

Emotion

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Awe Arises in Reaction to Exceeded Rather Than Disconfirmed Expectancies

Małgorzata A. Gocłowska¹, Andrew J. Elliot², Michiel van Elk³, Dominika Bulska⁴,
Christopher A. Thorstenson⁵, and Matthijs Baas⁶

¹ Department of Psychology, University of Bath

² Department of Psychology, University of Rochester

³ Department of Psychology, University of Leiden

⁴ Faculty of Psychology, University of Warsaw

⁵ Munsell Color Science Laboratory, Rochester Institute of Technology

⁶ Institute of Psychology, University of Amsterdam

Awe is a fascinating emotion, associated with positive consequences such as greater prosociality, generosity, and epistemic openness. Unfortunately, in spite of the weighty consequences of awe, the exact way in which it arises, and what it entails, is still a puzzle. Particularly puzzling is the question of whether awe is the result of expectancy violation. While awe is thought to arise in reaction to expectancy-violating objects or events, classical expectancy violations (e.g., a red queen of spades playing card) do not tend to cause awe. To shed light on this problem, we distinguished two types of expectancy violations—those that disconfirm and those that exceed one's expectancies—and we investigated whether awe is more likely to arise in reaction to one versus the other. We also looked at what appraisals constitute and are most important to the awe experience and how they structurally interact. To do this, we utilized network analysis and mapped out the network structure of appraisals linked to awe and to expectancy violations. Across two experimental studies ($N = 823$), we demonstrated that awe arises in reaction to exceeded (rather than disconfirmed) expectancies and that appraisals linked to exceeded expectancies (vastness and uniqueness) are central to awe, while appraisals linked to disconfirmed expectancies (uncertainty and inconsistency) are peripheral to the awe experience. Taken together, our investigation sheds new light on psychologists' understanding of expectancy violations and reveals when and how awe arises and what it entails.

Keywords: epistemic, expectancy, awe, vastness, uncertainty

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Małgorzata A. Gocłowska  <https://orcid.org/0000-0002-1504-5557>

Dominika Bulska  <https://orcid.org/0000-0002-5981-7272>

Christopher A. Thorstenson  <https://orcid.org/0000-0003-2268-8910>

Matthijs Baas  <https://orcid.org/0000-0003-4001-9657>

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Correspondence concerning this article should be addressed to Małgorzata A. Gocłowska, Department of Psychology, University of Bath, 10 West, Bath BA2 7AY, United Kingdom. Email: gocłowska.m@gmail.com

Beauties of nature, great works of art, and intellectual epiphanies evoke an intense emotional response, best summarized as a sense of awe (Shiota et al., 2007). Awe is undoubtedly a fascinating and valuable phenomenon: Feelings of awe have been associated with greater generosity (Piff et al., 2015), humility (Stellar et al., 2018), and creative thinking (Chirico et al., 2018). Awe, alongside surprise, interest, and confusion, is an epistemic emotion (McPhetres, 2019; van Elk et al., 2019) and could potentially arise in reaction to complex expectancy-violating situations, regulating people's behavior toward seeking such situations (Vogl et al., 2020).

Epistemic emotions are responsible for people's willingness to explore and update existing information and can affect a range of important societal outcomes, from education and scientific discovery (McPhetres, 2019) to processes of stereotyping and prejudice (Prati et al., 2015). For instance, feeling confused by an expectancy-violating poem might lead people to withdraw and become disinterested in its content (Silvia, 2010), while feeling interested (Fayn et al., 2019) in a counterstereotypic person may lead people to approach that person in order to better understand their situation (Gocłowska et al., 2017). While confusion, surprise, and interest

are relatively well understood, how awe arises and what it entails is still a puzzle. Particularly puzzling is the question of whether awe arises as the result of expectancy violation. Understanding how awe links to expectancy violation could help researchers predict and evoke awe, as well as distinguish it from other, related phenomena.

Awe and Expectancy Violations

According to a common definition, awe arises in reaction to scenes that are vast and that “overwhelm mental structures” (Keltner & Haidt, 2003). Thus, by definition, awe-inducing scenes are thought of as expectancy violating. This is reflected in experimental work where movies used to elicit awe in the laboratory offer sweeping vistas from a bird’s-eye perspective, accelerated cloud movements, or colorful droplets of water played in slow motion (Piff et al., 2015; Rudd et al., 2012). Such scenes, where real objects are presented in an unexpected way, have been shown to increase awe and to motivate a change and adjustment of existing beliefs, categories, and schemas (the need for accommodation; Keltner & Haidt, 2003; Piff et al., 2015). However, while this research implies that awe is somehow linked to expectancy violations, the exact way in which this happens is not clear. For instance, one study asked participants to recollect a scene that made them feel awe and to describe what they felt when experiencing this emotion (Campos et al., 2013). Open-ended responses indicated that when feeling awe, participants’ expectations were challenged (e.g., “seeing something not thought possible”; Campos et al., 2013), but the precise nature of this challenge (e.g., What class of expectancies are violated exactly?) and how it corresponds to what is known about forming and testing expectancies is hard to establish based on this study.

Understanding awe and the best ways to evoke this emotion requires a better integration with research on the formation and violation of expectancies. Expectancy formation is a core psychological process: Our minds generate constant predictions (expectancies) about the world, and attending to objects and situations that violate these predictions is a core function of the cognitive system (Clark, 2013). Expectancies are based on predictions derived from the cognitive schema, prototypes, or exemplars stored in long-term memory (e.g., “cheese is salty”), and violations of such expectancies are of central interest in social psychology, social cognition research, as well as communication research (Abelson et al., 1968; Burgoon, 1993; Gawronski & Strack, 2012). Schema and stereotype violations are typically operationalized as objects or targets that disconfirm expectancies: a woman who works as a car mechanic (Hutter et al., 2009), a piece of cheese that tastes of marzipan, or a deck of cards with black hearts and red spades (Proulx & Major, 2013).

Contrary to what awe research seems to imply, these targets that disconfirm expectancies do not tend to evoke awe. In fact, understood solely as a disconfirmation of expectancies, expectancy violation is quite dissimilar from the experience of awe. One of the central assumptions of expectancy violation research is that disconfirming expectancy violations evoke an unpleasant sense of inconsistency, negative affect, and uncertainty and may, at least at first, lead to avoidance motivation (Noordewier & van Dijk, 2018; Proulx & Major, 2013). This research demonstrates that people dislike and avoid inconsistencies and situations that disconfirm their expectations and are averse to having to change their mind or undergo “cognitive accommodation” (i.e., adjust their cognitive

schemas in light of new information; Piaget, 1975). In contrast, typical awe experiences are thought to be pleasant and to motivate the accommodation of new knowledge.¹ Furthermore, awe experiences seem to be associated with a motivation to approach, or at least not to avoid the source of awe, as individuals typically report that they did not want the awe experience to stop (Campos et al., 2013).

Thus, upon closer inspection, the link between most awe experiences and expectancy violations (understood as disconfirmed expectancies) is not only unclear but also unlikely. However, if awe does not arise in reaction to expectancy disconfirmation, why do participants experiencing awe report “seeing something not thought possible” (Campos et al., 2013)? We believe that this is the case because expectancies can be challenged in other ways too. Namely, expectancies may also be exceeded, which forms a qualitatively different type of expectancy violation.

An Overlooked Type of Expectancy Violation

We propose that awe arises in reaction to a type of expectancy violation that has hitherto been overlooked by psychologists and that is poorly understood. Namely, awe arises in reaction to exceeded (rather than disconfirmed) expectancies. In our view, awe-inducing stimuli are characterized by extreme and unexpected values in terms of specific and highly appreciated expected properties. For instance, a person gasping at the sight of a beautiful lake does not do so because the lake was unexpectedly yellow (therefore disconfirming expectancies) but because the lake was extremely blue—more blue than one might have ever imagined (therefore exceeding expectancies). In our view, awe-inducing scenes are perceived as unexpected because they are positive outliers and because they extend (rather than disconfirm) what is already known. These types of scenes violate expectancies about the extent to which they should possess some central and mostly positive characteristic such as beauty, force, talent, or courage.

In line with this hypothesis, natural scenes used in awe studies (e.g., *Planet Earth* videos) tend to be extremely beautiful (e.g., sweeping vistas of mountains) or can be seen as extremely powerful (e.g., volcano eruptions and avalanches), while YouTube videos portraying “awesome daredevils” (e.g., skydivers, downhill bikers) represent people of exceptional courage and ability that “exceeds our wildest dreams.” Furthermore, a qualitative analysis by Bonner and Friedman (2011) revealed that awe-inducing scenes are characterized by an extreme vividness of color, sound, and luminosity. This qualitative finding suggests that awe experiences emerge in reaction to scenes that are so intense that they are perceived as unique and out of this world. These descriptions of awe experiences suggest that, rather than violating schematic expectancies about the characteristics that they should possess, awe-inducing scenes violate expectancies about the intensity or extremity of their core features. More recently, Taylor and Uchida (2019) demonstrated that while the experience of horror was associated with a sense of mental overwhelm, experiences of awe were characterized by a greater sense of vastness. Thus, in line with those recent observations, we argue for the existence of two types of expectancy violations—those that disconfirm and those that exceed

¹ A recent study demonstrated that ~80% of awe experiences are positive and ~20% of such experiences can be classified as threat based and associated with negative affect (Gordon et al., 2016).

expectancies—and we hypothesized that feelings of awe should be mostly explained by the latter (but not the former) type of expectancy violation.

Mapping the Awe Experience

Like other epistemic emotions, awe is conceptualized as a complex interplay of appraisals (feelings and judgments) of the awe experience. Understanding which of these appraisals are key to the experience of awe could help better define awe and distinguish it from other, related emotions. While there is some indication as to what appraisals may constitute awe, how they structurally interact, and which of them are central to the construct of awe, remains unknown. In previous research, awe experiences were associated with perceptions of vastness (Shiota et al., 2007; Stellar et al., 2018) and positive valence (in the case of 80% of awe experiences; Gordon et al., 2017). In addition, since awe-inducing scenes are thought to violate expectancies, there is also the distinct possibility that awe-inducing scenes are appraised as high in terms of collative properties such as surprise, uniqueness, or unusualness. Collative properties are highly arousing stimulus properties (Berlyne, 1970), and expectancy-violating targets are often appraised in terms of these properties. For instance when persons, scenes, or objects are not the way people expected, they may be considered novel (Estes & Ward, 2002), complex (Berlyne, 1970), unusual (Rubin et al., 2011), inconsistent with expectations (Proulx & Major, 2013), or surprising (Noordewier & van Dijk, 2018). However, because our central hypothesis is that awe should be mostly linked to exceeded rather than disconfirmed expectancies, it may very well be that only some or even none of the above appraisals, which are already known to be linked to disconfirmed expectancies, will play a role in the experience of awe.

Whether certain appraisals are central or peripheral to a phenomenon can be established by employing network analysis. This new and increasingly popular statistical method could allow us to understand what appraisals constitute and are most central and essential to the awe experience and how they structurally interact (i.e., how they are grouped together). The results would allow us to better understand what awe entails and how it is different from other, related states. Furthermore, the analysis might help us tease apart whether appraisals linked to exceeded versus disconfirmed expectancy violations are important for the awe experience. In this way, network analysis should shed further light on the link between awe and expectancy violations.

Research Overview

In the present article, we propose a distinction between two types expectancy violations: those that disconfirm versus those that exceed people's expectancies. Our first goal was to investigate whether awe is more likely to arise in reaction to the latter rather than the former type of expectancy violation. Second, using network analysis, we inquired about the content, structure, and centrality of a range of emotion appraisals (e.g., vastness, uniqueness, inconsistency, and uncertainty) linked to awe and to expectancy violations. We asked what appraisals, in general, are central to the experience of awe and whether appraisals linked to exceeded versus disconfirmed expectancies play a different role in the awe experience.

Awe and Expectancy Violations

Our hypothesis that awe arises in reaction to scenes that exceed (rather than disconfirm) expectancies was tested in two experimental studies. In Study 1, we manipulated awe via a recall paradigm asking participants to think of a past nature scene (in general) versus a past nature scene that made them feel awe and wonder. We then measured the extent to which the recalled scene disconfirmed or exceeded prior expectancies and the extent to which the scene was perceived as awe-inspiring. Within this type of design, mediation analyses allowed us to test whether exceeding (vs. disconfirming) expectancies accounts for the arising feelings of awe. Because Study 1 relied on people's subjective construal of the awe experience, in Study 2, we decided to use a manipulation that did not explicitly mention the emotion label. Namely, we asked participants to view three videos that have been used in prior research either to evoke awe, to evoke amusement, or as a control condition. Next, we asked participants to rate these videos on a range of properties (similar to Study 1) and used mediation analysis to again test our hypothesis that the exceeding of expectations mediates the effects of our manipulation on feelings of awe.

Mapping the Awe Experience

To understand what appraisals constitute awe, how they structurally interact, and which of them are central to the construct of awe, we asked participants to rate the recalled experience (in Study 1) or viewed video (in Study 2) in terms of 41 adjectives. We then employed network analysis to estimate the relationships between the various appraisals and to learn which of those appraisals are central (vs. peripheral) to the experience of awe. Network analysis (Epskamp et al., 2012) was used in an exploratory fashion and was intended to further illustrate our argument rather than to draw strong inferences.

Throughout the study, we focused mainly on the experience of awe in nature as this type of context has been well researched and is among those most commonly associated with awe (Gordon et al., 2017; Shiota et al., 2007). In all studies, determination of sample size, all manipulations, data exclusions, and variables are reported. All data were collected prior to any analyses. Data sets and code have been carefully stored and are available upon request with the first author. Analyses (unless otherwise stated) have been conducted using standard packages of SPSS Statistics v. 25.

Study 1

Method

Participants

Two hundred ninety-eight U.S. participants ($M_{\text{age}} = 48$, $SD_{\text{age}} = 15$, 80% female, 87% White) were recruited online via Research Match (<https://www.researchmatch.org/>). The study was approved by the Research Subjects Review Board at the University of Rochester (RSRB 00061388). Participation was voluntary, and no remuneration or credit was offered to research participants. We aimed for an a priori sample size of at least 260 participants so that we could detect small to medium ($d = .35$) effects of the between-subjects manipulation on the outcome variables

Procedure and Manipulations

Study 1 employed a two-condition between-subjects design. In the control condition ($N = 152$), participants were asked to recall a nature scene, whereas in the experimental condition ($N = 146$), they were asked to recall a nature scene that made them “feel awe and wonder.” Only fully completed questionnaires were analyzed and reported. Participants were randomly assigned to condition (true randomization). The manipulation was set up to allow participants to immerse themselves in the memory of the recalled scene as much as possible. In both conditions, using an open-ended response format, participants were asked to describe what they saw, when it happened, what they thought the scene was like, what emotions the scene evoked, and the exact physical and visual properties of the scene (van Elk et al., 2016). To better understand participants’ awe experiences, we also asked “Was that particular day/moment the first time in your life that you saw this particular scene?” using a yes/no response format. Following this awe-recall manipulation, we asked participants to rate the extent to which various physical properties (e.g., light, sound, speed) of the scene violated (exceeded or disconfirmed) their expectancies. We also asked about participants’ appraisals of the scene in terms of awe and various other properties (e.g., vastness, inconsistency). Upon completion of the procedure, participants answered demographic questions, were thanked, and were given an opportunity to comment on the procedure and to contact experimenters with any questions.

Measures

Expectancy Violation. Participants were asked to indicate the extent to which the physical properties (such as color, vividness, sound) of the recalled scene exceeded and disconfirmed their expectancies (e.g., “The color of the scene exceeded/disconfirmed my expectations” answered on a scale from 1 = *was as expected* to 7 = *exceeded/disconfirmed my expectations*). Both scales (exceeding and disconfirming expectancies; $M_{\text{dis}} = 2.38$, $SD_{\text{dis}} = 1.58$ and $M_{\text{exc}} = 3.67$, $SD_{\text{exc}} = 1.76$) were constructed using 13 nouns describing physical properties of the experience, and both scales had good reliability (Cronbach’s $\alpha_{\text{dis}} = .96$ and $\alpha_{\text{exc}} = .94$, respectively). At the beginning of the task, participants were provided with definitions and examples of exceeding and disconfirming expectancies.

Awe. The experience of awe was measured using 14 items scored on a scale from 1 = *not at all* to 7 = *very much*. Six adjectives (amazing, awe-inspiring, beautiful, moving, profound, gave me chills; see A1–A6 in Figure 1) were taken from the “profound experience” measure by Silvia et al. (2015) with the remaining items (incredible, captivating, breathtaking, out of this world, unbelievable, overpowering, powerful, and forceful; A7–A14) being generated based on a review of the literature and with the use of a thesaurus. The resulting composite measure of awe (Cronbach’s $\alpha = .92$, $M = 4.93$, $SD = 1.29$) was used to test our key hypothesis.

Scene Appraisals. To uncover which appraisals are central to people’s experience of awe, we listed an additional 27 adjectives that could potentially be used to describe awe-inducing scenes or expectancy-violating phenomena. This broad list was compiled following a review of the literature on awe and expectancy violations and with the use of a thesaurus. To capture fine-grained differences between various appraisals, we employed network analyses (Epskamp et al., 2012). Unlike traditional factor analytic approaches, network analysis makes no assumptions about latent structures and is typically conducted on the level of observed

variables (i.e., individual appraisal items). This was useful for our purpose because we wanted to observe which characteristics drawn from a broad (but not necessarily unitary) pool of features are most important to the experience of awe. To facilitate interpretation of the network structure, we grouped the appraisal items in the thematic groups listed below and color coded them in respective network visualizations (see Figure 1); this grouping is intended as a visual aid and has no bearing on the statistical features of the network analysis.

The same respective appraisal items were used for analyses in Studies 1 and 2. The various appraisal items measured were focused on perceptions of vastness (vast, enormous, immense; VS1–VS3), uniqueness (unique, exceptional; UQ1–UQ2), valence (pleasant, positive, negative, unpleasant; VL1–VL4), familiarity (unfamiliar, novel, familiar; F1–F3), clarity (clear, harmonious; CL1–CL2), complexity (complicated, simple; CM1–CM2), unusualness (unusual, strange, typical; US1–US3), surprise (surprising, unanticipated, unforeseen, expected; SR1–SR4), inconsistency (inconsistent, clashing; IN1–IN2), and uncertainty (uncertain, ambiguous; UC1–UC2).

The grouping of individual adjectives bears no consequences for the network analysis; however, we did use summative scores of the above variables in order to compare and contrast the unique nomological networks of exceeded and disconfirmed expectancies, and the results of those analyses can be found in the online supplemental materials (Table S1). The picture that emerged was consistent with our proposition that the exceeding and disconfirmation of expectancies are, to an extent, qualitatively different from one another, with exceeded expectancies being perceived as more vast, unique, and positive and with disconfirmed expectancies being perceived as more inconsistent, uncertain, and negative. The commonalities of the two types of expectancy violations included a sense of unusualness, surprise, and unfamiliarity.²

Results

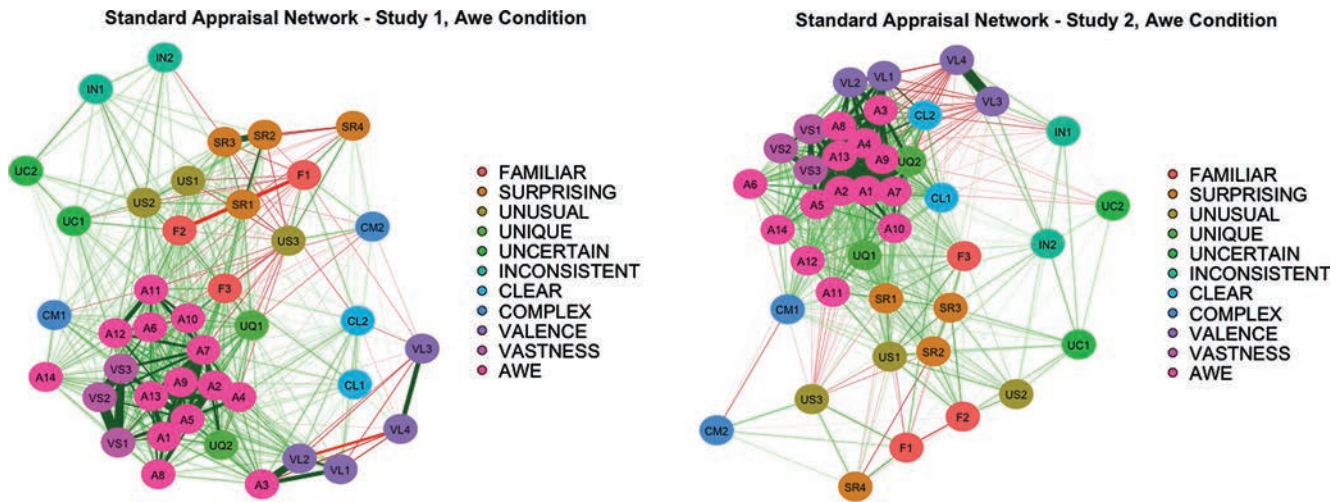
Awe Experience

Participants were asked to recall one nature scene or one awe-inducing nature scene. To test whether instructions were followed correctly, two authors coded described scenes from 10% of participants on the extent to which these scenes were awe-inducing (1 = *not at all* to 5 = *very much*). The coding was conducted in a separate excel spreadsheet that contained only the scene description and was blind to condition. Interrater reliability was good (intra-class correlation coefficient = .85), so the remaining scenes were coded by one rater only. A between-subjects analysis of variance (ANOVA) indicated that in the awe-inducing condition, participants mentioned awe more often ($M = 2.75$, $SD = 1.68$) than in the neutral ($M = 1.97$, $SD = 1.50$) condition, $F(1, 286) = 17.34$, $p < .001$, $\eta^2 = .06$. We also looked at answers to the question whether the scene described was one that participants had seen for the first time in their life. Here, participants in the awe condition (vs. control condition) more often reported on a scene that they saw for the first time in their life (51% in the awe condition vs. 31% in the control condition; chi-square = 7.88, $p = .019$, $\phi = .03$). Finally,

² Study 1 additionally contained items for scale development measuring prototypicality and the need for accommodation.

Figure 1

Visualization of the Networks of Awe-Related Appraisals Depicts Data From the Awe Condition in Study 1 (Left Panel) and Study 2 (Right Panel)



Note. Across both studies, adjectives indicating awe, vastness, and uniqueness emerged as the most central features of the awe experience, while adjectives indicating inconsistency and uncertainty were not central to the awe experience. Network of the awe experience based on pairwise correlation coefficients between individual appraisals in the awe induction condition ($N_{\text{Study1}} = 146$, $N_{\text{Study2}} = 194$). Positive correlations are plotted in green, and negative correlations are plotted in red. Edge thickness represents magnitude of correlation. Extremely small correlation coefficients ($r < .1$) have been omitted, while large correlation coefficients ($r > .5$) have been emphasized in bold. To ease interpretation, adjectives are color coded according to thematic relatedness. A1 = amazing; A2 = awe-inspiring; A3 = beautiful; A4 = moving; A5 = profound; A6 = gave me chills; A7 = incredible; A8 = captivating; A9 = breathtaking; A10 = out of this world; A11 = unbelievable; A12 = overpowering; A13 = powerful; A14 = forceful; VS1 = vast; VS2 = enormous; VS3 = immense; UQ1 = unique; UQ2 = exceptional; VL1 = pleasant; VL2 = positive; VL3 = negative; VL4 = unpleasant; F1 = familiar; F2 = unfamiliar; F3 = novel; CL1 = clear; CL2 = harmonious; CM1 = complicated; CM2 = simple; US1 = unusual; US2 = strange; US3 = typical; SR1 = surprising; SR2 = unanticipated; SR3 = unforeseen; SR4 = expected; IN1 = inconsistent; IN2 = clashing; UC1 = uncertain; UC2 = ambiguous. See the online article for the color version of this figure.

one-way ANOVAs revealed that the nature scene reported in the awe (vs. control) condition was seen as more awe-inspiring ($M_{\text{awe}} = 5.23$, $SD = 1.12$ vs. $M_{\text{control}} = 4.64$, $SD = 1.39$), $F(1, 286) = 15.80$, $p < .001$, $\eta^2 = .05$, and had higher scores of both exceeding ($M_{\text{awe}} = 3.99$, $SD = 1.67$ vs. $M_{\text{control}} = 3.35$, $SD = 1.78$), $F(1, 286) = 10.21$, $p = .002$, $\eta^2 = .03$, as well as disconfirming ($M_{\text{awe}} = 2.59$, $SD = 1.67$ vs. $M_{\text{control}} = 2.19$, $SD = 1.49$), $F(1, 286) = 4.49$, $p = .035$, $\eta^2 = .02$, expectancies (also see Table 1).

Expectancy Violations and Awe

Our main hypothesis was that awe should arise predominantly (or entirely) in reaction to scenes that exceed (rather than disconfirm) expectancies. Initial support for this was obtained in correlation analyses: The correlation of awe with exceeded expectancies was of high magnitude ($r = .55, p < .001$), while the correlation with disconfirmed expectancies was moderate ($r = .29, p < .001$). Furthermore, these two correlation coefficients were significantly different from one another (Dunn and Clark's $z = 5.53, p < .001$), suggesting that awe is more linked to exceeded expectancies than it is linked to disconfirmed expectancies (Diedenhofen & Musch, 2015).³

Given the common variance of the two types of expectancy violation ($r = .58, p < .001$), entering these variables as simultaneous predictors of awe should allow us to draw more accurate conclusions about whether exceeded (but not disconfirmed) expectancies mediate the effect of the awe manipulation on awe appraisals. We did this by computing a simple mediation model (PROCESS

macro for SPSS Statistics; Model 4 with 10,000 bootstrap intervals) with the manipulation of awe entered as a predictor, the two types of expectancy violations entered as simultaneous mediators, and awe appraisal entered as the dependent variable. In line with recommendations by Hayes (2013) and MacKinnon (2000), regression coefficients were used to attain a better understanding of the relations between variables, while bootstrap intervals constituted a formal test of the mediation hypothesis.

The PROCESS macro estimated mediation effects based on three regression models (see Figure 2). In Model 1, the first mediator (exceeding expectancies) was regressed on the manipulation, and the second mediator (disconfirming expectancies) was regressed on the manipulation. The results of these analyses were identical to the analyses of variance (see Table 1): The manipulation had a significant influence on both the exceeding and the disconfirming of expectancies. In Model 2, appraised awe was regressed on the two mediators and the predictor: Awe was significantly related to the manipulation, $B = .32$, $SE = .13$, $t(287) = 2.50$, $p = .013$, 95% CI [.07, .57], and to the exceeding of expectancies, $B = .42$, $SE = .04$, $t(287) = 9.40$, $p < .001$, [.33, .51], but

³ In both studies, comparisons of correlation coefficients (same group, overlapping correlations, $p < .05$, CI = .95, null value = 0, two-tailed test) have been conducted online using the web-based COCOR package (<http://comparingcorrelations.org>). The package produces 10 test results (for dependent groups with overlapping correlations), and all of those tests achieved significance.

Table 1*Mean Differences Across the Two Experimental Conditions (Study 1)*

Variable measured	Awe in nature		Nature		<i>F</i>	<i>p</i>	η^2
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Mentions of awe	2.75	1.68	1.97	1.50	17.34	<.001	.06
Awe	5.23	1.12	4.64	1.39	15.80	<.001	.05
Exceeding	3.99	1.67	3.35	1.78	10.21	.002	.03
Disconfirming	2.59	1.67	2.19	1.49	4.49	.035	.02

Note. $N_{awe} = 141$; $N_{neutral} = 147$; $df = (1, 286)$. Test results are based on a general linear model with listwise deletion.

not to the disconfirmation of expectancies, $B = -.04$, $SE = .05$, $t(287) = -.83$, $p = .405$, $[-.14, .06]$.

These results suggest that exceeding, but not disconfirming, expectancies may account for the effect of our manipulation on awe appraisals. To test this mediational pattern formally, we generated bootstrap confidence intervals ($N_{boot} = 10,000$) in PROCESS (Model 4; Hayes, 2013). The analyses indicated that the indirect effect via exceeding expectancies was statistically significant at the .05 level, $B_{boot} = .27$, $SE_{boot} = .09$, 95% CI $[-.10, .46]$, but that the indirect effect via disconfirming expectancies was not, $B_{boot} = -.02$, $SE_{boot} = .02$, $[-.07, .01]$.

Mapping the Awe Experience

To uncover what appraisals are central (vs. peripheral) in people's experience of awe, we entered the 27 adjectives describing awe-inducing scenes and the 14 adjectives used to strictly measure awe appraisals as input for our correlation network analysis.⁴ In network analysis, all observed variables are plotted as nodes and their associations as edges within a network. The strength of the associations and the position of the individual nodes provide information about the importance of each variable to the network. Important nodes are placed more centrally, while strong relationships between nodes are indicated with a thicker edge weight. Beyond visual inspection of the network (see Figure 1), the analysis provides centrality indices of respective nodes (see Figure 3) and allows for a comparison of the differences in the magnitude of centrality (see Figure 4). In our study, we decided to rely on the index of strength, which reflects the overall connectivity of a node with other nodes by summing up the (absolute values of) weights of the node's associations with other nodes. The higher the strength index, the greater the centrality (i.e., importance) of a node (i.e., observed variable) within the network.

Estimation Method. Correlation network analysis computes a network structure based on bivariate marginal correlations producing a saturated model with edges included in the model. This was computed on March 15, 2021, using the *cor* procedure in the *qgraph* package for R Version 3.6.3 (Epskamp et al., 2012). Graphical results of the stability and accuracy analysis (edge weight estimates and their confidence intervals; centrality stability) can be found in the online supplemental materials (Figures S1 and S2). These analyses should be routinely conducted as part of a network analysis but are not central to the current study.

Network Visualization. Fourteen awe-related adjectives and 27 adjectives measuring other features were entered into the network analysis. Furthermore, we chose to compute the network based on correlational data (pairwise comparisons) only from participants asked to recall the awe condition ($N = 146$) as the

experience described by those participants seems to be most suitable for our purpose (understanding which appraisals are central vs. peripheral to the experience of awe).

Figure 1 (left panel) represents the network structure of the features of the awe-inducing scene. The strength of relations between items can be inferred from the thickness of the edges and the distance between the individual nodes. Positive correlations are plotted in green, while negative correlations are plotted in red. For a colour version of the figure see article PDF. Edge thickness represents the magnitude of correlation. Very small correlation coefficients ($r < .10$) were not plotted, while large correlation coefficients ($r > .50$) have been emphasized by bolding the respective edges. For ease of interpretation, items of similar meaning have been plotted using the same color; however, this visual grouping has no bearing on the statistical analysis or its outcomes. Nodes related to awe (A1–A14) are at the very center of the network. Crucially to our main research question, nodes indicative of the expectancy-exceeding features of vastness (VS1–VS3) and uniqueness (UQ1 and UQ2) also play a central role within the network, while nodes denoting the expectancy-disconfirming appraisals of inconsistency (IN1 and IN2) and uncertainty (UC1 and UC2) are on the periphery of the network. Furthermore, two nodes relating to familiarity (F1 and F2), as well as all nodes denoting surprise (SR1–SR4), complexity (CM1 and CM2), clarity (CL1 and CL2), valence (VL1–VL4), and unusualness (US1–US3), are further away from the center of the network.

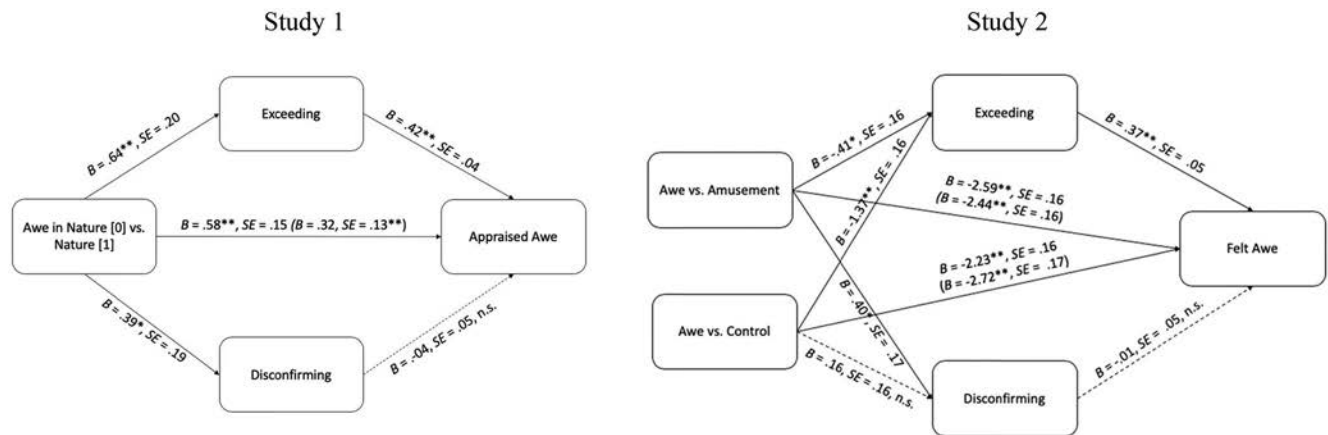
Centrality Index. We produced an index of node strength (the overall connectivity of one node to all other nodes), which is helpful in interpreting the centrality (i.e., importance) of each node within the network. The higher the strength index of a node, the more central that node is within the network of variables. Additional analyses plotting centrality over increasingly smaller bootstrapped subsamples indicated that the above order of the strength index is stable (see Figure S2). This was further supported by a correlation stability coefficient that was well over the recommended value of .50 (correlation stability coefficient $cor = .67$), indicating we can confidently interpret differences in strength.

Figure 3 (left panel) depicts strength indices of the various awe appraisals in Study 1. All but one (A14 = forceful) of the awe-related items have a positive strength score, and so do the nodes indicative of the expectancy-exceeding features of vastness

⁴ Because we focused on centrality, irrespective of whether it results from direct or of indirect relations, we analyzed a correlation (vs. partial correlation) network. When the shared variance of an item with multiple other items is controlled for in a partial correlation network, this makes the items extremely hard to interpret (Lynam et al., 2006; Verschuere et al., 2018), and using a correlation network helped us avoid such problems.

Figure 2

Mediation Analyses Indicated That the Exceeding (but Not Disconfirming) of Expectancies Was the Key Expectancy Violation Associated With Awe Appraisals



Note. In Study 1, the nature condition was coded as 0, and the awe in nature condition was coded as 1. In Study 2, the independent variable was coded as awe = 1, amusement = 2, neutral = 3. Coefficients represent unstandardized B coefficients. Numbers in parentheses are path coefficients after controlling for the mediator. SE = standard error; $n.s.$ = nonsignificant.

* $p < .05$. ** $p < .01$.

(VS1–VS3) and uniqueness (UQ1–UQ2). Nodes denoting the expectancy-disconfirming appraisals of inconsistency (IN1 and IN2) and uncertainty (UC1 and UC2) have low strength scores, and so do the nodes denoting clarity (CL1 and CL2), complexity (CM1 and CM2), surprise (SR1–SR4), and valence (VL1–VL4). Results for nodes related to familiarity (F1–F3) and unusualness (US1–US3) were mixed.

Centrality Differences. We also computed a bootstrapped centrality difference test using the bootnet package in R. This allowed us to test for significant differences in the magnitude of strength of individual nodes (parametric test, $\alpha = .05$, $N_{boot} = 10,000$). Figure 4 (top panel) contains a grid representing all node strength comparisons with black squares reflecting significant strength differences. For 430 out of 820 possible comparisons, there was a significant difference in node strength. Crucial to our main argument, the strength of all nodes indicating vastness (VS1–VS3) and uniqueness (UQ1–UQ2) was significantly different from the strength of nodes denoting the expectancy-disconfirming appraisals of inconsistency (IN1 and IN2) and uncertainty (UC1 and UC2). In other words, this strength difference test shows that appraisals denoting the exceeding of expectancies are significantly more central to awe than appraisals denoting the disconfirmation of expectancies.

Discussion

Study 1 demonstrated that, in line with our predictions, the perception of exceeded (but not disconfirmed) expectancies mediated the effect of awe recall on awe appraisals. Furthermore, network analyses demonstrated that while the sense of vastness and uniqueness, characteristic of experiences that exceed expectancies, are central to the experience of awe, appraisals that are typically associated with disconfirming expectancy violations—inconsistency and uncertainty—are peripheral to the experience of awe. Also, appraisals of valence

as well as other appraisals associated with expectancy violations (e.g., complexity and surprise) have turned out to be peripheral in the awe experience. Taken together, these results suggest that awe experiences are vast and unique and that they exceed expectancies but that they are also quite different from traditionally understood (i.e., disconfirmed) instances of expectancy violations.

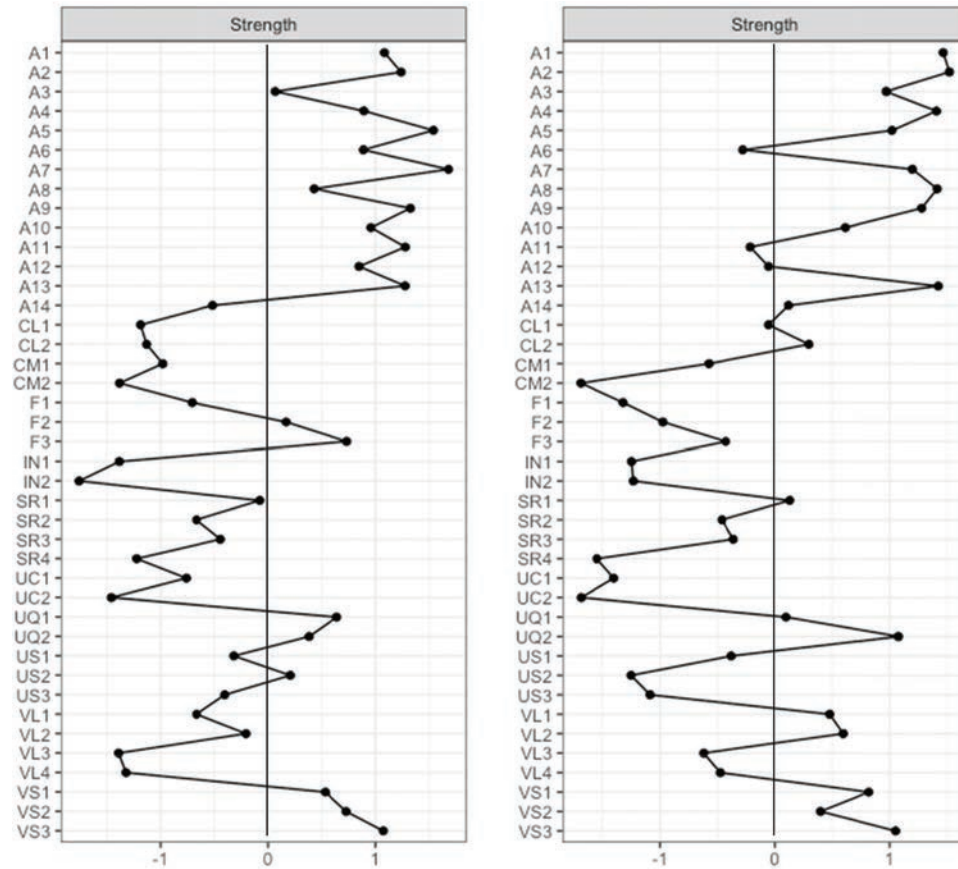
While supportive of our hypotheses, Study 1 was not without shortcomings. First, because we explicitly asked participants to recall a scene that made them feel “awe and wonder,” it is not clear to what extent participants’ responses reflected true feelings of awe rather than their construal of what awe should feel like or what they thought should be said about awe in this study (i.e., demand characteristics). Second, because in Study 1, awe was compared to a nature condition where no emotion was specified, it is not clear to what extent the effects observed were specific to an awe experience rather than any type of positive emotion experience. Third, while the retrospective procedure asked participants to rate whether the scene that they had described was awe-inducing, it would also be good to see whether the results will replicate when participants are more directly asked about whether they feel awe following the manipulation. Finally, as network analysis is an exploratory technique, Study 2 would allow us to ascertain whether the obtained pattern of results holds with a new sample and a slightly different experimental procedure.

Study 2

Study 2 employed one of the most popular and most researched awe-induction manipulations—a 5-min-long video from the TV show *Planet Earth*, with the Icelandic band Sigur Ros playing in the background (Piff et al., 2015; Valdesolo & Graham, 2014). Using this video to manipulate awe would allow us to eliminate earlier concerns about how participants construe and react to the notion of awe (because words like “awe” or “wonder” would not be mentioned

Figure 3

Visualization of the Network of Awe-Related Appraisals in Study 1 (Left Panel) and Study 2 (Right Panel)



Note. Across both studies, most adjectives indicating awe (A), all adjectives indicating vastness (VS), and all adjectives indicating uniqueness (UQ) emerged as central to the awe experience. Across both studies, all adjectives indicating inconsistency (IN), as well as most adjectives indicating surprise (SR), complexity (CM), and unusualness (US), emerged as low in centrality. Centrality index of the individual appraisals in the awe induction condition. A1 = amazing; A2 = awe-inspiring; A3 = beautiful; A4 = moving; A5 = profound; A6 = gave me chills; A7 = incredible; A8 = captivating; A9 = breathtaking; A10 = out of this world; A11 = unbelievable; A12 = overpowering; A13 = powerful; A14 = forceful; CL1 = clear; CL2 = harmonious; CM1 = complicated; CM2 = simple; F1 = familiar; F2 = unfamiliar; F3 = novel; IN1 = inconsistent; IN2 = clashing; SR1 = surprising; SR2 = unanticipated; SR3 = unforeseen; SR4 = expected; UC1 = uncertain; UC2 = ambiguous; UQ1 = unique; UQ2 = exceptional; US1 = unusual; US2 = strange; US3 = typical; VL1 = pleasant; VL2 = positive; VL3 = negative; VL4 = unpleasant; VS1 = vast; VS2 = enormous; VS3 = immense.

during the procedure, demand characteristics are less of an issue in such a design). In addition, to address the potential concern that our results are specific to positive emotions in general, we compared the awe-inducing video not only to a neutral control condition (neutral video) but also to an amusing control condition (comedic animal videos from the series *Walk on the Wild Side*). These later videos presented scenes from nature videos in which animals appear to be having conversations dubbed with human voices. Finally, in Study 2, we asked participants, immediately after the video, whether they were feeling awe (along with other emotions) in that very moment, so rather than looking at whether the video was seen as awe-inducing, we asked participants about the extent to which they felt awe, and this constituted our main measure of awe for the mediation

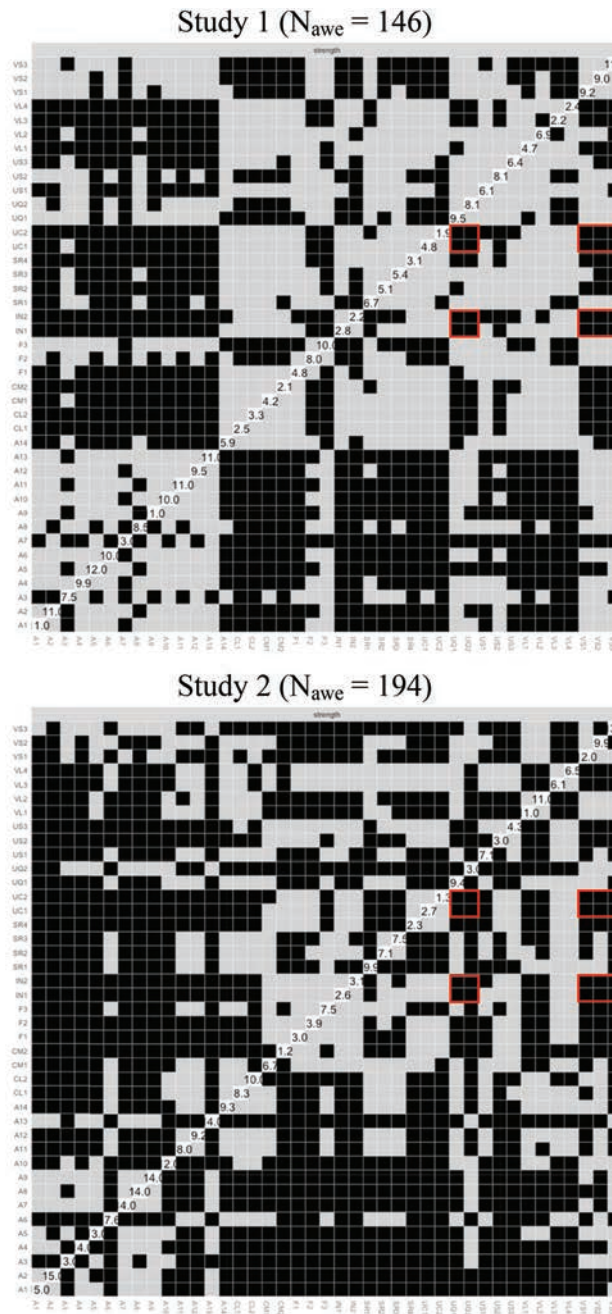
analysis. For the purpose of network analysis, appraisals were measured in the same manner as in Study 1.

Method

Participants

For Study 2, U.S. participants ($N = 505$, $M_{\text{age}} = 51$, $SD_{\text{age}} = 16$, 73% female, 87% White) completed the study via Research Match (<https://www.researchmatch.org/>). Our a priori target was to collect over 450 participants. A larger sample size than Study 1 was needed because we introduced an additional condition and because we wanted to not only demonstrate a link between awe and the

Figure 4
Strength Bootstrapped Difference Test in Study 1 (Top Panel) and Study 2 (Bottom Panel)



Note. Black squares indicate significant differences in strength ($< .05$). Out of 820 possible strength comparisons, 430 were significant in Study 1, and 513 were significant in Study 2. Strength difference tests for items indicative of exceeded versus disconfirmed expectancies are indicated with a red frame. A1 = amazing; A2 = awe-inspiring; A3 = beautiful; A4 = moving; A5 = profound; A6 = gave me chills; A7 = incredible; A8 = captivating; A9 = breathtaking; A10 = out of this world; A11 = unbelievable; A12 = overpowering; A13 = powerful; A14 = forceful; CL1 = clear; CL2 = harmonious; CM1 = complicated; CM2 = simple; F1 = familiar; F2 = unfamiliar; F3 = novel; IN1 = inconsistent; IN2 = clashing; SR1 = surprising; SR2 = unanticipated; SR3 = unforeseen; SR4 = expected; UC1 = uncertain; UC2 = ambiguous; UQ1 = unique; UQ2 = exceptional; US1 = unusual; US2 = strange; US3 = typical; VL1 = pleasant; VL2 = positive; VL3 = negative; VL4 = unpleasant; VS1 = vast; VS2 = enormous; VS3 = immense. See the online article for the color version of this figure.

exceeding of expectancies but also rule out a link with the disconfirmation of expectancies. Participation in the study was voluntary, and no remuneration was offered to participants. Only fully completed questionnaires were analyzed and reported. The study was approved by the Research Subjects Review Board at the University of Rochester (RSRB 00065107).

Procedure and Manipulations

Study 2 employed a three-condition between-subjects design with a neutral ($N = 165$), amusing ($N = 146$), and awe-inducing ($N = 194$) video. Participants were randomly assigned to condition (true randomization).

To ensure an immersive experimental procedure (van Elk et al., 2016), we asked participants to view the video manipulation in full-screen mode and to use headphones plugged into the computer. Following the emotion induction manipulation, we asked participants to rate their emotions as they felt them “right now.” On the following page, participants had to indicate to what extent various physical properties (e.g., light, sound, speed) of the scenes in the video violated (exceeded or disconfirmed) their prior expectancies, and they were asked to rate the scene in terms of various appraisals. Upon completion of the procedure, participants answered demographic questions, were thanked, and were given the opportunity to comment on the procedure and to contact experimenters with any questions.

Measures

Expectancy Violation. Expectancy violation was measured using the same format as in Study 1. Both exceeding expectancies ($M = 2.65$, $SD = 1.59$) and disconfirmation of expectancies ($M = 2.37$, $SD = 1.49$) had good reliability (Cronbach’s $\alpha = .97$ and $.95$, respectively).

Emotion Felt. To gauge the extent to which the video manipulation elicited various emotions, we asked participants to indicate the emotions they felt “right now” (following Piff et al., 2015). Awe was measured using three items (awe, wonder, amazement; Cronbach’s $\alpha = .90$, $M = 3.85$, $SD = 2.07$) forming a scale of felt awe, and the remaining emotions (measured for control purposes) were measured using single items (happiness, amusement, surprise, anger, disgust, fear, and sadness) scored on a scale from 1 = *not at all* to 7 = *very much* (following Piff et al., 2015).

Scene Appraisals. Scene appraisals were measured using the same adjectives as in Study 1. The network analyses relied on observed variables (i.e., individual adjectives); however, summative scores were produced to briefly compare the correlates of exceeded and disconfirmed expectancies. Consistent with Study 1, disconfirmed expectancies were linked to perceptions of inconsistency (with prior expectations) and uncertainty and were negatively tinged, while events that exceeded expectancies were linked to perceptions of vastness and uniqueness and were less negatively tinged (see Table S1).⁵

Results

Awe Experience

In Study 2, participants viewed an awe-inducing, amusing, or neutral video. To evaluate the impact of the video, a general linear model (see Table 2) compared the means of all of the emotions

across the three conditions. Omnibus tests revealed a significant effect of the manipulation on all of the eight emotions measured, $F(2, 478)$ range = 9.94–232.53, $ps < .001$, η^2 range = .04–.49. As indicated in Table 2, awe was highest in the awe-inducing condition ($M_{awe} = 5.67$, $SD = 1.48$; $M_{amusement} = 3.08$, $SD = 1.66$; $M_{neutral} = 2.45$, $SD = 1.27$), while amusement was highest in the amusing condition ($M_{amusement} = 5.77$, $SD = 1.69$; $M_{awe} = 3.33$, $SD = 1.83$; $M_{neutral} = 2.54$, $SD = 1.67$), and both the awe condition and the amusement condition scored higher in happiness ($M_{awe} = 5.03$, $SD = 1.62$; $M_{amusement} = 4.98$, $SD = 1.89$; $M_{neutral} = 2.10$, $SD = 1.43$) and in surprise ($M_{awe} = 2.95$, $SD = 1.89$; $M_{amusement} = 3.45$, $SD = 1.94$; $M_{neutral} = 2.50$, $SD = 1.64$) and lower in anger ($M_{awe} = 1.32$, $SD = 1.00$; $M_{amusement} = 1.27$, $SD = .88$; $M_{neutral} = 1.94$, $SD = 1.45$) and disgust ($M_{awe} = 1.24$, $SD = .86$; $M_{amusement} = 1.34$, $SD = 1.05$; $M_{neutral} = 2.24$, $SD = 1.75$) relative to the neutral control condition. Finally, fear ($M_{awe} = 1.35$, $SD = .82$; $M_{amusement} = 1.04$, $SD = .36$; $M_{neutral} = 1.62$, $SD = 1.24$) and sadness ($M_{awe} = 2.02$, $SD = 1.56$; $M_{amusement} = 1.16$, $SD = .62$; $M_{neutral} = 2.22$, $SD = 1.72$) were higher in the awe condition than in the amusement condition. There was also an effect on the exceeding of expectancies, $F(2, 478) = 37.05$, $p < .001$, $\eta^2 = .13$, with exceeding expectancies significantly higher in the awe condition ($M_{awe} = 3.20$, $SD = 1.69$; $M_{amusement} = 2.78$, $SD = 1.57$; $M_{neutral} = 1.84$, $SD = 1.07$). As the omnibus test was not significant for the disconfirming of expectancies, $F(2, 478) = 2.98$, $p = .052$, $\eta^2 = .01$, we did not follow this up with simple comparisons.

Expectancy Violations and Awe

Again, our main hypothesis stated that awe should arise predominantly in reaction to scenes that exceed (rather than disconfirm) expectancies. As in Study 1, initial support was obtained in correlation analyses: The correlation of awe with exceeded expectancies was of high magnitude ($r = .46$, $p < .001$), while the correlation with disconfirmed expectancies was very small ($r = .09$, $p = .060$). These two correlation coefficients were significantly different from one another (Dunn and Clark’s $z = 8.84$, $p < .001$), again suggesting that awe is more linked to exceeded expectancies than it is linked to disconfirmed expectancies (Diedenhofen & Musch, 2015). Furthermore, the analysis of variance demonstrated different levels of exceeding expectancies between the awe and the neutral conditions (see Table 2).

Similar to Study 1, a mediation test using PROCESS entailed a model in which awe was regressed on the exceeding and disconfirming of expectancies (controlling for the effect of the manipulation), and the two types of expectancy violations were regressed on the manipulation. However, because the current study had three (rather than two) experimental conditions, the analysis needed to take into account both the difference between the awe and the amusement conditions and the difference between the awe and the neutral conditions. This was resolved by means of indicator coding (Hayes & Montoya, 2017; using the “indicator” coding method in PROCESS), which led to the creation of two indicator-coded independent variables (also known as “relative indirect effects”): one

⁵ Study 2 also measured individual differences (need for closure, absorption, and openness) and exploratory questions asking about connectedness with nature and participants’ views on environmental concerns.

Table 2
Mean Differences Across the Three Experimental Conditions (Study 2)

Variable measured	Awe		Amusement		Neutral		<i>F</i>	<i>p</i>	η^2
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Awe	5.67 ^a	1.48	3.08 ^b	1.66	2.45 ^c	1.27	232.53	<.001	0.49
Happiness	5.03 ^a	1.62	4.98 ^a	1.89	2.10 ^b	1.43	164.40	<.001	0.41
Amusement	3.33 ^a	1.83	5.77 ^b	1.69	2.54 ^c	1.67	135.82	<.001	0.36
Surprise	2.95 ^a	1.89	3.45 ^b	1.94	2.50 ^a	1.64	9.94	<.001	0.04
Anger	1.32 ^a	1.00	1.27 ^a	0.88	1.94 ^b	1.45	17.02	<.001	0.07
Disgust	1.24 ^a	0.86	1.34 ^a	1.05	2.24 ^b	1.75	30.23	<.001	0.11
Fear	1.35 ^a	0.82	1.04 ^b	0.36	1.62 ^c	1.24	14.94	<.001	0.06
Sadness	2.02 ^a	1.56	1.16 ^b	0.62	2.22 ^a	1.72	22.78	<.001	0.09
Exceeding	3.20 ^a	1.69	2.78 ^b	1.57	1.84 ^c	1.07	37.05	<.001	0.13
Disconfirming	2.18	1.55	2.59	1.42	2.34	1.43	2.98	.052	0.01

Note. $N_{awe} = 188$, $N_{amusement} = 137$, and $N_{neutral} = 156$; $df = (2, 478)$. Mean values in the same row and not sharing the same superscript are significantly different at $p < .05$, two-tailed test, Bonferroni correction. Omnibus test results are based on a general linear model with listwise deletion.

comparing the awe and amusement conditions and another comparing the awe and neutral conditions (see Figure 2, right panel).

The PROCESS macro estimated mediation effects based on three regression models. In Model 1, the first mediator (exceeding expectancies) was regressed on each of the two indicator-coded variables (awe vs. amusement or awe vs. neutral), and the second mediator (disconfirming expectancies) was also regressed on each of the two indicator-coded variables. The results for these models were in line with those obtained using ANOVA, showing that the awe manipulation significantly increased a sense of exceeded (but not disconfirmed) expectancies (see Table 2 and Figure 1). Furthermore, in Model 2, felt awe was regressed on the two mediators and the two indicator-coded variables. Here, awe was significantly related to both indicator-coded manipulation contrasts, $B_{awe \text{ vs. amusement}} = -2.44$, $SE = .16$, $t(4, 483) = -15.46$, $p < .001$, 95% CI $[-2.75, -2.13]$; $B_{awe \text{ vs. neutral}} = -2.72$, $SE = .17$, $t(4, 483) = -16.39$, $p < .001$, $[-3.05, -2.40]$, as well as to exceeded expectancies, $B = .37$, $SE = .05$, $t(4, 483) = 7.26$, $p < .001$, $[.27, .47]$, but not to disconfirmed expectancies, $B = -.01$, $SE = .05$, $t(4, 483) = -.13$, $p = .895$, $[-.11, .09]$. This suggests that exceeding, but not disconfirming expectancies, accounts for the effect of our manipulation on felt awe.

To test this mediational pattern formally, we generated bootstrap confidence intervals ($N_{boot} = 10,000$) in PROCESS (Model 4; Hayes, 2013). This revealed an indirect effect via the exceeding of expectancies for both the awe versus amusement contrast ($B_{boot} = -.15$, $SE_{boot} = .07$, 95% CI $[-.30, -.02]$) as well as the awe versus neutral contrast ($B_{boot} = -.50$, $SE_{boot} = .09$, $[-.70, -.35]$). For disconfirmed expectancies, bootstrap intervals were not significant ($B_{boot} = -.003$, $SE_{boot} = .02$, 95% CI $[-.05, .04]$ and $B_{boot} = -.001$, $SE_{boot} = .01$, $[-.03, .02]$, respectively). These results demonstrate that exceeding (but not disconfirming) expectancies mediate the effect of the manipulation on felt awe both when comparing the awe versus the amusement condition and when comparing the awe versus the neutral condition. The pattern of findings was additionally identical when appraised (rather than felt) awe was entered as a dependent variable.

Mapping the Awe Experience

Network analyses were conducted using the same appraisal items and following the same protocol as in Study 1. We chose to

compute the network based only on data from participants in the awe condition as the experience of these participants is most relevant for our purpose, as well as to make the results of Studies 1 and 2 more comparable.

Network Visualization. Figure 1 (right panel) represents the correlational network structure of the features of the awe-inducing scene in Study 2. Nodes related to awe (A1–A14), as well as nodes indicating the expectancy-exceeding features of vastness (VS1–VS3) and uniqueness (UQ1 and UQ2), play a central role within the network. However, nodes related to inconsistency (IN1 and IN2), uncertainty (UC1 and UC2), as well as familiarity (F1–F3), surprise (SR1–SR3), and complexity (CM1 and CM2), play a peripheral role in the network.

Centrality Index. The order of the strength index was highly stable for a wide range of increasingly smaller bootstrapped samples (Figure S1). This was further supported by a correlation stability coefficient that was well over the recommended value of .50 (correlation stability coefficient $cor = .75$), indicating that we can confidently interpret differences in strength.

Figure 3 (right panel) depicts strength indices of the various awe appraisals. All but three (A11 = unbelievable, A12 = overpowering, and A6 = gave me chills) awe-related appraisals are strongly positioned in the network, and so are the three appraisals related to vastness (VS1–VS3) and two appraisals related to uniqueness (UQ1–UQ2). Notably, and in line with the results of Study 1, the items uniquely related to disconfirmed expectancies (IN1 and IN2; UC1 and UC2) had negative strength scores, indicating that they are not central to the experience of awe. A further examination of the results from both studies indicates that only items denoting awe, vastness, and uniqueness are consistently central to the experience of awe across both studies.

Centrality Differences. The bootstrapped strength difference test (parametric, $\alpha = .05$, $N_{boot} = 10,000$) revealed that, this time, on 513 out of 820 comparisons, there was a significant difference in terms of node strength (Figure 4, bottom panel). Similar to Study 1, the strength of all nodes denoting the expectancy-exceeding properties of vastness (VS1–VS3) and uniqueness (UQ1–UQ2) was significantly different from the strength of nodes denoting the expectancy-disconfirming appraisals of inconsistency (IN1 and IN2) and uncertainty (UC1 and UC2). In other words,

also in Study 2, appraisals denoting the exceeding of expectancies were significantly more central to awe than appraisals denoting the disconfirmation of expectancies.

General Discussion

Awe is a fascinating and important emotion, often associated with intense spiritual and life-changing experiences and positive consequences such as greater generosity and prosociality (Piff et al., 2015; Stellar et al., 2018). However, in spite of the weight of this emotion, the exact way in which awe arises, and what it entails, is still a puzzle. Understanding what kind of stimuli evokes awe is essential for predicting and evoking this emotion, and understanding what appraisals constitute awe can help define and distinguish awe from other, related emotions. To help better understand these issues, we examined the relationship of awe and expectancy violations and mapped the network structure of a range of appraisals related to awe.

Awe and Expectancy Violations

To answer the question of how awe arises, we looked at the link between awe and expectancy violations. At first glance, the idea that awe is the result of expectancy violations (Keltner & Haidt, 2003) seems contrary to what is known about forming and testing expectancies. Namely, according to social cognition research, expectancy-violating situations tend to be unpleasant, linked to uncertainty and inconsistency, and characterized by a state of disconfirmation of what we have known or expected. Awe experiences, on the other hand, do not seem to disconfirm people's expectancies in any major way and seem to be experienced as valuable and (in 80% of cases) pleasurable (Gordon et al., 2017).

In response to this paradox, we distinguished between two types of expectancy violations: experiences that exceed versus those that disconfirm prior expectancies. In line with our observations and reading of the literature, we argued that awe should arise in reaction to exceeded rather than disconfirmed expectancies. This is because while exceeded and disconfirmed expectancies share some commonalities (e.g., perceptions of surprise), they are also qualitatively different from one another: While exceeded expectancies are linked to perceptions of positive valence, vastness, and uniqueness, disconfirmed expectancies are linked to appraisals of negative valence, inconsistency, and uncertainty (see Table S1).

Our main hypothesis that awe arises in reaction to exceeded (rather than disconfirmed) expectancies was supported by mediation analyses. In these studies, recalling a past experience of awe (Study 1), as well as watching an awe-inspiring video (Study 2), led to greater appraisals (Studies 1 and 2) and feelings (Study 2) of awe, and this effect was mediated by a sense of exceeded (rather than disconfirmed) expectancies. Thus, by making a distinction between disconfirmed and exceeded expectancies, we demonstrated that awe arises in reaction to the latter (rather than the former) type.

Mapping the Awe Experience

To answer the question of what awe entails, we investigated the centrality of a range of awe-related appraisals. Awe is a complex emotion associated with numerous and varied appraisals, and our

goal was to better understand how those various appraisals structurally interact and which of them form the essential features of awe. Across two studies, we found that appraisals related to exceeded expectations (vastness and uniqueness) are consistently central to the experience of awe. Beyond illustrating what appraisals are at the core of the awe experience, the network analyses also illustrated what appraisals are peripheral to the awe experience. Zooming in on those appraisals is helpful because while some of them may be commonly associated with awe, they are not necessarily defining of this emotion. A good example of such an appraisal is valence. While in our own (and others') research, awe was correlated with positive valence (medium to large size correlations), network analyses estimated that valence is a peripheral feature of the awe network. This, broadly speaking, is compatible with the finding that while most awe experiences are positive, a negative variant of awe exists and constitutes approximately 20% of awe experiences (Gordon et al., 2017). In other words, while awe experiences are often positive, valence is not a necessary feature of awe. In a similar vein, even though our studies have consistently shown a correlation of awe and clarity (medium to large effect sizes), clarity has also emerged as a peripheral feature of awe.

Implications to Emotions Research

The above findings have implications for research on awe and on other epistemic emotions. First and foremost, they offer a better understanding of the state of awe and how it arises. They help to disambiguate what it is about awe-inducing experiences that "challenge people's worldviews" and evoke a greater "need for accommodation" (a sense of exceeded expectations). They also stress the need to shift from asking whether unexpectedness is part of awe to asking what type of unexpectedness is part of awe. An unexpectedness of scale (e.g., an extremely blue lake, which exceeds expectancies) seems to be part of the awe experience; however, an unexpectedness of nature (e.g., a red lake, which disconfirms expectancies) does not.

Furthermore, our findings provide greater insight into the appraisal structure of awe and allow researchers to understand which features are most essential to the awe experience (vastness and uniqueness) and which of them are not central or defining of the experience of awe (e.g., valence, uncertainty, inconsistency). This should allow researchers to better understand when awe arises and how it can be evoked experimentally. It may also aid practitioners, for instance teachers or educators, whose aim it is to captivate the audience in order to evoke awe and interest in an important topic (e.g., environmental science).

Going beyond these findings, it is important to note that, while awe arises in reaction to exceeded expectancies and a sense of vastness and uniqueness, these stimuli features need not always result in feelings of awe. For instance, moral elevation is an emotion felt when witnessing another person perform a virtuous act (Algoe & Haidt, 2009). This state is very similar to awe in that the target person exceeds one's expectancies about a high moral standard. However, unlike awe, elevation is applied in a moral domain. Awe, on the other hand, may be more likely to arise in reaction to high levels of performance or in the context of aesthetic judgments (Shiota et al., 2007). Thus, whether exceeded expectancies, vastness, and uniqueness are associated with awe could potentially depend on the context or domain in which expectancies are exceeded. Notably, context is

not the only condition that will determine whether a sense of exceeded expectancies will lead to the rising of awe. Other factors, such as whether the exceeded dimension is highly valued, will likely act as moderators between exceeded expectancies and the rising of awe. Thus, the question of when exceeded expectancies are most likely to result in awe is a question for future research.

While the distinction between exceeded and disconfirmed expectancies disambiguates the experience of awe in nature, further studies are needed to better understand the role of expectancy violations in negative emotions from the awe family—for instance, the experience of horror (Taylor & Uchida, 2019) or the threat-based variant of awe (Gordon et al., 2017). Threatening natural events (e.g., hurricanes) may exceed one's expectations about the magnitude to which these events are powerful or destructive. Taylor and Uchida (2019) have argued that what differentiates horror from awe is a sense of severity, unusualness, and overwhelm and that an experience of horror entails the realization that vital resources, relationships, or assumptions have become unviable or dangerous. From the perspective of our own findings, experiences leading to feelings of horror could exceed expectancies in a highly negative domain (e.g., exceeded expectancies about the extent of threat). Alternatively, or in addition, such experiences could also disconfirm expectancies about some vital convictions, for instance, about the safety and security of the world around us (Taylor & Uchida, 2019). Finally, there is the distinct possibility that even negative and potentially threatening events possess extreme features that are worthy of appreciation. For instance, while hurricanes are potentially life-threatening, they can also be appreciated for demonstrating extreme “forces of nature.” Thus, the notion of exceeded expectancies of a highly valued (but not necessarily safe or pleasant) property could explain the existence of the threat-based variant of awe. Further research drawing a clearer distinction between the expectancy domain (e.g., morality, force, beauty, safety) and the way in which expectancies are violated (e.g., via the exceeding or disconfirming of expectancies) may succeed at illuminating these questions.

Finally, the distinction between different types of expectancies has the potential to elucidate not only the family of awe-related emotions (e.g., awe, elevation, adoration) but also various emotion states regarding the acquisition of knowledge (“epistemic emotions,” e.g., interest, curiosity, surprise, confusion, or boredom). For instance, in the present article, we were able to explain how awe is different from amusement. This was demonstrated in Study 2 where awe (but not amusement) was associated with the exceeding (but not disconfirming) of expectancies.

Implications to Expectancy Violations Research

Aside from informing work on epistemic emotions, our findings also speak to expectancy violation research. While the bulk of expectancy research is focused on the disconfirmation of expectancies, which tends to be associated with complex, inconsistent, uncertain, and unusual phenomena, the present research suggests that expectancy violations that exceed expectancies may be appraised in different ways—as vast and unique. The present research demonstrates that while both of these types of expectancy violations have some commonalities (e.g., both are associated with a sense of surprise and unfamiliarity), they are also different. Namely, while disconfirmed expectancies are linked to negative affect, greater perceptions of complexity, unusualness, inconsistency, and uncertainty, exceeded expectancies are linked to

positive affect and greater perceptions of vastness, uniqueness, and clarity (see Table S1).

The notion of expectancy violations underlies a broad range of phenomena and thus connects a number of distinct fields, from emotions research, through dissonance-based theories, to the literature on communication or on stereotyping and prejudice, and applying the notion of exceeded expectancies could lead to new insights within these various fields. For instance, expectancy violations are vital for intergroup processes research, where counterstereotypic acts and individuals (e.g., a Black president in the United States) are considered as an effective method of decreasing stereotyping and prejudice. While exposure to counterstereotypes can reduce prejudice (Prati et al., 2015), counterstereotypic individuals themselves are often faced with negative, discriminatory reactions (e.g., Hunt et al., 2014), and recent evidence suggests that these outcomes differ depending on the way in which expectancies are violated. For example, foreign-looking but native-accented job candidates tend to be highly evaluated if they are first seen (and therefore expected to speak with an accent) and later heard; however, if the same job candidates are first heard and later seen (and therefore expected to be White), their evaluations tend to be much lower (Hansen et al., 2018). These findings parallel our own in suggesting that a better understanding of not just whether but how (e.g., via exceeding vs. disconfirming expectancies; in a positive vs. negative way) expectancies are violated is key to a better understanding of their consequences across a wide range of domains.

Limitations

Finally, our research has some limitations. While the emotion recall manipulation in the first study was relatively clean and confound free, it may have imposed on participants an expectation of what awe should be like. Our second manipulation, on the other hand, was less ecologically valid and, while widely used to elicit awe, was not free of confounding variables. For instance, the *Planet Earth* video had a song playing in the background, while the amusing videos contained animals that may have been seen as “cute” by participants. However, since results were consistent across both studies, these confounding influences were not critical.

Second, while demonstrating clear links between expectancy violations and awe, our study did not provide causal evidence that expectancy-exceeding scenes cause awe. To demonstrate this, a study that directly manipulates exceeded and disconfirmed expectancies (for instance, via recalling one type of experience) would be necessary. However, since in both studies, the awe condition was rated as higher in exceeded expectancies (relative to the remaining conditions), we can be confident that a causal relationship is extremely likely. Taking all this together, and given that our studies yielded clear, interpretable findings, we believe that the effects presented in the current article are likely quite robust.

Conclusion

In sum, we have argued for and demonstrated that the state of awe arises in reaction to exceeded rather than disconfirmed expectancies and that appraisals of vastness and uniqueness, but not appraisals of inconsistency and uncertainty, are central to the awe experience. This finding, we hope, can help researchers better understand how awe arises and what it entails, and it can further

enrich psychologists' understanding of epistemic emotions and their link to psychological expectancies.

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