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The development of the Awe Experience Scale (AWE-S): A multifactorial measure for a complex emotion

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ABSTRACT

Awe is a complex emotion composed of an appraisal of vastness and a need for accommodation. The purpose of this study was to develop a robust state measure of awe, the Awe Experience Scale (AWE-S), based on the extant experimental literature. In study 1, participants (N = 501) wrote about an intense moment of awe that they had experienced and then completed a survey about their experience. Exploratory factor analysis revealed a 6-factor structure, including: altered time perception (F1); self-diminishment (F2); connectedness (F3); perceived vastness (F4); physical sensations (F5); need for accommodation (F6). Internal consistency was strong for each factor ($\alpha \geq .80$). Study 2 confirmed the 6-factor structure (N = 636) using fit indices (CFI = .905; RMSEA = .054). Each factor of the AWE-S is significantly correlated with the awe items of the modified Differential Emotions Scale (mDES) and Dispositional Positive Emotion Scale (D-PES). Triggers, valence, and themes associated with awe experiences are reported.

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Introduction

'If you think of feelings you have when you are awed by something – for example, knowing that elements in your body trace to exploded stars – I call that a spiritual reaction, speaking of awe and majesty, where words fail you.'

- Neil deGrasse Tyson

Awe has a long history in philosophy, particularly in the domain of aesthetics and religious or spiritual experiences. Both Edmund Burke's (1759/1970) and Immanuel Kant's (1764/2007) analyses of the sublime as a compelling experience that transcends one's perception of beauty to something more profound are couched in terms that seem synonymous with the modern understanding of awe. Charles Darwin likewise discussed the capacity for and importance of the emotion of 'wonder,' a word that is also closely related to awe. In *The Varieties of Religious Experience* (1902/1936), William James brought intense experiences of awe into the domain of psychology. Later, Abraham Maslow provided a more secularized and straightforwardly positive assessment of awe, characterizing the capacity to experience this emotion as an essential component of the good life: 'The most fortunate are those who have a wonderful capacity to appreciate again and again, freshly and naively, the basic goods of life, with awe, pleasure, wonder and even

ecstasy' (Maslow, 1970). However, to date, no scale currently exists that can capture the full depth and breadth of the awe experience.

The contemporary psychological understanding of awe comes largely from a foundational article written by Keltner and Haidt (2003). According to the prototypical approach presented in this article, the following two cognitive appraisals are central to awe experiences: the perception of vastness and the need to mentally attempt to accommodate this vastness into existing mental schemas. While this definition is widespread in the field, a more robust definition may be necessary as additional qualities of awe reveal more of its latent structure.

Importantly, vastness can be either perceptual (e.g., seeing the Grand Canyon) or conceptual (e.g., contemplating eternity). Further, Keltner and Haidt (2003) describe various 'themes' of awe stimuli, including: threat, beauty, ability, virtue, and the supernatural. These themes may result from triggers or interpretations of the awe experience and are capable of influencing its hedonic tone. An aspect of awe that is somewhat unusual for an emotion is that it can have positive and/or negative valence. While negative experiences of awe have been studied (e.g., Gordon et al., 2017; Piff, Dietze, Feinberg, Stancato, & Keltner, 2015), awe is more often associated with a positive valence. While awe was once more explicitly mingled with fear (e.g., Burke,

1759/1970), awe has come to have a generally more positive connotation (Bonner & Friedman, 2011). Thus, positive forms of awe have received more experimental attention (e.g., Chirico, Yaden, Riva, & Gaggioli, 2016; Chirico & Yaden, 2018; Shiota, Keltner, & Mossman, 2007).

Recent experimental research has explored the relationships between awe and a number of other psychological traits as well as cognitive, affective, and perceptual processes. Awe has been shown to influence one's attention (Prade & Saroglou, 2016; Sung & Yih, 2016) in a way that tends to be consistent with Fredrickson's Broaden and Build theory of positive emotions (Fredrickson, 2001). Other works have shown that awe expands perception of time (Rudd, Vohs, & Aaker, 2012), enhances well-being (Krause & Hayward, 2015) and leads to prosocial behaviors (Piff et al., 2015), as well as decreases aggressive attitudes (Yang, Yang, Bao, Liu, & Passmore, 2016). This emotion can also affect the way we perceive our bodies, thus leading us to underestimate its size (van Elk, Karinen, Specker, Stamkou, & Baas, 2016). Additionally, awe can temporarily increase spiritual-type beliefs (Van Cappellen & Saroglou, 2012) and the tendency to find intentionality in random strings of numbers (Valdesolo & Graham, 2014). In terms of personality, the tendency to experience awe is predicted by the personality trait of Openness to Experience (Silvia, Fayn, Nusbaum, & Beaty, 2015). Awe has even been discussed as an important motivator and means to maintain interest in science education (Valdesolo, Shtulman, & Baron, 2017).

However, experimental research on awe has been limited by the lack of a *state* measure of awe that is theoretically *robust*. In fact, we could not find any validated state scales for awe. Instead, the literature contains trait measures of one's general tendency to experience awe that include just a few items of interest. By robust, we mean items that go beyond asking participants to explicitly assess whether they have felt 'awe.' For example, the item 'did you feel awe?' is problematic, as participants may hold a different conceptualization of awe than do researchers. We also take robust to mean incorporating items that tap into a number of dimensions of awe that have been discovered in empirical research – such as those described in the next section. These dimensions – or facets – of awe likely vary with some degree of independence across various kinds of awe experiences. Further, because some aspects of awe may uniquely moderate or mediate outcomes of these experiences, a robust state measure of awe necessitates inclusion of these facets.

Facets of awe

Researchers typically do not formally define the nature of the aspects of awe that have been the subject of

empirical studies. Yet, the implication seems to be that these aspects are assumed to be 'facets' of awe. That is, there exist theoretical dimensions of the awe construct that have not previously been statistically differentiated. Below, we briefly review major aspects of awe that have been investigated in previous experimental research, such as vastness, the need for accommodation, altered time perception, self-diminishment, connectedness, and physical sensations. The items that we generated for the AWE-S are derived from the following aspects, or facets, of awe.

Vastness

The perception of vastness is one of the two appraisal dimensions described by Keltner & Haidt (2003). Vastness can refer to *perceptual* vastness, as in viewing an enormous mountain or a towering building – or it can refer to *conceptual* vastness, as in hearing an idea with enormous implications or meditating on the meaning of eternity (Yaden et al., 2016). Items intended to measure vastness include: 'I feel the presence of something greater than myself' (Piff et al., 2015). In laboratory settings, a variety of different methods have been used to elicit awe through the perception of vastness. Usually, images or videos of natural scenery are shown to research participants (e.g., Prade & Saroglou, 2016; Silvia et al., 2015; Zhang & Keltner, 2016). Some studies involve actually taking participants outdoors and exposing them to sweeping views of natural scenery. For example, Piff et al. (2015) brought participants out of the lab to view a grove of very tall eucalyptus trees to induce awe. More recently (Chirico et al., 2016; Chirico et al., 2017), recommended and utilized virtual reality (VR) to successfully induce awe by simulating vastness in virtual space with panoramic views of nature.

Need for accommodation

The need for accommodation is the second appraisal dimension described by Keltner & Haidt (2003). Accommodation involves changes to existing mental schemas in order to mentally process and integrate an experience. Some have argued that this aspect of awe is too vaguely defined and has therefore been operationalized in several different ways in the research literature (Sundararajan, 2002). For instance, there exist measures of need for accommodation, as reported in Schurtz et al. (2012), but they have not been validated. However, one example of an item that has been used to measure the need for accommodation as a trait is: 'I seek out experiences that challenge my understanding of the world' (Shiota, Keltner, & John, 2006), though this item may have some culturally specific connotations (Razavi, Zhang, Hekiart, Yoo, & Howell, 2016). A study

found that the need for cognitive closure negatively correlates with the need for accommodation in awe experience (Shiota et al., 2007). Other components of the need for accommodation have also been examined, such as the degree of novelty one experiences, as well as the degree to which one's expectations have been violated upon experiencing awe (Lorini & Castelfranchi, 2007). Finally, the degree of uncertainty one feels has also been examined as a proxy for the need for accommodation dimension (Valdesolo & Graham, 2014).

Time

Awe has been shown to temporarily alter *time perception*. In one study, in which awe was induced in participants by asking them to describe past awe experiences in writing, participants reported that time had moved more slowly than did participants who did not write about or re-experience awe (Rudd et al., 2012). Alterations to time perception during awe experiences have been measured with items such as, 'Time is expanded' (Rudd et al., 2012). This perceptual change marks a distinction between awe and other emotions, as alterations to such fundamental faculties of consciousness are unusual in the emotion literature. Flow (Csikszentmihalyi, 1997) is another example of a mental state (not an emotion) in which the sense of self and time is altered, although in flow time appears to speed up, whereas in awe time typically subjectively slows.

Self-diminishment

Awe has also been shown to *diminish, or reduce the salience of, certain aspects of the self*. For example, on the level of the bodily self, awe can reduce the sense of one's own body size (van Elk et al., 2016). In terms of one's subjective sense of self, awe has been shown to reduce one's 'being and goals' (Piff et al., 2015). Items used to measure this include 'I feel small or insignificant' (Piff et al., 2015).¹ Though deep theoretical issues arise from claims about self-loss – one might ask: what is the self at all? – this brute phenomenological self-report is common in the theoretical and qualitative literature on awe (Yaden, Haidt, Hood, Vago, & Newberg, 2017). Additionally, measures in awe research that ask participants if their self was in some way diminished have been shown to be reliable (e.g., Piff et al., 2015). This aspect of awe has been shown to mediate its relationship with humility (Stellar et al., 2018).

Connectedness

Feelings of connection to other people and the environment beyond one's self feature in experiences of awe (Stellar et al., 2017; Yaden et al., 2017). When awe is induced, participants frequently report a deeper sense of

connection with other people and things around them (Krause & Hayward, 2015; Piff et al., 2015). Items used to measure this sense of connection include, 'I feel part of some greater entity' (Piff et al., 2015). What one connects to can include a number of different entities, though often they are considered somehow 'greater' than one's self (e.g., one's culture, all of humanity, religious or spiritual entities, or even all of existence). This should also be subject to further empirical research, but measures used to tap this aspect of awe have been shown to be stable and reliable (Piff et al., 2015). This aspect of awe has been found to increase collective engagement across individualist as well as collectivist cultures (Bai et al., 2017).

Physical sensations

Awe causes predictable changes to one's physiology. Several autonomic changes associated with awe have been recorded. Specifically, a freezing response to awe stimuli was measured at a psychophysiological level (Chirico, Cipresso, & Gaggioli, 2016; Chirco et al., 2017) and at a behavioral level (Joye & Dewitte, 2016). Moreover, the phenomenon of 'goosebumps' and chills have been demonstrated to co-occur during some experiences related to awe (Algoe & Haidt, 2009; Maruskin, Thrash, & Elliot, 2012; Schurtz et al., 2012). Additionally, in the tradition of the facial action coding of emotions (Ekman & Friesen, 2003), awe has been studied in terms of its associated facial expressions. Specifically, research has identified facial expressions associated with awe such as widened eyes and a dropped jaw (Shiota, Campos, & Keltner, 2003). Notably, bodily changes such as these have typically been observed using physiological measurement equipment, rather than inquired about via self-report measures.

The present studies

The present studies sought to test whether the *facets* or aspects of awe described above, which have been discussed in theoretical writings and operationalized in various *ad hoc* measures used in empirical research, are in fact *factors* describing a latent variable of a robust mental state, or complex emotion, of awe. Based on our review of the literature summarized above, we hypothesized that we would discover a 6-factor solution describing experiences of awe. To test this, we generated items based on previous theoretical writings, trait measures of awe, and *ad hoc* awe measures used in experimental studies. These aspects of awe co-occur with the experience of the emotion and therefore cannot accurately be considered 'outcomes,' which would occur as antecedents to the emotion. Note that the items were generated from facets of awe in the literature and it was not

our intent to attempt an exhaustive account of aspects of awe. This measure would be the first state measure of awe that accounts for granular subjective components of the complex emotion. Lastly, our items were intended to tap each of the hypothesized factors without explicitly mentioning the word 'awe.'

We compared the resulting items with other awe measures, the modified Differential Emotions Scale (mDES) and the awe subscale of the Dispositional Positive Emotion Scale (D-PES), to establish initial convergent validity. We also explored a measure of personality (BFAS) as well as other theorized aspects such as triggers, valence, themes, and degree of intensity.

Study 1 – exploratory factor analysis

In Study 1, we administered items related to the experience of awe to participants using an online survey platform. Participants were first asked to remember and then write about a recent, intense awe experience – a method that has been shown to be an effective way to elicit memories of emotion experiences (Rudd et al., 2012; Shiota et al., 2007). Participants then answered a battery of items about their awe experience. Following data collection, we performed Exploratory Factor Analysis (EFA) on these items.

Method

Participants

Participants were recruited through an online invitation to participate in the study on Amazon's Mechanical Turk (M-Turk). The link was provided along with the description: 'This research study is designed to gain a better understanding of awe.' Participants agreed to an informed consent document and confirmed that they were over 18 years of age. Participants were compensated about one dollar for their participation. The survey was administered using Qualtrics, a secure online survey distribution and data collection program. This study is part of a larger survey; only the subset of measures relevant to this study are reported here. The Institutional Review Board at the University of Pennsylvania approved this study.

Participant characteristics. Participants ($N = 501$) were adults (over 18) drawn from the U.S. and were mostly white (67.3%, $n = 227$; Asian 17.2%, $n = 86$; black 6.4%, $n = 32$; and Hispanic 6.4%, $n = 17$), Christian (46.1%, $n = 231$; atheist 13.4%, $n = 67$; Hindu 12.6%, $n = 63$), educated (all were at least high school educated; 47%, $n = 239$ had bachelor degree), and balanced between females and males (Male = 51.5%, $n = 258$; Female = 48.3%, 242; other = .2%, 1).

Procedure

Participants were asked to identify a recent, intense awe experience using directions adapted from Piff et al. (2015). Specifically, the instructions read: 'Please take a few minutes to think about a particular time, fairly recently, when you felt intense awe.' After identifying their awe experience, participants were asked to write about it. The next section of the instructions read: 'Now that you have chosen a SINGLE experience of intense awe, please describe your experience in about 2 full paragraphs in the box below. While you are writing, please focus as much as possible on the experience itself, rather than what led up to it, what happened afterwards, or your interpretation of the experience. Try to be as descriptive and specific as possible.'

Measures

The Awe Experience Scale. Participants responded to 61 items about aspects of their awe experience. Participants were asked specifically to answer regarding the single awe experience they had just described in writing. Each item was rated on a 7-point scale (1 = Strongly Disagree, 2 = Moderately Disagree, 3 = Somewhat Disagree, 4 = Neutral, 5 = Somewhat Agree, 6 = Moderately Agree, 7 = Strongly Agree).

Other scales and items to establish convergent validity and to perform exploratory analyses were also included in this survey, but these responses were pooled for analysis in Study 2 and are described there.

Data analyses

Study 1 focused on exploring the factor structure of the AWE-S.

Exploratory factor analysis (EFA)

Factor solutions were generated using SAS with a Promax rotation and an Equamax pre-rotation. The oblique promax rotation method was chosen due to the assumption that factors would significantly positively correlate with one another and the equamax pre-rotation was included in order to preserve variance (Gorsuch, 1983). Parallel Analysis (PA; Horn, 1965), Minimum Average Partialing (MAP; Velicer, 1976), and Scree tests (Cattell, 1966) were used in order to estimate the number of factors and standards of stability and reliability were applied to drop error factors and arrive at an adequate factor solution.

Results

EFA was conducted. PA recommended 9 factors, MAP recommended 7 factors, and Scree Analysis suggested 9 factors. When computed, factor solutions with 8

factors or higher contained error factors due to fewer than two items loading on these factors. A 7-factor solution produced an error factor due to inadequate alpha ($\alpha = .< .7$), composed of three items. Twelve items did not load on any factors and two items loaded on multiple factors; these items were dropped. A 6-factor solution therefore provided the maximum number of stable and reliable factors.

Items were trimmed in order to reduce participant burden. A state measure that is relatively brief that can be taken quickly is desirable as the duration of the state in question may be somewhat fleeting and disturbed by the process of providing answers to a measure, so brevity is a virtue in this context and for this reason we dropped error factors rather than adding items. On the reduced item set, the top five loading items from each factor were retained. The six-factor solution was then re-computed on SAS using the same pre-rotation and rotation (hyperplane count was optimized at $K = 3$). On the reduced 30-item set, PA recommended 6 factors, MAP recommended 9 factors, and Scree analysis recommended 6 factors. The seventh factor was dropped as it contained only two items, a common criterion for dropping factors.¹

The AWE-S therefore includes 30 items total, with 5 items per factor. Each factor showed strong internal reliability. Standardized alphas were as follows: (F1) altered time perception $\alpha = .91$; (F2) self-diminishment $\alpha = .89$; (F3) connectedness $\alpha = .87$; (F4) vastness $\alpha = .85$; (F5) physical sensations $\alpha = .81$; (F6) need for accommodation $\alpha = .80$. The scale total also demonstrated strong reliability ($\alpha = .93$).

Factor loadings were good (Table 1), as all were between .4 and .8, with the exception of two items in factor 1, which were high (.86). However, the semantic diversity between these items is notable: 'I noticed time slowing' and 'I sensed things momentarily slow down.' While both items clearly refer to the concept of time dilation, the high factor loadings were likely not due to semantic factors such as similar terms or phrasing.

Subscales demonstrated some skew and kurtosis, which was expected because the prompt asked for an awe-inspiring experience, so we expected scores on awe-related items would be somewhat high. However, skewness and kurtosis indicators were within acceptable range ($> |.2|$). Means, skewness, and kurtosis are reported in Table 2.

Discussion

EFA on these items revealed six stable and reliable factors with strong internal consistency. This factor structure and reliability remained consistent after items were trimmed to ease participant burden.

Table 1. AWE-S item loadings.

Item	Factors					
	1	2	3	4	5	6
I sensed things momentarily slow down.	0.86	.	.	.	.	.
I noticed time slowing.	0.86	.	.	.	.	.
I felt my sense of time change.	0.78	.	.	.	.	.
I experienced the passage of time differently.	0.76	.	.	.	.	.
I had the sense that a moment lasted longer than usual.	0.68	.	.	.	.	.
I felt that my sense of self was diminished.	.	0.79	.	.	.	.
I felt my sense of self shrink.	.	0.76	.	.	.	.
I experienced a reduced sense of self.	.	0.76	.	.	.	.
I felt my sense of self become somehow smaller.	.	0.75	.	.	.	.
I felt small compared to everything else.	.	0.6	.	.	.	.
I had the sense of being connected to everything.	.	.	0.77	.	.	.
I felt a sense of communion with all living things.	.	.	0.73	.	.	.
I experienced a sense of oneness with all things.	.	.	0.69	.	.	.
I felt closely connected to humanity.	.	.	0.67	.	.	.
I had a sense of complete connectedness.	.	.	0.67	.	.	.
I felt that I was in the presence of something grand.	.	.	.	0.76	.	.
I experienced something greater than myself.	.	.	.	0.75	.	.
I felt in the presence of greatness.	.	.	.	0.71	.	.
I perceived something that was much larger than me.	.	.	.	0.71	.	.
I perceived vastness.	.	.	.	0.46	.	.
I felt my jaw drop.	0.79	.
I had goosebumps.	0.66	.
I gasped.	0.63	.
I had chills.	0.59	.
I felt my eyes widen.	0.53	.
I felt challenged to mentally process what I was experiencing	0.74
I found it hard to comprehend the experience in full.	0.68
I felt challenged to understand the experience.	0.62
I struggled to take in all that I was experiencing at once	0.54
I tried to understand the magnitude of what I was experiencing.	0.46

$n = 501$. Loadings less than .40 are not shown.

Study 2 – confirmatory factor analysis

In this study, we confirmed the factor structure of the AWE-S in a separate sample. We then compared the AWE-S with other measures of awe. We also explored themes, triggers, valence, and intensity, each of which has been discussed in the theoretical literature.

Methods

Participants

The methods used in Study 2 were similar to Study 1. A Qualtrics survey was distributed using M-Turk.

Table 2. Descriptive statistics for AWE-S factors in sample 1.

Factors	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
F1 Time	4.83	0.07	1.48	2.20	-0.73	0.11	0.07	0.22
F2 Self-loss	4.63	0.07	1.53	2.33	-0.56	0.11	-0.38	0.22
F3 Connectedness	5.03	0.06	1.33	1.76	-0.67	0.11	0.15	0.22
F4 Vastness	5.56	0.05	1.19	1.42	-0.97	0.11	0.87	0.22
F5 Physiological	4.85	0.06	1.36	1.86	-0.58	0.11	-0.04	0.22
F6 Accommodation	4.99	0.06	1.26	1.59	-0.62	0.11	0.05	0.22
Total AWE-S	4.98	0.05	0.10	0.10	-0.65	0.11	0.49	0.22

n = 501

Table 3. Descriptive statistics for each AWE-S factor in sample 2.

Factors	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
F1 Time	4.83	0.06	1.46	2.14	-0.71	0.10	0.15	0.19
F2 Self-loss	4.35	0.06	1.60	2.56	-0.33	0.10	-0.72	0.19
F3 Connectedness	4.99	0.06	1.43	2.04	-0.78	0.10	0.24	0.19
F4 Vastness	5.63	0.05	1.22	1.50	-1.21	0.10	1.62	0.19
F5 Physiological	5.02	0.05	1.36	1.84	-0.67	0.10	0.06	0.19
F6 Accommodation	4.76	0.06	1.40	1.95	-0.45	0.10	-0.44	0.19
Total AWE-S	4.93	0.04	0.98	0.96	-0.55	0.10	0.50	0.19

n = 636

Participant characteristics. Study participants (*N* = 636) were recruited using the same methods as in Study 1. A link to an online survey about awe on Qualtrics was posted on Amazon's Mechanical Turk. This sample had similar characteristics to those of Study 1 – Male (51%, 325; female 48.7%, 310; other .2%, 1), White (72.2%, 460; black 10.5%, 67; Asian 7.7%, 49; Hispanic 5.5%, 35), Christian (46.5, 296; none 15.9%, 101; agnostic 15.1%, 96; atheist 12.4%, 79) and otherwise similar to those in Study 1.

Procedure

In this study, we administered the same prompt for participants to write about their experiences of awe followed by the 30 items of the AWE-S that were identified in Study 1. We also administered the modified Differential Emotion Scale (mDES), the Dispositional Positive Emotion Scale (D-PES), Big Five Personality (BFAS), as well as exploratory items for other awe aspects (theme, valence, triggers).

Measures

Awe items

In Study 2, participants responded to the 30 AWE-S items about aspects of their awe experience identified in Study 1. Again, participants were asked specifically to answer regarding a single awe experience that they had just described in writing on the same 7-point Likert scale described in Study 1. Again, the overall scale showed a high internal consistency (Cronbach Alpha = .92). Each

scale also displayed a strong reliability: (F1) altered time perception $\alpha = .85$; (F2) self-diminishment $\alpha = .81$; (F3) connectedness $\alpha = .89$; (F4) vastness $\alpha = .88$; (F5) physical sensations $\alpha = .89$; (F6) need for accommodation $\alpha = .81$. Descriptive statistics for factors were similar to sample 1 (see Table 3).

The modified differential emotion scale (mDES)

We administered the mDES (Fredrickson, Tugade, Waugh, & Larkin, 2003), a scale that measures the degree to which one has felt different emotions over the past 24 hours. Each item presents three related words that signify a cluster of emotions (e.g., 'awe, wonder, astonishment' or 'serene, content, peaceful'). To establish the convergent and divergent validity of the AWE-S, we slightly modified the instructions of this scale to make it a state measure referring specifically to the awe experience participants had described in writing. We expected that the awe cluster of emotions from the mDES would correlate highest with the AWE-S. Participants were pooled from study 1 and study 2 resulting in a sample size of (*N* = 1137). This scale captures the two main clusters of the affective experience: the positive and the negative. Thus, 11 items are devoted to measuring positive emotional experiences, while 10 items assess negative emotional states. In this sample, the positive emotions subscale showed good internal consistency (Cronbach's Alpha = .87) and the negative emotions subscale also displayed high reliability (Cronbach's Alpha = .93). See scale descriptive statistics in Table 4.

Table 4. Descriptive statistics of mDES: mean, standard deviation, skewness and kurtosis.

Factors	Mean		Std. Deviation		Variance		Skewness		Kurtosis	
	Statistic	Std. Error	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error	
Amuse	2.3	0.031	1.046	1.093	0.21	0.073	-1.16	0.145		
Angry	1.31	0.022	0.736	0.541	2.371	0.073	4.642	0.145		
Ashamed	1.27	0.02	0.689	0.475	2.559	0.073	5.614	0.145		
Awe	3.59	0.021	0.703	0.494	-1.816	0.073	3.01	0.145		
Scared	1.53	0.027	0.914	0.835	1.571	0.073	1.216	0.145		
Serene	3.06	0.029	0.989	0.979	-0.75	0.073	-0.537	0.145		
Glad	3.26	0.028	0.935	0.874	-1.115	0.073	0.234	0.145		
Disgust	1.29	0.022	0.729	0.532	2.625	0.073	5.921	0.145		
Grateful	3.23	0.028	0.95	0.902	-1.021	0.073	-0.033	0.145		
Embarrassed	1.39	0.023	0.783	0.613	1.932	0.073	2.655	0.145		
Hope	3.12	0.027	0.924	0.854	-0.813	0.073	-0.256	0.145		
Hate	1.29	0.022	0.729	0.532	2.565	0.073	5.533	0.145		
Inspiration	3.24	0.027	0.917	0.841	-1.097	0.073	0.317	0.145		
Guilt	1.32	0.022	0.739	0.547	2.332	0.073	4.452	0.145		
Interest	3.27	0.025	0.84	0.705	-0.957	0.073	0.169	0.145		
Sad	1.36	0.024	0.794	0.631	2.173	0.073	3.617	0.145		
Love	2.91	0.031	1.033	1.068	-0.519	0.073	-0.925	0.145		
Content	1.34	0.023	0.771	0.594	2.14	0.073	3.381	0.145		
Proud	2.68	0.031	1.036	1.073	-0.222	0.073	-1.115	0.145		
Stress	1.67	0.029	0.988	0.976	1.209	0.073	0.119	0.145		
Tenderness	2.86	0.03	1.01	1.021	-0.473	0.073	-0.885	0.145		

$n = 1137$

Table 5. Descriptive statistics of D-PES: mean, standard deviation, skewness and kurtosis.

Factor	Mean		Std. Dev		Variance		Skewness		Kurtosis	
	Statistic	Std. Error	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error	
Awe	4.89	0.04	1.08	1.16	-0.42	0.10	-0.01	0.19		
Joy	4.62	0.05	1.25	1.56	-0.40	0.10	-0.30	0.19		
Contentment	4.84	0.06	1.42	2.03	-0.74	0.10	-0.04	0.19		
Pride	4.96	0.04	1.09	1.20	-0.57	0.10	0.42	0.19		
Love	4.63	0.05	1.24	1.54	-0.38	0.10	-0.38	0.19		
Compassion	5.47	0.04	1.12	1.25	-1.02	0.10	1.39	0.19		
Humor	4.78	0.05	1.20	1.43	-0.50	0.10	0.06	0.19		

$n = 636$

The dispositional positive emotion scale (D-PES)

We administered the D-PES (Shiota et al., 2003). The D-PES is a trait measure that includes subscales of one's tendency to experience a number of different positive emotions – awe, joy, contentedness, pride, humor – in daily life. This trait measure provides some additional convergent and divergent validity of the AWE-S, as we expected AWE-S scores would correlate with the awe subscale of the D-PES. This was administered in study 2 ($N = 636$). In this sample, Cronbach's alpha for each scale was: joy (6 items), 0.89; contentment (6 items), 0.95; pride (4 items*), 0.78; love (6 items), 0.88; compassion (5 items), 0.90; amusement (5 items), 0.83; awe (6 items), 0.82. See scale descriptive statistics in Table 5.

The big five aspect scales (BFAS)

To examine which personality factors were associated with awe experiences, we included a Big-5 measure of personality. We expected, based on previous findings, that the AWE-S would correlate with Openness to Experience. This scale was administered only with study 2 ($N = 636$).

Other awe aspects

Other items were also administered, in order to assess: theorized 'themes' that characterized participants' awe experiences (i.e., Beauty, Threat, Ability, Virtue, Supernatural), triggers of the experience (e.g., natural scenery, witnessing great skill, being in the presence of a leader, etc.), valence including positive (Scale of 1–4; $M = 3.57$, $SD = .79$), negative (Scale of 1–4; $Mean = 1.21$, $Std Dev = .67$), and a 7-point measure ranging from negative to positive ($Mean = 6.34$, $Std Dev = 1.360$), and the overall intensity (Scale of 1–5; $Mean = 4.20$, $Std Dev = .845$) of their awe experience. These were single-item measures included for exploratory purposes.

Analysis

Confirmatory factor analysis

We performed Confirmatory Factor Analysis (CFA). To test the fit of the 30-item 6-factor model for CFA, we used EQS multivariate software to compute Comparative Fit Index (CFI) and Root Mean-Square Error of Approximation (RMSEA).

Results

Confirmatory factor analysis

CFI was adequate (.905) and RMSEA was good (.054), with 90% confidence intervals of .051 and .058. In order to confirm that the six-factor solution represented the best fit, we then calculated a 1-factor solution, which showed inadequate fit: CFI = .481 and RMSEA = .125. Therefore, the 6-factor model of the AWE-S demonstrated robust and superior fit.

Inter-factor correlations. We pooled the samples from Study 1 and Study 2 and calculated inter-factor correlations. All factors showed moderate to strong positive correlations with one another (Table 6).

Initial validity

We conducted initial validation of the AWE-S by comparing it with two other scales that measure a number of emotions, including awe. We slightly modified one trait measure (mDES) to make it a state measure, and we included a trait measure (D-PES).

mDES. The mDES was included in both samples, so participant data was pooled. Importantly, each item of the mDES includes three similar emotions (e.g., the awe item included 'awe,' 'wonder,' and 'astonishment').

In terms of positive emotions, the AWE-S total was positively and significantly correlated with every positive emotion cluster (Table 7). Interestingly, the AWE-S total

was slightly more correlated with some positive emotion clusters (e.g., 'inspired, uplifted, elevated' and 'grateful, appreciative, thankful') than with the awe cluster 'awe, wonder, astonishment.' However, no other positive emotion cluster was significantly correlated with all six factors of the AWE-S, except for the awe cluster.

In terms of the mDES positive emotions, after controlling for age, gender, education, and SES, the only independent predictors of the AWE-S were 'awe, wonder, astonishment' ($\beta = .12, p < .01$), 'serene, content, peaceful' ($\beta = .09, p < .05$), 'grateful, appreciative, thankful' ($\beta = .11, p < .01$), 'inspired, uplifted, elevated' ($\beta = .09, p < .05$), 'interested, alert, curious' ($\beta = .09, p < .01$), 'love, closeness, trust' ($\beta = .13, p < .01$), and in the negative direction 'glad, happy, joyful' ($\beta = -.18, p < .01$).

However, the moderate correlation between the 'awe, wonder, astonishment' cluster and the AWE-S is likely due to a ceiling effect. The 'awe, wonder, astonishment' item of the mDES was outside of the acceptable range of skewness (.494) and kurtosis (3.01), thus accounting for the constrained variance observed. A histogram of responses to this item demonstrates its non-normal distribution (Figure 1).

In terms of negative emotions, the 'stressed, nervous, overwhelmed' and the 'scared, fearful, afraid' clusters were significantly positively correlated with the total of the AWE-S (Table 8). After controlling for age, gender, education, and SES, the only independent predictor of the AWE-S was the mDES item, 'stressed, nervous, overwhelmed' ($\beta = .15, p < .01$). This suggests that awe is a primarily positive emotion with the possible exception of feeling stressed, nervous, overwhelmed in response to the experience, and speaks to awe as a unique state of being that combines exaltation with fear/reverence (Harrison, 1975).

D-PES. We also included a trait measure of emotions that includes an item about one's dispositional tendency to experience awe. We found that the AWE-S

Table 6. Inter-factor correlations of AWE-S factors.

	1.	2.	3.	4.	5.	6.
F1. Time	-					
F2. Self-loss	.44**	-				
F3. Connection	.49**	.32**	-			
F4. Vastness	.39**	.42**	.55**	-		
F5. Physical	.43**	.31**	.35**	.43**	-	
F6. Accommodation	.44**	.47**	.26**	.38**	.41**	-

$n = 1137$; ** = $p < .001$

Table 7. Correlations of AWE-S total and factors with mDES positive emotions.

Factors	AWE-S Global score	Time	Self-loss	Connection	Vastness	Physical	Accommodation
Awe, Wonder, Astonishment	.23**	.10**	.07*	.19**	.41**	.19**	.09**
Inspired, Uplifted, Elevated	.28**	.13**	.06	.39**	.43**	.19**	.04
Serene, Content, Peaceful	.24**	.14**	.09**	.40**	.36**	.07*	.01
Grateful, Appreciative, Thankful	.28**	.16**	.03	.42**	.39**	.18**	.05
Love, Closeness, Trust	.27**	.21**	-.01	.47**	.26**	.19**	.05
Interested, Alert, Curious	.19**	.09**	.04	.13**	.26**	.17**	.14**
Hopeful, Optimistic, Encouraged	.26**	.15**	.00	.42**	.34**	.18**	.07*
Tender, Gentle, Warmhearted	.26**	.17**	.03	.45**	.28**	.16**	.05
Amused, Fun-Loving, Silly	.12**	.09**	-.02	.26**	.03	.17**	-.01
Proud, Confident, Self-assured	.15**	.13**	-.06*	.32**	.12**	.16**	-.02
Glad, Happy, Joyful	.18**	.07*	-.06*	.33**	.32**	.18**	-.05

$n = 1137$; ** = $p < .01$, * = $p < .05$

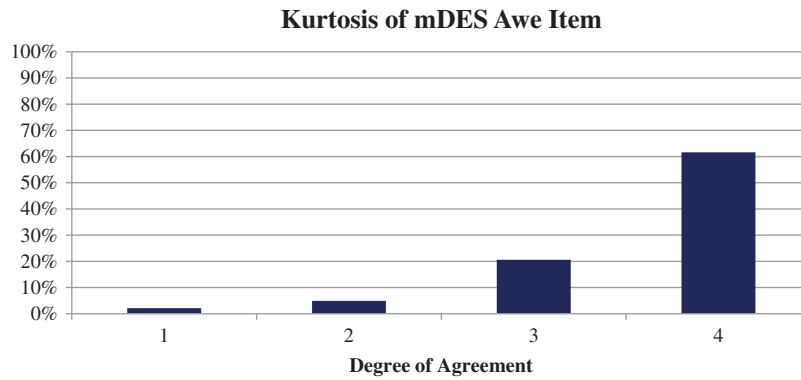


Figure 1. Skewness and Kurtosis of mDES Awe Item (N = 1137). Y-axis shows frequency of sample as a percentage and x-axis shows Likert response options for the item.

Table 8. Correlations of AWE-S total and factors with mDES negative emotions.

	AWE-S _Total	Time	Self-loss	Connection	Vastness	Physical	Accommodation
Stressed, Nervous, Overwhelmed	.13**	.15**	.13**	-.06*	-.07*	.14**	.22**
Scared, Fearful, Afraid	.07*	.01**	.12**	-.09**	-.14**	.09**	.18**
Angry, Irritated, Annoyed	.04	.08**	.14**	-.07**	-.21**	.04	.14**
Disgust, Distaste, Revulsion	.05	.08**	.15**	-.06	-.17**	.06	.12**
Sad, Downhearted, Unhappy	.04	.08**	.14**	-.08**	-.21**	.04	.16**
Ashamed, Humiliated, Disgraced	.02	.06*	.12**	-.03	-.20**	.01	.09**
Embarrassed, Self-conscious, Blushing	.05	.06*	.12**	.01	-.16**	.01	.12**
Hate, Distrust, Suspicious	.03	.06*	.12**	-.05	-.20**	.04	.10**
Contemptuous, Scornful, Disdainful	.02	.06*	.13**	-.06*	-.22**	.02	.11**
Guilty, Repentant, Blameworthy	.04	.08**	.11**	-.02	-.13**	.00	.09**

n = 1137; ** = p < .01, * = p < .05

Table 9. Correlations of D-PES with AWE-S total and factors.

Factors	Total AWE-S	F1 Time	F2 Self_loss	F3 Connection	F4 Vastness	F5 Physical	F6 Accommodation
Awe	.38**	.28**	.17**	.43**	.30**	.23**	.19**
Joy	.26**	.17**	.05	.36**	.21**	.20**	.12**
Content	.17**	.12**	-.04	.27**	.14**	.14**	.09*
Pride	.20**	.19**	-.02	.26**	.11**	.19**	.10*
Love	.17**	.09*	.00	.30**	.13**	.15**	.09*
Compassion	.31**	.18**	.14**	.32**	.32**	.23**	.10*
Humor	.15**	.12**	.06	.15**	.07	.13**	.09*

n = 636; ** = p < .01, * = p < .05

total was significantly positively related to all of the other positive emotions. The relationships between the total and each factor of the AWE-S and the awe subscale of the D-PES were stronger than for any other emotion (Table 9). In regards to AWE-S, the correlation with D-PES Awe was stronger than any of the other positive emotions.

After controlling for age, gender, education, and SES, the only independent predictors of the AWE-S total were the Awe ($\beta = .31, p < .01$) and Compassion ($\beta = .18, p < .01$) subscales of the D-PES.

Intensity. An item used to gauge how intense participants considered their awe experience to be showed significant positive correlations with the AWE-S total and for each factor (Table 10). This suggests that higher

scores on the AWE-S generally mean the experience was more subjectively intense.

Other aspects of awe

We explored the relationship between the AWE-S and several other single-item measures to investigate other theorized aspects of awe.

Valence. While participants were asked only to report a ‘recent, intense’ awe experience, awe experiences were reported as overwhelmingly positive (Figure 2).

Themes. Awe is associated with a number of themes potentially related to the experience (Keltner & Haidt, 2003), including beauty, ability, virtue, threat, and the

Table 10. Intensity of awe experience: correlations between the degree of intensity of the awe experience and AWE-S total and factors.

Factors	Intensity
AWE-S Total	0.37**
F1 Time	0.26**
F2 Self-loss	0.12**
F3 Connectedness	0.25**
F4 Vastness	0.36**
F5 Physical	0.37**
F6 Accommodation	0.25**

$n = 636$; ** = $p < .01$, * = $p < .05$

supernatural. Participants reported experiences fitting each of these categories, though beauty was the most frequent (Figure 3).

Triggers. While awe themes may relate to triggers or interpretations, we asked participants to specifically indicate what elicited their experience of awe

(Figure 4). We found, echoing the finding that beauty was the most frequent theme, that natural scenery was described as the most frequent trigger. We provided an 'other' option with the opportunity to write in a response if the desired response did not appear on our list. Notably, a number of these write-in responses referred to childbirth – future studies of awe should list childbirth as a trigger for intense awe experiences.

Big five personality. Finally, we examined the relationship between the AWE-S and Big-5 personality factors (Table 11). At the factor level, AWE-S was significantly correlated with Agreeableness, Conscientiousness, Extraversion, and Openness to Experience. The only independent predictors of AWE-S at the factor level, however, were Neuroticism ($\beta = .10$, $p < .05$), Agreeableness ($\beta = .11$, $p < .05$), and, especially, Openness/Intellect ($\beta = .18$, $p < .01$). At the aspect level, AWE-S was positively

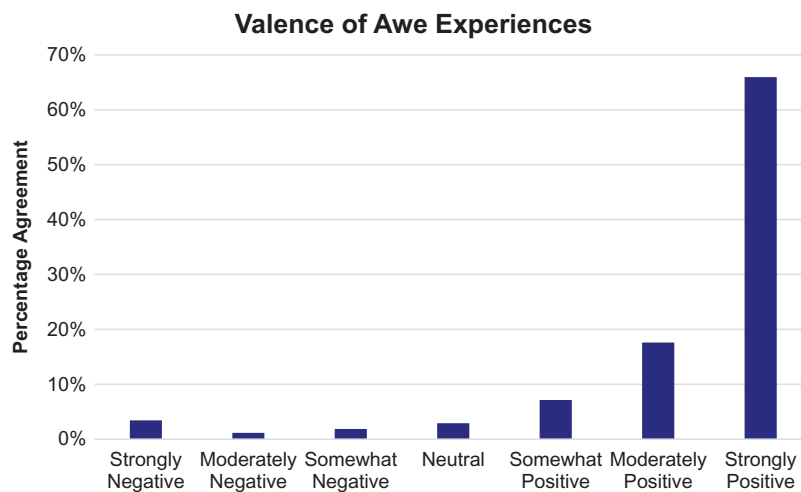


Figure 2. Valence of Awe. $n = 636$.

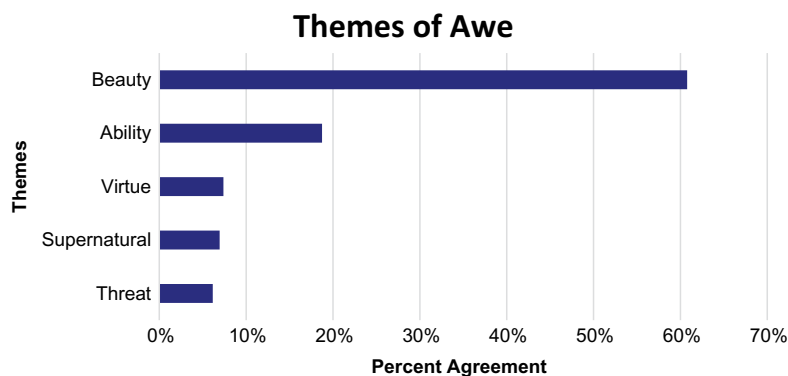


Figure 3. Themes of Awe. $n = 636$.

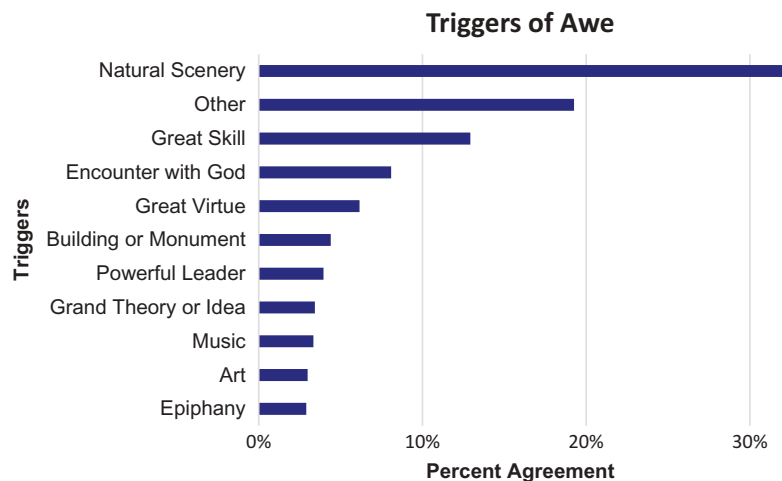


Figure 4. Triggers of Awe. $n = 636$.

correlated with compassion, politeness, industriousness, orderliness, enthusiasm, intellect, and openness, and negatively correlated with volatility. The only independent predictors of AWE-S at the aspect level were Withdrawal ($\beta = .16$, $p < .05$) and Openness ($\beta = .19$, $p < .01$).

Discussion

A 6-factor structure for the Awe Experience Scale (AWE-S), a robust state measure of awe that taps several aspects of awe identified in previous empirical and theoretical work, was revealed in two online surveys. In Study 1, Exploratory Factor Analysis (EFA) of 61 items administered to online participants ($N = 501$), revealed a 6-factor structure. Items were pruned to 30 items and EFA was recomputed. The 6-factor structure held, with good internal validity for each factor. In Study 2, the 30-item AWE-S was administered to participants ($N = 636$) using the same methods as in Study 1. Confirmatory

Factor Analysis (CFA) showed that the 6-factor model has a robust fit. In general, a 6-factor solution with high internal reliability was found through Exploratory and Confirmatory Factor Analysis.

To establish convergent, divergent, and construct validity, the AWE-S (which does not contain the word 'awe' in any of its items) was compared with the modified Differential Emotion Scale (mDES) and the Dispositional Positive Emotion Scale (D-PES). The awe item of the mDES (awe, wonder, astonishment) was significantly correlated with every factor of the AWE-S and the total, though some other clusters of emotions were more strongly related to individual factors. While the fact that the mDES involves multiple emotions per item limits the conclusions that can be drawn, it is still a good indicator that the AWE-S and the mDES awe item were significantly correlated. The D-PES is a measure of the tendency to experience a number of different emotions, but the fact that it is a trait measure also limits our interpretation. Nevertheless,

Table 11. Correlation of personality with AWE-S total and factors.

Factors	Total AWE_S	F1 Time	F2 Self_loss	F3 Connection	F4 Vastness	F5 Physical	F6 Accommodation
Neuroticism	-.05	-.06	.10*	-.09*	-.07*	-.05	-.04
Withdrawal	.01	-.02	.14**	-.06	-.01	-.02	-.03
Volatility	-.09*	-.03*	.04	-.11**	-.12**	-.07	.06
Agreeableness	.20**	.07	.08*	.20**	.33**	.16**	.05
Compassion	.22**	.12**	.08*	.23**	.32**	.16**	.05
Politeness	.15**	.01	.07	.14**	.28**	.13**	.04
Conscientiousness	.13**	.1*	.00	.12**	.14**	.16**	.05
Industriousness	.11**	.09*	-.03	.13**	.11**	.15**	.05
Orderliness	.12**	.09*	.03	.08	.12**	>.13**	.05
Extraversion	.10*	.13**	-.13**	.19**	.09*	.13**	.01
Enthusiasm	.14**	.09*	-.08	.24**	.18**	.18**	-.01
Assertiveness	.02	.12**	-.14**	.09*	-.02	.04	.02
Openness/Intellect	.24**	.18**	.08	.19**	.31**	.12**	.13**
Openness	.25**	.17**	.11**	.23**	.35**	.13**	.10*
Intellect	.16*	.15**	.02	.11**	.19**	.07	.13**

Note. $n = 636$; ** = $p < .01$, * = $p < .05$

the AWE-S and each of its factors were significantly and strongly associated with the awe subscale of the D-PES. Lastly, the AWE-S and its factors were strongly correlated with the overall intensity of the awe experience, as indicated by a single item measure of intensity. We believe the AWE-S demonstrated adequate convergent, divergent, and construct validity.

We also reported analyses of other aspects of awe. We found that spontaneous reports of awe were often overwhelmingly positive, with some (but much fewer) neutral or negatively valenced experiences of awe. In terms of themes, there was a spread of responses across beauty, virtue, skill, threat, and supernatural – but beauty was the most frequent. An item about triggers provides more specific information in this regard, showing that natural scenery was the most frequent elicitor of awe. We report correlations with aspects of personality, replicating previous findings that awe is associated with Openness to Experience (Shiota et al., 2006; Silvia et al., 2015). However, our findings extended this prior connection between awe and Openness to Experience by suggesting that awe is *uniquely* associated with a tendency toward engagement with perception, fantasy, aesthetics, and emotions (Openness) rather than cognitive engagement with abstract and semantic information, primarily through conscious reasoning (Intellect; see Kaufman et al., 2016).

In terms of the specific factors of awe in the AWE-S, the existence of the factors *perception of vastness* (F4) and the *need for accommodation* (F6), suggested some construct validity, as these are the two appraisal dimensions identified by Keltner & Haidt (2003) in their foundational article on awe. Similarly, the next two factors, *self-diminishment* (F2) and *connectedness* (F3), are well supported by the extant literature. Changes to the self from awe experiences have also been explored empirically (Piff et al., 2015) and theoretically (Yaden et al., 2017). This study provides empirical support to the theoretical claims that awe contains an aspect of self-diminishment and connectedness and that these two aspects are separable.

The factor related to *alterations to time* (F1) represents a notable shift in mental state that may indicate that awe may be somewhere between an emotion and an altered state of consciousness. The factor regarding *physical sensations* (F5) contains somewhat unusual items for a self-report emotion scale. However, we suggest that physical sensations are knowable and reportable by participants. Awe resembles some kinds of surprise, as Huron (2006) stated. Hence, much like chills are not unusual sensations to be associated with forms of musical surprise (Sloboda, 1991), one can imagine how an awe experience could elicit a similar physiological response. When we encounter something

overwhelming, able to diminish our sense of self, our body prepares to react. While bodily reactions from awe are mostly internal, Joye and Dewitte (2016) demonstrated that awe can lead to a behavioral freezing (i.e., longer time reactions) In their research paradigm, the more intense an awe experience was, the more paralyzed participants become in response to it. At the psychophysiological level, Shiota, Neufeld, Yeung, Moser, and Perea (2011) consistently found evidence of the presence of a sympathetic withdrawal during the experience of awe. Finally, awe has been shown to be associated with a sudden parasympathetic activation (Chirico et al., 2017).

Limitations and future directions

This study was limited in several ways. First, we asked participants to answer items related to an awe experience that they remembered and wrote about. While other studies have found this method worthwhile (e.g., Schurtz et al., 2012; Shiota et al., 2007), questions remain about the validity of this technique, particularly due to the constructive qualities of memory for emotion recall (Kaplan, Levine, Lench, & Safer, 2016; Levine, 1997; Levine & Safer, 2002). However, given that relatively large samples are required from EFA and CFA, this memory recall method seemed indicated. In general, this scale is intended for use immediately after an awe experience. We expect this will occur in laboratory settings through triggers such as virtual reality (Chirico, Yaden, et al., 2016) as well as videos, images, meditation, noninvasive brain stimulation, psychopharmacology, and other means.

A second limitation of this study was the sample characteristics. We drew our participants from online M-Turk samples. While M-Turk samples have been shown to be generally representative of the normal population (Berinsky, Huber, & Lenz, 2012), further studies on more diverse samples should be done to better establish external validity.

A third limitation derives from the current lack of a validated state measure of awe in the research literature that would allow us to better establish convergent and divergent validity. While we used well known scales frequently employed in awe research – the mDES and D-PES – the relatively nascent quality of this field made it difficult to establish more robust convergent and divergent validity. While the significant correlation between the state measure and an existing trait measure of awe is a promising starting point, the effect sizes of the correlations are lower than expected. A ceiling effect is likely constraining the correlation coefficient, but this should be investigated in future work.

Additionally, while there is substantial semantic diversity between factors, there is some redundancy of content in items within factors. This was due, in part, to stay true to existing attempts in the literature to tap these facets of awe. Despite some semantic redundancy, the items do diverge in their specific terminology while maintaining reliability.

In general, this measure may be most useful for those interested in inducing and measuring various aspects of awe identified in the extant literature at a more granular level. In most cases, single awe items as part of larger emotion scales will suffice to measure awe. This measure is intended for researchers interested in examining specific aspects of awe experiences.

There are several future directions in which to take this research. Further validity studies of the AWE-S are the most urgent. This scale should be tested using different methods of awe induction and in diverse sample (e.g., adolescents, children, elderly populations). The factors of the AWE-S should also undergo individual convergent and divergent validity testing. This should be done using related psychometric scales, including emotion scales as well as scales measuring intense subjective experiences such as mystical experience (Hood et al., 2001; MacLean, Leoutsakos, Johnson, & Griffiths, 2012) and other varieties of Self-Transcendent Experience (Yaden et al., 2017). Additionally, the specific self-related and connection-related processes in awe have yet to be adequately empirically elaborated and clarified. We plan to conduct qualitative analysis on the written descriptions to explore these more nuanced aspects of awe.

Keltner (2009) has previously distinguished true experiences of awe from awe-related states (e.g., admiration), by requiring the presence of both perceived vastness and the need for accommodation as components of the experience. Relatedly, it would be worth investigating which of the six factors identified through the validation of this scale most frequently occur and co-occur in awe states. In the case of the fifth factor, *physical sensations* (F5), physiological measures such as heart rate, skin conductance, and others should be used to compare self-report and physiological measures. For example, we would expect higher scores on the physiological dimension to correlate with a strong parasympathetic activation (Chirico et al., 2017; Shiota et al., 2011).

Finally, future research might explore the different types of awe that may result in different awe experience profiles. These may, for example, feature the presence or absence of various factors (e.g., feelings of self-diminishment) in different circumstances or when experiences are triggered from different stimuli (e.g.,

natural beauty), or influenced by different ‘flavoring’ themes (e.g. fear). As a result of these efforts, heretofore-unknown similarities and differences may emerge between awe and different emotions and mental states, as well as with other self-transcendent experiences such as flow, mindfulness, love, peak experiences, and mystical experiences (Yaden et al., 2017).

Conclusion

The AWE-S is a stable and reliable 6-factor state measure of the complex emotion of awe. This scale synthesizes previous research on awe and opens up new and interesting research possibilities for exploring various aspects of awe. This multi-factorial scale makes it possible to distinguish the different roles each dimension of awe plays on various subsequent outcomes. Moreover, it could be possible to induce specific awe themes to distinguish the consequences and emotional nuances of different flavors of awe. For now, this measure provides substantial breadth and depth in the measurement of the profound and often positive experience of awe.

Note

1. The two items in the dropped seventh factor merged with the sixth factor in the final solution. These two items are: ‘I had goosebumps’ and ‘I had chills.’

Disclosure statement

No potential conflict of interest was reported by the authors.

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