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The Impact of Mindful Meditation in Nature on Self-Nature Interconnectedness

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Abstract Previous research has shown that mindfulness and spending time in nature are both related to perceived self-nature interconnectedness, with implications for environmental and psychological well-being. More research is needed to better understand the relative influence of mindful meditation and nature exposure on self-nature interconnectedness. In study 1, we replicated evidence for a relationship between mindfulness and self-nature interconnectedness in a sample of Buddhist meditators attending a nature and meditation retreat. In study 2, undergraduate students participated in 3-day nature trips that were randomly assigned to either a meditation condition (which included formal meditation in the mornings) or a non-meditation condition (which did not include formal meditation practices). The results from pre- and post-trip surveys showed that the combined influence of mindful meditation in nature on self-nature interconnectedness is greater than nature exposure that does not include mindful meditation. One focus of the present research was to examine cognitive dimensions of nature connectedness, given that mindfulness meditation is based on cognitive processes such as selective attention. Study 2 revealed three types of concepts underlying self-nature interconnectedness: (1) mental models for behaviors in nature, (2) self-nature categorization, and (3) self-nature associations. In addition, participants who meditated in nature were more likely to foreground nature in their memories of the trip by emphasizing nature rather than other aspects (such as social interactions). Together, the results from the present research suggest that mindful meditation in nature can be used to reestablish or strengthen concepts of self-nature interconnectedness nature for urban adults.

Keywords Mindfulness · Meditation · Nature exposure · Self-nature interconnectedness

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Introduction

A growing body of research has revealed a relationship between mindful meditation, exposure to nature, and perceived self-nature interconnectedness, with important implications for pro-environmental attitudes and behaviors, and psychological well-being (e.g., Howell et al. 2011; Nisbet and Zelenski 2011; Wolsko and Lindberg 2013). Given the importance of perceived self-nature interconnectedness for environmental and psychological well-being, more research is needed to examine the relative influence of mindful meditation and nature exposure on self-nature interconnectedness. Mindful meditation involves focusing one's attention on thoughts, perceptions, and sense experiences occurring in the present moment (Kabat-Zinn 2005). Is there a difference in perceived connectedness to nature when spending time in nature vs. spending time in nature *mindfully*?

Previous research has revealed individual differences in perceived human-nature connectedness, including cross-cultural differences in the likelihood to conceptualize humans as a part of nature (Bang et al. 2007; Medin et al. 2010; Unsworth et al. 2012) and a developmental decline in this tendency within urban populations (Hermann et al. 2010; Levin and Unsworth 2013). Recent research has provided evidence for possibilities of cultivating connectedness to nature that include mindful meditation and exposure to nature, and studies have shown that these constructs are also linked to

pro-environmentalism and subjective well-being (Amel et al. 2009; Jacob and Brinkerhoff 1999; Jacob et al. 2009). The psychological benefits of mindfulness meditation are becoming increasingly apparent in psychological and educational research (e.g., Hofmann et al. 2010; Meiklejohn et al. 2012; Sedlmeier et al. 2012). Kabat-Zinn has defined mindfulness as the "… moment-to-moment, non-judgmental awareness, cultivated by paying attention in a specific way, that is, in the present moment, and as non-reactively, as non-judgmentally, and as open heartedly as possible" (Kabat-Zinn 2005, p. 108). Meditation, a practice in which individuals actively direct their attention toward an experience in the present moment (e.g., breathing, walking, thoughts, emotions), is a formal technique that is often used to cultivate mindfulness. Howell et al. (2011) have found that mindful attention was positively correlated with self-nature interconnectedness. In addition, Wolsko and Lindberg (2013) found that connectedness to nature was positively associated with mindfulness and psychological well-being,

Wolsko and Lindberg (2013) also found that perceived connectedness to nature was positively associated with participation in outdoor recreation activities, which is consistent with research demonstrating a psychological impact of nature exposure. For instance, Nisbet et al. (2009) found that connection to nature was related to time spent in nature and Schultz and Tabanico (2007) found that hiking, spending time at the beach, and spending 1 day at an animal wild park was associated with greater self-nature interconnectedness. Mayer et al. (2009) randomly assigned participants to conditions in which they took a walk for 20 min in either a nature preserve or an urban setting and found that connectedness to nature was greater after spending time in nature. They also found that an increase in connectedness to nature was greater after spending time in a real nature environment compared to a virtual nature environment. Similarly, Kjellgren and Buhrkall (2010) found that individuals with self-reported stress/burnout syndrome reported that they were more likely to feel harmony and union with nature after spending 30 min in a real forest setting compared to a "simulated nature" setting in which they viewed photographs of the same forest setting for 30 min. Finally, Bang et al. (2007) found that Menominee Native Americans are more likely than rural European Americans to perceive themselves as a part of nature, and that Menominee adults are also more likely to engage in outdoor activities that "foreground" nature (i.e., activities that emphasize the role of nature, such as walking/hiking or sitting outside). Together, findings from previous research demonstrate relationships between mindfulness, nature exposure, and perceived connectedness to nature. Importantly, however, there has been little research that systematically examines the effect of *mindfulness in nature* on perceived connectedness to nature.

It is important to note that "self-nature interconnectedness" is a multidimensional construct and that several measures have been developed to study this construct. In a comprehensive analysis of these different measures, Tam (2013) found that some measures capture a cognitive dimension of the construct, while other measures capture an emotional dimension or a dimension reflecting a sense of interdependence (which he suggested is separate from a cognitive dimension). Previous research has shown that mindful meditation improves attentional focus (e.g., Jha et al. 2007; Tang et al. 2007), and Duvall (2011) has proposed that becoming intentional about the ways in which an individual attends to the environment can increase cognitive engagement with his/her surroundings. Given that mindfulness meditation involves selective attention (a fundamentally cognitive process), it is interesting to investigate the implications for cognitive dimensions of self-nature interconnectedness.

One measure that examines a cognitive dimension of connectedness to nature is the Inclusion of Nature in the Self (INS) scale (Schultz 2001). This measure is a very short measure consisting of seven Venn diagrams, with one circle representing "self" and the other circle representing "nature." The circles vary in degree of overlap with one another and participants are asked to circle the picture that best describes the way they see the relationship between themselves and nature. The INS is an adaptation of the Inclusion of Other in the Self scale (Aron et al. 1992), which has been used extensively in social psychology research. In Schultz' (2001) original research using this measure, he suggested that the INS captures a cognitive schema of the degree of overlap between the knowledge structure representing the self and the knowledge structure representing nature. Tam (2013) has suggested that the INS primarily captures the self-categorization dimension aspect of a cognitive dimension of nature connectedness. One way to investigate this possibility is to include a brief probe after completing the INS task in which participants are asked to explain their responses. Such a probe would assess the extent to which participants' concepts reflect self-categorization and whether other concepts of nature connectedness are evoked. Importantly, diverse responses to this follow-up question would not undermine the validity of the measure, so long as all responses relate to nature connectedness in some way. These responses would simply serve as the first step toward understanding the conceptual complexity that may underlie the cognitive component of self-nature interconnectedness.

There are several studies that have examined the reliability and validity of the INS scale. Schultz et al. (2004) demonstrated strong test-retest reliability of the INS after 1 week ($r = .90$, $p < .01$) and after 4 weeks ($r = .84$, $p < .01$). In an examination of several "nature connectedness" scales, Tam (2013) noted that the INS measure has produced "… meaningful and theoretically consistent findings in the present and past studies" (p.

72). Tam also found that there were significant positive correlations between the INS and other measures of nature connectedness and that these correlations were strong in magnitude, varying from .40 to .53 (see Cohen 1988). These results are consistent with other studies examining convergent reliability of the INS scale (Mayer and Frantz 2004; Schultz et al. 2004; Dunlap et al. 2000). However, Tam also noted that correlations between the INS and other measures of nature connectedness were generally weaker compared to other inter-correlations. Tam examined multiple possible explanations, including the possibility that the weaker correlations reflected psychometrical weakness of a 1-item measure. The results of study 2 in Tam's research failed to provide support for this possibility. Specifically, the results showed similarly weak correlations for the Allo-Inclusive Identity scale (AID; Leary et al. 2008), which is a *multi*-item measure that also assesses the more cognitive dimension of inclusion of nature in the self. Tam concluded that, "These findings imply that the weaker correlations are not attributable to such psychometric problems associated with single-item measures" and that "The conceptual account … appears to be more plausible" (p. 74). Robins et al. (2001) have found substantial correspondence between single- and multi-item measures (in their case, for measures of self-esteem) and have also described the benefit of using single-item measures when researchers are balancing psychometric concerns with practical constraints. Mayer and Frantz (2004) have proposed that the INS is a good replacement for multi-item measures of nature connectedness when a short measure is needed.

The aim of the present research was to investigate the relative influence of mindful meditation and nature exposure on perceived connectedness to nature. In study 1, adults attending a meditation and nature retreat at a Buddhist monastery completed surveys measuring mindfulness and self-nature interconnectedness. In study 2, undergraduates participated in one of two conditions that varied in the presence or absence of mindful meditation in nature. They completed pre- and post-nature trip surveys that included measures of mindfulness and self-nature interconnectedness. In both studies, the INS task was employed to investigate cognitive dimensions of self-nature interconnectedness. Participants had limited time to complete the surveys, so the single-item INS measure was selected (rather than the multi-item AID measure). To our knowledge, there are no single-item mindfulness measures that have demonstrated strong validity and reliability, so a multi-item measure of mindfulness was used. To further investigate concepts of self-nature interconnectedness, participants were asked to explain their responses to the INS task. We were also interested in whether meditation in nature affects participants' memories for their experience in nature. If meditation in nature promotes cognitive engagement with nature (as suggested by Duvall 2011), we should expect consequences for the salience of nature in participants' memories of their nature experience. We predicted that participants who meditated in nature would be more likely to foreground nature in their memories (i.e., by emphasizing aspects of nature rather than other aspects related to the trip, such as social interactions) compared to participants who were exposed to nature but did not meditate. To investigate this hypothesis in study 2, a short measure was used in which participants were asked to describe their favorite memory from the nature camp in the post-nature trip surveys.

Study 1

The purpose of study 1 was to assess the relationship between mindfulness and self-nature interconnectedness among a sample of participants who either have meditation experience or are seeking meditation experience. In previous research, Howell et al. (2011) obtained evidence for a relationship between mindfulness and self-nature interconnectedness among introductory psychology undergraduates, and our goal was to (1) replicate this finding using the INS scale and (2) extend this research to a sample of Buddhist meditators. All participants in study 1 were recruited during a meditation retreat at a Buddhist monastery, which is situated in a nature space on the side of a small mountain.

Method

Participants Participants included 25 adults (17 females, 8 males; Mean age = 31 years) who received monetary compensation for their participation. Twenty-one participants reported that they had experience with meditation before attending the retreat, and four participants reported that they had not experienced meditation before attending the retreat. Ethnicity data were not collected for this study, but see the "Discussion" section for recommendations regarding cultural comparisons in future research.

Procedure Participants were asked to fill out the surveys during registration for the 3-day meditation and nature retreat. The registration period occurred at the beginning of the retreat and was limited in duration, which constrained the time available to complete the survey. For this reason, the survey was constructed so that it took as little time as possible. Participants were told that there are no right or wrong answers to the survey questions.

Measures The measure used to assess self-nature interconnectedness was the Inclusion of Nature in the Self (INS) scale (Schultz 2001). As mentioned earlier, the INS scale consists of seven Venn diagrams, with one circle representing self and the other circle representing nature. The circles vary in degree of overlap with one another and participants are asked to circle

the picture that best describes the way they see the relationship between themselves and nature.

The Freiburg Mindfulness Inventory was used to measure mindfulness (Walach et al. 2006). This scale consists of 14 items, and participants were asked to rate their experience with each of the items using the last 3 days as the time frame in which to consider each item. Ratings were measured using a 4-point Likert scale, with 1 being "rarely" and 4 being "almost always." Sample items include "I am open to the experience of the present moment." Walach et al. have found that this scale has very good internal consistency (Cronbach's alpha = .86) and that responses on this scale correlate with meditation experience in years.

Demographic questions about gender, age, and meditation experience were also included on the survey.

Data Analyses Data analyses included correlations between scores on the INS scale, scores on the Freiburg Mindfulness Inventory, and age, as well as *t* tests to examine gender differences in mindfulness and self-nature interconnectedness.

Results

Correlation analyses revealed a significant positive correlation between mindfulness and self-nature interconnectedness, $r(25) = .52$, $p < .01$. There were no effects of gender, all *t*s <1, and no significant correlations between age and mindfulness, $r(25) = -.13$, $p = .53$, or age and self-nature interconnectedness, $r(25) = .16$, $p = .45$. These results replicate findings from Howell et al. (2011) and provide evidence for the acceptability of the INS (Schultz 2001) scale in research examining relationships between self-nature interconnectedness and mindful meditation. Importantly, however, these results are only correlational. Many Buddhist contexts include teachings about interconnectedness between self, other, and nature, so a Buddhist worldview may serve as a common cause for both mindfulness and self-nature interconnectedness. Study 2 builds on study 1 by examining the relative influence of mindful meditation and nature exposure on self-nature interconnectedness.

Study 2

To compare changes in self-nature interconnectedness as a function of meditation in nature vs. nature without meditation, we recruited undergraduate students who had registered for 3-day nature camp trips through the Aztec Adventures program at San Diego State University (SDSU). We randomly assigned half of the trips to a meditation condition and half of the trips to a non-meditation condition. In the meditation condition, students completed 15 min of meditation every morning and were encouraged to continue mindfulness practices throughout the day. Measures included the INS scale for assessing self-nature interconnectedness (Schultz 2001) and the Freiburg Mindfulness Inventory (Walach et al. 2006). Predictions were that the combined effect of mindful meditation and nature exposure on self-nature interconnectedness would be greater than the independent effect of nature exposure. We were also interested in examining the cognitive dimension of self-nature interconnectedness. After participants completed the INS task, they were asked to explain their selection, and responses were categorized according to different concepts of self-nature interconnectedness. We also were also interested in whether meditation in nature affects participants' memories for their experience in nature. We predicted that participants who meditated in nature would be more likely to foreground nature in their memories (i.e., by emphasizing aspects of nature rather than other aspects related to the trip, such as social interactions) compared to participants who were exposed to nature but did not meditate. Other measures included brief probes assessing enjoyment of meditation, participants' prior participation in nature activities (given that students self-selected into these nature trips), and demographic questions.

Method

Participants Participants included 71 undergraduates (40 females, 31 males; mean age = 21 years) who were registered for an Aztec Adventures nature camp at SDSU. Thirty-nine participants were registered in trips that were randomly assigned to the meditation condition (25 females, 14 males; mean age = 21 years), and 32 participants were registered trips that were randomly assigned to the non-meditation condition (17 females, 15 males; mean age = 22 years). Aztec Adventures received monetary compensation for each of these participants. None of the students who were presented with the opportunity to participate in the study declined to participate. As in study 1, ethnicity data were not collected for this study, but see the "Discussion" section for recommendations regarding cultural comparisons in future research.

Procedure The study involved a 2 (meditation vs. no meditation) x 2 (pre- vs. post-nature trip surveys) mixed-model design. All participants experienced a 3-day trip in nature through a pre-established outdoor guiding program called "Aztec Adventures" at San Diego State University. Participants were recruited across multiple trips, and trips were randomly assigned to the "Meditation" and "No Meditation" conditions. In the meditation conditions, formal meditation occurred for 15 min in the morning of days 2 and 3. Aztec Adventures staff who led the nature trips were trained to provide meditation instructions to participants in the meditation condition. The staff were trained by the first and second authors to practice and lead meditation, and they were provided

with opportunities to practice meditation as part of a formal meditation group before leading the outdoor program trips. The first author has extensive experience with meditation, has lead several group meditation experiences, and has published previous research examining the effectiveness of meditation programs (Viafora et al. 2014). Additional support was provided over the course of the study by both the second author (who was an Aztec Adventures employee at the time as well as an experienced meditator) and the third author (who was the Director of Aztec Adventures at the time). At the beginning of the meditation, participants were given a brief description of mindfulness as "the energy of being aware and awake to the present moment ...." They were then instructed to sit comfortably and focus their attention on their breathing so as to become aware of their experience in the present moment. They were told that if their mind wanders, they should gently bring their mind back to their breath, attending to the sensation of each in-breath and each out-breath. Following these instructions, participants were given 15 min to focus on their breath in silence. After 15 min of meditation, participants were instructed that they could "return to mindful breathing at many points throughout the day" on their own. All participants completed pre-nature trip surveys at the beginning of day 1 and post-nature trip surveys at the end of day 3. The surveys were administered via paper copies to individual participants in a group setting. Students were monitored by the Aztec Adventures staff to ensure that the setting was quiet and that participants could not view the responses of other participants in the group.

Measures The measure used to assess perceived connectedness with nature was the INS scale (Schultz 2001), which was used in study 1. In study 2, participants were also asked to write a brief explanation for why they circled the picture that they circled. The Freiburg Mindfulness Inventory was used to measure mindfulness (Walach et al. 2006). To measure prior nature experience, participants in both conditions were asked to report the number of times they had participated in nature activities such as hiking, canoeing, and camping. In addition, enjoyment of meditation in the meditation condition was measured on the post-nature trip surveys by asking participants in that condition to rate the extent to which they enjoyed the meditation on a scale from 1 to 10, with 1 being "Not at All" and 10 being "A Great Deal." Demographic questions about gender and age were also included in the survey. To measure the likelihood of foregrounding nature in memory, participants were asked to describe their favorite memory from the nature camp in the post-nature trip surveys.

Data Analyses Explanations of responses to the INS task were examined to determine whether responses included self-nature categorization (such as being "one with nature" or "a part of nature") as well as other types of concepts. Other concepts included activities that participants engage in, including recreational activities and activities related to environmental sustainability. We labeled this type of response as "mental models of behaviors related to nature." Another frequently emerging concept was "self-nature associations" (e.g., being "connected to nature"). Other dimensions were also coded, including the emotional dimension of affinity toward nature and an interdependence dimension which includes a sense of balance between self and nature (a dimension that Tam 2013, considers to be distinct from cognitive dimensions).

In the memory task, responses were coded according to whether nature was foregrounded, with an emphasis on the aspects of nature that were present during the experience. Examples included, "being able to sit and enjoy the sounds of nature" and "our hike to the waterfalls, I could appreciate the intensity and how powerful nature is while also admiring its beauty." Other responses such as "seeing everyone work together to accomplish something" and "eating lunch on the canoes" were not coded as foregrounding nature, as the emphasis was on other aspects of the experience (e.g., social aspects). Although some participants provided descriptions of multiple memories, we were only interested in the most salient memories and we therefore limited our coding to participants' first response. One of the authors coded the responses, in addition to another rater who was blind to the hypotheses of the study. The inter-rater reliability was very good (Kappa = .84, $p < .001$; Landis and Koch 1977).

Data analyses included an analysis of variance (ANOVA) and follow-up t tests to examine differences in pre- vs. post-self-nature interconnectedness across meditation vs. no meditation conditions, as well as a chi-square analysis to examine differences in foregrounding nature between meditation vs. non-meditation conditions. T tests were also conducted to examine differences in changes in mindfulness and gender differences, and correlation analyses examined the relationship between self-nature interconnectedness and mindfulness as well as potential variation in these variables in relation to age, nature experience, and enjoyment of the outdoor adventure trip.

Results

As predicted, the results showed that meditating in nature had a significant influence on perceived nature connectedness, above and beyond simply being in nature. In addition, participants who meditated in nature were more likely to foreground nature in their memories compared to participants who were exposed to nature without meditation, and increases in mindfulness scores over the course of the nature adventure program were associated with increases in nature connectedness. The results also showed that the two groups were equivalent in their pre-program INS scores, thereby providing a relevant

baseline for examining the influence of nature meditation on perceived nature connectedness.

To examine the relative influence of meditation in nature on INS scale responses above and beyond changes in mindfulness scores, we conducted a 2 (INS scale responses: pre- vs. post-nature trip) × 2 (meditation condition: meditation vs. no meditation) mixed-model analysis of variance (ANOVA). The 2-way interaction between pre- vs. post-nature trip INS scale responses and meditation condition was statistically significant, $F(1, 138) = 14.95$, MSE = 1.74, $p < .001$ (see Fig. 1). Follow-up t tests (using Bonferroni correction to control for familywise error rate) showed that there was a significant increase in INS scale responses in the meditation condition, $t(38) = -2.99$, SE = .17, $p < .01$, ($M = 4.77$ and SD = 1.31 for pre-nature trip INS scale responses; $M = 5.28$ and SD = 1.36 for post-nature trip INS scale responses). There was no statistically significant difference in the no meditation condition, $t(31) = -1.00$, SE = .16, $p = .33$, ($M = 4.75$ and SD = 1.50 for pre-nature trip INS scale responses; $M = 4.91$ and SD = 1.40 for post-nature trip INS scale responses). There were also no significant correlations between INS difference scores and nature experience, $r(69) = -.01$, $p = .93$, or between INS difference scores and enjoyment of meditation in the meditation condition, $r(31) = .20$, $p = .25$.

Examination of open-ended responses regarding why participants circled a particular Venn diagram representation on the INS scale revealed various reasons (note that some participants provided multiple responses, so the sum of percentages is greater than 100 %). There were three types of responses that could be categorized as reflecting more cognitive dimensions of nature connectedness. The most common response was reflected mental models of behaviors related to nature (31 % of participants). Other common responses included self-nature categorization (17 % of participants) and self-nature associations (29 % of participants). Participants also reported an affinity toward nature (17 % of participants) and interdependence (13 % of participants). Together, these responses suggest that there are individual differences regarding the ways in which participants are interpreting the INS scale, that the most common responses reflect a cognitive dimension of nature connectedness, and that the INS scale captures multiple dimensions of nature connectedness including emotion and interdependence.

Sixty-four participants completed this item on the survey. A chi-square analysis showed that participants who experienced meditation were significantly more likely to foreground nature than those who did not experience meditation, χ^2 (1, $N = 64$) = 13.448, $p < .001$ (see Table 1).

Contrary to expectations, a t test analysis revealed that there was no significant difference in changes in mindfulness across the meditation vs. no meditation conditions, $t < 1$ (mean difference score = −.13 vs. .78, respectively). However, correlation analyses showed that there was a significant positive correlation between INS difference scores (i.e., the change in pre- to post-program INS scores) and mindfulness difference scores (i.e., the change in pre- to post-program mindfulness scores), $r(69) = .27$, $p < .05$.

There was no effect of gender for self-nature interconnectedness, $t < 1$, and no significant correlations between age and mindfulness difference scores, $r(69) = .06$, $p = .62$; age and self-nature interconnectedness, $r(69) = -.05$, $p = .68$; nature experience and mindfulness, $r(69) = .13$, $p = .28$; nature experience and self-nature interconnectedness, $r(69) = -.01$, $p = .93$; or trip enjoyment and self-nature interconnectedness, $r(65) = -.04$, $p = .75$. However, there was a gender difference in mindfulness scores that approached significance, $t(68) = 1.67$, $p = 09$, such that increases in mindfulness were greater for males than for females from pre- to post-nature trip ($M = 1.26$, SD = 3.53, and $M = -.48$, SD = 5.01, respectively). There was also a significant positive correlation between trip enjoyment and mindfulness difference scores, $r(65) = .29$, $p < .05$, such that an increase in trip enjoyment was associated with greater increases in mindfulness scores from pre- to post-nature trip.

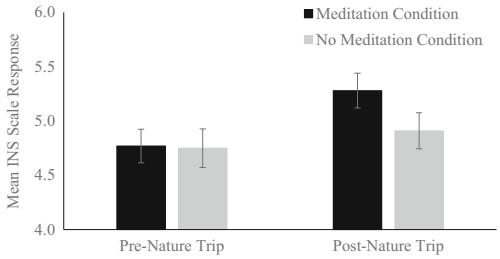

Fig. 1 Mean pre- and post-nature trip responses for Inclusion of Nature in the Self (INS) as a function of mindful meditation. Higher values indicate greater connectedness to nature

Table 1 The number of participants who foregrounded nature in memory as a function of meditating in nature in study 2

Foregrounded nature in memory	Condition	
	Nature exposure with meditation	Nature exposure without meditation
Yes	28	9
No	8	19

Discussion

The findings of the present research provide evidence for an influence of mindful meditation in nature on self-nature interconnectedness. The results from study 1 replicate evidence for a positive correlation between self-nature interconnectedness and mindfulness (Howell et al. 2011) using the INS scale (Schultz 2001) in a Buddhist community. The results from study 2 showed that the combined influence of meditation and nature exposure is greater than the influence of nature exposure without mindful meditation. Although participants in study 2 self-selected into the nature program, they did not explicitly seek a program that included mindful meditation, suggesting that mindful meditation in nature has an influence for individuals who are not already specifically predisposed toward seeking mindful meditation. The results from study 2 also supported the hypothesis that meditation in nature would increase the likelihood to foreground nature in memory by emphasizing nature in descriptions of their experience rather than other aspects, such as social interactions. Together, these findings are consistent with findings from Bang et al.'s (2007) research suggesting that self-nature interconnectedness is associated with a tendency to foreground nature, and future research should investigate the possibility that foregrounding nature serves as a mechanism by which nature activities and cognitive engagement strategies (such as mindful meditation) cause an increase in self-nature interconnectedness.

The results of study 2 also suggest that interconnectedness with nature is a multifaceted construct. We found that there were five common yet distinct interpretations for the INS task. Three of these interpretations reflected more cognitive dimensions of self-nature interconnectedness, including (1) mental models of behaviors in nature, (2) self-nature categorization, and (3) self-nature associations. Tam (2013) suggested that INS scale measures a cognitive dimension of self-nature interconnectedness, and our results appear to support this suggestion. However, Tam also suggested that the cognitive dimension primarily captured by the INS scale is self-categorization, and our results suggest that self-categorization is one of three cognitive dimensions captured by the INS scale. In addition, participants also provided responses reflecting an emotional dimension (affinity toward nature) and a sense of interdependence, which Tam suggested is distinct from cognitive dimensions. Unfortunately, the sample size was not large enough to examine effects of meditation in nature on different concepts of self-nature interconnectedness, though this would be an interesting direction for future research. It is important to note that responses to the open-ended question, while diverse in meaning, still related to self-nature interconnectedness. These responses strengthen the validity of the measure by demonstrating that participants were interpreting the measure in terms of connectedness to nature, while also offering new and interesting directions for future research that examines a more multifaceted understanding of the conceptual complexity of self-nature interconnectedness.

Another interesting finding from study 2 is that participants who experienced an increase in mindfulness also experienced an increase in self-nature interconnectedness. It is surprising, however, that increases in mindfulness were no greater in the meditation condition compared to the non-meditation condition. Previous research examining effects of meditation on mindfulness typically employ programs that are substantially longer than our manipulation (Sedlmeier et al. 2012). More meditation experience may be necessary in order to observe longer-lasting effects on overall mindfulness, as measured by the Freiburg Mindfulness Inventory (Walach et al. 2006). Unsurprisingly, there was evidence of increases in self-nature interconnectedness in both the meditation and non-meditation conditions, although the increase was significantly greater in the meditation condition. This pattern is consistent with previous research showing that nature exposure increases perceived connectedness to nature (e.g., Bang et al. 2007; Nisbet et al. 2009; Wolsko and Lindberg 2013). Interestingly, enjoyment of the trip was positive correlated with increases in mindfulness, and increases in mindfulness were greater for men than for women (though the latter finding only approached significance). These factors deserve more attention in future research.

The present research provides a foundation to explore several new directions in future research. One limitation of the present research is the lack of a cultural comparison. Previous research suggests that people learn cultural frameworks for organizing their knowledge of the natural world and the place of humans in it (e.g., Anggoro et al. 2010; Astuti et al. 2004; Waxman et al. 2007). Examining differences as a function of ethnicity or culture was beyond the scope of the present research, but future research should include an investigation of the interaction between culture, meditation practices, and nature experience.

Another potential limitation of the present research is that self-nature interconnectedness was measured using a single-item measure. However, validity and reliability for the INS have been established in previous research (Dunlap et al. 2000; Schultz et al. 2004; Tam 2013). A single-item measure was used rather than a multi-item measure because of the practical constraints of the present research (i.e., limited time to complete the surveys). Future research should broaden the use of self-nature interconnectedness measures to include more elaborate measures that more thoroughly examine cognitive dimensions of self-nature interconnectedness. We consider the present research as a first step toward understanding the conceptual complexity of this construct.

An additional limitation is the lack of meditation experience by employees of the SDSU outdoor adventure program who were trained to deliver meditation instruction in the

meditation condition. Although these employees were trained and monitored by individuals with extensive meditation practice and had opportunities to practice meditation before the beginning of the nature trips, the impact of meditation may have been more substantial if the meditation instruction was delivered by meditation experts. Future research should include a comparison of instructors with different levels of meditation experience to assess the extent to which instructor experience impacts the influence of meditation in nature on self-nature interconnectedness.

The results of the present research suggest that mindful meditation in nature can be used to reestablish or strengthen perceived connectedness to nature for urban adults. Substantial evidence for a relationship between self-nature interconnectedness and other important constructs, such as pro-environmental attitudes and psychological well-being (e.g., Nisbet et al. 2011; Schultz 2001) highlight important implications for these findings. Our results also suggest that interconnectedness with nature is a complex construct. As our understanding of the factors that influence self-nature interconnectedness continues to grow, it will become increasingly important to understand the ways in which different concepts of self-nature interconnectedness interact with these factors.

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Conflict of interest The authors declare that they have no conflict of interest.

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