

Gratitude letters to nature: Effects on self-nature representations and pro-environmental behavioral intentions

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ARTICLE INFO

Handling Editor: W. Schultz

Keywords:

Gratitude
Natural and built environments
Self-nature representations
Sustainability

ABSTRACT

Although gratitude is often defined as an emotion that motivates reciprocity and social connectedness, people can also experience gratitude to nonhuman entities such as nature. Despite expressions of gratitude to nature being common in many cultures, little research has examined its implications for sustainability. In two studies, we explored how writing letters of gratitude to nature increase pro-environmental behavior by leading people to see nature as large and by leading to more inclusion of nature in one's self-concept. Study 1 compared the effects of nature gratitude letters to gratitude letters to built environments and to a control condition, finding that nature gratitude letters led to greater inclusion of nature in self and greater perceptions of nature size. Although there was no direct effect on intentions to act pro-environmentally, nature gratitude letters had indirect effects leading to greater pro-environmental intentions via both increased nature size and nature inclusion. Study 2 replicated these findings and explored two potential moderators: biospheric value orientation and personal norms of positive reciprocity. Replicating Study 1, nature gratitude letters led to more nature inclusion and greater nature size, and they produced stronger self-transcendent emotions and more pro-environmental behavioral intentions. Further, an interaction showed that the benefits of nature gratitude letters on pro-environmental behavioral intentions was only significant among those with relatively greater endorsement of biospheric values. Implications for sustainability and emotions research are discussed.

1. Introduction

Gratitude is typically viewed as an interpersonal emotion experienced between people that builds relationships, strengthens social groups, and motivates altruism (Algoe, 2012; Chang et al., 2012). Although psychology has almost entirely focused on gratitude to people, individuals also express gratitude to nonhuman entities (Tam, 2022). Nature, in particular, is an entity for which people express thankfulness. Nature provides food, water, and resources necessary for human survival. Accordingly, many cultures incorporate gratitude to nature into traditions and rituals, including Indigenous American spirituality (Kimmerer, 2013), animism in sub-Saharan Africa (Kimmerle, 2006), and Daoism in China (Miller, 2003). Despite gratitude to nature being common, little psychological research has examined its effects (cf., Naito et al., 2010; Tam, 2022). In particular, understanding gratitude to nature could be important for addressing environmental issues such as climate change because people are more likely to help entities to which they feel gratitude (Bartlett & DeSteno, 2006; Zelenski & Desrochers,

2021), and the current research examines how gratitude letters to nature can increase pro-environmental action by fostering more sustainable self-nature representations.

1.1. Gratitude and its mechanisms

Gratitude is the emotion felt when one perceives that another person or entity has taken a voluntary, costly action that benefits the perceiver (McCullough et al., 2001). Stronger gratitude is felt when benefits are valuable to the self, costly to the benefactor, and given without ulterior motives (Tesser et al., 1968; Wood et al., 2008). Seeing the benefactor as responsive to one's needs is important for eliciting gratitude (Algoe et al., 2008), producing feelings of warmth and appreciation towards the benefactor and a tendency to express thanks and to act prosocially (Emmons, 2004; Fitzgerald, 1998).

Because of these other-orientated appraisals and action tendencies, gratitude is viewed as a self-transcendent emotion (Stellar et al., 2017), which is a category of positive emotions that includes awe, compassion,

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<https://doi.org/10.1016/j.jenvp.2024.102319>

Received 4 June 2023; Received in revised form 5 May 2024; Accepted 5 May 2024

Available online 7 May 2024

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love, and moral elevation. Self-transcendent emotions shift attention from the self to the needs of others, leading to greater inclusion of others into the self-concept (Aron et al., 1991; Bai et al., 2017), shrinking of the self (Piff et al., 2015), and adopting other-orientated values (Jacobs & McConnell, 2022). These responses increase subjective well-being, promote physical health, and instigate prosocial behavior (Stellar et al., 2017). Although much of this research has studied awe and compassion, gratitude is thought to also increase connection with others (Emmons & McCullough, 2003; Gordon et al., 2012) and lead people to focus on the needs of the benefactor and of other people generally (McCullough et al., 2008). Therefore, gratitude should have similar effects to other self-transcendent emotions.

This increased inclusion of others in self may explain why gratitude motivates prosocial behavior. The “find, remind, and bind” theory (Algoe, 2012) argues that gratitude drives attention towards potentially helpful relationship partners and groups and binding individuals to them rather than focusing on social exchange opportunities. For example, participants who kept a gratitude journal felt greater connectedness with others, which increased subjective well-being and prosociality (Emmons & McCullough, 2003). According to this theory, expressing gratitude binds people to others, and this connectedness and focus on others’ needs is why gratitude promotes prosocial behavior (Algoe, 2012). This theory is tested in the current work by examining whether shifts in self-nature representations can account for how gratitude to nature promotes more pro-environmental behavioral intentions.

1.2. Gratitude, nature, the self, and sustainability

Based on past research on gratitude and on self-transcendence, we hypothesized that feeling gratitude to nature will increase pro-environmental behavioral intentions by shifting self-nature representations. Similar to how interpersonal gratitude binds the self-concept to other people (Algoe, 2012; Stellar et al., 2017), feeling gratitude to nature should increase the degree to which people include nature in

their self-concepts. Nature inclusion (see Fig. 1) is the degree to which people incorporate nature into their self-concepts (Schultz, 2001). Because people are motivated to help entities who are included in the self (Cialdini et al., 1997; Schultz, 2002), greater nature inclusion should encourage greater conservation behavior. Indeed, many studies have affirmed the importance of nature inclusion for sustainability (e.g., McConnell & Jacobs, 2020; Schultz, 2001; Schultz et al., 2004; Tam, 2013), including meta-analyses finding that nature inclusion (Mackay & Schmitt, 2019) and other forms of nature connectedness (Vesely et al., 2021) predict greater pro-environmental behavior. Because gratitude has binding qualities, feeling gratitude to nature should lead people to feel closer to nature and have greater nature inclusion, which in turn should promote more sustainable actions.

Although most research on the self and nature has focused on nature inclusion (e.g., Martin & Czellar, 2016; Schultz, 2001; Schultz et al., 2004; Tam, 2013), other self-nature representations can play an important role in understanding how gratitude promotes pro-environmental behavior. In particular, seeing nature as relatively large could account for the effects of nature gratitude on pro-environmental outcomes. Nature size is the degree to which people perceive nature as relatively large, which reflects perceptions of nature’s physical size and its importance (McConnell & Jacobs, 2020). McConnell and Jacobs (2020) found that greater nature size uniquely predicted greater pro-environmental behaviors and self-transcendent emotions when compared with other self-nature representations, suggesting it may be an especially important construct for understanding connections between emotions and pro-environmental behavior. Gratitude to nature could increase perceived nature size because self-transcendent emotions lead people to see the elicitor as large and powerful (Keltner & Haidt, 2003) and to focus on others (Oveis et al., 2010). Moreover, expressing gratitude entails viewing the benefactor as having the power to impact events and being capable of providing costly resources (McCullough & Tsang, 2004). Therefore, expressing gratitude to nature may lead people to see nature as being larger and more important, encouraging

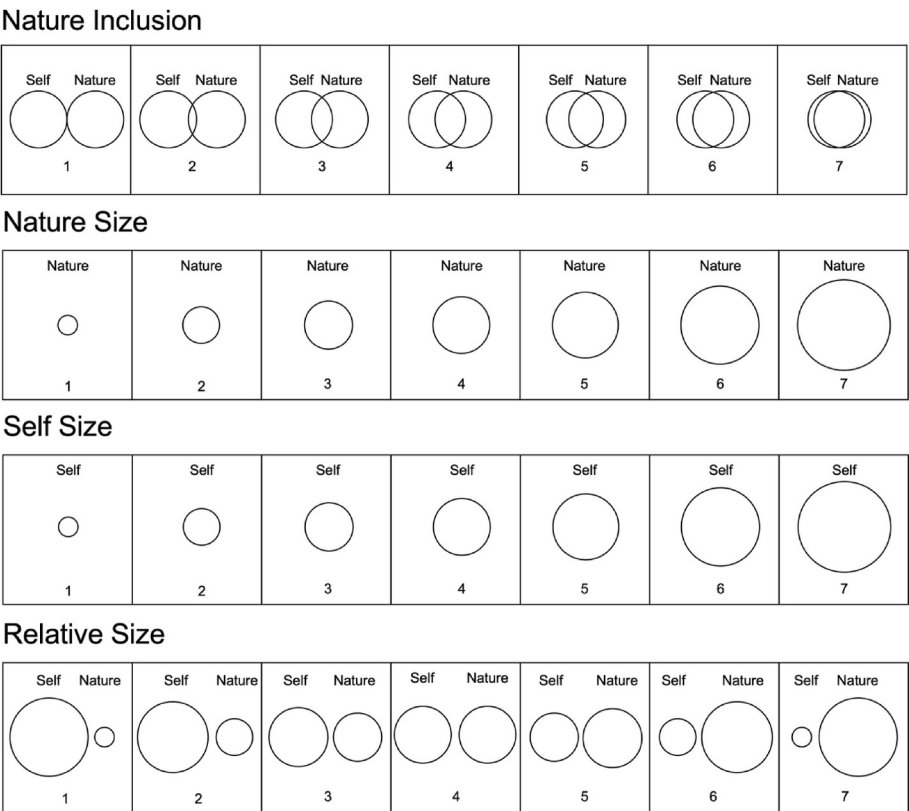


Fig. 1. Types of self-nature representations.

pro-environmental behavior (McConnell & Jacobs, 2020).

We also included measures of self size and relative size of nature compared to the self because other self-transcendent emotions such as awe can lead to a smaller self, which mediates effects on prosocial behavior (Piff et al., 2015). However, we hypothesized that gratitude's effects on pro-environmental intentions would not be driven by a smaller self because greater gratitude tends to be associated with higher self-esteem (Forest & Wood, 2012) and a greater personal sense of power (Bartlett et al., 2020). Thus, it seems unlikely that gratitude would cause a reduction in self size that would explain the effects on behavior.

Despite the promise of gratitude to nature for increasing pro-environmental behavior (Zelenski & Desrochers, 2021), little work has examined these hypotheses. In the first known paper to psychologically explore integral gratitude to nature, Naito et al. (2010) conducted two correlational studies to explore how gratitude to nature was related to environmentalism and how it might differ from other emotions such as indebtedness and regret. They found promising initial evidence for the existence of natural gratitude as a distinct emotion and reported that gratitude (and regret) towards natural places in the context of resource use were associated with greater pro-environmental behavioral intentions and attitudes. However, this work was limited in by its correlational design and lack of evaluating underlying mechanisms.

A recent paper reported six studies to more rigorously explore how gratitude to nature has sustainability benefits. Specifically, Tam (2022, Studies 1–4) developed a trait gratitude to nature scale and found that it predicted more pro-environmental attitudes, greater nature inclusion, and more pro-environmental charity donations. In the remaining studies, Tam manipulated gratitude to nature (e.g., participants either recalled instances when they felt grateful to nature, felt gratitude to people, thought objectively about how people's living is supported by nature, or recalled how people's living can be destroyed by nature). Mixed results were found regarding the effects of the manipulation on donations to environmental charities and on pro-environmental intentions. Also, Study 6 found that nature gratitude recall only led to greater behavioral intentions for participants with weak trait gratitude to nature, demonstrating an important moderator. It was unclear if the manipulation fully induced gratitude to nature because the nature gratitude recall condition was not significantly different from the objective recall condition, although planned contrasts comparing nature gratitude recall to all comparison groups together found significant (Study 6) or marginally significant (Study 5) differences. Although this work made a major contribution towards understanding nature gratitude, it did not explore the role of size constructs involving nature or the self, and it did not examine additional potential moderators such as ecological values. Thus, the current work builds on past research (e.g., Naito et al., 2010; Tam, 2022) by seeking to replicate findings that gratitude to nature is beneficial for sustainability, and it incorporates a potentially stronger manipulation, and it evaluates novel moderators and mediators to produce a more comprehensive understanding of how and for whom nature gratitude can spur greater pro-environmental outcomes.

1.3. Gratitude letters

Having participants write letters expressing gratitude to those for whom they are thankful is a common method for inducing gratitude (Emmons et al., 2019), and they have primarily been used in positive psychology research to study how gratitude increases happiness and improves well-being (Seligman et al., 2005; Toepfer et al., 2012; Toepfer & Walker, 2009). Gratitude letters have also been used in clinical interventions (Magyar-Moe, 2009; Wood et al., 2010) and as a manipulation in social psychological research (Kumar & Epley, 2018) to increase prosocial behavior (Shiraki & Igarashi, 2018), and thus gratitude letters to nature may increase pro-environmental behavior. Gratitude letters to nature have used informally by the David Suzuki Foundation (an environmental organization) to generate environmental

concern (Lindsay, 2016), though their effects have not been tested scientifically.

It is important to consider how the effects of gratitude to natural environments may differ from gratitude to other places. In the environmental psychology literature, an important distinction is made between natural and built (human-made) environments, particularly for prosocial and pro-environmental behavior. For example, Piff et al. (2015) found that spending time in a redwood forest led to more prosocial behavior compared to time looking at tall buildings. Similarly, Weinstein et al. (2009) found that viewing images of nature compared to images of buildings led to greater generosity. Zelenski et al. (2015) expanded on these findings by demonstrating that viewing a positive video of nature led to more pro-environmental behavior compared to viewing a positive video of a city. The current work adopts this distinction by comparing gratitude letters to nature with gratitude letters to human-built environments, predicting that only the nature gratitude letter will increase pro-environmentalism.

1.4. The current work

In two studies, we examined how gratitude letters to nature (versus comparison conditions) trigger pro-environmental outcomes. In both studies, self-nature representations (i.e., nature inclusion, nature size, self size, relative size) were assessed as mediators to explore how gratitude affects connectedness with other entities (Algoe, 2012) and self-transcendence (Stellar et al., 2017; Zelenski & Desrochers, 2021). Both studies also tested the hypothesis that nature gratitude would lead to more self-transcendent (but not self-interested) emotions compared to gratitude to built environments because nature exposure is typically associated with awe and reduced self-focus (Piff et al., 2015) whereas built environments are often associated with greater self-focus (Mayer et al., 2009) and personal consumption (Poruschi & Ambrey, 2016). Study 1 included a neutral control group to determine the direction of effects between nature and built gratitude, and Study 2 investigated individual difference moderators.

2. Study 1: Nature gratitude effects on self-nature representations and pro-environmental behavioral intentions

Study 1 tested the central hypotheses that writing a letter of gratitude to nature leads to more sustainable self-nature representations, self-transcendent emotions, and intentions. It also explored whether self-nature representations (i.e., nature inclusion, nature size, self size, relative size) mediate the effects of nature gratitude on pro-environmental action. Two comparison groups were examined, one in which participants wrote a gratitude letter to a city and a second control condition in which participants wrote about their morning routine (a commonly-used control condition; Cesario et al., 2006; Shiraki & Igarashi, 2018).

2.1. Method

2.1.1. Participants

An a priori power analysis using the *pwr* package (Champely, 2020) in the R Programming Language specified a minimum sample size of 246 participants, assuming an effect size of $f = 0.20$ ($\eta^2 = 0.04$) and desired power of 0.80. Effect size was estimated based on an effect of nature gratitude letters on nature inclusion of $d = 0.40$ from pilot data. Participants were recruited via Prolific, a high-quality recruitment platform for social science research (Palan & Schitter, 2018). Participants were compensated \$2.14 for a 16-min study. Attention checks were included to foster high-quality data (Aust et al., 2013). The first attention check consisted of a directed query check (Abbey & Meloy, 2017) in which participants were told to respond with a "50" on a slider scale such that responses other than 50 indicated a lack of attention. For the second check, participants were asked "Which of the following have you done

within the past month? Please select all that apply” and were asked to select from a list of common behaviors, one of which included “Used a computer or mobile phone.” Because this study was conducted on a computer, all participants should select this option, and not doing so indicates a lack of attention or of English comprehension. Finally, during the demographics portion of the study, participants were asked to indicate if English was their primary language. Anticipating a potential for 20% failed attention and comprehension checks, a sample of 296 participants was recruited. Indeed, 26 participants (9%) were excluded for failed attention or English comprehension checks. In addition, participant’s letters were reviewed to ensure that they followed the instructions. We found that seven participants in the nature condition wrote about built environments, 31 participants in the built condition wrote about natural environments, seven participants in the control condition wrote about nature, and four participants wrote irrelevant or blank responses. Because these cases reflect problematic experimental condition assignment, we excluded them from the primary analyses, resulting in a final sample of 221 participants ($M_{age} = 38.51$, $SD = 15.56$; 107 men, 108 women, 6 nonbinary/non-conforming). Analyses including all attentive participants are reported in the Supplementary Materials. Additionally, a post hoc power analysis was conducted for the parallel mediation model conducted in this study (Schoemann et al., 2017), finding 76% power for the nature size indirect effect and 78% power for the nature inclusion indirect effect.

2.1.2. Procedure

Gratitude letter manipulation. First, participants were randomly assigned to write one of three responses as the key experimental manipulation for 5–10 minutes. The gratitude letter prompts (see Supplemental Materials) were adapted from gratitude letters to people used in past research (Magyar-Moe, 2009). In the nature gratitude condition, participants were asked to write a letter expressing gratitude to a natural location for which they have never formally thanked. In the built gratitude condition, participants were asked to write a letter giving thanks to a city for which they have never formally thanked. Participants in the neutral control condition were asked to write about their morning routine (Cesario et al., 2006; Shiraki & Igarashi, 2018).

Emotion manipulation check. Following the writing task, participants completed measures of state gratitude and indebtedness (Tam, 2022) towards natural and built environments to assess whether the gratitude letters induced more gratitude but not more indebtedness toward their respective targets. Indebtedness is a distinct, negatively-valenced emotion that also can occur after receiving a gift that does not usually have the same beneficial effects as gratitude (Tsang, 2006). Three items measured gratitude to nature (e.g., “Right now, I feel thankful to the natural environment”) and three measured indebtedness to nature (e.g., “Right now, I feel I owe a great deal to the natural environment”) on a scale from 1 (strongly disagree) to 7 (strongly agree). Next, all participants completed the same six items, but with “city” replacing “natural environment” to create separate indices of gratitude and indebtedness to natural (gratitude: $M = 5.67$, $SD = 1.41$, $\alpha = 0.95$, $\omega = 0.95$; indebtedness: $M = 4.92$, $SD = 1.61$, $\alpha = 0.92$, $\omega = 0.92$) and built environments (gratitude: $M = 4.01$, $SD = 1.70$, $\alpha = 0.94$, $\omega = 0.94$; indebtedness: $M = 3.22$, $SD = 1.61$, $\alpha = 0.93$, $\omega = 0.93$).

Self-transcendent and self-interested positive emotions. Participants then completed a measure of positive state emotions based on the Dispositional Positive Emotions Scale (Shiota et al., 2006), used in past research (McConnell & Jacobs, 2020). They indicated the degree to which they were feeling four self-transcendent emotions (love, compassion, awe, moral elevation) and four self-interested (joy, contentment, pride, amusement). Each emotion was assessed with two items (e.g., “awe” and “wonder” to capture awe). Mean responses to the eight items for each category were used to create indices of self-transcendent ($M = 4.63$, $SD = 1.23$, $\alpha = 0.92$, $\omega = 0.92$) and self-interested ($M = 4.76$, $SD = 1.10$, $\alpha = 0.88$, $\omega = 0.88$) emotions. However, it is important to control for the shared variance in these

emotion types because of their shared positive valence (Jacobs & McConnell, 2022; Shiota et al., 2014). Thus, to index unique effects on self-transcendent and self-interested emotions, we used regressions to create residualized standardized scores for both emotion types while partialing out the shared variance between the two and used these residual scores in subsequent analyses. Thus, each participant’s residual score for self-transcendent and self-interested emotions reflected the relative degree to which they showed stronger emotions in the current sample while partialing out the other positive emotion category.

Self-nature representations. Next, participants completed measures of the four self-nature representations: nature size, self size, nature inclusion, and relative nature-self size (McConnell & Jacobs, 2020). First, participants completed a measure of nature size in which they were presented with a series of circles, which are labeled as representing nature of different sizes from smallest (1) to largest (7; $M = 5.74$, $SD = 1.23$), and then selected the circle “that best demonstrates how [they] feel about nature.” Then, they completed a measure of self size ($M = 4.68$, $SD = 1.76$), which is identical to the first measure except that nature is replaced by “the self.” Next, participants completed the nature inclusion measure (Schultz, 2001) in which they indicated the degree to which they considered nature included in their self-concept by selecting from a series of increasingly overlapping circles representing the self and nature, with depictions ranging from 1 (no overlap) to 7 (almost complete overlap; $M = 4.56$, $SD = 1.55$). Finally, participants completed the relative size component of relative nature-self size (relative size; McConnell & Jacobs, 2020) in which they were presented with another series of circles representing the self and nature in which participants selected the set that best represents their sense of self relative to nature ranging from 1 (self much larger than nature) to 7 (nature much larger than self; $M = 5.00$, $SD = 1.78$) while not considering the overlap between the circles.

Pro-environmental behavioral intentions. Finally, participants completed a measure of pro-environmental behavioral intentions used in past research on gratitude to nature (Tam, 2022). Specifically, participants indicated their likelihood of performing 10 different pro-environmental behaviors on a continuous scale ranging from 0 (I certainly will NOT do it) to 100 (I certainly will do it). The mean response to the items was computed ($M = 69.40$, $SD = 19.57$, $\alpha = 0.90$, $\omega = 0.90$) with greater scores indicating stronger intentions to perform pro-environmental behaviors.

2.2. Results

2.2.1. Gratitude manipulation check

First, correlations between gratitude and indebtedness were conducted to examine their shared variance, and they were large ($r = 0.76$ for nature and $r = 0.82$ for cities) and either above or approaching the threshold for discriminant validity of $r = 0.80$ (Brown, 2006). We then conducted an exploratory factor analysis on the six gratitude and indebtedness to nature items using principal axis factoring and a direct oblimin rotation, which produced a one-factor solution ($\lambda = 4.68$), explaining 78.02% of the variance. We then conducted a similar factor analysis on the six gratitude and indebtedness to built environments items, which resulted in a one-factor solution ($\lambda = 4.83$), explaining 80.58% of the variance. Because of the strong correlations between gratitude and indebtedness and the one-factor solutions, it seems that the gratitude and indebtedness items failed to differentiate between the two discrete states and were capturing the same construct. Therefore, we used the factor scores for nature and built environments as our measures of gratitude in the analyses.

Descriptive statistics across experimental groups for the variables of interest are presented in Table 1, and analyses of variance (ANOVAs) examined between conditions differences. Experimental condition had an effect on the gratitude to nature factor score, $F(2,218) = 26.27$, $p < .001$, $\eta^2 = .19$, such that the nature letter led to more gratitude to nature than the other conditions, and the built letter led to more gratitude to

Table 1

Means and standard deviations for the experimental conditions in study 1.

	Nature Letter (N = 81)		Built Letter (N = 54)		Control Condition (N = 86)	
	M	SD	M	SD	M	SD
Gratitude to Nature	0.52 _a	0.65	-0.07 _b	0.88	-0.45 _c	1.05
Gratitude to Built	-0.13 _a	0.62	0.61 _b	1.41	-0.26 _a	1.57
Residualized STEs	0.42 _a	0.95	0.11 _a	0.99	-0.47 _b	0.85
Residualized SIEs	-0.29 _a	1.03	-0.05 _a	0.89	0.31 _b	0.85
Nature Size	6.06 _a	1.20	5.52 _b	1.11	5.57 _b	1.29
Self Size	4.51 _a	1.80	4.54 _a	1.86	4.93 _a	1.65
Nature Inclusion	4.96 _a	1.55	4.33 _b	1.39	4.28 _b	1.58
Relative Size	5.15 _a	1.75	4.98 _a	1.82	4.88 _a	1.78
PEB Intentions	72.42 _a	18.78	66.53 _a	21.43	68.35 _a	18.93

Note. Means that do not share subscripts differ at $p < 0.05$ as determined by least-significant-difference post-hoc tests. Bolded rows indicate a significant effect of condition ($p < 0.05$).

nature than was observed in the control condition. Experimental condition also had an effect on the gratitude to built environments factor score, $F(2,218) = 16.74$, $p < .001$, $\eta^2 = .13$, such that the built letter led to more gratitude to built environments compared to the other two conditions, which did not differ from each other. These findings suggest that the manipulations were effective in inducing gratitude to the anticipated targets.

2.2.2. Primary analyses

One-way ANOVAs assessed the effects of experimental conditions on self-transcendent and self-interested emotions, self-nature representations, and behavioral intentions (see Table 1). First, experimental condition had an effect on residualized self-transcendent emotions, $F(2,218) = 20.12$, $p < .001$, $\eta^2 = .16$, such that both gratitude letters led to more state self-transcendent emotion compared to the control condition. The nature and built letters did not reliably differ from each other. Experimental condition also had an effect on residualized self-interested emotions, $F(2,218) = 8.01$, $p < .001$, $\eta^2 = .07$, such that both gratitude letters led to less state self-interested emotions compared to the control condition. The nature and built letters did not differ from each other.

For self-nature representations and pro-environmental behavioral intentions, experimental condition had an effect on nature size, $F(2,218) = 4.59$, $p = .011$, $\eta^2 = .04$, such that participants who wrote the nature gratitude letter reported nature as larger than those in the built gratitude or control conditions, which did not differ from each other. There was also an effect of experimental condition on nature inclusion, $F(2,218) = 4.90$, $p = .008$, $\eta^2 = .04$, such that participants who wrote nature gratitude letters reported greater inclusion of nature in their self-concepts compared to participants in the built gratitude letter and control conditions, which did not differ from each other. Experimental condition did not have an effect on self size, $F(2,218) = 1.45$, $p = .238$, $\eta^2 = .01$, on relative nature-self size, $F(2,218) = 1.48$, $p = .627$, $\eta^2 < .01$, or on pro-environmental behavioral intentions, $F(2,218) = 1.67$, $p = .190$, $\eta^2 = .02$.

2.2.3. Mediation analyses

Although we did not find a main effect indicating that nature gratitude letters led to more pro-environmental behavioral intentions, it is possible for there to be an indirect effect through self-nature representations (Hayes, 2020). This possibility is suggested because nature gratitude letters led to significantly greater nature size and inclusion, and nature size ($r = .45$, $p < .001$) and inclusion ($r = .45$, $p < .001$) were both significantly associated with behavioral intentions. To assess the possibility of an indirect effect, a mediation analysis was conducted using PROCESS Model 4 (Hayes, 2020) with 5000 bootstrapped percentile confidence intervals with nature inclusion and nature size

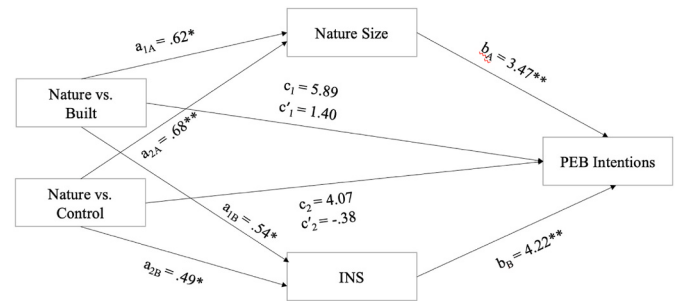


Fig. 2. Mediation model of the indirect effects of the nature letter on pro-environmental behavioral intentions via nature size and nature inclusion in Study 1.

entered as parallel mediators and pro-environmental behavioral intentions as the dependent variable (see Fig. 2). Indicator coding was used with the nature gratitude condition as the reference group and the built gratitude and control conditions as comparison groups. First, significant indirect effects were found such that nature size mediated the effect of the nature gratitude letter leading to more pro-environmental behavioral intentions compared to the built letter (Indirect Effect = 2.29, $SE = 1.10$, 95% CI [0.37, 4.65]) and to the control condition (Indirect Effect = 2.08, $SE = 1.02$, 95% CI [0.34, 4.24]) letters. Second, significant indirect effects were found such that nature inclusion also mediated the effect of the nature gratitude letter leading to more pro-environmental behavioral intentions compared to the built letters (Indirect Effect = 2.19, $SE = 1.16$, 95% CI [0.35, 4.86]) and to the control condition (Indirect Effect = 2.37, $SE = 1.12$, 95% CI [0.58, 4.93]) letters. Thus, although the nature gratitude letter did not have a direct effect on intentions to help the environment, it did have indirect effects on behavioral intentions via nature size and inclusion.¹

2.3. Discussion

Study 1 found preliminary support for our hypotheses regarding the pro-environmental benefits of gratitude to nature. First, nature gratitude letters led to greater feelings of gratitude to nature compared to the control conditions, which was not observed in past work using nature gratitude inductions (Tam, 2022). Additionally, we observed novel effects on self-nature representations such that the gratitude letter to nature led participants to see nature as larger and as more included in their self-concepts. There were no significant effects on self size or on relative size, suggesting that nature gratitude led participants to see nature as large rather than seeing the self as small or as relatively smaller than nature. Finally, we observed that the nature gratitude letter indirectly led to greater pro-environmental behavioral intentions via greater nature inclusion and greater nature size in the parallel mediation analyses, providing evidence that nature gratitude letters had an indirect effect on pro-environmental intentions. The lack of a direct effect of condition on behavioral intentions was surprising, and it is possible that the effect of nature gratitude on behavior intentions might be stronger for some

¹ We conducted a test of differences between the nature inclusion indirect effect of letter type on intentions and the nature size indirect effect of letter type on intentions using the “contrast” command in the SPSS PROCESS macro (Hayes, 2020). Specifically, two dummy codes were created to compare the nature letter (reference group) to the built letter and control conditions. First, when comparing the nature letter to the built letter, there was no significant difference between the indirect effects for nature size and nature inclusion, $IE_{diff} = -0.11$, $SE = 1.46$, 95% CI [-2.79, 3.07]. Similarly, when comparing the nature letter to the control condition, there was no significant difference between the indirect effects for nature size and nature inclusion, $IE_{diff} = -0.30$, $SE = 1.15$, 95% CI [-2.42, 3.59]. Thus, there were no meaningful differences in the magnitude of the mediational effects involving nature size and nature inclusion.

individuals than for others, and Study 2 considered individual difference moderators (i.e., biospheric values, reciprocity beliefs) that might identify for whom nature gratitude letters are especially powerful.

Although this study provided a promising initial demonstration, some limitations led to adopting methodological changes in a follow-up study. First, in Study 1, a meaningful number of participants (30%) wrote about nature in the built gratitude condition (e.g., they were grateful to Denver because it allowed them to view the Rocky Mountains), which suggested that the manipulation prompts could be more focused on instructing participants to write about human-built places. We excluded these participants from analyses in Study 1 because they were not appropriately manipulated, which led to uneven sample sizes between conditions and resulted in the overall sample size being smaller than desired. Although ANOVAs are relatively robust to unequal sample sizes (Blanca et al., 2017), retaining more participants would improve statistical power, and thus more specific instructions might be helpful. In Study 2, we modified the built gratitude prompt to focus participants on writing specifically about “human-built places” rather than cities. Second, the manipulation check failed to distinguish between gratitude and indebtedness. One possibility could be that participants exhibited acquiescence bias, which is the tendency to respond to survey items in a positive manner or to provide similar responses without meaningful reflection on the items presented (Hurd & Kapteyn, 2000). To counteract this possibility, we included some items phrased in the opposite direction (e.g., “At this moment, I do *not* feel appreciative of what nature gives me”) and reverse scored them. Finally, to conserve statistical power and because the built gratitude and control conditions did not differ on the key measures in Study 1, only the nature and built letter conditions were used in Study 2.

3. Study 2: Individual difference moderators

In addition to incorporating the aforementioned methodological changes, we expanded on Study 1 by examining individual differences that may moderate the effects of nature gratitude on pro-environmental outcomes. First, we explored the role of biospheric value orientation, which is the degree to which people hold stable, *trans*-situational beliefs about the importance of caring for nature (e.g., preventing pollution, respecting the Earth; de Groot & Steg, 2008; de Groot & Thøgersen, 2018). Notably, conservation interventions are often more effective for those who hold biospheric values because they recognize discrepancies between their actual behavior and values when reminded of the importance of nature, which motivates them to act, whereas these motivations are not present for those who do not value the environment (Bolderdijk et al., 2013; de Groot & Steg, 2010). Additionally, affective experiences can make goals and values more salient (Aarts et al., 2008) and biospheric values have a greater impact on pro-environment behavior when they are salient (van der Werff et al., 2013). Thus, we hypothesized that the effect of nature gratitude letters on pro-environmental behavioral intentions might be stronger for those holding greater biospheric value orientations because of how nature gratitude may activate these values. In addition, we also assessed egoistic (e.g., power, achievement) and altruistic (e.g., equality, social justice) values, which are other motivations that typically do not predict pro-environmental action at all (in the case of egoistic values) or as strongly (in the case of altruistic values; de Groot & Steg, 2008; Hansla et al., 2008). Observing moderation specifically for biospheric values would further underscore the importance of pro-environmental concern rather than general concern for others or for one's own circumstances.

We also considered the potential role of personal norms of positive reciprocity, or the degree to which people endorse the belief that it is morally correct to repay favors or gifts from others (Perugini et al., 2003). Specifically, it is possible that expressing gratitude toward nature

might encourage stronger pro-environmental behavioral intentions among those who view reciprocity as a moral imperative, and thus, we assessed this individual difference as a possible moderator in Study 2.

Finally, we aimed to replicate the indirect effects on intentions found in Study 1, which were driven by self-nature representations. We expected to observe parallel mediation, such that greater nature size and greater nature inclusion could explain the effects of the nature gratitude letter leading to more pro-environmental behavioral intentions. Because we hypothesized interactions with biospheric value orientation and with positive reciprocity norms, conditional process models with these moderators and mediators (nature size and inclusion) were tested.

3.1. Method

3.1.1. Participants

An a priori power analysis using the *pwr2ppl* package (Aberson, 2019) in the R Programming Language specified a minimum sample size of 250 participants, assuming the Model $R^2 = .07$ and the Interaction $\Delta R^2 = .03$ based on small-to-medium effect sizes common in social psychology research (Richard et al., 2003). Participants were recruited via Prolific and were compensated \$2.40 for an 18-min study. The same attention and comprehension checks used in Study 1 were included. To account for 20% failed attention checks, an overall sample of 300 participants was recruited. Indeed, 36 participants (11.67%) were excluded for failed attention or comprehension checks and one participant was removed from analyses for being an outlier of 3.97 standard deviations below the mean on biospheric value orientation and for responding with “1” or “7” for all responses. As in Study 1, we coded participant gratitude letters for whether participants wrote about the correct target (i.e., natural places in the nature gratitude condition and human-built places in the built gratitude condition). Seven responses in the nature gratitude condition focused on built places, and 30 responses in the built gratitude condition focused on natural places. To be consistent with Study 1, we excluded these participants resulting in a final sample of 226 participants ($M_{age} = 39.97$, $SD = 15.65$; 107 men, 111 women, 4 non-binary/non-conforming, 1 transgender men, 1 genderqueer, 1 prefer not to answer). We report the analyses involving all attentive and English-speaking participants in the Supplementary Materials. Additionally, a post hoc power analysis was conducted for the parallel mediation model (Schoemann et al., 2017), finding 85% power for the nature size indirect effect and 79% power for the nature inclusion indirect effect.

3.1.2. Procedure

Environmental value orientations. First, participants completed the 13-item Environmental Value Orientations Scale (de Groot & Steg, 2008), which measures personal values relevant to pro-environmental behavior, on scale ranging from 1 (opposed to my values) to 7 (very important). The scale measures three types of values: egoistic values measured by five items (e.g., power, wealth; $M = 2.72$, $SD = 1.49$, $\alpha = 0.78$, $\omega = 0.78$), altruistic values measured by four items (e.g., equality, social justice; $M = 5.51$, $SD = 1.28$, $\alpha = 0.83$, $\omega = 0.84$), and biospheric values measured by four items (e.g., protecting the environment, unity with nature; $M = 5.13$, $SD = 1.49$, $\alpha = 0.91$, $\omega = 0.91$). The mean responses for each value orientation were computed with greater scores indicating stronger endorsement of that value type.

Individual differences in positive reciprocity. Next, participants completed the Positive Reciprocity Subscale of the Personal Norms of Reciprocity Scale (Perugini et al., 2003), a nine-item measure of the degree to which people report a propensity to repay positive actions from others with their own positive behaviors (e.g., “If someone does a favor for me, I am ready to return it,” “I go out of my way to help somebody who has been kind to me before”) on a scale ranging from 1

(not to true to me) to 7 (very true to me). The mean response was computed to form an index of personal norms of positive reciprocity ($M = 5.60$, $SD = 0.83$, $\alpha = 0.83$, $\omega = 0.82$) with greater scores indicating stronger beliefs that it is necessary to reciprocate benefits provided by others.

Gratitude letters manipulation. Afterwards, participants were randomly assigned to complete either the nature gratitude or built gratitude letter. In an effort to increase the likelihood that participants wrote about the correct environment, we changed the wording of the built gratitude prompt such that participants were asked to write about “human-built” places rather than “cities.”

Emotion manipulation check. Measures of state gratitude and indebtedness were included as manipulation checks. To match the reworked instructions, the built gratitude and indebtedness measures were reworded to focus on human-built environments rather than cities. One of the items for each gratitude and indebtedness measure was worded in the opposite direction (reverse coded) in an attempt to reduce potential acquiescence effects. The mean response was computed for each of the measures: gratitude to nature ($M = 5.76$, $SD = 1.21$, $\alpha = 0.69$, $\omega = 0.73$), indebtedness to nature ($M = 5.38$, $SD = 1.37$, $\alpha = 0.80$, $\omega = 0.82$), gratitude to built environments ($M = 4.99$, $SD = 1.43$, $\alpha = 0.80$, $\omega = 0.83$), and indebtedness to built environments ($M = 4.33$, $SD = 1.53$, $\alpha = 0.81$, $\omega = 0.84$).

Self-transcendent and self-interested positive emotions. Participants completed the same self-interested and self-transcendent positive emotion measures used in Study 1. The mean scores for the eight self-transcendent emotion items ($M = 4.81$, $SD = 1.25$, $\alpha = 0.92$, $\omega = 0.92$) and for the eight self-interested emotion items ($M = 4.73$, $SD = 1.19$, $\alpha = 0.90$, $\omega = 0.90$) were computed. As in Study 1, residualized standardized scores for each emotion type were computed to index the relative magnitude that each participant experienced it while controlling for the other emotion type, and these residual positive emotion scores were used in subsequent analyses.

Self-nature representations. Next, participants completed the same measures of nature size ($M = 5.75$, $SD = 1.27$), self size ($M = 4.61$, $SD = 1.76$), nature inclusion ($M = 4.67$, $SD = 1.56$), and relative nature-self size ($M = 5.21$, $SD = 1.69$) used in Study 1.

Pro-environmental behavioral intentions. Finally, participants completed the measure of pro-environmental behavioral intentions ($M = 72.56$, $SD = 17.97$, $\alpha = 0.87$, $\omega = 0.87$) used in Study 1.

3.2. Results

3.2.1. Gratitude manipulation check

As in Study 1, we first examined the correlations between gratitude and indebtedness, finding that they were large ($r = 0.72$ for nature and $r = 0.68$ for built), though not as extreme as in Study 1. We then conducted an exploratory factor analysis on the six gratitude and indebtedness to nature items using principal axis factoring and a direct oblimin rotation, which found a two-factor solution ($\lambda_1 = 3.71$; $\lambda_2 = 1.91$) explaining 81.72% of the variance. However, the two factors did not map on to gratitude and indebtedness. Instead, they captured the four standard items and the two reverse-coded items, suggesting the possibility of acquiescence. We then conducted the same analysis on the six gratitude and indebtedness to built environments items, which found a one-factor solution ($\lambda = 3.76$) explaining 62.60% of the variance. Because of the strong correlations between gratitude and indebtedness and the lack of the hypothesized two-factor solutions, it seems that the gratitude and indebtedness items failed to differentiate between the two discrete states and were capturing the same construct. Thus, in the following analyses, we used the factor scores (factor 1 for nature gratitude and the only factor score for built gratitude) as our measures of gratitude in subsequent analyses. We then conducted independent samples *t*-tests to check if the manipulation was successful (see Table 2). As predicted, the nature letter led to more gratitude to nature compared to the built letter condition, $t(192.77) = 5.23$, $p < .001$, 95% CI [0.39,

Table 2

Means and standard deviations by letter type in study 2.

	Nature Letter ($N = 124$)		Built Letter ($N = 102$)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Gratitude to Nature	6.09	1.11	5.35	1.27
Indebtedness to Nature	5.77	1.20	4.90	1.41
Gratitude to Built	4.41	1.36	5.71	1.15
Indebtedness to Built	3.97	1.55	4.77	1.40
Residualized STEs	0.16	0.98	-0.19	1.01
Residualized SIEs	-0.10	1.01	0.13	0.97
Nature Size	6.01	1.11	5.44	1.38
Self Size	4.51	1.79	4.73	1.72
Nature Inclusion	4.94	1.49	4.33	1.58
Relative Size	5.39	1.54	5.00	1.89
PEB Intentions	75.20	17.77	69.38	17.78

Note. Bolded rows indicate a significant effect of condition ($p < 0.05$).

0.88], $d = 0.70$.² Also, the built letter led to more gratitude to built environments compared to the nature letter condition, $t(223.97) = -6.67$, $p < .001$, 95% CI [-1.00, -0.54], $d = 0.88$. These results suggest that the letters successfully induced gratitude to the intended targets.

3.2.2. Primary analyses

Independent samples *t*-tests evaluated the effects of the gratitude letter manipulation on the outcome variables, with descriptive statistics presented in Table 2. For positive emotions, the nature gratitude letter led to more residualized self-transcendent emotions compared to the built gratitude letter, $t(224) = 2.67$, $p = .008$, 95% CI [0.09, 0.61], $d = 0.36$. There was no significant difference for residualized self-interested emotions, $t(224) = -1.75$, $p = .082$, 95% CI [-0.49, 0.03], $d = 0.23$.

For self-nature representations, the nature gratitude letter led participants to see nature as larger compared to participants in the built gratitude letter condition, $t(201.06) = 3.36$, $p < .001$, 95% CI [0.23, 0.90], $d = 0.46$. The nature gratitude letter also led to greater nature inclusion compared to the built gratitude letter, $t(224) = 2.98$, $p = .003$, 95% CI [0.21, 1.01], $d = 0.40$. There were no condition differences on self size, $t(224) = -0.93$, $p = .356$, $d = 0.12$, 95% CI [-0.68, 0.25], or on relative size, $t(190.57) = 1.68$, $p = 0.094$, $d = .23$, 95% CI [-0.07, 0.83]. Finally, the nature gratitude letter led to more pro-environmental behavioral intentions compared to the built letter, $t(224) = 2.45$, $p = .008$, $d = 0.33$, 95% CI [1.14, 10.50].

3.2.3. Multiple regression analyses

Moderated multiple regression analyses tested the hypothesized interaction effects between letter condition and the moderators (i.e., biospheric value orientation, personal norms of positive reciprocity) on the outcome measures (e.g., self-nature representations, behavioral intentions) in separate analyses. First, multiple regressions were conducted with biospheric value orientation as a continuous predictor, letter condition dummy coded (1 = nature, 0 = built), and their interaction (product term) in predicting each outcome (i.e., emotions, self-nature representations, behavioral intentions). Biospheric value orientation was standardized to aid in interpretation. No interactions were found for emotions, nature inclusion, nature size, self size, or relative size. However, as illustrated in Fig. 3, an interaction between gratitude letter condition and biospheric value orientation was observed for pro-environmental behavioral intentions, $\beta = 0.17$, $t(222) = 2.01$, $p = .045$, 95% CI [0.09, 8.41], $\Delta R^2 = .01$. This interaction was further decomposed and examined using the Johnson-Neyman Technique, which calculates the exact values of a moderator (i.e., biospheric value

² For some *t*-tests in Study 2, Levene's test for equality of variances was significant ($p < .05$), indicating that homogeneity assumptions were violated. To adjust for tests where this assumption was violated, unpooled variances and adjusted degrees of freedom were used.

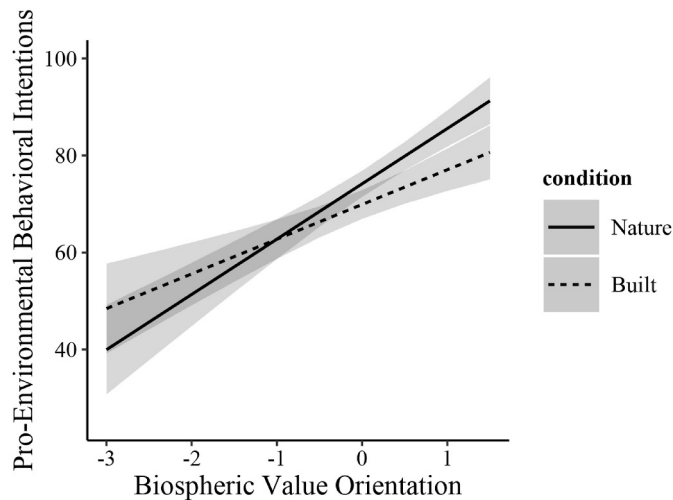


Fig. 3. Interaction between biospheric value orientation (standardized) and gratitude letter target for pro-environmental behavioral intentions.

orientation) where the slope of the relation between an independent variable (letter condition) and dependent variable (behavioral intentions) reaches significance (Bauer & Curran, 2005). As shown in Fig. 4, the effect of the nature letter leading to more pro-environmental behavioral intentions was significant for participants who were 0.05 standard deviations below the mean or greater on biospheric value orientation (57.96% of participants). This finding is consistent with past research showing that nature-centered interventions are sometimes only effective for those who endorse biospheric values (Bolderdijk et al., 2013).

Next, multiple regressions were conducted with standardized personal norm of positive reciprocity as a continuous predictor, letter condition dummy coded (1 = nature, 0 = built), and their interaction (product term). Contrary to the possibility of norms of positive reciprocity having a moderating effect, no interaction between personal norms of positive reciprocity and letter type for behavioral intentions was observed, $\beta = 0.02$, $t(222) = 0.29$, $p = .770$, 95% CI [0.09, 8.41], $\Delta R^2 < .001$. There was a direct effect of personal norms of reciprocity ($\beta = 0.43$, $t(222) = 7.12$, $p < .001$, 95% CI [5.58, 9.81]) such that greater endorsement of positive reciprocity norms were associated with more pro-environmental intentions and a direct effect of letter type ($\beta = 0.13$,

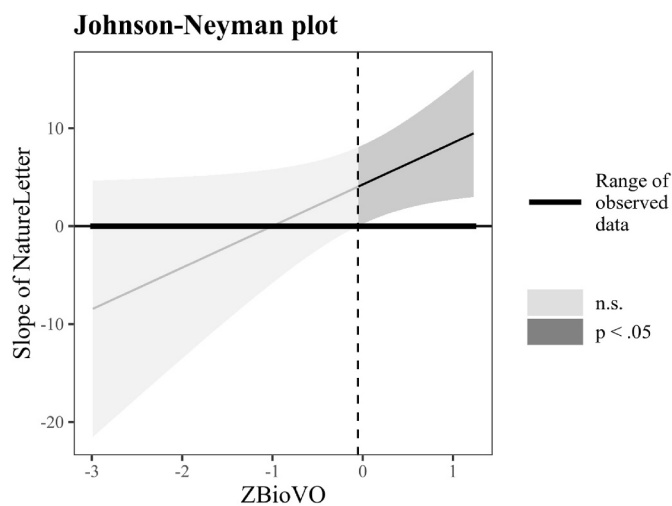


Fig. 4. Johnson-Neyman plot showing the region-of-significance for the interaction between biospheric value orientation and nature gratitude letters for pro-environmental behavioral intentions.

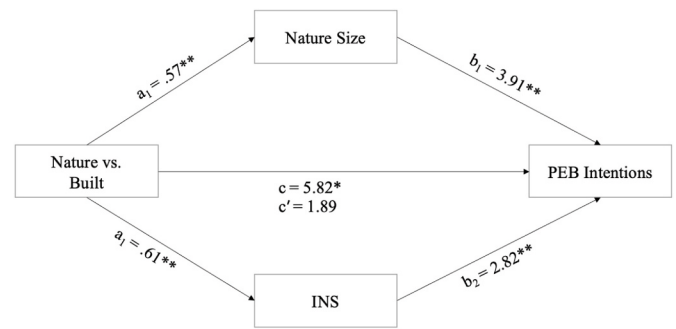


Fig. 5. Mediation model of the indirect effects of nature gratitude letter on pro-environmental behavioral intentions via nature size and nature inclusion in Study 2.

$t(222) = 2.16$, $p = .032$, 95% CI [0.40, 8.89]) such that the nature letter led to more pro-environmental intentions.

3.2.4. Mediation analyses

To replicate Study 1 and to explore the mechanisms underlying the effect of nature gratitude in promoting greater intentions to help nature, a mediation analysis was conducted using PROCESS Model 4 (Hayes, 2020) with 5000 bootstrapped percentile confidence intervals with nature inclusion and nature size entered as parallel mediators and pro-environmental behavioral intentions as the dependent variable (Fig. 5). Replicating Study 1, significant indirect effects were found such that both nature inclusion (Indirect Effect = 2.22, $SE = 0.90$, 95% CI [0.67, 4.13]) and nature size (Indirect Effect = 1.72, $SE = 0.85$, 95% CI [0.39, 3.69]) mediated the effect of the nature gratitude letter leading more pro-environmental behavioral intentions.³

Finally, because of the interaction between biospheric value orientation and the nature gratitude letter on pro-environmental behavioral intentions, we also tested a complete conditional process model including nature size and inclusion as parallel mediators and biospheric value orientation as a moderator of the direct effect of letter type on behavioral intentions (Fig. 6). Specifically, this analysis was tested using PROCESS Model 5 with 5000 percentile bootstrapped confidence intervals (Hayes, 2020). The complete model was significant and explained 33% of the variance in pro-environmental behavioral intentions, $F(5, 220) = 21.24$, $p < 0.001$, $R^2 = 0.33$. The interaction between biospheric value orientation and letter type was still significant. The indirect effect for nature inclusion was still significant (Indirect Effect = 1.09, $SE = 0.64$, 95% CI [0.10, 2.54]) but, unexpectedly, not the indirect effect for nature size (Indirect Effect = 0.96, $SE = 0.71$, 95% CI [-0.25, 2.59]). The lack of an indirect effect for nature size could be due to a suppression effect (see discussion) or could indicate that the individual differences may weaken the meditating power of nature size.

3.3. Discussion

Study 2 replicated Study 1 and extended it by exploring the underlying processes and boundary conditions involved in how gratitude to nature encourages pro-environmental behavior. As in Study 1, the

³ We conducted a test of differences between the nature inclusion indirect effect of letter type on intentions and the nature size indirect effect of letter type on intentions using the “contrast” command in the SPSS PROCESS macro (Hayes, 2020). There was no significant difference between the indirect effects, $IE_{diff} = -0.50$, $SE = 1.15$, 95% CI [-2.70, 1.86]. We also conducted the contrast test with biospheric value orientation included as a moderator of the total effect (Model 5) and found no significant difference between the indirect effects $IE_{diff} = 0.13$, $SE = 0.95$, 95% CI [-1.66, 2.15]. Thus, there were no meaningful differences in the magnitude of the mediational effects involving nature size and nature inclusion.

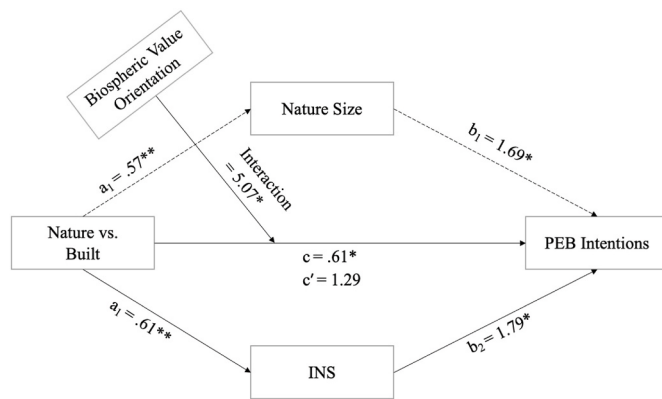


Fig. 6. Complete Study 2 conditional process model.

nature gratitude letter led to larger nature size and greater inclusion of nature in the self compared to the built gratitude letter. Unlike Study 1, the nature gratitude letter also directly led to more self-transcendent emotions and pro-environmental behavioral intentions than the built gratitude letter, in line with predictions. The differences between study findings (i.e., finding direct effects on self-transcendent emotions and on behavioral intentions in Study 2 but not in Study 1) could be due to the increased statistical power in Study 2 compared to Study 1. Indeed, post hoc sensitivity analyses indicate that Study 1 had 80% power to detect an omnibus effect of $f = 0.21$ (equivalent to $d = 0.42$), with the effect size being even smaller for post hoc tests, whereas Study 2 had 80% power to detect an effect size of $d = 0.37$.

We also investigated whether individual differences involving biospheric values and personal norms of positive reciprocity might moderate the effect of nature gratitude on pro-environmental outcomes. In short, personal norms of positive reciprocity showed no evidence of moderation. However, an interaction was observed between biospheric value and experimental condition, finding that nature gratitude letters were effective at inspiring greater pro-environmental behavioral intentions among participants who endorse at least moderate degrees of biospheric values. This interaction indicates that nature gratitude letters may be an effective intervention for audiences who endorse biospheric values but not for those who reject biospheric values, which is congruent with past work on how audiences with weaker biospheric values are less receptive to pro-environmental messaging (Bolderdijk et al., 2013) and with work on how biospheric values are more powerful after being made salient (van der Werff et al., 2013). It is also worth noting that nature gratitude letters had indirect effects on intentions that were not moderated by values, meaning that they could indirectly lead to greater intentions among participants with weaker biospheric value orientation by increasing nature size and nature inclusion.

We also sought to replicate the indirect effects on pro-environmental intentions driven by self-nature representations observed in Study 1. Indeed, we found that both greater nature inclusion and greater nature size mediated the effects of the nature gratitude letter leading to more pro-environmental behavior, replicating Study 1. However, when the interaction between the letter and biospheric orientation for intentions was included in the omnibus model, the indirect effect of nature size was no longer significant. One explanation for this outcome is that the shared variance between biospheric value orientation, nature size, and intentions suppresses the effect of nature size on intentions. Indeed, biospheric value orientation showed large correlations with both nature size ($r = .63, p < .001$) and intentions ($r = .51, p < .001$). To explore this possibility further, follow-up analyses included biospheric value orientation as a covariate (without the interaction term) in the parallel mediation model, which resulted in the nature size indirect effect becoming nonsignificant (95% CI [-0.42, 1.76]) whereas it was significant when the covariate was absent. Thus, it seems reasonable that

nature size likely mediates the effects of nature gratitude on intentions but that including a strongly-related individual difference dilutes its impact, although future research should further document the robustness of these findings.

Consistent with Study 1, the gratitude and indebtedness measures did not effectively distinguish between the two constructs. This lack of differentiation is surprising because other studies have found gratitude and indebtedness to be distinct from each other (e.g., Solom et al., 2017; Tsang, 2006; Watkins et al., 2006). In light of the strong relations between the two measures in both studies, it is unclear whether the factor scores in the current work are capturing gratitude, indebtedness, or a blend of both. Because the factor scores were related to stronger positive self-transcendent emotions, it seems most likely that they are primarily reflecting gratitude, but future work should develop and validate these measures more fully. Although the measure used in the current work was adapted from past research (Tam, 2022), the current scale only consists of three items for each emotion, and these measures might benefit from more rigorous scale development.

4. General discussion

Giving thanks to nature is common in many cultures (Kimmerer, 2013; Kimmerle, 2006; Miller, 2003), yet little research has examined gratitude to nature and its importance for sustainability. Because gratitude is a self-transcendent emotion (Stellar et al., 2017) that binds people to others (Algoe, 2012) and motivates helping behavior towards the benefactor (Bartlett & DeSteno, 2006), we hypothesized that feeling gratitude to nature would increase pro-environmental behavioral intentions by leading people to hold more sustainable self-nature representations. Because past research encountered challenges with manipulating nature gratitude (Tam, 2022), we developed a new manipulation adapted from interpersonal gratitude research in which participants wrote gratitude letters to natural environments. In addition, we predicted that nature gratitude would increase self-transcendent emotions.

Across two studies, we generally found support for these hypotheses. Study 1 successfully manipulated gratitude to natural and built environments and found that writing nature gratitude letters led to greater perceived nature size and nature inclusion compared to a gratitude letter to built environments and to a non-gratitude control condition. Although we did not observe a direct effect on pro-environmental behavioral intentions, greater nature size and nature inclusion mediated an indirect effect between nature gratitude and stronger behavioral intentions. Study 2 replicated and extended these findings by refining the methodology and exploring individual difference moderators. Replicating Study 1, nature gratitude led to greater nature size and nature inclusion compared to built environments gratitude, and these two self-nature representations mediated an indirect effect of nature gratitude producing greater pro-environmental behavioral intentions. In support of our initial hypotheses, we also found a direct effect of nature gratitude leading to greater pro-environmental intentions compared to built environment gratitude (an outcome that did not obtain in Study 1). This difference between studies for the direct effect on behavioral intentions could result from increased statistical power in Study 2 or because of the reworked built environment gratitude prompt being more effective at inducing participants to not think about nature, but future work should further clarify the robustness of this effect. Further, biospheric value orientation moderated the direct effect on behavioral intentions such that nature gratitude only led to greater intentions for participants with moderate or greater endorsement of nature-centered values. Including biospheric value orientation in the full mediational model eliminated the nature size indirect effect (though the nature inclusion indirect effect maintained), but as noted above, there is compelling evidence that the weakening of the nature size indirect effect may result from suppression (e.g., strong correlations between nature size and biospheric value orientation), though future work should

explore this possibility further. An exploration examining personal norm of positive reciprocity did not show any moderating effects. Finally, Study 2 also found that nature gratitude led to more self-transcendent emotions compared to built-environment gratitude.

Interestingly, we explored four self-nature representations (nature inclusion, nature size, self size, and relative nature-self size) as possible mechanisms for the effects of nature gratitude, and we consistently observed that nature inclusion and nature size were increased by nature gratitude, and these two representations mediated the effects on pro-environmental behavioral intentions, showing similar effects across both studies. There are theoretical explanations for why nature inclusion and nature size served as mediators whereas self size and relative size did not. With respect to inclusion, both theories of self-transcendent emotion (Haidt, 2003; Stellar et al., 2017) and the “find, remind, and bind” theory (Algoe, 2012) forward that gratitude should lead people to include others in their self-concept, and indeed, past research has found that gratitude increases feelings of connectedness with others (Emmons & McCullough, 2003; Gordon et al., 2012). Furthermore, greater trait gratitude to nature is associated with greater nature inclusion (Tam, 2022). Thus, when the benefactor is nature, it makes sense that nature gratitude led to greater inclusion of nature in the self-concept.

Turning to the size measures, the current studies suggest that the effects of gratitude on pro-environmental behavioral intentions occur by making nature seem larger rather than making the self seem smaller, which is different from some past research on other self-transcendent emotions such as awe that interpret results as suggesting self-diminishment (Piff et al., 2015; Shiota et al., 2007). However, a central appraisal of awe is perceptual vastness vis-a-vis the self (Piff et al., 2015), whereas gratitude is not driven by this appraisal, which could explain why awe might reduce self size while gratitude does not. Additionally, self-schemas tend to be stable and difficult to change (Markus, 1977), thus it is possible that a single instance of gratitude is insufficient to change perceptions of self size whereas schemas for external entities such as nature may be easier to alter. Furthermore, multiple studies have found that feeling gratitude is associated with greater self-esteem (Bartlett et al., 2020; Forest & Wood, 2012; Zhang et al., 2017), suggesting that gratitude does not necessarily diminish views of the self. Although it may not lead to self-diminishment, gratitude has been theorized to lead people to see the benefactor as more powerful and important (McCullough & Tsang, 2004), which is supported by recent research findings that gratitude is related to seeing the benefactor as having more social value (Forster et al., 2022). Therefore, it makes sense that gratitude to nature promotes seeing nature as large rather than the self as small, although future research should further explore this effect and the processes by which it occurs. The consistency between findings in Studies 1 and 2, however, suggest that nature size and nature inclusion should play important roles in how gratitude to nature promotes sustainability.

In addition to demonstrating how nature gratitude affects self-nature representations, these findings have theoretical implications for understanding the effects of gratitude on prosocial behavior. The current findings are consistent with the “find, bind, and remind” theory, showing that gratitude leads to prosocial behavior by increasing connectedness with others (Algoe, 2012), particularly by showing the effect of nature gratitude on greater behavioral intentions was mediated by nature inclusion. Thus, this work extends past research by showing that gratitude can bind the self with non-human entities.

4.1. Limitations

Although this research provides preliminary support for using nature gratitude letters for pro-environmental outcomes, there are caveats to this work. First, there were some issues with the manipulation and gratitude measures, particularly with the number of participants in the built gratitude conditions who wrote about nature in their gratitude letters. Excluding these participants resulted in not meeting idealized

sample sizes specified by the a priori power analyses and in unequal sample sizes across conditions, although post hoc sensitivity analyses found sufficient power to detect small-to-medium direct effects ($d = 0.42$ in Study 1 and $d = 0.37$ in Study 2). Nonetheless, in future work, researchers may be able to avoid this issue by explicitly instructing participants in built gratitude conditions to not write about natural places (though this might trigger suppression rebound effects; Wegner, 1989), although it seems some people may inevitably turn to nature when they think of places to which they are thankful even when explicitly asked not to do so. Future work should also compare how the effects of gratitude to nature differ from gratitude to other places such as archeological sites or other strong elicitors such as close others (Algoe, 2012) or religious deities (Rosmarin et al., 2011) to examine whether the current findings are unique to nature and not just any strong source of gratitude.

Another methodological issue was that measures of gratitude to natural and built places did not differentiate between gratitude and indebtedness. This outcome was surprising because past studies reported that gratitude and indebtedness were unrelated (e.g., Solom et al., 2017; Tsang, 2006; Watkins et al., 2006). One potential explanation for the lack of differentiation in the current work is acquiescence, which was supported by the second factor for the reverse-coded gratitude to nature items in Study 2. However, a one-factor solution was still found for gratitude and indebtedness to built environments in Study 2 despite using reverse-coded items. Thus, acquiescence does not fully explain the interrelations between these measures. Although the resulting factor scores likely reflect gratitude rather than indebtedness as demonstrated by significant correlations with greater self-transcendent emotions (Study 1: $r = 0.32$, Study 2: $r = 0.42$), future work should develop measures of state gratitude and indebtedness to natural and built environments with better discriminant and construct validity.

Also, the current studies used crosssectional designs and therefore cannot speak to the ability of nature gratitude to have pro-environmental effects across time. Indeed, real-world gratitude interventions typically have people reflect several times on the gratitude object over the course of weeks or months (Emmons et al., 2019; Wood et al., 2010). Follow-up work could use a longitudinal design and have participants write multiple nature gratitude letters to assess pro-environmental engagement over time. Even within a crosssectional design, future work could include pretest measures of the mediators and dependent variables to better understand the causal structure of the mediation effects. Additionally, the current work only measured behavioral intentions rather than actual behavior, which could be problematic because sometimes laboratory measures of pro-environmental behavioral intentions do not generalize to real-world behavior (Lange & Dewitte, 2019). Thus, future work should measure actual pro-environmental behavior, perhaps using an environmental donation task (Tam, 2022) or a well-validated laboratory measure such as the Work for Environmental Protection Task (Lange & Dewitte, 2021). Field experiments could also provide more external validity. Finally, the current work was not preregistered, and future work should use this important open science practice (Nosek et al., 2019).

4.2. Future directions

One additional mechanism by which nature gratitude could promote pro-environmental behavior is through anthropomorphism of nature, or the degree to which people ascribe human-like traits to nature (Epley et al., 2007; Tam et al., 2013). Gratitude letters could lead to anthropomorphizing nature because writing a letter to a natural place (e.g., “Dear Atlantic Ocean”) involves treating it like a social entity and giving thanks to it acknowledges that it may have supportive qualities, which is an important facet of anthropomorphism (Epley et al., 2007). This possibility is further supported by finding that greater trait gratitude to nature is associated with greater anthropomorphism of nature (Tam, 2022). The greater anthropomorphism caused by a nature gratitude

letter could then lead to greater pro-environmental behavior because anthropomorphized entities generate more empathy (Harrison & Hall, 2010), because anthropomorphism of nature generally leads to more conservation behavior (Tam et al., 2013), and because even anthropomorphizing one's pets promotes pro-environmental action (Jacobs et al., 2023). Thus, future research could include anthropomorphism as a potential mediator of the effects of nature gratitude on pro-environmental behavior.

Additional work could also examine the effects of nature gratitude letters on health and well-being. Expressing gratitude predicts greater well-being (Emmons & McCullough, 2003; Wood et al., 2010), but gratitude to nature could be particularly beneficial. Feeling connected with nature can act as a source of belonging (Poon et al., 2015), and belongingness is a strong predictor of both mental and physical health (Eisenberger et al., 2017). Thus, if nature gratitude increases connectedness to nature, it could have benefits for one's health. Additionally, greater anthropomorphism of one's companion animals has been found to improve people's health (e.g., McConnell et al., 2019) and to encourage pro-environmental engagement (Jacobs et al., 2023). Exploring the possible benefits of nature gratitude for health and well-being suggests benefits in the short-run (e.g., health and well-being improvement) and long-run (e.g., less global warming and pollution).

5. Implications and conclusion

Gratitude to nature is expressed throughout the world and increasingly it has been cited as a necessity by educators and philosophers for improving humankind's relationship with the environment (Joldersma, 2009; Kimmerer, 2013). By finding that nature gratitude may promote pro-environmental outcomes by increasing nature inclusion and nature size and how these effects are moderated by biospheric values, the current findings advance basic research on how self-transcendent emotions triggered by nonhuman entities shape the self-concept and identify new avenues by which real-world interventions can address existential environmental challenges such as climate change.

CRedit authorship contribution statement

Tyler P. Jacobs: Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Allen R. McConnell:** Writing – review & editing, Validation, Supervision, Resources, Project administration.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jenvp.2024.102319>.

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