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Nature lifts when feeling low: Daily high and low awe nature clips decrease repetitive negative thinking and dampening and increase subjective happiness in adults

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Abstract

Exposure to nature can enhance mental well-being, making nature-based interventions promising for the treatment and prevention of mental health problems like depression. Given the decreased self-focus and sense of self-diminishment associated with awe, the present study investigated the impact of exposure to awe-evoking nature on two key risk and maintenance factors of depression—repetitive negative thinking (RNT) and dampening of positive feelings—and on subjective happiness. In a randomized controlled trial, we tested the effects of exposure to awe-evoking nature clips through a 1-week intervention, consisting of watching a 1-min clip on a daily basis of either awe-evoking (n high awe = 108) or more mundane nature scenes (n low awe = 105). Before, immediately after (post-intervention) and 1 week after the intervention (follow-up), participants completed self-report scales probing RNT, dampening, and subjective happiness. Results indicated significant decreases in these outcomes at post-intervention and follow-up in both groups. We discuss study limitations, touch upon future research ideas, and reflect upon the role of nature for clinical applications.

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KEYWORDS

awe, dampening, nature, repetitive negative thinking, subjective happiness

INTRODUCTION

Contact with natural (vs. built) environments has well-established benefits for mental health and psychological functioning, supported by evidence across various types of (everyday) nature (greenspace: Barton & Rogerson, 2017; bluespace: White et al., 2020), study designs and exposure forms (e.g., outdoor environment and virtual reality; overview, see Bratman et al., 2021), and populations (children and teenagers: Tillmann et al., 2018; older adults: Finlay et al., 2015). Common psychological benefits of nature include (self-reported) stress reduction, mood improvement, and enhanced cognitive functioning (Frost et al., 2022; Herchet et al., 2022; Jimenez et al., 2021). With the rising prevalence of depression and related mental health issues (Moreno-Agostino et al., 2021), there is a growing research interest in using contact with nature as an intervention to alleviate psychopathology (Berman et al., 2012).

Two influential frameworks, Attention Restoration Theory (ART; Kaplan & Kaplan, 1989) and Stress Reduction Theory (SRT; Frost et al., 2022; Ulrich et al., 1991), are commonly invoked to explain nature's psychological benefits, suggesting that these benefits arise from restoring depleted cognitive and emotional resources, respectively (Joye et al., 2024). Empirical studies inspired by these frameworks typically expose participants to relatively mundane natural settings (e.g., urban parks and forests) that are filled with "soft" fascinating nature stimuli that moderately attract attention and elicit little arousal (Basu et al., 2019; Joye & Bolderdijk, 2015).

This focus on *mundane* nature settings raises the question of whether greater restorative benefits could be achieved through exposure to *awe-evoking* kinds of nature. Awe is often characterized as a distinct positive emotional state (Cowen & Keltner, 2021) that involves feelings of wonder and amazement and directs individuals' attention away from the self towards their surrounding environment (Keltner & Haidt, 2003). Feelings of awe typically arise in response to vast natural environments such as expansive mountain ranges or majestic canyons. Vastness involves the perception of things experienced as "... larger than the self, or the self's ordinary level of experience of frame of reference" (Keltner & Haidt, 2003, p. 303). A limited body of research has started to investigate the effects of awe-evoking nature on well-being and mental health. For example, Joye and Bolderdijk (2015) found that watching a slideshow of awe-evoking (vs. mundane) nature scenes led to a greater mood improvement (from pre to post) among participants. Similarly, a field study among military veterans and youths from underserved communities (Anderson et al., 2018) showed that the awe triggered by an extraordinary nature experience—wild water rafting—predicted improved well-being and less stress-related symptoms (see also Bai et al., 2021). A recent study by Lopes et al. (2020) revealed that the awe experienced during a nature walk, as opposed to an urban walk, enhanced participants' mood, subsequently leading to reduced levels of rumination. Overall, these studies suggest that not only mundane nature but also awe-evoking nature can lead to, or is associated with, improvements in mental health.

The present research aims to further investigate the effect of awe-evoking nature on mental health by examining its effects on two key vulnerability and maintaining factors and on one resilience factor associated with common psychopathology. Specifically, we focus on repetitive

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negative thinking (RNT) and dampening, two important key risk and maintaining factors of depression (Bean et al., 2022; Burr et al., 2017; Dunn et al., 2018; Ehring & Watkins, 2008; McEvoy et al., 2018; Stefanovic et al., 2022), and on subjective happiness as a resilience factor of depression (Burns et al., 2011; Pompili et al., 2016; Veenhoven, 2012).

RNT involves persistent negative intrusive thinking that is uncontrollable and difficult to disengage from, like worrying about one's future or engaging in depressive rumination about one's past (Ehring et al., 2011, 2012; Ehring & Watkins, 2008). Essentially, it maintains negative cognitive and affective content by consistently directing attention towards such content (Ehring & Watkins, 2008). Dampening, on the other hand, is a response style that minimizes the intensity or frequency of positive emotional states (Feldman et al., 2008). Examples of dampening thoughts are "I don't deserve this positive feeling" or "This positive feeling won't last" (Dunn et al., 2018). This response style causes individuals to miss out on the wellbeing effects associated with positive affect, as proposed by theories like the broaden-and-build theory (Fredrickson, 1998; Tugade et al., 2004). Beyond downplayed positive affect, a dampening thinking style has been found to directly increase negative affect in controlled experimental lab and naturalistic studies (e.g., Burr et al., 2017; Dunn et al., 2018).

RNT and dampening differ in terms of the affective valence involved, being negative in the case of RNT (e.g., ruminating over a personal failure/loss or worrying about a loved one) and positive in the case of dampening (e.g., downplaying a positive personal accomplishment or believing that one does not deserve it). However, both RNT (Mennin & Fresco, 2013) and dampening thoughts can be seen as manifestations of predominantly unconstructive cognitive processing, often rooted in negative self-schemas or self-views (Collins et al., 2021; Collins & Winer, 2023). These mental strategies are considered maladaptive forms of self-focus or self-focused attention, because they direct attention to internally generated information such as unwanted thoughts or emotions (Ingram, 1990). Given this shared self-focus, RNT and dampening may be optimal targets for interventions involving exposure to awe-evoking nature.

We propose two main pathways through which exposure to awe-evoking nature may more effectively reduce RNT and dampening compared to mundane nature settings, both related to significant differences in physical vastness between both nature types (Keltner & Haidt, 2003). The first pathway is that experiencing awe-evoking nature can reduce the self-focus characteristic of RNT and dampening. That is, the vastness and/or intense beauty of awe-evoking nature are known to draw attention away from the self, towards the surrounding environment (Monroy & Keltner, 2023; Schaffer et al., 2024; Sung & Yih, 2015; Yaden et al., 2017). As a result, individuals' attention is expected to be diverted from negative self-referential thinking processes (Nejad et al., 2013), preventing it from being hijacked by negative self-schemas or self-views. Compared to "soft fascinating" mundane nature, which only moderately diverts attention (Basu et al., 2019), "hard fascinating" awe-evoking nature may more strongly attract attention and draw it away from the self. This way, it provides greater counterbalance to the entrenched self-focus linked to RNT and dampening.

The second pathway is that experiencing awe-evoking nature can alter the perceived importance of the content of one's self-focused attention, such as worries and concerns. This value change is particularly prompted by the sense of self-diminishment or "small self" that often accompanies the experience of awe (Piff et al., 2015). In the face of the vastness of awe-evoking nature, individuals can come to recognize the relative insignificance of their personal worries, concerns, and unhelpful beliefs reflecting RNT and dampening. It may help them realize what truly matters in the grand scheme of things (Chirico & Gaggioli, 2021), understand what can (not) be controlled, and put personal issues into perspective (Joye et al., 2024). Mundane nature,

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which lacks this level of awe-evoking vastness to put personal issues in perspective, is expected to be less capable of reducing RNT and dampening.

While our main interest and key contribution is examining the effect of awe-evoking (versus mundane) nature on RNT and dampening, we also investigated its impact on subjective happiness, which constitutes a resilience factor against depression. Subjective happiness refers to a global, subjective assessment of oneself as a happy or unhappy person, thereby reflecting a broad, molar category of psychological well-being (Lyubomirsky & Lepper, 1999). Specifically, when awe-evoking nature diverts attention from the self (i.e., first pathway) and from negative thoughts and emotions (characterizing RNT and dampening), it may also temporarily increase one's sense of happiness, especially when the distracting stimulus is positively valenced. Additionally, the "small self" (i.e., second pathway) involves feelings of being connected to something larger than oneself (Shiota et al., 2007), which is associated with increased happiness (Liu et al., 2023) and greater life satisfaction (Bai et al., 2021).

We hypothesized that awe-evoking nature clips characterized by vastness would be more effective in reducing RNT (H1) and dampening (H2), and in improving subjective happiness (H3) from pre- to post-intervention assessment and to follow-up assessment, than more mundane nature clips. Using daily diaries, participants completed a short questionnaire each day probing feelings and thoughts while watching the nature clips, which allowed us to explore momentary experiences and short-term changes across the intervention phase.

To examine the benefits of awe-evoking nature, we employed an innovative ecological momentary intervention (EMI). Studies examining the psychological effects of awe often rely either on single inductions of awe-experiences in a controlled (lab) setting (e.g., video or guided walk), limiting ecological validity, or on self-reports of past, naturally occurring awe-experiences (e.g., narratives), which may be confounded by recall biases. Fully in accordance with the most recent developments in psychological intervention delivery (Balaskas et al., 2021), we employed an innovative 1-week EMI to overcome those potential confounding factors. Over the course of 1 week, participants were instructed to watch a 1-min nature clip per day on their personal smartphones. Moreover, we included two post-intervention assessments: one immediately after the intervention and another 1 week later. This approach helps illuminate the potential longevity of the effects (if any)—an aspect rarely examined in experimental studies on the mental health benefits of nature.

METHOD

Participants

In total, 254 Dutch speaking adults enrolled to participate in the study (i.e., baseline, intervention, post-intervention, and follow-up), which lasted from November 2021 until February 2022. From that sample, 41 participants ($n_{\text{low awe}} = 18$, $n_{\text{high awe}} = 23$) were excluded from the data analysis as they watched less than the required five (out of the seven) nature clips for at least 30 (out of 60) seconds during the manipulation phase. In addition, likely due to technical issues, three enrolled participants ($n_{\text{low awe}} = 2$, $n_{\text{high awe}} = 1$) did not receive any notifications to fill out the post- and follow-up assessment. Reported results are therefore based on a final sample of 213 participants. The "low awe" condition consisted of 105 participants ($M_{\text{age}} = 37.4$, $SD_{\text{age}} = 11.9$, range 19–66; 63.81% female) and the "high awe" condition of 108 participants ($M_{\text{age}} = 38.8$, $SD_{\text{age}} = 14.1$, range 19–72; 62.96% female).

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Participants were recruited via flyers distributed through two channels, namely, the involved researchers' personal social media channels (e.g., Twitter/X and Facebook) and several non-profit nature conservation organizations (e.g., Natuurpunt and BOS+). Eligibility criteria included the minimum age of 18 years and being Dutch speaking (the study protocol and self-report scales were in Dutch). Sample size planning, conducted in G*Power (version 3.1.9.4), was based on multiple linear regression models with a small to medium expected effect size ($f^2 = .085$ [cf. Lopes et al., 2020, for rumination], $\alpha_{\text{Bonferroni corrected}} = .01667$, $\beta = .80$). The required sample size was 127 participants. To account for 10% natural attrition and low compliance typical for experience sampling procedures (10%; Vachon et al., 2019), we aimed for a total sample size of 153 participants.[1]

Measures

RNT, dampening, and subjective happiness were measured via validated self-report scales presented via m-Path (https://m-path.io; Mestdagh et al., 2023) at three time points (i.e., baseline, post-intervention, and follow-up). The Core Characteristics subscale of the Dutch version of the Perseverative Thinking Questionnaire (PTQ; Ehring et al., 2011, 2012) was used to assess RNT. This self-report scale consists of nine items measuring the core characteristics of RNT, namely, repetitiveness, intrusiveness, and difficulties to disengage from thoughts. Items (e.g., "The same thoughts keep going through my mind again and again") were rated on a 5-point scale from 0 (*never*) to 4 (*almost always*), with higher scores indicating higher levels of RNT. Excellent internal consistencies were found across the three time points for both conditions (high awe: $\alpha_{T1} = .94$; $\alpha_{T2} = .95$; $\alpha_{T3} = .97$; low awe: $\alpha_{T1} = .93$; $\alpha_{T2} = .94$; $\alpha_{T3} = .97$).

The Dutch version of the dampening subscale of the Responses to Positive Affect scale (RPA-d; Feldman et al., 2008) was used to measure participants' engagement in dampening thoughts. Item applicability (e.g., "When you feel happy, how often do you think about things that could go wrong?") was rated on a Likert scale ranging from 1 (*almost never*) to 4 (*almost always*). Higher scores represent higher dampening levels. Instead of using all eight items of the original English subscale, only six items were presented in the current study due to poor item performance in two validation studies of the Dutch scale (Nelis et al., 2016; Raes et al., 2009). For both conditions, good (to excellent) internal consistencies were found across time points (high awe: $\alpha_{T1} = .86$; $\alpha_{T2} = .88$; $\alpha_{T3} = .89$; low awe: $\alpha_{T1} = .86$; $\alpha_{T2} = .88$; $\alpha_{T3} = .87$).

Subjective happiness was measured via the Subjective Happiness Scale (SHS; Lyubomirsky & Lepper, 1999; van Denissen & de Fruyt, n.d.), consisting of four items (e.g., "In general, I consider myself as ...") being rated on a 7-point scale ranging from 1 (e.g., *not a very happy person*) to 7 (e.g., *a very happy person*). After reverse scoring Item 4, higher scores indicate a higher level of subjective happiness. For both conditions, good (to excellent) internal consistencies were found across the three time points (high awe: $\alpha_{T1} = .85$; $\alpha_{T2} = .88$; $\alpha_{T3} = .84$; low awe: $\alpha_{T1} = .87$; $\alpha_{T2} = .86$; $\alpha_{T3} = .84$).

In line with the study design, participants were asked (on Days 1, 8, and 17) to evaluate their engagement in RNT and dampening and experienced subjective happiness *during the past week* (a temporal qualification not present in the original instructions). In that way, participants exclusively considered the duration of the 1-week intervention and the 1-week follow-up interval when answering the questions.

To explore momentary experiences and short-term changes during the 7-day-intervention phase, participants completed daily questions that probed their feelings and thoughts while

watching the 1-min nature clip. The single-item questions (Table S1) were rated on a Likert scale from 0 to 100, with higher scores indicating greater applicability. Awe-related measures included feelings of awe, being part of a larger whole (Shiota et al., 2007), connection with nature (Yang et al., 2018), and escaping things for a moment. An additional question controlled for potential feelings of anxiety elicited by threatening features of some awe-evoking nature scenes (e.g., the intimidating character of a deep canyon; Gordon et al., 2017). Finally, single-item daily diary measures on RNT, dampening, and happiness were included to explore the instant impact of nature exposure.

Procedure

After receiving ethical approval (Social and Societal Ethics Committee of KU Leuven, G-2021-4058) and preregistering the study on the Open Science Framework (https://osf.io/q6un2), recruitment started by distributing study flyers via social media channels. Through an online survey link to Qualtrics, interested individuals could read a brief study explanation and provide their contact information if they wished to take part. Upon subscribing, participants received an email with instructions and a unique invitation code to install m-Path, our experience sampling app, on their smartphones. Immediately after installation, m-Path prompted participants to sign the informed consent form, provide demographic information (age and gender), and complete baseline self-report scales of RNT, dampening and subjective happiness (Day 1). From Days 2 to 8, participants watched a 1-min nature clip (either "high awe" or "low awe"; between-person manipulation) and answered eight single-item questions (see *Measures*), once a day on seven consecutive days (intervention phase). Depending on condition (i.e., high awe vs. low awe), different nature clips were presented (see *Conditions*), for which a daily notification was sent at 9 a.m. To minimize drop-out, participants could postpone watching the clip to a more suitable moment on the same day. M-Path sent an automatic reminder if no data had been received at 8 p.m.

Immediately after completing the intervention phase (Day 9) and 1 week later (Day 17), participants were invited to complete the post-intervention and follow-up assessment via m-Path on their mobile phones. They could choose a convenient time during that day to fill in the questions. If necessary, an automated reminder was sent by 8 p.m. of the same day.

As part of the post-intervention and the follow-up assessment, two open questions were planned to get insight into (and control for) potentially relevant life events during the intervention or the follow-up period respectively. However, due to a clerical error, no data were recorded for these questions. Upon completion of the follow-up assessment on Day 17, a final notification was sent offering participants the opportunity to be informed about the general study results and/or to take part in a raffle of two vouchers of 25 EUR and one of 50 EUR. Figure S1 summarizes the study procedure.

Conditions

Participants were randomly assigned to either the high awe or low awe condition, showing them awe-evoking and more mundane natural environments, respectively. Each condition involved watching seven different 1-min nature movie clips (https://osf.io/fjx8h/), each consisting of eight short fragments of different nature scenes. Each day of the intervention phase,

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participants were presented a different clip (i.e., pseudorandomized). Selection of the visual (copyright free) material of which the nature clips for both conditions were composed (see Figure S2 for examples) was guided by the degree of vastness of the scenes, a key feature of awe-evoking scenes (Keltner & Haidt, 2003). In the high awe condition, participants watched sweeping shots of beautiful landscapes characterized by vastness that would transcend most participants' usual experience of nature. This vastness derived from the expansiveness of the landscapes, as well as from the sheer physical size of particular landscape features (e.g., a deep canyon). In the low awe condition, the nature presented was of beautiful nature (e.g., flowers and meadow), but it lacked the sense of grandeur or expansiveness characteristic of the high awe condition. The validity of the classification of the nature movie clips into either "high awe" and "low awe" evoking clips was verified in a pilot study. That is, significantly higher levels of awe and related concepts (i.e., feeling part of a larger whole, being able to escape for a moment, and feeling connected with nature) were reported by participants in the high (vs. low) awe condition (see Table S2). To increase vividness and immersion, all nature clips were accompanied by different fragments of calm background piano music (copyright free). The same audio fragments were used in both conditions.

Research design and statistical analysis plan

A randomized-controlled trial (1:1 allocation) with a 2×3 factorial design was used (i.e., condition: low awe vs. high awe, and time point: baseline, post-intervention, 1-week follow-up). As preregistered (https://osf.io/q6un2), significant group differences by gender and age for all study variables were calculated, as well as baseline correlations. Separate multiple linear regression models were preregistered as the next step, with post-intervention and follow-up levels of the outcomes being predicted by condition (1 = *high awe*; 0 = *low awe*), and age, gender, and baseline levels of the respective variable included as covariates. However, following preregistration, we deemed that piecewise multilevel models would more accurately account for dependence in the data (time, dummy-coded as T2 and T3, nested in persons).[2] Finally, as preregistered, the degree to which pre- and post-intervention or follow-up measures significantly differed between conditions was examined via paired sample *t* tests.

RESULTS

Preliminary analyses

Descriptive statistics for RNT, dampening, and subjective happiness of both groups are presented in Table 1. No significant differences were found between groups for age ($t[161] = -0.71$, $p = .48$) and self-identified gender ($\chi^2(1) = 0.24$, $p = .62$). Standardized mean differences (SMDs) showed no baseline imbalance for dampening (<.10; Schober & Vetter, 2019). Some baseline imbalance was found for RNT and subjective happiness (SMD = .21, SMD = .15, respectively), reflecting higher and lower scores for the low (vs. high) awe group, respectively. All variables correlated significantly at baseline ($r_{\text{RNT, dampening}} = .48$; $r_{\text{RNT, subjective happiness}} = -.52$, $r_{\text{dampening, subjective happiness}} = -.52$, p's $< .001$).

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TABLE 1 Descriptive statistics for all study variables (means) measured via the self-report scales at pre-assessment (T1), post-assessment (T2), and follow-up (T3) assessment.

	High awe			Low awe		
	M (SD)	**Min**	**Max**	**M (SD)**	**Min**	**Max**
RNT						
T1	2.08 (0.78)	0.11	4.00	2.24 (0.76)	0.56	3.67
T2	1.71 (0.92)	0	4.00	1.83 (0.79)	0	4.00
T3	1.60 (0.94)	0	3.89	1.70 (0.97)	0	4.00
Dampening						
T1	1.62 (0.59)	1.00	3.50	1.67 (0.65)	1.00	3.67
T2	1.54 (0.61)	1.00	3.67	1.51 (0.58)	1.00	3.17
T3	1.45 (0.57)	1.00	3.17	1.48 (0.53)	1.00	3.33
Subjective happiness						
T1	4.15 (1.23)	1.50	6.75	3.95 (1.35)	1.00	6.75
T2	4.49 (1.24)	1.75	7.00	4.31 (1.26)	1.25	7.00
T3	4.49 (1.21)	1.25	7.00	4.26 (1.23)	1.50	6.75

Main analyses

For RNT,[3] after controlling for age and gender, a significant fixed effect was found for the direct T2-slope (Est. $_{T2} = -3.54$, SE $= 0.57$, $t[190.41] = -6.19$, $p < .001$) and the T3-slope (Est. $_{T3} = -4.52$, SE $= 0.65$, $t[175.74] = -6.93$, $p < .001$), indicating a significant decrease after the intervention and at follow-up. Effects remained significant after outlier removal (values > Q3 + 1.5 × IQR [i.e., interquartile range] or < Q1–1.5 × IQR), inclusion of baseline RNT levels to control for the moderate baseline imbalance, and Benjamini-Hochberg (BH) correction for multiple testing (p's < q $_{\text{corrected significance level}} = .017$; Benjamini & Hochberg, 1995). No significant interactions between T2/T3 and condition were found (p's > .49), suggesting that the decreases in RNT from baseline to post-intervention and follow-up were independent of condition. From baseline to post-intervention, follow-up paired samples t tests indeed showed reductions in RNT (medium sized) for both groups (high awe: $t(76) = -4.67$, $p < .001$, Cohen's $d = 0.53$; low awe: $t(82) = -6.28$, $p < .001$, $d = 0.69$). However, the non-parametric paired two-sample Wilcoxon test (due to assumption violation) did not show significant decreases from post-intervention to follow-up for both groups (p's > .06). Comparison of baseline and follow-up RNT levels showed significant large reductions for both groups (high awe: $t(61) = -6.06$, $p < .001$, $d = 0.77$; low awe: $t(61) = -6.53$, $p < .001$, $d = 0.83$).

For dampening, after controlling for age and gender, significant fixed effects were found for the T2-slope (Est. $_{T2} = -0.93$, SE $= 0.28$, $t(276.14) = -3.39$, $p < .001$; 95% CI $_{\text{wild bootstrapping}}$ [−1.45; −0.45]) and the T3-slope (Est. $_{T3} = -3.54$, SE $= 0.31$, $t(190.41) = -6.19$, $p < .001$; 95% CI $_{\text{wild bootstrapping}}$ [−1.49;-0.21]). Significant time effects remained significant after outlier removal and BH correction for multiple testing (p's < q $_{\text{corrected significance level}} = .017$). No significant interactions between T2/T3 and condition were found (p's > .20), again suggesting that decreases in dampening were independent of condition. For the high awe group, the follow-up non-parametric paired two-sample Wilcoxon tests did not reveal a significant difference

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between baseline and post-intervention ($p = .17$). However, Wilcoxon tests showed significant small decreases in this group when comparing post-intervention and follow-up ($p = .03$, $d = 0.25$) and baseline and follow-up ($p = .004$, $d = 0.36$). For the low awe group, Wilcoxon tests showed a significant small decrease from baseline to post-intervention ($p < .001$, $d = 0.36$), but not when comparing post-intervention and follow-up ($p = .98$) and baseline and follow-up ($p = .051$, $d = 0.29$).

Finally, for subjective happiness, significant fixed effects were found for the T2-slope (Est. $_{T2} = 1.30$, SE $= 0.38$, $t(278.39) = 3.54$, $p < .001$; 95% CI $_{\text{wild bootstrapping}}$ [0.56;2.01]) and the T3-slope (Est. $_{T3} = 1.67$, SE $= 0.42$, $t(282.73) = 4.01$, $p < .001$; 95% CI $_{\text{wild bootstrapping}}$ [0.85; 2.55]). No significant interactions between T2/T3 and condition were found (p's $> .23$). Again, outlier removal nor BH correction for multiple testing (p's $< q_{\text{corrected significance level}} = .017$) affected the results in any notable way. Follow-up paired t tests showed significant small decreases for both groups from baseline to post-intervention (high awe: $t(76) = 2.42$, $p < .02$, $d = 0.28$; low awe: $t(82) = 3.73$, $p < .001$, $d = 0.41$). From post-intervention to follow-up, no further significant decreases were detected (p's $> .49$). Only for the low awe group a significant increase was detected from baseline to follow-up (low awe: $t(61) = 4.54$, $p < .01$, $d = 0.58$; high awe: $t(61) = 1.72$, $p = .09$, $d = 0.21$). Figure 1 provides a visual presentation of the observed changes in RNT, dampening and subjective happiness across the three time assessment points, clustered by condition.

Exploratory analyses (daily diary questions)

Grouped descriptive statistics for the daily diary outcomes across the nature clips are presented in Table 2. For in-the-moment experiences of awe (*Q1_awe*) and of being part of a larger whole (*Q6_partofwhole*), mean levels across the presented clips were significantly higher for the high (vs. low) awe group. For the other outcomes, no significant group differences were found ($p > .05$). In addition, multilevel models were run for each outcome with time treated as a continuous variable (i.e., across days) to explore short-term changes in the outcomes throughout the intervention phase. Detailed results can be found in the supporting information. Importantly, the validity of the clips was confirmed by significant fixed effects for condition in the expected direction for feelings of awe and of being part of a larger whole as outcomes. However, no significant time by condition effects were found for the daily diary outcomes, which would reflect short-term changes dependent on condition.

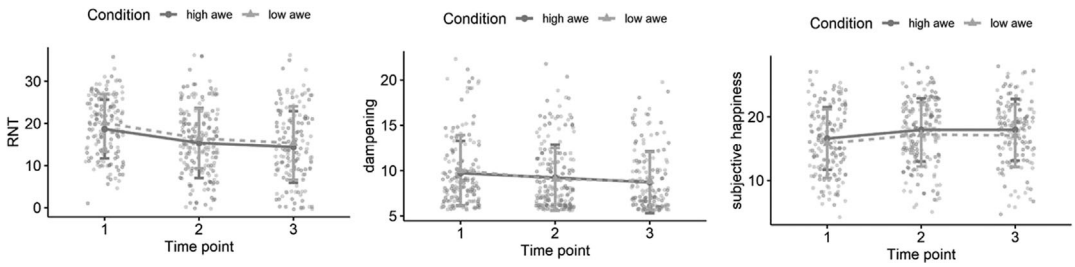

FIGURE 1 Line graphs summarizing changes in the study variables across time for the low awe and high awe group.

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TABLE 2 Descriptive statistics across nature clips presented during the intervention phase and group comparisons via independent two-tailed samples *t* tests.

	Low awe			High awe			Group comparison		
	M (SD)	Min	Max	M (SD)	Min	Max	*t* (*df*)	*p*	95% CI
Q1_awe	59.6 (23.3)	0	100	72.5 (21.4)	0	100	−4.85 (213)	**<.001**	**[−17.36; −7.33]**
Q2_RNT	24.0 (24.8)	0	100	22.3 (24.2)	0	92	0.79 (213)	.43	[−2.89; 6.77]
Q3_dampening	24.0 (18.6)	0	100	13.2 (20.9)	0	100	−0.15 (213)	.88	[−4.39; 3.79]
Q4_anxiety	10.1 (15.2)	0	100	11.2 (17.1)	0	85	−0.55 (213)	.59	[−4.35; 2.46]
Q5_happiness	66.7 (17.2)	0	100	68.1 (17.8)	15	100	−0.62 (213)	.53	[−4.91; 2.55]
Q6_partofwhole	50.9 (27.3)	0	100	59.0 (26.4)	0	100	−2.32 (213)	**.02**	**[−13.62; −1.12]**
Q7_escapeforamoment	62.1 (21.3)	0	100	64.4 (23.8)	0	100	−0.86 (205)[a]	.39	[−7.05; 2.77]
Q8_connectionwithnature	63.9 (22.3)	0	100	64.1 (23.7)	0	100	0.06 (213)	.96	[−5.25; 5.55]

[a]Due to unequal variances, a Welch Two-Sample *t* test was conducted.

DISCUSSION

In this randomized controlled trial, we examined the effects of exposure to high versus low awe-evoking nature clips through a week-long online intervention on RNT (H1), dampening (H2), and subjective happiness (H3). Participants watched 1-min nature clips on a daily basis on their smartphones, featuring either high or low awe eliciting content (one clip/day). Self-report scales were completed at baseline, immediately after the intervention and 1 week later. Additionally, participants responded to single-item questions after each daily nature clip to explore in-the-moment experiences and short-term changes during the intervention phase (i.e., daily diaries). Overall, we found that watching both types of nature clips led to similar decreases in RNT (H1) and dampening (H2) levels, along with increases in subjective happiness (H3) from pre- to post-intervention to follow-up assessment. Thus, contrary to our expectations, changes were observed in *both* nature groups, regardless of the awe-eliciting features of the nature exposure.

For RNT, we found the most conclusive, consistent, and strongest effects (i.e., at post-intervention and follow-up), which is in line with prior evidence for the beneficial impact of nature on rumination (Lopes et al., 2020). Medium-to-large effect sizes were observed, even though our nature intervention only consisted of a small "dose" (i.e., one 1-min nature clip per day). Such sizeable effects on rumination interventions are mostly obtained through more comprehensive interventions that require intensive effort over a longer period of time (e.g., a 6-week internet-based intervention drawing on rumination-focused cognitive behavioral therapy in individuals with high baseline RNT scores; Joubert et al., 2023).

For dampening, small improvements were found following the intervention for both nature groups. For the high awe group, the decrease in dampening was situated at the follow-up assessment (i.e., baseline vs. follow-up), while for the low awe group, the decrease was situated at post-intervention (i.e., baseline vs. post-intervention). Nevertheless, the observed small effects on this measure are in line with past intervention studies. For example, a 14-week positive psychology intervention in students only resulted in small-to-medium sized decreases in fear of happiness, a concept related to dampening (Lambert et al., 2019).

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Finally, small-sized improvements in subjective happiness were observed at post-intervention for both groups and at follow-up for the low awe group. These effect sizes are comparable to, for instance, improvements in subjective happiness detected as a result of a self-performed online gratitude intervention in a community sample (Cunha et al., 2019). Our findings are thus in line with the body of evidence supporting the positive influence of nature on emotional well-being and mental health (e.g., Campos et al., 2013; Rivera et al., 2020).

The absence of differences between the nature groups may be attributed to the relatively high levels of elicited awe in both groups. Despite significant differences, the low awe group also reported moderate levels of awe ($M = 59.6$, $SD = 23.3$; 0–100 range), which might already have been large enough to impact our outcomes. Furthermore, the background music might unintentionally have increased feelings of awe in the low awe group. Future studies could ensure greater variability in the nature scenes' capacity to elicit awe (e.g., videos of moving man-made objects, not eliciting awe; see van Elk et al., 2019).

Alternatively, contextual factors may have given rise to confounding effects that attenuated the expected beneficial effect(s) of the awe-evoking nature clips. For example, the study took place during the COVID-19 crisis, a period marked by restricted or prohibited travel. Scenes from the high awe condition are typically associated with holiday destinations. This might have reminded participants of travel restrictions and limited freedom, potentially evoking negative feelings and goal frustration, thereby diminishing the effectiveness of the awe-evoking nature scenes. This reasoning aligns with the exploratory finding that in the low awe group, higher awe was significantly correlated with decreases in RNT from pre- to post-intervention. In the high awe group, self-reported awe did not significantly correlate with decreases in RNT, suggesting that buffering moderating variables might have been at play.

Another issue might be that the awe-evoking nature did not serve as a positive stimulus for all participants, potentially diminishing the general positive effects on our outcomes. Specifically, some clips in the high awe condition depicted nature that is significantly impacted by climate change (e.g., scenes of glaciers), which possibly triggered concerns about imminent climate problems and the well-being of future generations (Clayton, 2020). Even regardless of climate anxiety, some high awe-evoking scenes contained features that certain participants, especially those who are highly threat sensitive (Nakayama et al., 2020), might have perceived as threatening (e.g., great heights). This could have rendered the intervention with awe-evoking stimuli overall less positive than anticipated. Future research should address these issues by ensuring that the awe-evoking scenes are of benign rather than threatening nature and lead to positively rather than negatively valenced awe. In addition, ideally, measures should be included to disentangle more subtle differential effects of positively and negatively valenced awe (e.g., mixed feelings; Chaudhury et al., 2022).

Importantly, although the exploratory analyses on the daily diary data confirmed the validity of the nature clips, no significant effects were found suggesting an in-the-moment impact of watching the nature clips (e.g., RNT, dampening, happiness, and anxiety). However, future studies, ruling out possible methodological issues (e.g., limited power; Dejonckheere et al., 2022), are required to draw firm conclusions in this regard.

The present study is not without limitations. First, beyond the awe-eliciting capacities of the nature clips, they differed on other dimensions such as scene organization or color information. Future studies might therefore benefit from using more similar stimuli for these and other dimensions.

Second, we focused on the *effects* of awe-evoking versus mundane nature. However, future research could investigate the mechanisms through which nature interventions yield

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their beneficial effects and pinpoint the extent to which these effects are driven by awe-related characteristics such as self-transcendence, feelings of inner peace, or solitude. Most importantly, the two proposed pathways via which awe-evoking nature might exert its effect (i.e., decreased self-focus and self-diminishment) should be empirically tested using accurately designed mediation models. Related to the suggested pathway of decreased self-focus due to attentional diversion away from the self (see Introduction), an interesting additional research question is whether awe-evoking nature would solely benefit thought patterns involving maladaptive self-focus, such as self-critical rumination (Smart et al., 2016), rather than adaptive types of self-focus, such as self-compassion (Neff, 2003). It might be fruitful to as well include a measure tapping into depressive symptomatology and examine whether changes in RNT, dampening and subjective happiness indeed result in changes in depressive symptomatology.

Third, the current study design does not allow us to disentangle whether the observed effects reflect a time/treatment effect rather than a nature effect (e.g., related to increased nature connectedness; Capaldi et al., 2014). Therefore, future research should ideally include a study arm with nature clips that elicit (barely to) no feelings of awe, alongside a neutral control group presenting clips devoid of natural content and a passive control group.

Fourth, recruiting participants partially from non-profit nature conservation organizations might have given rise to selection effects. Because these participants are probably inherently sensitive to the impact of contact with nature and its awe-eliciting capacities, this may have minimized or canceled out differences between groups, while at the same time compromising the generalizability of the current study findings. In addition, recent research suggests that this (sub)sample, being more knowledgeable about nature than laypeople, is more likely to perceive vastness and experience awe in even mundane nature (Ng et al., 2023). Moreover, the risk of acquiescence bias leading to potential demand effects cannot be excluded.

Fifth, while our study presumed that the effect of awe-evoking nature would hold for all participants, it is likely that the strength of the effects of awe depends on personal and context-related characteristics. To address this, future studies could explore multiple potentially moderating (e.g., predisposition to attend to negative aspects of awe, dispositional nature connectedness, and confounding contextual elements) and mediating (e.g., changes in physical activity) factors.

Finally, the Subjective Happiness Scale we used taps into a rather broad, trait-like category of well-being (Lyubomirsky & Lepper, 1999). Therefore, it could be helpful for future studies to select additional measures of affect that are more sensitive to detect small and fleeting fluctuations in feeling states, especially considering the "small" dose of nature exposure delivered via EMIs.

In sum, the findings of this study underscore the usefulness of nature-based EMIs in mitigating RNT and dampening, and boosting subjective happiness. They could serve as a preventive measure and/or treatment for depression, either as a stand-alone program in early treatment stages of depression or as a means to bridge waitlist periods for individuals in need of clinical support. Irrespective of its awe-eliciting capacities, such nature-based EMIs could serve as a potential low-cost, low-threshold, and non-invasive clinical application. Given cognitive and motivational difficulties associated with depression, interventions that do not require too much (cognitive) personal effort can be valuable as they may be an attainable step to improve well-being and to create room for adopting a more functional palette of affective response styles. We look forward to future well-controlled clinical studies that further explore and harness nature's beneficial impact on RNT, dampening and subjective happiness.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The anonymized data and analysis code are publicly available online (https://osf.io/fjx8h/).

ETHICS STATEMENT

Ethical approval for this study was obtained from the Social and Societal Ethics Committee of KU Leuven, under reference number G-2021-4058.

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ENDNOTES

[1] More details about determination of the oversampling rate and post hoc reflections on the adopted sample size planning procedure can be found in the supporting information section.

[2] For the sake of transparency, results of the preregistered multiple linear regression models and details about the composition of the multilevel models and statistical software used can be found in the supporting information.

[3] In line with the higher internal consistency for RNT, results for the three core characteristics (i.e., repetitiveness, intrusiveness, and difficulties to disengage from thoughts) treated as separate outcome variables showed highly similar patterns as the findings for RNT as a combined construct.

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