Article

Adverse Weather Evokes Nostalgia

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Wijnand A. P. van Tilburg[1], Constantine Sedikides[2], and Tim Wildschut[2]

Abstract

Four studies examined the link between adverse weather and the palliative role of nostalgia. We proposed and tested that (a) adverse weather evokes nostalgia (Hypothesis 1); (b) adverse weather causes distress, which predicts elevated nostalgia (Hypothesis 2); (c) preventing nostalgia exacerbates weather-induced distress (Hypothesis 3); and (d) weather-evoked nostalgia confers psychological benefits (Hypothesis 4). In Study 1, participants listened to recordings of wind, thunder, rain, and neutral sounds. Adverse weather evoked nostalgia. In Study 2, participants kept a 10-day diary recording weather conditions, distress, and nostalgia. We also obtained meteorological data. Adverse weather perceptions were positively correlated with distress, which predicted higher nostalgia. Also, adverse natural weather was associated with corresponding weather perceptions, which predicted elevated nostalgia. (Results were mixed for rain.) In Study 3, preventing nostalgia (via cognitive load) increased weather-evoked distress. In Study 4, weather-evoked nostalgia was positively associated with psychological benefits. The findings pioneer the relevance of nostalgia as source of comfort in adverse weather.

Keywords

nostalgia, weather, self-regulation, emotion, psychological benefits

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[Neptune] gather'd clouds from land,
Frighted the seas up, snatch'd into his hand
His horrid trident, and aloft did toss,
Of all the winds, all storms he could engross;
All earth took into sea with clouds, grim night
Fell tumbling headlong from the scope of light,
The East and South winds justled in the air,
The violent Zephyr, and North making-fair,
Roll'd up the waves before them. And then bent
Ulysses' knees, then all his Spirit was spent.

The storm conjured in Neptune's (Poseidon's) rage, as narrated in the passage from Homer's (2002) *Odyssey* (p. 107), bent Ulysses (Odysseus) but did not break him. Propelled by his nostalgia for family and home, Odysseus resumed his quest and, after a considerable delay ridden with physical and psychological hardships, reunited with his loved ones. The role of nostalgia, "a sentimental longing or wistful affection for the past" (Pearsall, 1998, p. 1266), in meeting challenges is not limited to mythology. Prior research has documented nostalgia's capacity to counteract assorted psychological threats (e.g., social-, existential-, or self-related; Sedikides, Wildschut, Arndt, & Routledge, 2008; Sedikides, Wildschut, Routledge, Arndt, Hepper, & Zhou, 2015; Wildschut, Sedikides, & Cordaro, 2011). Extending these findings to a new domain, we examined nostalgia's role in alleviating distress caused by adverse weather. Might Poseidon's storm have strengthened Odysseus's resolve by fanning the flames of his nostalgia?

Nostalgia

Nostalgia is a universal emotion (Hepper et al., 2014) that is experienced across the life span (Hepper, Wildschut, Sedikides, Robertson, & Routledge, 2018). According to a prototype analysis of nostalgia (Hepper, Ritchie, Sedikides, & Wildschut, 2012), the central features of this emotion are predominantly positive (e.g., fond memories, happiness), whereas its peripheral features are predominantly negative (e.g., pain, sadness). Indeed, nostalgia aligns more closely with positive emotions, such as pride, self-compassion, or gratitude, than with negative emotions, such as shame,

[1]King's College London, UK
[2]University of Southampton, UK

Corresponding Author:
Wijnand A. P. van Tilburg, Department of Psychology, Guy's Campus, King's College London, Room 2.12, Addison House, London, SE1 1UL, UK.
Email: Wijnand.van_Tilburg@kcl.ac.uk

guilt, or unrequited love (Van Tilburg, Wildschut, & Sedikides, 2017). Nostalgia involves a rose-colored representation of momentous occasions (e.g., graduations, anniversaries, cultural rituals), which are typically shared with valued others (e.g., family, partners, friends) and are characterized by a redemptive narrative (i.e., the protagonist confronts difficulties, but eventually surmounts them; Abeyta, Routledge, Roylance, Wildschut, & Sedikides, 2015; Sedikides & Wildschut, 2016a; Wildschut, Sedikides, Arndt, & Routledge, 2006).

Nostalgia soothes discomforting states. In particular, it is a response to psychological threat. Examples involve social threat (e.g., loneliness, exclusion; Seehusen et al., 2013; Wildschut et al., 2006), existential threat (e.g., meaninglessness, mortality salience; Routledge, Arndt, Sedikides, & Wildschut, 2008; Routledge et al., 2011), and self-threat (e.g., negative performance feedback, self-discontinuity; Sedikides, Wildschut, Gaertner, Routledge, & Arndt, 2008; Vess, Arndt, Routledge, Sedikides, & Wildschut, 2012). In turn, nostalgia establishes psychological homeostasis by fostering social connectedness (Wildschut, Sedikides, Routledge, Arndt, & Cordaro, 2010; Zhou, Sedikides, Wildschut, & Gao, 2008), fortifying meaning in life and assuaging fear of death (Juhl, Routledge, Arndt, Sedikides, & Wildschut, 2010; Van Tilburg, Igou, & Sedikides, 2013), and elevating self-continuity (Sedikides et al., 2016; Sedikides, Wildschut, Routledge, & Arndt, 2015) and self-esteem (Hepper et al., 2012; Wildschut et al., 2006). Nostalgia also confers other psychological benefits such as positive affect (Batcho, 2013), optimism (Cheung et al., 2013), and creativity (Van Tilburg, Sedikides, & Wildschut, 2015). In all, nostalgia harnesses a rose-tinted past, enabling individuals to cope with present and future challenges (Sedikides & Wildschut, 2016b, 2017).

Nostalgia and Adverse Weather

We are interested whether, in addition to regulating psychological threat, nostalgia regulates physical (i.e., weather related) threat. Weather shapes human life. Spending time outside on warm, sunny days increases positive mood and helping (Cunningham, 1979; Keller et al., 2005). Cold, wet, and windy weather, on the contrary, is associated with negative mood, discomfort, and perceived risk of personal injury (Agdas, Webster, & Masters, 2012; Ettema, Friman, Olsson, & Gärling, 2017; Hartig, Catalano, & Ong, 2007; Jackson, 1978). Is nostalgia a spontaneous response to adverse weather? If so, does the distress elicited by adverse weather trigger nostalgia? Does weather-evoked nostalgia, in turn, alleviate distress and confer psychological benefits (i.e., social connectedness, meaning in life, self-continuity, self-esteem, positive affect, optimism)? To answer these questions, we examined the link between adverse weather and nostalgia in four studies. We elaborate below on the rationale and hypotheses.

Is Nostalgia a Response to Adverse Weather?

We wondered whether individuals nostalgize—reflect sentimentally on a meaningful event from their life—in response to adverse weather, namely, wind, thunder, and rain. Several lines of inquiry suggest that they may. To begin, positive emotions (of which nostalgia is one) often act to establish psychological homeostasis (DeWall & Baumeister, 2007; Manstead, Frijda, & Fischer, 2004). In Levenson's (1988) words, "The evolutionary meaning of positive emotions such as happiness might be to function as efficient 'undoers' of states of ANS (autonomic nervous system) arousal produced by certain negative emotions" (p. 125). Consistent with this view, the anterior insular cortex appears to be a neurological basis for the homeostatic function of positive emotions. This is a structure involved in emotional awareness and implicated in registering interoceptive states such as temperature and pain (Craig, 2009; Damasio et al., 2000).

The homeostatic function of positive emotions manifests through two processes. First, positive emotions can undo the physiological arousal associated with negative emotions, allowing the individual to reestablish homeostasis (Damasio, 1993; Levenson, 1999). Nostalgia, a predominantly positive emotion (Hepper et al., 2012; Van Tilburg et al., 2017), can thus be expected to remedy negative emotions, such as those experienced during adverse weather. A second process by which positive emotions achieve homeostasis is through simulation. The emotions can involve the simulation of bodily states "as if" they were truly occurring (i.e., the as-if body loop; Damasio, 1993). Nostalgia has considerable potential to serve homeostasis through this second process. Nostalgic reverie inherently involves reflecting on past meaningful, pleasant, and social events (Wildschut et al., 2006), and the simulation of these events can in turn be expected to confer benefits to the individual as if they occurred in the present. This second process is captured by the famous song, California Dreaming: "I'd be safe and warm, if I was in LA. California dreaming on such a winter's day."

Zhou, Wildschut, Sedikides, Chen, and Vingerhoets (2012) reported that nostalgia indeed serves psychological homeostasis in the context of physical discomfort. Over the course of 30 days, cold days were associated with elevated nostalgia (Study 1). A follow-up experiment (Study 2) revealed that participants in an artificially cooled environment (20 °C) reported higher levels of nostalgia compared with participants in a comfortable environment (24 °C) or a warm environment (28 °C). Zhou et al. also examined whether nostalgic individuals can harness the emotion's potential palliative benefits to withstand coldness. Participants who had recollected a nostalgic (vs. ordinary) event manifested greater tolerance in a cold pressor test (i.e., they kept their hand immersed in cold water for longer periods; Study 5). Nostalgia reduced thermoregulatory discomfort. More generally, these findings suggest that individuals can resort successfully to nostalgia following uncomfortable physiological states: They can implement nostalgia as a tool in countering physical adversity. Building on this literature, we formulated our first hypothesis (H1): *adverse weather evokes nostalgia*. We tested this hypothesis in all four studies.

Does Nostalgia Accompany the Distress Associated With Adverse Weather?

We proposed that adverse weather is threatening. If so, adverse weather ought to be associated with higher distress. In turn, distress would be linked with increased nostalgia. We formulated our second hypothesis (H2) as follows: *adverse weather is associated with increased distress, which in turn predicts elevated nostalgia*. We tested this hypothesis in Study 2.

Does Preventing Nostalgia Exacerbate Weather-Induced Distress?

We argue that nostalgizing in response to adverse weather assuages the distress that such weather induces. If so, then preventing people from recruiting nostalgia should render them more vulnerable to weather-induced distress. This was our third hypothesis (H3): *preventing people from nostalgizing in response to adverse weather exacerbates distress*. We tested this hypothesis in Study 3.

Does Weather-Evoked Nostalgia Confer Psychological Benefits?

Nostalgia—induced via narratives, music, or scents—confers psychological benefits in the form of social connectedness, meaning, self-continuity, self-esteem, positive affect, and optimism (Cheung, Sedikides, & Wildschut, 2016; Reid, Green, Wildschut, & Sedikides, 2015; Sedikides, Wildschut, Routledge, Arndt, Hepper, & Zhou, 2015). We predict that weather-evoked nostalgia will contribute to psychological homeostasis by conferring the same benefits. Our fourth hypothesis (H4) stated, *weather-evoked nostalgia engenders psychological benefits (social connectedness, meaning, self-continuity, self-esteem, positive affect, and optimism)*. We tested this hypothesis in Study 4.

Supplementary Issue: Objective Meteorological Conditions

We have thus far emphasized subjective weather perceptions. But is nostalgia evoked in response to objectively adverse weather? If so, are adverse meteorological conditions associated with higher nostalgia due to corresponding weather perceptions? We addressed these questions in Study 2.

Overview

In Study 1, participants listened to recordings of adverse weather conditions (wind, thunder, and rain as well as neutral sounds) in a within-subjects design and reported their level of nostalgia. In Study 2, we asked participants to record the weather, their level of distress, and their level of nostalgia on a daily basis for 10 days. We also obtained meteorological data for the corresponding time period. In Study 3, participants either listened to recordings of adverse weather (wind) or neutral sounds while carrying out either a nostalgic recall or cognitive load task. We tested if cognitive load, by preventing participants from recruiting nostalgia, would exacerbate the distress brought about by adverse weather. In Study 4, participants listed to recordings of adverse weather in a between-subjects design. We assessed nostalgia and its ensuing psychological benefits in the form of social connectedness, meaning in life, self-continuity, self-esteem, positive (and not negative) affect, and optimism.

Study 1: Weather-Evoked Nostalgia

Does adverse weather evoke nostalgia (H1)? Participants listened to recordings of wind, thunder, and rain, as well as neutral control sounds and reported how nostalgic each recording made them feel.

Method

Participants and design. We recruited 75 participants (51 women, 24 men; M_{age} = 30.29, SD_{age} = 12.20) via MTurk (www.MTurk.com).[1] The study involved a within-subjects design with four weather conditions: wind, thunder, rain, and control.

Materials. We created four 2-min recordings. The control recording consisted of sounds from a quiet parking lot (e.g., cars arriving and driving, door opening and closing, mild breeze). To this baseline recording, we added the sounds of heavy wind, heavy thunder, and heavy rain, thus forming the tracks of the corresponding three conditions. Two pilot studies confirmed that the weather recordings (compared with neutral control) increased distress. The first of these studies also ruled out a potential confound between adverse weather and the state of awe (Shiota, Keltner, & Mossman, 2007). We report these pilot studies in Supplemental Materials, available online.

Procedure. Participants listened to the four recordings presented in separate random orders. After each recording, participants indicated their level of nostalgia on a validated scale (Hepper et al., 2012; Stephan et al., 2014; Wildschut et al., 2006), which we adapted for the purposes of this study. The three items were, "This recording makes me feel quite nostalgic," "This recording gives me nostalgic feelings," and "This recording makes me feel nostalgic at the moment" (1 = *strongly disagree*, 6 = *strongly agree*; grand M = 2.40, SD = 0.88; within each weather condition, Cronbach's α exceeded .96).

Results and Discussion

A repeated-measures ANOVA (wind, thunder, rain, and control) on state nostalgia yielded a significant main effect, $F(3, 222) = 9.76$, $p < .001$, $\eta_p^2 = .12$. Relative to control recordings ($M = 1.85$, $SD = 1.14$), wind, $M = 2.43$, $SD = 1.41$, $F(1, 74) = 11.40$, $p = .001$, $d = 0.78$; thunder, $M = 2.76$, $SD = 1.51$, $F(1, 74) = 22.52$, $p < .001$, $d = 1.10$; and rain $M = 2.22$, $SD = 1.26$, $F(1, 74) = 5.64$, $p = .020$, $d = 0.55$, recordings evoked higher levels of nostalgia. Thunder additionally evoked more nostalgia than rain, $F(1, 74) = 10.60$, $p = .002$, $d = 0.76$. The differences in evoked nostalgia between rain and wind, and between wind and thunder, were not significant, $F(1, 74) = 1.55$, $p = .218$, $d = 0.29$, and $F(1, 74) = 3.44$, $p = .068$, $d = 0.43$, respectively. These results demonstrate for a first time that wind, thunder, and rain can elicit nostalgia. The findings are consistent with H1.

Study 2: Weather, Distress, and Nostalgia

In Study 1, we examined the influence of weather adversity on nostalgia (H1), using simulated weather conditions. In Study 2, we engaged in a naturalistic extension by instructing participants to monitor daily weather conditions, as well as their daily levels of nostalgia. We also intended to find out if adverse weather is experienced as threat. If so, participants would report higher distress during more adverse weather conditions. Furthermore, weather-induced distress would predict elevated nostalgia (H2). For these reasons, we instructed participants to report their daily distress levels as well.

For weather conditions to evoke nostalgia, people must notice them. That is, rather than the objective weather characteristics (e.g., wind speed, millimeters of rainfall) directly evoking nostalgia, subjective perceptions of these weather characteristics (e.g., perceived wind intensity or rain) should be a more proximal antecedent of nostalgia. A person spending the majority of time indoors during a windy day is unlikely to experience the weather as particularly adverse and another person laboring into a headwind on her or his bicycle will appraise the same weather as adverse. We tested the idea that weather perceptions would mediate the influence of objective weather conditions on nostalgia, by retrieving relevant meteorological data.

We had a supplementary goal in Study 2, and it concerned the work of Zhou et al. (2012). Chinese participants reported higher levels of nostalgia when ambient temperature was lower (colder). We tested the replicability of these findings in a Western sample.

Method

Participants and design. Participants were 133 undergraduates from University of Southampton (117 women, 16 men; $M_{age} = 28.36$, $SD_{age} = 12.45$).[2] They completed an online diary during each of 10 working days in exchange for course credit.[3] On average, they completed the online diary on 6.78 of these scheduled days ($SD = 3.38$), resulting in 902 observations nested within participants and days. The study began on November 19, 2013, but some participants entered the study on a later date. All participants had completed the study by December 17, 2013. The study thus covered almost a month of natural weather variation.

Procedure and materials. Every day, for 10 days, participants received a late-afternoon email invitation containing a link to the online materials. They completed the following measures.

Temperature and weather conditions. Participants reported their subjective perceptions of temperature (in degree Celsius). They also reported the occurrence of wind ("How strong was the wind today, if any?"; 1 = *no wind at all*, 7 = *extremely strong wind*; grand $M = 2.67$, $SD = 1.24$), thunder ("How heavy was the thunder today, if any?"; 1 = *no thunder at all*, 7 = *extremely heavy thunder*), and rain ("How heavy was the rainfall today, if any?"; 1 = *no rain at all*, 7 = *extremely heavy rain*; grand $M = 1.48$, $SD = 1.00$) for each day. No thunder occurred during the study period, and we therefore dropped this variable from data analyses.

Distress. Participants reported the extent to which they felt distressed on the day ("Did you feel distressed today?"; "Did you feel anxious today?" 1 = *not at all*, 7 = *very much*; $\alpha = .87$; grand $M = 2.90$, $SD = 1.71$). We constructed these items for the objectives of our study, given that common alternative scales were too long, were developed for clinical assessment, or assessed distress at the trait level (Andrews & Slade, 2001; Heimberg, Hope, Rapee, & Bruch, 1988).

Nostalgia. Participants indicated their daily nostalgia on five items, which we modified slightly after the Southampton Nostalgia Scale (Barrett et al., 2010; Routledge et al., 2008). The items were, "How valuable was nostalgia for you today?" (1 = *not at all*, 7 = *very much*); "How important was it for you to bring to mind nostalgic experiences today?" (1 = *not at all*, 7 = *very much*); "How significant was it for you to feel nostalgic today?" (1 = *not at all*, 7 = *very much*); "How prone were you to feeling nostalgic today?" (1 = *not at all*, 7 = *very much*); "How often did you experience nostalgia today?" (1 = *very rarely*, 7 = *very frequently*) ($\alpha = .97$; grand $M = 2.53$, $SD = 1.49$).

Results

Distress. Daily records (Level 1) were nested within participants (Level 2). We therefore used hierarchical linear modeling (HLM) analyses, in which the participant-level intercept was treated as a random effect (i.e., we included a variance component to represent the effect of participants; Singer, 1998).

Higher perceived wind intensity predicted greater daily distress, $\gamma = 0.14$, $SE = 0.05$, $t(881.35) = 3.08$, $p = .002$. More perceived rain was marginally associated with greater daily distress, $\gamma = 0.10$, $SE = 0.06$, $t(893.29) = 1.70$, $p = .089$. Thus, perceptions of wind, and perhaps rain, were positively associated with distress.

Nostalgia. HLM analysis revealed that perceived wind intensity was positively associated with nostalgia, $\gamma = 0.15$, $SE = 0.04$, $t(888.91) = 3.73$, $p < .001$. There was no significant association between perceived rain and nostalgia, $\gamma = 0.05$, $SE = 0.05$, $t(892.35) = 0.92$, $p = .360$. The wind-related (but not the rain-related) results are consistent with those of Study 1 in support of H1. Perceived rain may not have been sufficiently severe to evoke nostalgia.

Does distress mediate the "influence" of perceived weather adversity on nostalgia?. We examined whether the distress associated with perceived weather adversity predicts higher nostalgia (H2). In previous analyses, we found that both distress and nostalgia increased with perceived wind intensity. An HLM analysis, with perceived wind intensity and distress as independent variables and nostalgia as dependent variable, established that distress significantly predicted higher levels of nostalgia, above and beyond perceived wind intensity, $\gamma = 0.26$, $SE = 0.03$, $t(882.92) = 8.147$, $p < .001$. The positive association between perceived wind intensity and nostalgia became weaker, but remained significant, when controlling for distress, $\gamma = 0.11$, $SE = 0.04$, $t(887.95) = 2.90$, $p = .004$. As a final step, we tested the indirect effect (denoted as ab) of perceived wind intensity on nostalgia through distress. We treated paths a (from the predictor to the mediator) and b (from the mediator to the outcome) as fixed effects and used the MCMED macro (Hayes, 2013a) to construct 95% Monte Carlo confidence intervals (CIs) for the indirect effect.[4] This analysis yielded a significant indirect effect, $ab = 0.031$, 95% CI = [0.011, 0.054]. These findings are consistent with the idea that individuals recruit nostalgia in response to weather-induced distress.

Supplementary analyses

Replication of Zhou et al (2012). Prior work showed that ambient temperature is negatively associated with nostalgia (i.e., low temperature increases nostalgia; Zhou et al., 2012). In agreement, HLM analyses revealed a significant negative association between perceived temperature and nostalgia, $\gamma = -0.05$, $SE = 0.02$, $t(870.00) = 2.68$, $p = .007$.

Perceived temperature and perceived weather. We wondered whether perceived temperature accounted for the association between perceived wind intensity and nostalgia. To test this, we regressed nostalgia on perceived temperature and wind intensity in an HLM analysis. Results revealed that perceived wind intensity remained a significant predictor of nostalgia, $\gamma = 0.13$, $SE = 0.04$, $t(8870.00) = 3.26$, $p = .001$, whereas the association between perceived temperature and nostalgia became marginal, $\gamma = -0.03$, $SE = 0.02$, $t(865.23) = 1.88$, $p = .060$. Perceived wind is positively associated with nostalgia, above and beyond perceived temperature fluctuations.

Do. weather perceptions mediate the "influence" of weather conditions on nostalgia?

We retrieved open-source daily weather records from the local weather station and examined variables directly relevant to wind (average wind speed and maximum wind speed in mph), rain (total rainfall and maximum rainfall per minute in millimeter), and temperature (average temperature, maximum temperature, and minimum temperature °C). Multilevel analyses indicated that each of these objective weather features was positively associated with its corresponding weather perception (ps < .001; for example, average wind speed was correlated with perceived wind intensity). Accordingly, we wondered if weather conditions are linked to higher nostalgia through subjective weather perceptions. We therefore conducted a series of mediation analyses, using the MCMED macro to construct 95% CIs for the indirect effects (Hayes, 2013a). In each analysis, we treated an objective weather index (e.g., average wind speed) as continuous independent variable, the corresponding weather perception (e.g., perceived wind intensity) as mediator, and nostalgia as outcome variable. We present the indirect effects in Table 1.

Results revealed that both average wind speed and maximum wind speed predicted nostalgia through perceived wind intensity. Neither total rainfall nor maximum rainfall per minute predicted nostalgia via perceived rain intensity. This is not surprising, given the nonsignificant association between perceived rain and nostalgia. Finally, minimum temperature (but not average temperature or maximum temperature) predicted increased nostalgia through perceived temperature. During autumn in England (when the study was conducted), minimum temperature may be more relevant than maximum temperature, because the former is generally reached in the early morning (when many commuters are outdoors), whereas the latter is reached in mid-afternoon (when many are indoors). In all, objective weather characteristics, in particular wind indices, were linked with elevated nostalgia through corresponding weather perceptions.

Discussion

Study 2 was a naturalistic replication and extension of Study 1. Supporting H1, results corroborated the link between adverse weather—in particular, perceived wind intensity—and nostalgia. Consistent with H2, the positive association between perceived weather adversity and nostalgia was mediated by distress. These findings are consistent with the idea that nostalgia is a homeostatic response that serves to downregulate weather-induced distress. This generates the prediction that preventing people from nostalgizing in response to adverse weather should exacerbate distress (H3). Study 3 tested directly this hypothesis.

Table 1. Indirect Effects of Adverse Weather Conditions on Nostalgia via Weather Perceptions in Study 2.

Independent variable	Mediator	*ab*	95% CI
Wind			
Average wind speed	Perceived wind intensity	0.038	[0.014, 0.063]
Maximum wind speed	Perceived wind intensity	0.016	[0.006, 0.026]
Rain			
Total rain	Perceived rain intensity	−0.001	[−0.020, 0.018]
Maximum rain per minute	Perceived rain intensity	0.549	[−0.170, 1.290]
Temperature			
Average temperature	Perceived temperature	−0.012	[−0.027, 0.001]
Maximum temperature	Perceived temperature	−0.011	[−0.026, 0.001]
Minimum temperature	Perceived temperature	−0.007	[−0.015, −0.000]

Note. ab = indirect effect; CI = confidence interval.

Study 3: An Experimental Test of Nostalgia's Palliative Function

In Study 3, we examined the palliative role of nostalgia under weather adversity. In particular, using a moderation-of-process approach (Spencer, Zanna, & Fong, 2005), we tested if preventing people from nostalgizing in response to adverse weather aggravates weather-induced distress (H3). We manipulated orthogonally two variables. One was weather: Half of participant listened to wind recordings and half to control. The other variable was task: half of participants underwent a cognitive load manipulation and half nostalgized. The cognitive load manipulation involved counting backward (Fitousi & Wegner, 2011) while listening to weather recordings, thus hampering the opportunity to bring to mind and reflect upon nostalgic events. We predicted that adverse weather (vs. control) would produce more distress in the backward counting condition than in the nostalgia condition.

Study 3 served an ancillary goal. We tested the possibility that awe (rather than nostalgia) is responsible for the putative alleviation of weather-induced distress. According to folk wisdom, windy or stormy weather is awe inspiring (Keltner & Haidt, 2003). In turn, awe may reduce distress.

Method

Participants and design. We recruited 323 MTurk participants (186 women, 137 men, 1 gender-fluid; M_{age} = 35.59, SD_{age} = 11.97).[5] We randomly assigned them to one of four conditions of a 2 (weather: control, wind) × 2 (task: nostalgizing, backward counting) between-subjects design.

Procedure and materials. Participants listened either to 2-min control (n = 166) or wind (n = 157) recordings, while performing one of the two tasks. Those assigned to the nostalgizing task (n = 156) recalled and described a nostalgic event (Sedikides, Wildschut, Routledge, Arndt, Hepper, & Zhou, 2015). Specifically, they read,

> According to the Oxford Dictionary, "nostalgia" is defined as a "sentimental longing for the past." While you listen to this recording, please think of a nostalgic event in your life. Specifically, try to think of a past event that makes you feel most nostalgic. Bring this nostalgic experience to mind. Immerse yourself in the nostalgic experience. Using the space provided below, for the next few minutes, we would like you to write about the nostalgic event. Immerse yourself into this nostalgic experience. Describe the experience and how it makes you feel.

Those assigned to the backward counting task (n = 167) counted back from 350 in steps of 7 (Wegner, 1994). They received 50 response boxes to enter these numbers. They read,

> Do the following while listening to this recording: In the boxes below, count down from 350 to 0 in steps of 7. For example, for the first three boxes enter 350, 343, and 336, and then continue doing so until you complete all the boxes or until the recording ends.

Next, participants reported their distress on the items "Listening to this recording makes me feel distressed" and "Listening to this recording makes me feel calm" (1 = *strongly disagree*, 6 = *strongly agree*); $r(318) = -.43$, $p < .001$; $M = 2.56$, $SD = 1.26$. We introduced the second, reverse-scored, item to reduce potential response bias. Finally, participants completed the same measures of nostalgia as in Studies 1 and 2 ($\alpha = .98$; $M = 3.33$, $SD = 1.66$). They also indicated their level of awe on the item "This recording makes me feel in awe" (1 = *strongly disagree*, 6 = *strongly agree; M* = 3.26, *SD* = 1.58).

Results and Discussion

Manipulation check. A 2 (weather) × 2 (task) ANOVA on nostalgia yielded a significant task main effect, $F(1, 318) = 169.66$, $p < .001$, $d = 1.46$. Participants felt more nostalgic when they nostalgized ($M = 4.34$, $SD = 1.31$) than when they counted backward ($M = 2.38$, $SD = 1.36$). The weather main effect was not significant, $F(1, 318) = 0.02$, $p = .879$, $d = 0.02$, and neither was the Weather × Task interaction, $F(1, 318) = 0.00$, $p = .956$, $d = 0.01$. The manipulation was effective.[6]

Distress. A 2 (weather) × 2 (task) ANOVA on distress yielded a significant main effect of weather, $F(1, 319) = 15.47$, $p < .001$, $d = 0.44$. Participants became more distressed by the wind recording ($M = 2.85$, $SD = 1.44$) than the control recording ($M = 2.28$, $SD = 0.99$). The task main effect was also significant, $F(1, 319) = 6.69$, $p = .010$, $d = 0.29$. Participants reported lower distress when nostalgizing ($M = 2.36$, $SD = 1.19$) than counting backward ($M = 2.75$, $SD = 1.30$). Importantly, the Weather × Task interaction was significant, $F(1, 319) = 4.68$, $p = .031$, $d = 0.24$. Tests of simple effects revealed that, in the cognitive load condition, participants who listened to the wind recording ($M = 3.12$, $SD = 1.34$) reported more distress than those who listened to the neutral control recording ($M = 2.23$, $SD = 1.04$), $t(318) = 4.57$, $p < .001$, $d = 0.51$. As predicted, the difference between the wind ($M = 2.66$, $SD = 1.43$) and neutral control ($M = 2.04$, $SD = 1.18$) recordings was reduced in the nostalgia condition but remained significant, $t(318) = 3.03$, $p = .003$, $d = 0.34$. Viewed from a different angle, in the control weather condition, participants who counted backward did not report significantly more distress than those who nostalgized, $t(318) = 0.96$, $p = .338$, $d = 0.11$. In the wind condition, however, participants who counted backward reported higher levels of distress than those who nostalgized, $t(318) = 2.31$, $p = .021$, $d = 0.26$. These findings are consistent with H3: Preventing people from nostalgizing (via cognitive load induction) intensifies the impact of adverse weather on distress. Alternatively, nostalgia softens the distressing impact of adverse weather.

Awe. A 2 (weather) × 2 (task) ANOVA on awe produced a significant main effect of task, $F(1, 317) = 24.95$, $p < .001$, $d = 0.56$. Participants felt more in awe when they nostalgized ($M = 3.68$, $SD = 1.56$) than counted backward ($M = 2.85$, $SD = 1.50$). A marginal main effect of weather indicated that participants tended to report more awe in the wind ($M = 3.39$, $SD = 1.68$) than the control ($M = 3.13$, $SD = 1.48$) condition, $F(1, 317) = 3.62$, $p = .058$, $d = 0.21$. The Weather × Task interaction was not significant, $F(1, 317) = 0.48$, $p = .487$, $d = 0.08$.

Awe was only marginally higher in the wind than control condition, and a mediation analysis (Hayes, 2013a; Model 5; 5,000 bootstraps) showed that the indirect effect of adverse weather on distress via awe was not significant, $ab = -0.028$, $SE = 0.020$, 95% CI = [–0.072, 0.007]. These results do not support the idea that awe counteracts the distress caused by adverse weather. We also allowed for the possibility that weather-induced awe would have a stronger inverse relation with distress in the nostalgia than cognitive load condition. This pattern would arise if cognitive load (but not nostalgia) interferes with successful accommodation of the awe-inspiring stimulus. According to Keltner and Haidt (2003), "one's attempts at accommodation may partially explain why awe can be both terrifying (when one fails to understand) and enlightening (when one succeeds)" (p. 304). However, this moderated mediation model (Hayes, 2013a; Model 15) was not supported either; index of moderated mediation = 0.026, $SE = 0.024$, 95% CI = [–0.004, 0.096]. In all, the lower level of weather-induced distress in the nostalgia (compared with cognitive load) condition was not due to the awe-inspiring effect of adverse weather.

Study 4: The Psychological Benefits of Weather-Evoked Nostalgia

Study 4 tested H4, namely, that weather-evoked nostalgia contributes to homeostasis by conferring psychological benefits (i.e., social connectedness, meaning in life, self-continuity, self-esteem, positive affect [and not negative affect], optimism). As in Study 1, we used recordings of wind, thunder, rain, and neutral control sounds. However, rather than having participants listen to each recording, we randomly assigned them to one of the four weather conditions. We did so to reduce potential demand characteristics, participant fatigue, and carryover effects that can plague within-subjects designs.

Method

Participants and design. We recruited 202 participants via MTurk (100 women, 100 men, two undeclared; $M_{age} = 33.22$, $SD_{age} = 12.10$).[7] We randomly assigned them to one of four weather conditions: wind ($n = 56$), thunder ($n = 45$), rain ($n = 49$), control ($n = 52$).

Procedure and materials. Participants listened to a 2-min recording, as in Study 1, and completed weather manipulation checks by reporting the perceived intensity of wind ("How strong was the wind in the recording that you heard?" $M = 4.23$, $SD = 1.99$), thunder ("How heavy was the thunder in the recording that you heard?" $M = 2.65$, $SD = 2.18$), and rain ("How heavy was the rainfall in the recording that you heard?" $M = 3.70$, $SD = 2.19$) on a 7-point scale (1 = *none at all*, 7 = *extremely so*). Next, participants responded to the same measure of nostalgia ($\alpha = .97$; $M = 2.64$, $SD = 1.45$) as in Study 1. They then completed measures of social connectedness (e.g., "This recording makes me feel connected to loved ones"; $M = 2.57$, $SD = 1.39$), meaning (e.g., "This recording makes me feel life is meaningful"; $M = 3.00$, $SD = 1.48$), self-continuity (e.g., "This recording makes me feel connected with my past"; $M = 2.97$, $SD = 1.37$), self-esteem (e.g., "This recording makes me feel good about myself"; $M = 2.84$, $SD = 1.39$), positive affect (e.g., "This recording makes me feel happy"; $M = 3.13$, $SD = 1.57$), and negative affect (e.g., "This recording makes me feel sad"; $M = 2.28$, $SD = 1.27$), as well as optimism (e.g., "This recording makes me feel optimistic about my future"; $M = 2.73$, $SD = 1.39$). With the exception of self-continuity (Sedikides, Wildschut, Routledge, & Arndt, 2015) and optimism (Cheung et al., 2013), we adapted these measures from Hepper et al. (2012). Items were rated on a 6-point scale (1 = *strongly disagree*, 6 = *strongly agree*) and Cronbach's αs exceeded .90 (see Supplemental Materials for full list of items).

Table 2. Adverse Weather Conditions, Perceptions (Manipulation Checks), and Nostalgia in Study 4.

	Control		Rain		Wind		Thunder					
Dependent variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*df*	*p*	η_p^2
Perceived rain	2.41_a	1.81	5.47_b	1.91	2.89_a	1.83	4.24_c	1.82	28.29	3, 197	.000	.30
Perceived wind	3.60_{ab}	1.75	3.20_a	2.09	5.68_c	1.01	4.27_b	2.03	20.78	3, 198	.000	.24
Perceived thunder	1.58_a	1.11	1.82_a	1.40	1.83_a	1.31	5.86_b	1.61	105.89	3, 195	.000	.62
Nostalgia	2.33_a	1.38	2.37_{ab}	1.18	2.88_{bc}	1.64	2.97_c	1.44	2.73	3, 198	.045	.04

Note. Means with different subscripts differ at $p < .05$. Degrees of freedom (*df*) vary due to missing values.

Results and Discussion

Manipulation checks. ANOVAs yielded significant differences in perceived wind, thunder, and rain across the four conditions (Table 2). Wind was perceived to be stronger in the wind condition than in all others. Likewise, perceived thunder was higher in the thunder condition than in all others, and perceived rain was higher in the rain condition than in all others. The manipulations were effective.

Nostalgia. An ANOVA with weather condition as independent variable and the nostalgia composite as dependent variable yielded a significant main effect (Table 2). Thunder and wind evoked more nostalgia than control, whereas rain did not evoke more nostalgia than control. Thunder evoked more nostalgia than rain. The thunder and wind conditions did not differ significantly nor did the rain and wind conditions. These results are broadly consistent with those of Studies 1 and 2, supporting H1.

Psychological benefits of nostalgia. We next tested if adverse weather offers psychological benefits through nostalgia. First, we conducted a series of ANCOVAs with weather condition and nostalgia (i.e., the covariate) as predictors of nostalgia's putative benefits. These analyses examined if nostalgia predicts psychological benefits, above and beyond weather condition. The ANCOVAs evidenced significant positive partial associations between nostalgia and social connectedness, $B = 0.60$, $SE = 0.06$, $t(197) = 11.00$, $p < .001$, $\eta_p^2 = .38$; meaning, $B = 0.56$, $SE = 0.06$, $t(197) = 9.02$, $p < .001$, $\eta_p^2 = .29$; self-continuity, $B = 0.66$, $SE = 0.05$, $t(197) = 13.40$, $p < .001$, $\eta_p^2 = .48$; self-esteem, $B = 0.58$, $SE = 0.06$, $t(197) = 10.38$, $p < .001$, $\eta_p^2 = .35$; positive affect, $B = 0.64$, $SE = 0.06$, $t(197) = 10.08$, $p < .001$, $\eta_p^2 = .34$; and optimism, $B = 0.49$, $SE = 0.06$, $t(197) = 11.00$, $p < .001$, $\eta_p^2 = .25$. The partial association between nostalgia and negative affect was not significant, $B = -0.06$, $SE = 0.06$, $t(197) = 1.00$, $p = .317$, $\eta_p^2 = .01$.

Next, we conducted a series of mediation analyses (Hayes, 2013a; Model 4; 5,000 bootstraps) to test the indirect effect of adverse weather conditions on psychological benefits through nostalgia. We focused these mediation analyses on the contrast between the control condition and the pooled wind and thunder conditions (contrast 1: control = −1, rain = 0, wind = ½, and thunder = ½). We did so because prior results indicated that wind and thunder, relative to control, both increased nostalgia, whereas rain did not.[8] With this focal contrast as independent variable and nostalgia as mediator, the analyses revealed a range of indirect effects (Table 3). We obtained significant indirect effects of adverse weather conditions (control vs. wind and thunder) via nostalgia on social connectedness, meaning, self-continuity, self-esteem, positive affect, and optimism. The indirect effect via nostalgia on negative affect was not significant. These results showcase the palliative role of nostalgia. Adverse weather conditions (in particular, wind and thunder) predict increased nostalgia. In turn, nostalgizing in response to adverse weather is associated with heightened levels of social connectedness, meaning, self-continuity, self-esteem, positive affect, and optimism. These findings support H4.

Table 3. Indirect Effects of Adverse Weather Conditions on Psychological Benefits via Nostalgia in Study 4.

Dependent variable	*ab*	*SE*	95% CI
Social connectedness	0.238	0.101	[0.040, 0.442]
Meaning	0.221	0.092	[0.041, 0.401]
Self-continuity	0.262	0.110	[0.045, 0.483]
Self-esteem	0.230	0.096	[0.046, 0.427]
Positive affect	0.254	0.106	[0.051, 0.474]
Negative affect	−0.025	0.030	[−0.107, 0.017]
Optimism	0.194	0.081	[0.037, 0.360]

Note. ab = indirect effect; CI = confidence interval.

General Discussion

We examined how weather conditions affect, or are associated with, nostalgia. We proposed and tested four hypotheses: adverse weather evokes nostalgia (H1); adverse weather is associated with increased distress, which in turn predicts elevated nostalgia (H2); preventing nostalgia aggravates weather-induced distress (H3); and weather-evoked nostalgia confers psychological benefits (social connectedness, meaning, self-continuity, self-esteem, positive affect, optimism; H4). We tested these hypotheses in four studies.

Study 1 involved a within-subjects design. We presented participants with recordings of adverse weather (wind, thunder, rain, control) and assessed nostalgia. Study 2 involved a diary methodology. Participants reported their perceptions of weather (wind, thunder, rain), level of distress, and level of nostalgia over a 10-day period. Study 3 featured a between-subjects design. We exposed participants to adverse weather (wind) versus control, and we induced nostalgia versus cognitive load (to prevent nostalgia). Study 4 also had a between-subjects design. We presented participants with one of four weather recordings and assessed ensuing nostalgia and its putative benefits.

Results were generally consistent with hypotheses. In Study 1, adverse weather evoked nostalgia. In Study 2, perceptions of naturally occurring adverse weather (in particular wind) were associated with increased distress, which predicted higher nostalgia. Perceived wind was linked with higher nostalgia independently of perceived fluctuations in temperature. Objective weather was linked with higher nostalgia, but only via corresponding weather perceptions. Stated otherwise, adverse weather conditions gave rise to matching weather perceptions, which were associated with elevated nostalgia. Furthermore, in Study 3, weather-induced distress was higher in the absence of nostalgia (i.e., under cognitive load) than in its presence; nostalgia softened the distress caused by adverse weather. Finally, in Study 4, adverse weather evoked nostalgia, which in turn conferred psychological benefits, namely, social connectedness, meaning, self-continuity, self-esteem, positive affect, and optimism. Overall, our findings highlighted the soothing function of nostalgia in response to adverse weather.

We used different approaches to test the relationship between weather-evoked distress and nostalgia. In Study 2, we tested if the distress caused by adverse weather subsequently predicted nostalgia using a statistical mediation approach. In Study 3, we tested this proposed palliative function of nostalgia using a moderation-of-process approach (Spencer et al., 2005). We found that, when we prevented participants from becoming nostalgic (via cognitive load), adverse weather resulted in more distress than when we instructed participants to nostalgize. Although these two approaches are different, they converge in their conclusion: Nostalgia counteracts distress evoked by adverse weather. Weather-evoked distress predicts elevated nostalgia (Study 2), and nostalgia, in turn, sooths weather-evoked distress (Study 3).

In Study 4, the links from adverse weather to psychological benefits through nostalgia do not qualify as true mediations, but rather fall into the category of indirect effects (Hayes, 2013a; Mathieu & Taylor, 2006). The reason for this is that adverse weather was not directly associated with psychological outcomes (i.e., the total effects of adverse weather were not significant, all ps > .10). This results pattern may indicate the presence of additional intervening variables, which complicates the direct relation between adverse weather and psychological outcomes. This issue can be settled in future research.

We obtained somewhat inconsistent findings regarding the relation between rain and nostalgia. In Study 1, rain (compared with control) evoked higher nostalgia. In Studies 2 and 4, however, we found no relation between rain and nostalgia. It is possible that rain has a smaller impact on, or association with, nostalgia than wind or thunder.

We explored the role of awe (Keltner & Haidt, 2003) as an alternative to nostalgia's palliative role. In a pilot study (see Supplemental Materials, Pilot Study 1), adverse weather did not induce awe. In Study 3, adverse weather (wind) produced only a marginal increase in awe. Furthermore, neither simple nor moderated mediation analyses found evidence that the reduction in weather-induced distress in the nostalgia (compared with cognitive load) condition was due to the awe-inspiring effect of adverse weather. Interestingly, however, nostalgia elevated awe, suggesting that the latter is one of the psychological benefits of nostalgia. Relatedly, nostalgia increases inspiration (Stephan et al., 2015), which shares similarities with awe (Shiota et al., 2007).

Our findings indicate that people recruit nostalgic memories to cope with adverse weather. But could there be a more direct, memory-based link between adverse weather and nostalgia? For example, adverse weather could prompt people to seek shelter together, and this shared hardship could form the basis for later nostalgia. Although our research supports the palliative function of nostalgia in the face of weather adversity, we did not test if adverse weather reminds people directly of nostalgic events. These two processes could potentially complement each other: Adverse weather might make nostalgic events (which occurred under similarly inclement circumstances in the past) more accessible in memory, and these events would then be readily available to assuage distress caused by current weather.

Our investigation pioneers a novel methodological and theoretical approach to the psychology of weather. With regard to methodology, our systematic approach to weather simulation through recordings can be readily implemented in online or laboratory research. Turning to theory, the pertinent literature has typically focused on attitudes toward climate as a whole (Corner, Whitmarsh, & Xenias, 2012) or on processing styles associated with the weather (often mediated by mood; Forgas, Goldenberg, & Unkelbach, 2009; Keller et al., 2005). Here, we examined the relevance of a regulatory resource, nostalgia. Rather than treating climate as an attitudinal object or prime, we assessed how people cope with actual weather conditions. Besides offering insights into nostalgia's palliative role in adverse weather, our findings contribute to understanding of weather-induced self-regulation on a broader level. We hope that our findings spark further interest in this area.

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Notes

1. This sample size allowed us to detect effects of $\eta^2 = .10$, with a power of $1 - \beta \approx 1.00$, assuming $\alpha = .05$, a correlation across measurements of $r = .00$, and no violation of sphericity in our within-subjects analysis.
2. Treating the design as a repeated factor with 10 levels (days), this sample size allowed us to detect effects of $\eta^2 = .10$, with a power of $1 - \beta \approx 1.00$, assuming $\alpha = .05$, a correlation across measurements of $r = .00$, and no violation of sphericity.
3. A small number of participants completed the survey for 11 days ($N = 10$), 12 days ($N = 1$), and 14 days ($N = 1$).
4. Given that *a* and *b* paths were treated as fixed effects, there is no Level 2 covariance between these parameters, and the simple *ab* product is sufficient to quantify the indirect effect (Hayes, 2013b).
5. This sample size allowed us to detect effects of $\eta^2 = .10$ in a between-subjects design with a power of $1 - \beta \approx 1.00$, assuming $\alpha = .05$.
6. Note that the lack of a main effect of weather on nostalgia was as expected. Participants in the nostalgia condition were instructed to recall a nostalgic event and participants in the counting-backward condition were prevented from recalling nostalgic event, hence, there was very little room for the weather manipulation to influence nostalgia levels.
7. A sample size of $N = 200$ allowed us to detect effects of $\eta^2 = .10$ in a between-subjects design with a power of $1 - \beta = 0.99$, assuming $\alpha = .05$.
8. To represent completely and accurately the four weather conditions in the mediation analyses, we included two additional and orthogonal contrasts as control variables (contrast 2: control = ⅓, rain = −1, wind = ⅓, and thunder = ⅓; contrast 3: control = 0, rain = 0, wind = −1, and thunder = 1; Cohen, Cohen, West, & Aiken, 2013; Hayes, 2013a).

Supplemental Material

Supplementary material is available online with this article.

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