, R., Colangelo, G., Ferrini, F., Salbitano, F., Agrimi, M., Portoghesi, L., Semenzato, P., & 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. https://doi.org/10.1016/j.landurbplan.2014.10.022

Chang, W. (2014). extrafont: Tools for using fonts. R package version 0.17. https://CRAN.R-project.org/package=extrafont

Cleary, A., Roiko, A., Burton, N. W., Fielding, K. S., Murray, Z., & Turrell, G. (2019). Changes in perceptions of urban green space are related to changes in psychological well-being: Cross-sectional and longitudinal study of mid-aged urban residents. *Health & Place*, *59*, 102201. https://doi.org/10.1016/j.healthplace.2019.102201

Core Team, R. (2019). *R: A language and environment for statistical computing. R Foundation for Statistical Computing*. https://www.R-project.org/

Dandy, N., & Van Der Wal, R. (2011). Shared appreciation of woodland landscapes by land management professionals and lay people: An exploration through field-based interactive photo-elicitation. *Landscape and Urban Planning*, *102*(1), 43-53. https://doi.org/10.1016/j.landurbplan.2011.03.008

Dasgupta, N., McGhee, D. E., Greenwald, A. G., & Banaji, M. R. (2000). Automatic preference for white americans: Eliminating the familiarity explanation. *Journal of Experimental Social Psychology*, *36*(3), 316-328. https://doi.org/10.1006/jesp.1999.1418

Deuffic, P., Garms, M., He, J., Brahic, E., Yang, H., & Mayer, M. (2020). Forest dieback, a tangible proof of climate change? A cross-comparison of forest stakeholders' perceptions and strategies in the mountain forests of europe and china. *Environmental Management*, *66*(5), 858-872. https://doi.org/10.1007/s00267-020-01363-9

Doimo, I., Masiero, M., & Gatto, P. (2020). Forest and wellbeing: Bridging medical and forest research for effective forest-based initiatives. *Forests*, *11*(8), 791. https://doi.org/10.3390/f11080791

Dornhoff, M., Sothmann, J. N., Fiebelkorn, F., & Menzel, S. (2019). Nature relatedness and environmental concern of young people in Ecuador and Germany. *Frontiers in Psychology, 10*, 453. https://doi.org/10.3389/fpsyg.2019.00453

Dowle, M., & Srinivasan, A. (2021). data.table: Extension of `data.frame`. R package version 1.14.0. https://CRAN.R-project.org/package=data.table

Dudley, N., & Alexander, S. (2017). Agriculture and biodiversity: A review. *Biodiversity*, *18*(2-3), 45-49. https://doi.org/10.1080/14888386.2017.1351892

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175-191. https://doi.org/10.3758/BF03193146

Frumkin, H., Bratman, G. N., Breslow, S. J., Cochran, B., Kahn Jr, P. H., Lawler, J. J., Levin, P. S., Tandon, P. S.,Varanasi, U., Wolf, K. L., & Wood, S. A. (2017). Nature contact and human health: A research agenda. *Environmental Health Perspectives*, *125*(7), 075001. https://doi.org/10.1289/EHP1663

Fuller, R. A., Irvine, K. N., Devine-Wright, P., Warren, P. H., & Gaston, K. J. (2007). Psychological benefits of greenspace increase with biodiversity. *Biology Letters*, *3*(4), 390-394. https://doi.org/10.1098/rsbl.2007.0149

Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. (1998). Measuring individual differences in implicit cognition: The implicit association test. *Journal of Personality and Social Psychology*, *74*(6), 1464. https://doi.org/10.1037/0022-3514.74.6.1464

Greenwald, A. G., Nosek, B. A., & Banaji, M. R. (2003). Understanding and using the implicit association test: I. An improved scoring algorithm. *Journal of Personality and Social Psychology, 85*(2), 197–216. https://doi.org/10.1037/0022-3514.85.2.197

Greenwald, A. G., Poehlman, T. A., Uhlmann, E. L., & Banaji, M. R. (2009). Understanding and using the implicit association test: III. Meta-analysis of predictive validity. *Journal of Personality and Social Psychology, 97*(1), 17-41. https://doi.org/10.1037/a0015575

Grigsby-Toussaint, D. S., Turi, K. N., Krupa, M., Williams, N. J., Pandi-Perumal, S. R., & Jean-Louis, G. (2015). Sleep insufficiency and the natural environment: Results from the US behavioral risk factor surveillance system survey. *Preventive Medicine*, *78*, 78-84. https://doi.org/10.1016/j.ypmed.2015.07.011

Hartig, T., van den Berg, A. E., Hagerhall, C. M., Tomalak, M., Bauer, N., Hansmann, R., Ojala, A., Syngollitou, E., Carrus, G., van Herzele, A., Bell, S., Camilleri-Podesta, M. T., & 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). Springer. https://doi.org/10.1007/978-90-481-9806-1_5

Hedges, L. V. (1981). Distribution theory for Glass's estimator of effect size and related estimators. *Journal of Educational Statistics, 6*(2), 107–128. https://doi.org/10.3102/10769986006002107

Hooper, D. U., Adair, E. C., Cardinale, B. J., Byrnes, J. E., Hungate, B. A., Matulich, K. L., Gonzalez, A., Duffy, J. E., Gamfeldt, L., & O'Connor, M. I. (2012). A global synthesis reveals biodiversity loss as a major driver of ecosystem change. *Nature*, *486*(7401), 105-108. https://doi.org/10.1038/nature11118

Howley, P. (2011). Landscape aesthetics: Assessing the general publics' preferences towards rural landscapes. *Ecological Economics*, *72*, 161-169. https://doi.org/10.1016/j.ecolecon.2011.09.026

Jactel, H., Bauhus, J., Boberg, J., Bonal, D., Castagneyrol, B., Gardiner, B., Gonzalez-Olabarria, J. R., Koricheva, J., Meurisse, N., & Brockerhoff, E. G. (2017). Tree diversity drives forest stand resistance to natural disturbances. *Current Forestry Reports, 3*(3), 223-243. https://doi.org/10.1007/s40725-017-0064-1

Kabisch, N., Püffel, C., Masztalerz, O., Hemmerling, J., & Kraemer, R. (2021). Physiological and psychological effects of visits to different urban green and street environments in older people: A field experiment in a dense inner-city area. *Landscape and Urban Planning, 207*, 103998. https://doi.org/10.1016/j.landurbplan.2020.103998

Kaltenborn, B. P., & Bjerke, T. (2002). Associations between environmental value orientations and landscape preferences. *Landscape and Urban Planning*, *59*(1), 1-11. https://doi.org/10.1016/S0169-2046(01)00243-2

Kaplan R., & Kaplan S. (1989). The prediction of preference. In *The experience of nature: a psychological perspective* (pp. 40 - 71). Cambridge University Press.

Kelley, K. (2020). MBESS: The MBESS R package. R package version 4.8.0.https://CRAN.R-project.org/package=MBESS

Komsta, L. (2011). outliers: Tests for outliers. R package version 0.14. https://CRAN.R-project.org/package=outliers

Leiner, D. J. (2019). SoSci Survey (Version 3.1.06) [Computer software]. Available at https://www.soscisurvey.de

Lenth, R. V. (2021). emmeans: Estimated marginal means, aka least-squares means. R package version 1.6.1. https://CRAN.R-project.org/package=emmeans

Liu, C. L. C., Kuchma, O., & Krutovsky, K. V. (2018). Mixed-species versus monocultures in plantation forestry: Development, benefits, ecosystem services and perspectives for the future. *Global Ecology and Conservation*, *15*, e00419. https://doi.org/10.1016/j.gecco.2018.e00419

Marselle, M. R. (2019). Theoretical foundations of biodiversity and mental well-being relationships. In M. R. Marselle, J. Stadler, H. Korn, K. N. Irvine & A. Bonn (Eds.), *Biodiversity and health in the face of climate change* (pp. 133 - 158). Springer Nature. https://doi.org/10.1007/978-3-030-02318-8

Marselle, M. R., Hartig, T., Cox, D. T., de Bell, S., Knapp, S., Lindley, S., Triguero-Mas, M., Böhning-Gaese, K., Braubach, M., Cook, P. A., de Vries, S., Heintz-Buschart, A., Hofmann, M., Irvine, K. N., Kabisch, N., Kolek, F., Kraemer, R., Markevych, I., Martens, D., Müller, R., Nieuwenhuijsen, M., Potts, J. M., Stadler, J., Walton, S., Warber, S. L., & Bonn, A. (2021). Pathways linking biodiversity to human health: A conceptual framework. *Environment International*, *150*, 106420. https://doi.org/10.1016/j.envint.2021.106420

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. https://doi.org/10.1016/j.jenvp.2016.04.008

Mavoa, S., Davern, M., Breed, M., & Hahs, A. (2019). Higher levels of greenness and biodiversity associate with greater subjective wellbeing in adults living in Melbourne, Australia. *Health & Place*, *57*, 321-329. https://doi.org/10.1016/j.healthplace.2019.05.006

Mavoa, S., Lucassen, M., Denny, S., Utter, J., Clark, T., & Smith, M. (2019). Natural neighbourhood environments and the emotional health of urban New Zealand adolescents. *Landscape and Urban Planning*, *191*, 103638. https://doi.org/10.1016/j.landurbplan.2019.103638

Methorst, J., Rehdanz, K., Mueller, T., Hansjürgens, B., Bonn, A., & Böhning-Gaese, K. (2021). The importance of species diversity for human well-being in Europe. *Ecological Economics*, *181*, 106917. https://doi.org/10.1016/j.ecolecon.2020.106917

Navarro, D. J. (2015) Learning statistics with R: A tutorial for psychology students and other beginners. (Version 0.6) University of New South Wales.

Nisbet, E. K., & Zelenski, J. M. (2013). The NR-6: a new brief measure of nature relatedness. *Frontiers in Psychology*, *4*, 1–11. https://doi.org/10.3389/fpsyg.2013.00813

Nisbet, E. K., Zelenski, J. M., & Murphy, S. A. (2009). The nature relatedness scale. Linking individual's connection with nature to environmental concern and behavior. *Environment and Behavior*, *27*(1), 1–26. https://doi.org/10.1177/0013916508318748

Ode, Å., Fry, G., Tveit, M. S., Messager, P., & Miller, D. (2009). Indicators of perceived naturalness as drivers of landscape preference. *Journal of Environmental Management*, *90*(1), 375-383. https://doi.org/10.1016/j.jenvman.2007.10.013

Olson, M. A., & Fazio, R. H. (2009). Implicit and explicit measures of attitudes: The perspective of the MODE model. In R. E. Petty, R. H. Fazio & P. Briñol (Eds.), *Attitudes: Insights from the new implicit measures* (pp. 19-63). Psychology Press.

Pett, T. J., Shwartz, A., Irvine, K. N., Dallimer, M., & Davies, Z. G. (2016). Unpacking the people–biodiversity paradox: a conceptual framework. *BioScience*, *66*(7), 576-583. https://doi.org/10.1093/biosci/biw063

Purcell, A. T., & Lamb, R. J. (1998). Preference and naturalness: An ecological approach. *Landscape and Urban Planning*, *42*(1), 57-66. https://doi.org/10.1016/S0169-2046(98)00073-5

Robinson, D., Hayes, A., & Couch, S. (2021). broom: Convert statistical objects into tidy tibbles. R package version 0.7.10. https://CRAN.R-project.org/package=broom

Röhrig, E., Bartsch, N. & von Lüpke, B. (2020). Ziele der Forstwirtschaft und Aufgaben des Waldbaus. In *Waldbau auf ökologischer Grundlage* (pp. 12 - 78). UTB GmbH.

Sánchez-Miranda, P., de la Garza González, A., & Isolde Hedlefs, M. (2016). Implicit measures of environmental attitudes: a comparative study. *International Journal of Psychological Research*, *9*(1), 40-51. https://doi.org/ 10.21500/20112084.209

Sandifer, P. A., Sutton-Grier, A. E., & Ward, B. P. (2015). Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to enhance health and biodiversity conservation. *Ecosystem Services*, *12*, 1-15. https://doi.org/10.1016/j.ecoser.2014.12.007

Sato, M., Aoshima, I., & Chang, Y. (2021). Connectedness to nature and the conservation of the urban ecosystem: Perspectives from the valuation of urban forests. *Forest Policy and Economics, 125*, 102396. https://doi.org/10.1016/j.forpol.2021.102396

Schebella, M. F., Weber, D., Schultz, L., & Weinstein, P. (2019). The wellbeing benefits associated with perceived and measured biodiversity in Australian urban green spaces. *Sustainability*, *11*(3), 802. https://doi.org/10.3390/su11030802

Schebella, M. F., Weber, D., Schultz, L., & Weinstein, P. (2020). The nature of reality: Human stress recovery during exposure to biodiverse, multisensory virtual environments. *International Journal of Environmental Research and Public Health*, *17*(1), 56. https://doi.org/10.3390/ijerph17010056

Schultz, P. W. (2001). The structure of environmental concern: Concern for self, other people, and the biosphere. *Journal of Environmental Psychology, 21*(4), 327-339. https://doi.org/10.1006/jevp.2001.0227

Schultz, P. W., Shriver, C., Tabanico, J. J., & Khazian, A. M. (2004). Implicit connections with nature. *Journal of Environmental Psychology*, *24*(1), 31-42. https://doi.org/10.1016/S0272-4944(03)00022-7

Secretariat of the Convention on Biological Diversity (2005). *Handbook of the convention on biological diversity including its cartagena protocol on biosafety* (3rd edition).

Simkin, J., Ojala, A., & Tyrväinen, L. (2020). Restorative effects of mature and young commercial forests, pristine old-growth forest and urban recreation forest - A field experiment. *Urban Forestry & Urban Greening, 48*, 126567. https://doi.org/10.1016/j.ufug.2019.126567

Slowikowski, K. (2021). ggrepel: Automatically position non-overlapping text labels with 'ggplot2'. R package version 0.9.1. https://CRAN.R-project.org/package=ggrepel

Snelgar, R. S. (2006). Egoistic, altruistic, and biospheric environmental concerns: Measurement and structure. *Journal of Environmental Psychology, 26*(2), 87-99. https://doi.org/10.1016/j.jenvp.2006.06.003

Stern, P. C., & Dietz, T. (1994). The value basis of environmental concern. *Journal of Social Issues*, *50*(3), 65-84. https://doi.org/10.1111/j.1540-4560.1994.tb02420.x

Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Review, 3*, 220-247. https://doi.org/10.1207/s15327957pspr0803_1

Tosi, J. D., Ledesma, R. D., Kuhnen, A., & Felippe, M. L. (2019). Actitudes implícitas en Psicología Ambiental: Una revisión de literatura. *Estudos de Psicologia (Natal), 24*(3), 292-304. https://doi.org/10.22491/1678-4669.20190030

Tveit, M., S., Sang, Å., O., & Hagerhall, C., M. (2019). Scenic beauty: Visual landscape assessment and human landscape perception. In L. E. Steg & J. I. De Groot (Eds.), *Environmental psychology: An introduction* (2nd ed., pp. 46 - 54). Wiley.

United Nations Convention on Biological Diversity, (1992). *Convention on biological diversity.* https://www.cbd.int/doc/legal/cbd-en.pdf

Van den Berg, A. E., de Vries, D. H., & Vlek, C. A. (2006). Images of nature, environmental values and landscape preference: exploring their interrelationships. In R. J. G. van den Born, W. T. de Groot & R. H. J. Lenders (Eds.), *Visions of nature; a scientific exploration of people's implicit philosophies regarding nature in Germany, the Netherlands and the United Kingdom* (pp. 43-60). LIT.

Van den Berg, A. E., Joye, Y., & Koole, S. L. (2016). Why viewing nature is more fascinating and restorative than viewing buildings: A closer look at perceived complexity. *Urban Forestry & Urban Greening*, *20*, 397-401. https://doi.org/10.1016/j.ufug.2016.10.011

Venhoeven, L. A., Bolderdijk, J. W., & Steg, L. (2020). Why going green feels good. *Journal of Environmental Psychology*, *71.* https://doi.org/10.1016/j.jenvp.2020.101492

Ward Thompson, C., Aspinall, P., Roe, J., Robertson, L., & Miller, D. (2016). Mitigating stress and supporting health in deprived urban communities: The importance of green space and the social environment. *International Journal of Environmental Research and Public Health, 13*(4), 440. https://doi.org/10.3390/ijerph13040440

Weber, A., Büssing, A. G., Jarzyna, R., & Fiebelkorn, F. (2020). Do german student biology teachers intend to eat sustainably? Extending the theory of planned behavior with nature relatedness and environmental concern. *Sustainability, 12*(12), 4909. https://doi.org/10.3390/su12124909

Whelan, R. (2008). Effective analysis of reaction time data. *The Psychological Record, 58*(3), 475-482. https://doi.org/10.1007/BF03395630

Wickham, H. (2016). ggplot2: Elegant graphics for data analysis. Springer-Verlag New York.

Wickham, H., Averick, M., Bryan, J., Chang1, W., McGowan, L. D. A., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T. L., Miller, E., Bache, S. M., Müller, K., Ooms, J., Robinson, D., Seidel, D. P., Spinu, V., Takahashi, K., Vaughan, D., Wilke, C., Woo, K., & Yutani, H. (2019). Welcome to the tidyverse. *Journal of Open Source Software, 4*(43), 1686. https://doi.org/10.21105/joss.01686

Williams, K. J., & Cary, J. (2002). Landscape preferences, ecological quality, and biodiversity protection. *Environment and Behavior*, *34*(2), 257-274. https://doi.org/10.1177/0013916502034002006

Wilson, T. L., & Smith, T. H. (2017). Implicit environmental attitudes: Critique and technique to promote awareness. *IAFOR Journal of Psychology & the Behavioral Sciences*, 3(1). https://doi.org/10.22492/ijpbs.3.1.02

Wood, E., Harsant, A., Dallimer, M., Cronin de Chavez, A., McEachan, R. R., & Hassall, C. (2018). Not all green space is created equal: Biodiversity predicts psychological restorative benefits from urban green space. *Frontiers in Psychology*, *9*, 2320. https://doi.org/10.3389/fpsyg.2018.02320

Wyles, K. J., White, M. P., Hattam, C., Pahl, S., King, H., & Austen, M. (2019). Are some natural environments more psychologically beneficial than others? The importance of type and quality on connectedness to nature and psychological restoration. *Environment and Behavior*, *51*(2), 111-143. https://doi.org/10.1177/0013916517738312

Younan, D., Tuvblad, C., Li, L., Wu, J., Lurmann, F., Franklin, M., Berhane, K., McConnell, R., Wu, A. H., Baker, L. A., & Chen, J. C. (2016). Environmental determinants of aggression in adolescents: Role of urban neighborhood greenspace. *Journal of the American Academy of Child & Adolescent Psychiatry*, *55*(7), 591-601. https://doi.org/10.1016/j.jaac.2016.05.002

Zhang, J., Yu, Z., Zhao, B., Sun, R., & Vejre, H. (2020). Links between green space and public health: A bibliometric review of global research trends and future prospects from 1901 to 2019. *Environmental Research Letters*, *15*(6), 063001. https://doi.org/10.1088/1748-9326/ab7f64

Appendix A

Table A1

Attribute Categories for the Implicit Association Test

Attribute category	Words
positive	Liebe, Gesundheit, Jubel, Ehrlich, Freiheit, Frieden, Vergnügen, Glücklich
negative	Hass, Krankheit, Armut, Qual, Trauer, Unfall, Gestank, Hässlich

Note. The presentation of the words was randomized. Immediate repetitions were avoided.

Figure A1

Images for the Target Category Biodiversity in the Implicit Association Test

Note. The images were selected based on a pilot study. The presentation of the images was randomized. Immediate repetitions were avoided.

Figure A2

Images for the Target Category Non-biodiversity in the Implicit Association Test

Note. The images were selected based on a pilot study. The presentation of the images was randomized. Immediate repetitions were avoided.

Table A2

Biospheric Concern in the German Environmental Concern Scale (Dornhoff et al., 2019)

Introduction	Menschen auf der ganzen Welt sind von Umweltproblemen durch die Zerstörung der Natur betroffen. Allerdings unterscheiden sich Menschen darin, welche Auswirkungen ihnen am wichtigsten erscheinen. Wie wichtig sind dir persönlich die Folgen von Umweltproblemen für...?
Item 1	Pflanzen
Item 2	Meereslebewesen
Item 3	Vögel
Item 4	Tiere (Säugetiere)

Note. Items are rated on a 5-point Likert scale from 1 (not important) to 5 (important).

Table A3

German Short Version of the Nature Relatedness Scale (Nisbet et al., 2009; Nisbet & Zelenski, 2013; Weber et al., 2020)

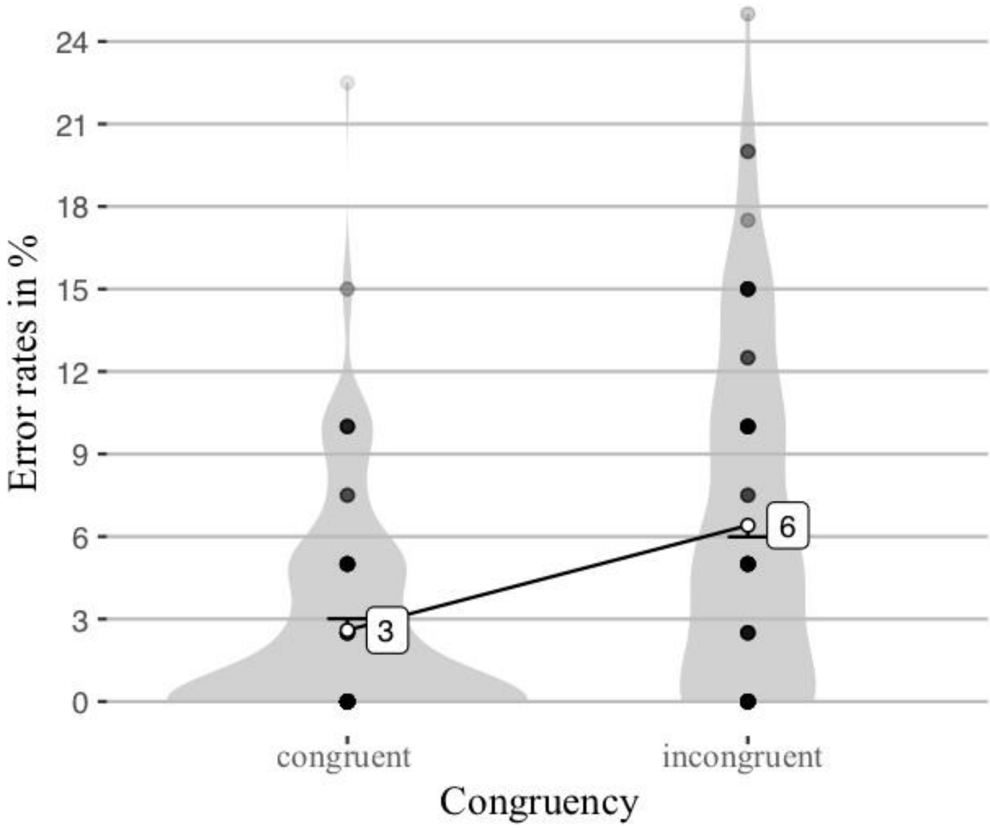
Item
Meine Verbindung zur Natur und der natürlichen Umwelt ist Teil meiner Spiritualität.
Mein idealer Urlaubsort wäre eine abgelegene Wildnis.
Ich denke immer daran, wie mein Handeln die Umwelt beeinflusst.
Ich bemerke wilde Tiere, wo immer ich bin.
Meine Beziehung zur Natur ist ein wichtiger Teil meines Selbst.
Ich fühle mich sehr verbunden mit allen Lebewesen und der Erde.

Note. Items are rated on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree).

Appendix B

Figure B1

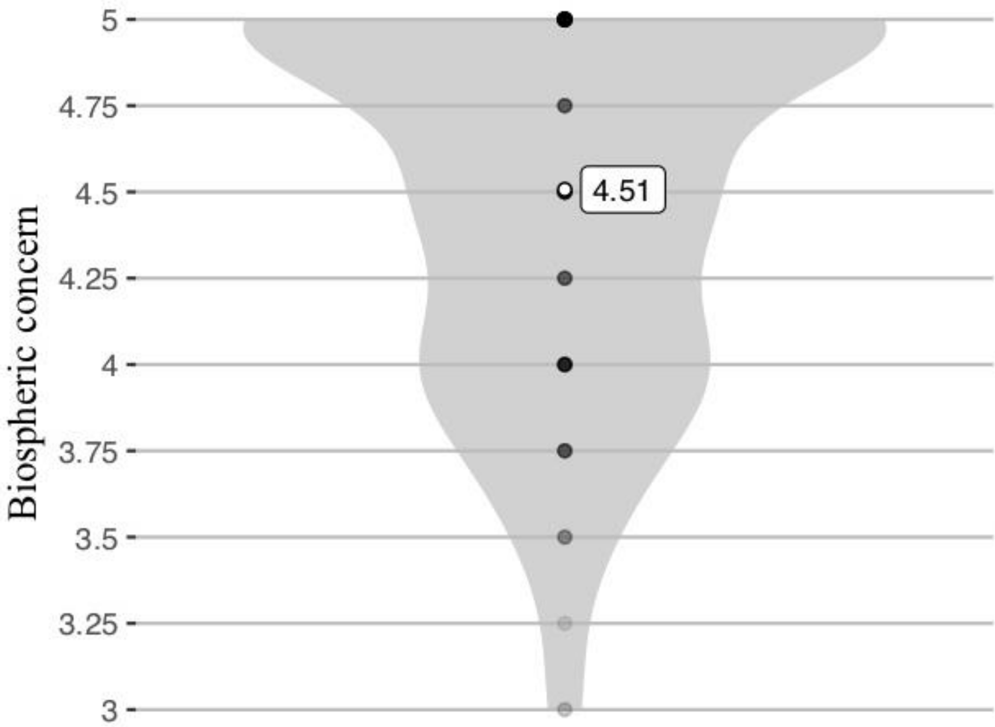
Violin Plots of the Error Rates per Condition



Note. Error rates are shown for the congruent and incongruent condition. The mean error rate in the congruent condition is 3% and in the incongruent condition is 6%. Error bar shows standard error. Created with the R packages *ggplot2* (Wickham, 2016), *ggrepel* (Slowikowski, 2021), *ggthemes* (Arnold, 2021) and *extrafont* (Chang, 2014).

Figure B2

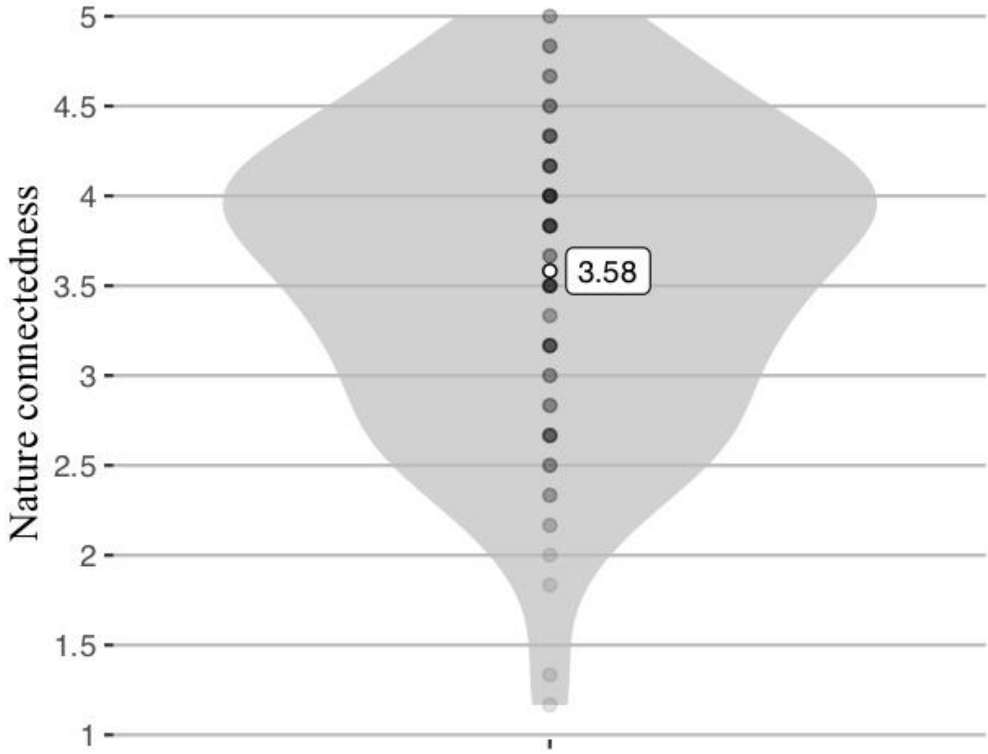
Violin Plot of the Distribution of Biospheric Concern



Note. Each dot represents an individual participant. Mean biospheric concern was 4.51. Created with the R packages *ggplot2* (Wickham, 2016), *ggrepel* (Slowikowski, 2021), *ggthemes* (Arnold, 2021) and *extrafont* (Chang, 2014).

Figure B3

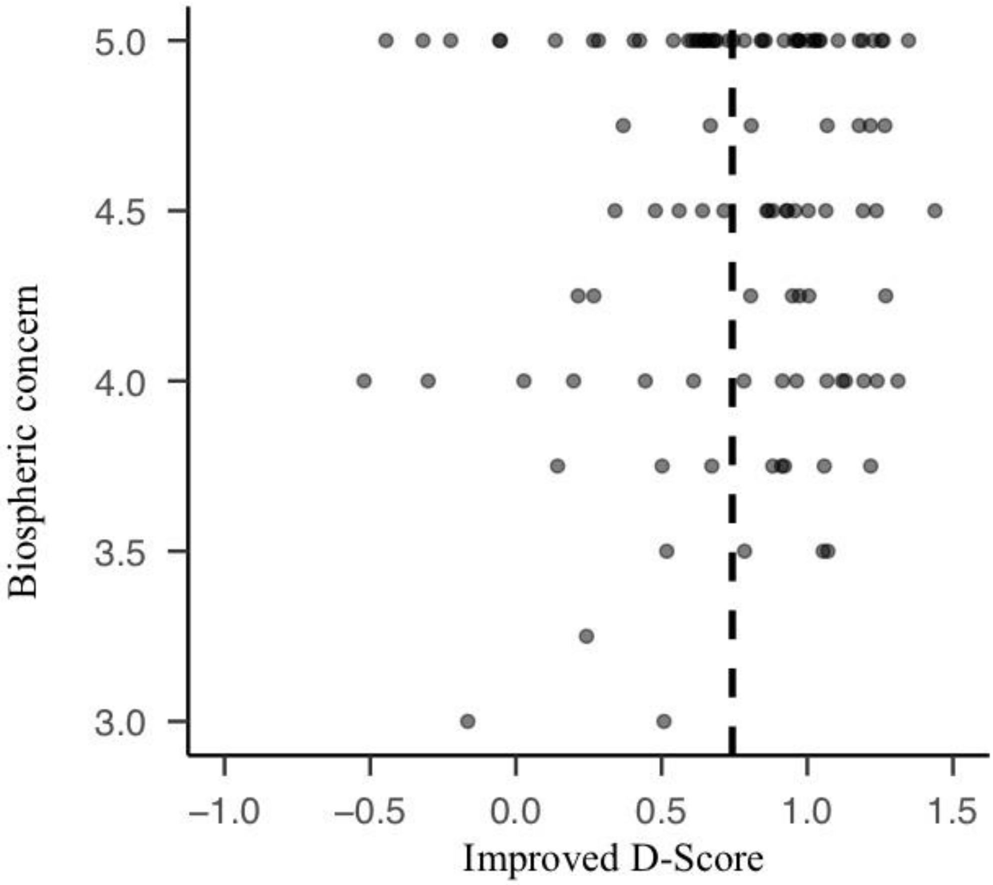
Violin Plot of the Distribution of Nature Connectedness



Note. Each dot represents an individual participant. Mean nature connectedness was 3.58. Created with the R packages *ggplot2* (Wickham, 2016), *ggrepel* (Slowikowski, 2021), *ggthemes* (Arnold, 2021) and *extrafont* (Chang, 2014).

Figure B4

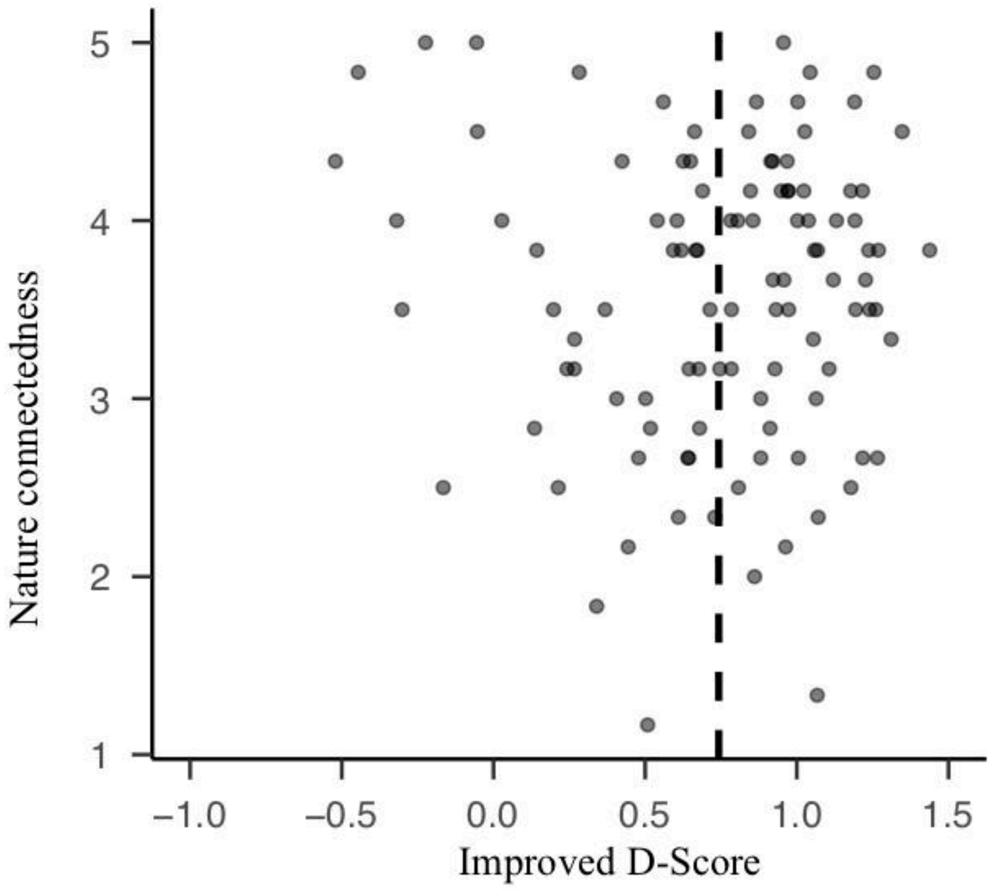
Relationship Between the Improved D-Score and Biospheric Concern



Note. Each dot represents an individual participant. The dashed line represents the mean improved D-Score (M = 0.74, SD = 0.42). The relationship was not significant (p = .831). Created with the R packages *ggplot2* (Wickham, 2016), *ggrepel* (Slowikowski, 2021), *ggthemes* (Arnold, 2021) and *extrafont* (Chang, 2014).

Figure B5

Relationship Between the Improved D-Score and Nature Connectedness



Note. Each dot represents an individual participant. The dashed line represents the mean improved D-Score ($M = 0.74$, $SD = 0.42$). The relationship was not significant ($p = .666$). Created with the R packages *ggplot2* (Wickham, 2016), *ggrepel* (Slowikowski, 2021), *ggthemes* (Arnold, 2021) and *extrafont* (Chang, 2014).