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When Science Journalism is Awesome: Measuring Audiences' Experiences of awe from Reading Science Stories

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ABSTRACT

In collaboration with professional science journalists, we conducted a national online survey ($N = 2,088$) to explore facets of awe as potential response states to science journalism and how audiences' dispositional science curiosity may influence these response states. Our science journalist collaborators identified several "awe-inducing" articles as well as a "business-as-usual" article to use in the survey, and we measured participants' experiences of awe using the Awe Experience Scale (AWE-S). We replicated the factor structure of the AWE-S and found that participants' generally experienced greater awe from reading the "awe-inducing" science articles compared to the "business-as-usual" one. Only partial support for the Differential Susceptibility to Media Effects model was found. Although we found that greater science curiosity predicted greater awe reactions to science journalism, science curiosity did not moderate the relationship between type of article read and experiences of awe. Together, these results demonstrate that audiences can experience awe from reading science journalism and the AWE-S is a good way to capture this emotion for media psychology research.

KEYWORDS

Awe; engagement; media effects; researcher-practitioner partnership; science curiosity; science journalism

Introduction

Awe is increasingly a focus of science communication researchers and practitioners seeking to engage science media audiences more effectively. A positive, epistemic, emotional state, awe is often described as occurring when one experiences vastness and as a result needs to accommodate new information into pre-existing mental schemas (Keltner and Haidt 2003; McPhetres 2019; Valdesolo, Shtulman, and Baron 2017). In other words, awe may elicit an awareness of what one does *not* know, thus prompting deeper information seeking or processing, and "broaden[ing] one's thoughts, actions, and awareness, leading them to explore new behaviours, and build new skills and resources" (McPhetres 2019, 1599).

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Science media often attempt to evoke awe by capturing and transporting audiences using text, visuals, and/or narratives that denote "vast" (conceptually or physically) scientific findings or discoveries (e.g., the "overview effect"; Yaden et al. 2016). Evoking a sense of awe by encountering awe-inspiring science content may be an inroad to achieving what are often seen as the strategic goals of science media—to cultivate knowledge or induce attitude or behavior change. Research has begun to explore the role of awe in the context of participants' recall of awe-inspiring experiences (Yaden et al. 2019), experiences at a science or art museum (Price et al. 2021), in virtual reality (Stepanova, Quesnel, and Riecke 2019), and in viewing science videos (McPhetres 2019).

Given the potential role of awe in engaging audiences, this study examines the extent to which audiences report experiencing awe from reading science journalism that strives to be awe-inspiring. In addition, this study leverages a collaboration with professional science journalists who want to evoke positive emotional responses from their writing with the goal of encouraging further engagement with scientific content. In this study, we first test whether five facets of the Awe Experience Scale (AWE-S), developed by Yaden et al. (2019), replicate and can be validated within our study context (i.e., reading science journalism). We then examine the degree to which specific science stories that were selected by our science journalist collaborators do or do not evoke awe in audiences along five of Yaden et al.'s (2019) facets of awe, compare degrees of self-reported awe among participants who read an awe-inspiring science story versus those who read one that is not expected to elicit awe (i.e., a "business as usual" science story), and determine whether experiences of awe vary by participants' level of science curiosity. With these studies we seek to better understand the potential to inspire awe via broadly accessible science media content.

Differential Susceptibility to Media Effects, Science Curiosity, and Awe

The current study leverages the differential susceptibility to media effects model (or DSMM; Valkenburg and Peter 2013) to understand differential awe experiences in response to reading science journalism. The DSMM describes how individuals' dispositional, developmental, and social characteristics influence the types of media they choose to engage with as well as their cognitive, emotional, and excitative reactions to that media. Fundamental to this model is the nuanced approach to media effects, recognizing that different people respond differently to the same messages.

Science Curiosity as a Dispositional Variable

Prior research suggests that science curiosity is a key *dispositional* variable that predicts whether—and to what extent—people engage with science news and science media. Scores on the science curiosity scale (i.e., SCS, Kahan et al. 2017) strongly predict, for example, how closely people follow news on scientific research or discoveries and the probability that they have read a book about scientific research in the last year (Kahan et al. 2017). Furthermore, in one study, science curiosity appeared to mitigate selective exposure; participants with greater science curiosity scores were more likely to select to read an article about climate change that conflicted with their political worldview than those with lower science curiosity scores (Kahan et al. 2017). Subsequent research

using the scale has found that participants' science curiosity scores predict their hypothetical engagement with a science news article (i.e., whether participants believe they would share, read, and/or comment on the article; Janét, Richards, and Landrum 2022) and whether people have recently watched a science or technology video on YouTube (Landrum 2021). Though dispositional science curiosity predicts *selection of* and *engagement with* science media, it is an open question whether the disposition influences cognitive, emotional, or excitative *reactions to* science media, such as experiencing awe.

Awe as a Reaction to Science Journalism

Here, we focus on awe as a multi-dimensional experience that might be elicited from engaging with science media. We chose to examine awe as our professional science journalist collaborators suppose that writing to elicit awe in a reader has the potential to increase downstream engagement with science content and the important societal issues the content tackles (e.g., climate change). Before we can determine how to write in an "awesome" way, we need to explicate this experience of awe and to determine whether we can capture participants' experiences of awe from reading science journalism. This study aims to do that.

Measuring Awe: Awe Experience Scale (AWE-S)

At its core, to experience awe is to experience something so perceptually or conceptually vast that one needs to accommodate, or adjust, their understanding to absorb the new experience (Keltner and Haidt 2003; Valdesolo, Shtulman, and Baron 2017). This latter part, the need for accommodation, may or may not be fulfilled as individuals may or may not seek out or process information following an awe experience. Successful accommodation can lead to feelings of enlightenment, whereas failures of accommodation can be terrifying (Keltner and Haidt 2003).

Perceptual vastness and need for accommodation, however, are only two facets of awe; Yaden et al. (2019) argue that there may be as many as six. Besides vastness and need for accommodation, additional facets may include alterations in time perception (e.g., time slowing), feelings of self-diminishment, feelings of connectedness to other

Table 1. Facets of Awe measured by the Yaden et al. (2019) paper.

Facet of Awe	Definition
Vastness	Vastness can refer to perceptual vastness (seeing something very large, like a mountain) or conceptual vastness (thinking about eternity).
Need for Accommodation	Needing to make changes to one's understanding to make sense of new information or a new experience.
Time Perception	Some participants have described the feeling that time moves more slowly when experiencing awe.
Self-Diminishment	Awe can reduce or diminish aspects of the self; some people, for example, report feeling small or insignificant.
Connectedness	When awe is induced, participants sometimes report feeling a greater sense of connection with other people and things around them.
Physical Sensations*	Awe can cause changes to one's physiology such as the phenomenon of goosebumps.

*Note: We did not include the physical sensations items in the current study as we had planned on measuring physical sensations with psychophysiological methods in the lab. However, this in-lab work was cancelled due to COVID-19 restrictions.

people and the environment, and physical sensations such as goosebumps (Yaden et al. 2019). See Table 1.

To measure the experience of awe along these six facets, Yaden et al. (2019) developed the Awe Experience Scale (AWE-S). To our knowledge, as of this study, the AWE-S has only been used in situations in which participants write about a time they had experienced awe (Yaden et al. 2019; Graziosi and Yaden 2021) or when they viewed video (van Houwelingen-Snippe, van Rompay, and Ben Allouch 2020). We aimed to determine whether this scale could also be used to identify whether awe is experienced (including along which facets and to what extent) from reading science news articles.

Method

This study was approved by the Institutional Review Board at Texas Tech University as exempt research involving human subjects (IRB2018-531). Participants ($N = 2,088$) were recruited by Qualtrics Research Services from multiple market research panels to match U.S. census data on gender, education, age, area of residence, and race/ethnicity. Before answering any questions, participants were provided with a digital consent form that explained the study and the participants' rights. Those who elected not to participate after reading the digital consent form were redirected to the end of the survey. Survey participants were compensated by their research panel administrators consistent with their agreements. Data collection began on January 29 and ended February 3, 2020.

Data availability. The data and materials for this study are openly available on our osf.io project page at https://osf.io/2ckgq/.

Study Design and Stimuli

To test whether the AWE-S can capture people's experiences of awe from reading science journalism, we conducted an online survey. Each participant was asked to read one of eight science stories (randomly assigned to participants) selected by our science journalist collaborators (see Article Selection Process below). The articles ranged from 800 to 1600 words, did not include any images, and were expected to take approximately three to seven minutes to read. Identified by title, the eight articles were:

1. What a Grieving Orca Tells Us (i.e., *Orca*)
2. The History of the Oceans is Locked in Whale Earwax (i.e., *Earwax*)
3. Death, Then a Search for the Kindest of Words (i.e., *Death*)
4. A Silent Invader Bursts into View (i.e., *Termites*)
5. Do We Need a Special Language to Talk to Aliens? (i.e., *Aliens*)
6. What America Lost when it Lost the Bison? (i.e., *Bison*)
7. The Terrain of Strategic Death (i.e., *Terrain*)
8. Fungus that Killed Millions of Bats Detected in California (i.e., *Fungus;* control article)

The full text for each of these stories can be found on our project page on osf.io (see data availability statement). We did not set out to test differences between each article (just the differences between the articles expected to elicit awe and the business-as-usual control article); we were merely trying to use diverse stimuli. However, we report

the results for each story for our second research aim and further analyses by story can be found on our osf.io project page. After reading the article, participants answered a series of questions about what they read (see Study Procedure and Measures below).

Article Selection Process

Prior to data collection, we asked our professional collaborators (who are members of a science news team at a public media station) to select seven articles that they felt, based on their professional judgment, elicit awe in audiences. In addition, they were asked to provide an example of a "business as usual" article—one written in the style that their news team tends to craft science journalism—to serve as a control.

Each journalist on the news team took a day to scope out science stories that they each thought would evoke a sense of awe, recognizing that "awe" may mean different things to the different team members. The team put each of their stories into a spreadsheet (available on our osf.io page) and assessed them on the following: how long it takes to read the story; what attributes of awe they felt the story induced; what narrative tools and techniques they felt the author used to achieve a sense of awe; and how profound the awe was that they felt. Then, through discussion of their story evaluations, the team selected the eight articles listed above. As the original articles varied in length (and many were quite long), our collaborators edited the articles so that they would take no longer than 10 min for our survey participants to read (while maintaining the essence of the story). The *Fungus* story serves as the control article (which reflects the news outlet's "business-as-usual" writing style), whereas the other seven stories were expected by the science journalists to elicit awe amongst audiences.

Study Procedure and Measures

After consenting to participate, participants first answered demographic questions used for sampling quotas and then completed the questions for the Science Curiosity Scale (Kahan et al. 2017). Next, participants were randomly assigned to read one of the eight articles. After reading the article, individuals were asked how closely they paid attention to the article and if they felt their time was well spent. Participants were also asked to select the Facebook reaction that most closely describes their reaction to the story (i.e., "like", "love", "haha", "wow", "sad", and "angry"). Following this, participants answered three questions from the "Self-assessment Mannikin Scale", or SAM, which has been used in prior research to capture feelings of dominance (e.g., feeling big and powerful versus small and insignificant), physical arousal (e.g., feeling calm versus anxious/excited), and emotional valence (e.g., feeling negative emotional experiences versus feeling positive emotional experiences, Bradley and Lang 1994). Next, individuals were given the measures from the Awe Experience Scale (AWE-S), followed by a "direct awe" question, which asked whether they experienced awe while reading the article. Finally, participants answered some remaining demographic questions that were not used for quota sampling including religious guidance, frequency of prayer, and voting preference. See our full survey and stimuli on our osf.io project page.

Research Aims

Our first study aim was to replicate and validate previous work. That is, we aimed (1a) to determine whether the items in the AWE-S sort into the different dimensions, or "facets"[1], of awe that are expected based on the previous work by Yaden et al. (2019). We also aimed (1b) to validate the AWE-S by examining associations of the facets of the AWE-S with a direct measurement of awe and the Self-Assessment Manikin scale items. Furthermore, we aimed (1c) to examine whether greater experiences of awe are associated with a greater likelihood of selecting the "wow" Facebook reaction. Aim 1c was requested by a few of our science news team collaborators who monitor audience engagement using social media metrics. They wanted to know whether audiences' use of the "wow" reaction would be a good indicator for summative evaluation—determining whether audiences for any specific article experienced awe.

Our second aim (2a) was to examine whether participants experienced awe from reading the stories we presented, and if so, which facets of awe were experienced and to what extent. The AWE-S provides participants with statements such as "I experienced something greater than myself" and asks participants the extent to which they agree or disagree with each statement on a 6-point scale, where strongly agree = 6, agree = 5, somewhat agree = 4, somewhat disagree = 3, disagree = 2, and strongly disagree = 1. Raw scores for each dimension of the scale are calculated by averaging participants' response values, thus they could range from 1 to 6.

However, we also examine what scores on the AWE-S reflect ***not*** experiencing awe. If people do not experience awe when reading the articles, would they generally choose "strongly disagree" for most items, leading to a low raw score (around 1 on the 1-to-6 scale)? Or, would participants who did not experience awe fluctuate between somewhat agree and somewhat disagree, leading to an indecisive, middle-of-the-road score on each dimension (between 3 and 4)? For this study, we chose to compare raw awe scores to the midpoint of the scale (3.5). Awe scores that are statistically lower than 3.5 were presumed to reflect *not* experiencing awe and scores that are statistically greater than 3.5 were presumed to reflect experiencing awe.

Furthermore, we aimed (2b) to examine *relative* experiences of awe (in contrast to demonstrating whether awe was or was not experienced, Aim 2a). We set up the study to answer our questions in this way by comparing the awe-inducing articles to the business-as-usual control one. The future goal would be to determine which of the writing styles elicit which dimensions of awe over and above the awe elicited by the business-as-usual article. However, evaluating awe in this way does not make judgments about whether awe was or was not experienced. For example, it is possible that participants will experience awe from reading the "business-as-usual" article, but it will likely be to a lesser degree than the articles expected to induce awe.

Finally, our third aim (3a) was to determine if experiences of awe were predicted by their science curiosity scores and (3b) whether the effect of condition (awe-eliciting story versus business-as-usual control story) on experience of awe was moderated by science curiosity. These aims come from considering our research questions in the context of the Differential Susceptibility to Media Effects model (Valkenburg and Peter 2013).

Results

Aim 1: Replication and Validation of Previous Work

Confirmatory Factor Analysis of 5-dimension AWE-S (Aim 1a)

We wanted to know whether this scale could be used to capture participants' experiences of awe from reading written stories. We conducted a confirmatory factor analysis and we evaluated global fit using the four fit indices recommended by Bowman and Goodboy (2020): the model χ^2 with degrees of freedom and significance test ($\chi^2 = 2088.57$, $p < .001$), standardized root mean squared residual (SRMR = 0.06), Steiger-Lind root mean square error of approximation with accompanying 90% confidence interval (RMSEA = 0.06, 90% CI [0.055, 0.060]), and Bentler comparative fit index (CFI = 0.944). These metrics indicated that the model proposed by Yaden et al. (2019) was a good fit for the data. Note that one difference between our study and the original Yaden et al. (2019) study is that we did not include the physical sensations items in our survey, thus, our model was for five facets of awe as opposed to six.

Associations Between AWE-S Dimensions and Other Variables (Aim 1b)

All five facets of the AWE-S were positively and significantly associated with the question directly asking participants if they experienced awe (i.e., "direct awe" item). The facets of connectedness (r = 0.68) and vastness (r = 0.72) were the facets most strongly associated with the item. Connectedness and vastness were also the facets of awe most strongly associated with the SAM arousal item and the SAM valence (happy) item. These two facets were also highly correlated with one another (r = 0.82). We expected that the self-diminishment facet of awe would be inversely related to the SAM dominance item, which asks people how the story makes them feel on a scale from small and insignificant (1) to big and powerful (5). Yet, the association was not significant. Feeling dominant (SAM) was negatively associated, however, with most of the other variables including the direct awe item and the AWE-S facets of connectedness, vastness, and time slowing. See Table 2.

Associations Between AWE-S Dimensions and Choosing the "Wow" Reaction (Aim 1c)

We also examined whether greater experiences of awe would be associated with a greater likelihood that participants' select the "wow" reaction in response to the story. Again, this was a request by our professional collaborators who wondered whether they could interpret audiences' use of the reaction as an experience of awe when examining social media metrics. Across all the stories, most participants (n = 809, 40%) chose the wow reaction over the other reactions ("like" – 20%, "love" – 6%, "haha" – 3%, "sad" – 26%, and "mad" – 5%). However, the probability of choosing the "wow" reaction decreased along each of the dimensions of awe (except for need for accommodation). The probability of choosing the "wow" reaction:

- Decreased by 17% with each unit increase in self-diminishment ($b = -0.19$, $\exp(b) = 0.83$, $p < .001$) and with each unit increase in the perception of time slowing ($b = -0.12$, $\exp(b) = 0.83$, $p < .001$);

Table 2. Correlations among study variables. Statistical significance is indicated using asterisks.

	1	2	3	4	5	6	7	8	9
1. Direct Awe	1.00	0.35***	0.14***	−0.23***	0.34***	0.68***	0.43***	0.45***	0.72***
2. SAM Aroused	0.35***	1.00	0.01^{ns}	−0.21***	0.14***	0.34***	0.24***	0.23***	0.34***
3. SAM Happy	0.14***	0.01^{ns}	1.00	−0.34***	0.07**	0.16***	−0.03^{ns}	0.08***	0.15***
4. SAM Dominance	−0.23***	−0.21***	−0.34***	1.00	−0.02^{ns}	−0.27***	0.01^{ns}	−0.15***	−0.19***
5. Accommodation	0.34***	0.14***	0.07**	−0.02^{ns}	1.00	0.44***	0.58***	0.54***	0.49***
6. Connectedness	0.68***	0.34***	0.16***	−0.27***	0.44***	1.00	0.59***	0.66***	0.82***
7. Self-Diminishment	0.43***	0.24***	−0.03^{ns}	0.01^{ns}	0.58***	0.59***	1.00	0.69***	0.64***
8. Time Slowing	0.45***	0.23***	0.08***	−0.15***	0.54***	0.66***	0.69***	1.00	0.65***
9. Vastness	0.72***	0.34***	0.15***	−0.19***	0.49***	0.82***	0.64***	0.65***	1.00

Note: ***$p < .001$, **$p < .01$, * $p < .05$

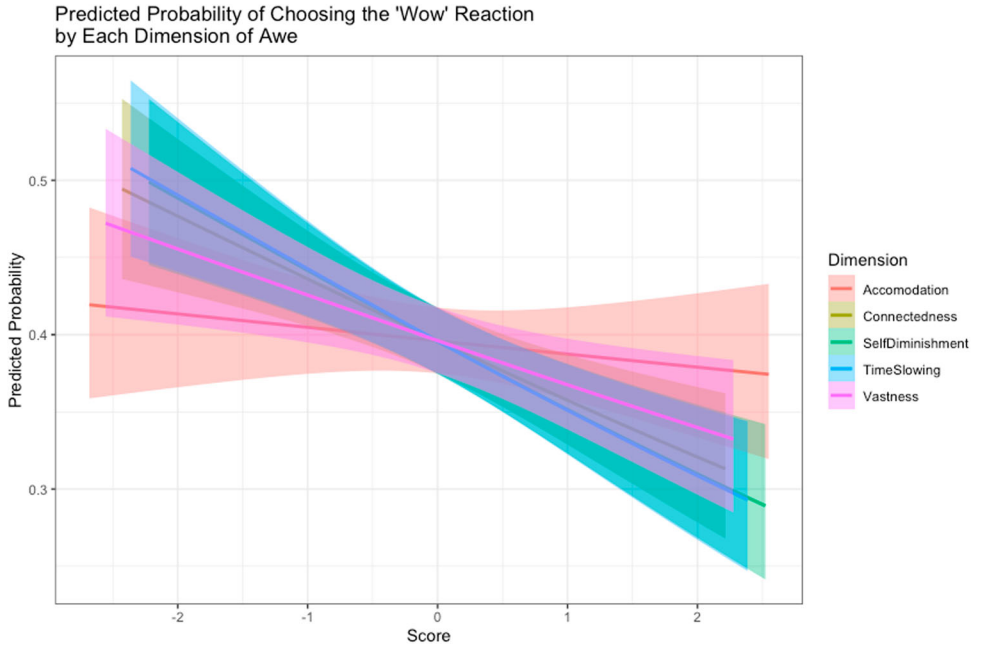

Figure 1. The predicted probability of choosing the "wow" Facebook reaction by each dimension of awe. For each of the dimensions, except accommodation, the probability of choosing the "wow" reaction drops as experiences of awe along that dimension increase.

- Decreased by 15% with each unit increase in connectedness ($b = -0.16$, $\exp(b) = 0.85$, $p < .001$);
- Decreased by 11.4% with each unit increase in vastness ($b = -0.12$, $\exp(b) = 0.89$, $p = .008$); and
- Did not significantly increase or decrease with each unit increase in need for accommodation ($b = -0.04$, $\exp(b) = 0.97$, $p = .430$).

See Figure 1. In a similar vein, the probability of choosing the "wow" reaction also decreased along participants' ratings for the direct awe item ($b = -0.08$, $\exp(b) = 0.92$, $p = .018$). Thus, participants' selection of the "wow" reaction does not appear to be a strong (or useful) indicator that audiences are experiencing awe.

Aim 2: Determine Whether Participants Experience awe from Reading the Stories

To What Extent Was Each Dimension of Awe Experienced (Aim 2a)

Our second aim was to determine whether, and if so, to what extent participants experienced awe when reading the stories. To examine this, we used Wilcoxon signed rank tests, comparing the median value of each facet of awe for each story to the midpoint of the scale (3.5, which we expected to indicate indifference). We hypothesized that the stories expected to elicit awe would have ratings *greater* than the midpoint on each dimension of awe whereas the business-as-usual control

(*Fungus* story) would be at the midpoint or below. These results are summarized in Table 3.

Participants appeared to experience need for accommodation after reading each of the awe stories, whereas those who read the business-as-usual story were at the midpoint on this dimension. Participants also appeared to experience vastness for most of the awe stories (except the *Termites* story), whereas people who read the business-as-usual story were at the midpoint on this dimension. Experiences of connectedness were more varied. Participants who read the *Orca*, *Earwax*, *Death*, and *Bison* stories experienced connectedness greater than the midpoint; however, participants who read the business-as-usual *Fungus* story, *Termites*, *Aliens*, and *Terrain* did not experience connectedness greater (or lower) than the midpoint. Notably, participants did not experience self-diminishment for any of the stories; those who read the *Fungus*, *Earwax*, *Termites*, *Aliens*, and *Terrain* story on average rated this dimension below the midpoint and those who read *Orca*, *Death*, and *Bison* were at the midpoint.

Comparing Experiences of Awe Between the Stories Expected to Elicit Awe and the Business-as-usual Control (Aim 2b)

We also aimed to capture potential differences in experiences of awe between the stories expected to elicit awe and the business-as-usual control. As one measure of this, we conducted one-way ANOVAs (with pairwise comparisons corrected with Tukey HSD) predicting each of the dimensions of awe by story condition. We specifically aimed to compare the stories expected to elicit awe to the business-as-usual control story. These results are displayed in Table 3 (see the table note). Only for the facet of vastness do most of the awe stories differ significantly from the business-as-usual control. However, collapsed across the awe stories, which we do for Aim 3, the stories expected to elicit awe are rated higher along each facet of awe than the business-as-usual story (see Table 4). This analysis is described in more detail below.

Aim 3: Examine Differential Experiences of Awe based on Science Curiosity

Our final aim was to examine whether the experiences of awe varied based on participants' science curiosity. From the DSMM, we first hypothesized that science curiosity would be positively associated with experiences of awe and, second, that science curiosity would *moderate* the relationship between being exposed to an awe-evoking story (versus the business-as-usual story) and participants' experiences of each dimension of awe. For this analysis, we conducted generalized linear models predicting each dimension of awe from condition (awe-eliciting story versus business-as-usual story), science curiosity score, and the interaction between the two. Supporting our first hypothesis, science curiosity positively predicted awe scores: people who were more science curious rated their experiences of awe higher on each of the facets of awe. Furthermore, participants who were randomly assigned to read one of the awe-eliciting stories reported greater experiences of awe along each of the facets compared to those assigned to read the business-as-usual story. Notably, tests of relative importance using the lmg metric (which partitions R^2 by averaging over the possible orders using sequential sums of squares), suggests that science curiosity is a stronger predictor of experiencing awe than the condition assignment (See Table 4 and Figure 2).

Table 3. Descriptives for the awe dimensions for each story. We also report whether each median value was greater, less than, or no different than the midpoint of the scale (3.5).

	Fungus	Orca	Earwax	Death	Termites	Aliens	Bison	Terrain
Accommodation								
Mean	3.54	3.78	3.60	3.68	3.72	3.94[c]	3.76	3.97[c]
SD	1.02	1.00	1.03	0.98	1.06	1.01	1.03	1.00
Median	3.60	3.80	3.60	3.80	3.80	4.00	3.80	4.00
diff 3.5	No	Greater	Greater	Greater	Greater	Greater	Greater	Greater
Connectedness								
Mean	3.56	3.99[c]	3.78	4.05[c]	3.47	3.57	3.87[a]	3.60
SD	1.23	1.03	1.19	1.02	1.20	1.18	1.12	1.27
Median	3.60	4.00	4.00[a]	4.00	3.40	3.70	4.00	3.80
diff 3.5	No	Greater	Greater	Greater	No	No	Greater	No
Self-Diminishment								
Mean	3.11	3.55[c]	3.19	3.48[b]	3.21	3.16	3.37	3.32
SD	1.19	1.13	1.14	1.14	1.15	1.13	1.10	1.17
Median	3.20	3.60	3.20	3.60	3.20	3.10	3.40	3.20
diff 3.5	Less	No	Less	No	Less	Less	No	Less
Time Slowing								
Mean	3.30	3.62[a]	3.43	3.77[c]	3.35	3.41	3.59	3.67[b]
SD	1.29	1.17	1.10	1.05	1.15	1.12	1.12	1.16
Median	3.40	3.60	3.40	4.00	3.40	3.40	3.60	3.74[b]
diff 3.5	Less	Greater	No	Greater	No	No	No	Greater
Vastness								
Mean	3.45	3.96[c]	3.89[c]	3.91[c]	3.61	3.83[b]	4.08[c]	3.66[c]
SD	1.19	1.07	1.22	1.02	1.08	1.14	1.04	1.22
Median	3.40	4.00	4.00	4.00	3.60	4.00	4.20	3.80
diff 3.5	No	Greater	Greater	Greater	No	Greater	Greater	Greater

Note: We used one-sample Wilcoxon signed rank tests to evaluate differences between the median value and the midpoint of the scale (3.5) as data is not expected to be normally distributed. Statistical differences from the "business-as-usual" Fungus article for each dimension were obtained using pairwise comparisons corrected with Tukey HSD for 28 comparisons: [a]$p < .05$, [b]$p < .01$, [c]$p < .001$, and are displayed next to the means.

Table 4. Estimated coefficients from the model and lmg values indicating relative importance by showing the average percent of variance accounted for across all possible orders of the variables.

		Accommodation	Connectedness	Self-Diminishment	Time Slowing	Vastness
Story Condition	*b*	0.24***	0.21**	0.22**	0.26***	0.41***
	lmg	0.58%	0.34%	0.38%	0.51%	1.41%
Science Curiosity	*b*	0.21**	0.58***	0.34***	0.51***	0.50***
	lmg	2.00%	11.88%	4.24%	7.70%	9.42%
Story X Science Curiosity	*b*	−0.06	−0.15^{t}	−0.08	−0.17*	−0.12
	lmg	0.03%	0.14%	0.04%	0.18%	0.10%

Note: ***$p < .001$, **$p < .01$, *$p < .05$, $^{t}p < .10$

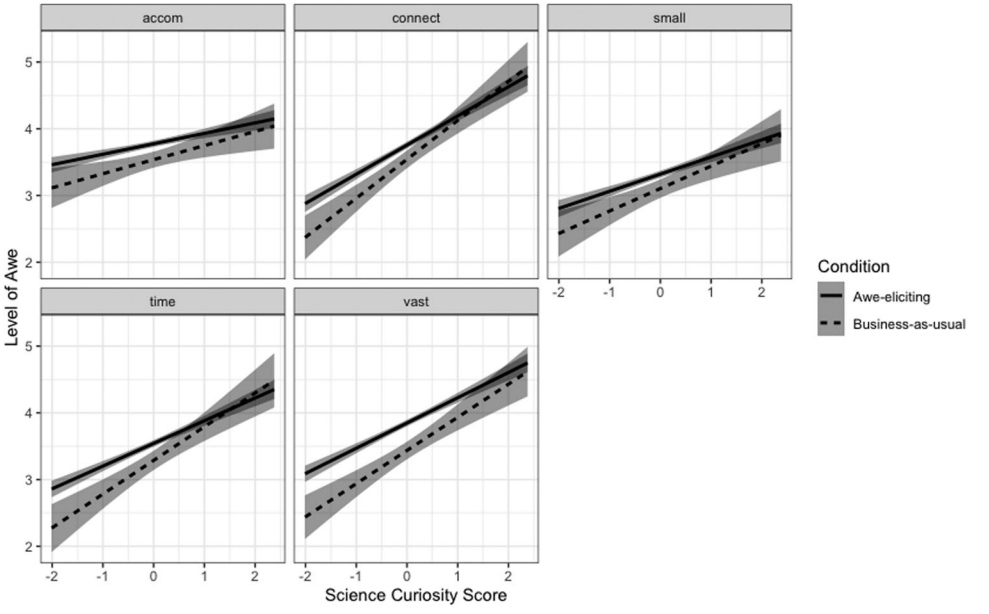

Figure 2. The relationship between science curiosity and story condition on experiences of each facet of awe. The interaction between science curiosity and story condition is significant only for the time slowing facet of awe.

We did not, however, find support for our second hypothesis based on the DSMM that science curiosity would moderate the relationship between condition assignment and experience of awe (Aim 3b). We found only one facet of awe (time slowing) where this interaction was significant.

Discussion

This study set out to examine whether participants experienced awe from reading science stories, and if so, which dimensions of awe were experienced and to what extent. Specifically, we tested whether the AWE-S replicates in the context of participants reading science journalism (stories considered "awe inspiring" by our science journalist collaborators and one "business-as-usual" science story), how the facets of the AWE-S correlate with giving a Facebook "wow" reaction to the randomly assigned article, and which

dimensions of awe were reported from reading the story assigned. Additionally, we examine whether awe is predicted by participants' science curiosity and whether the effect of reading an awe-inducing story (versus a business-as-usual one) on ratings along the facets of awe is moderated by the disposition of science curiosity (which would be consistent with the DSMM, Valkenburg and Peter 2013). Generally, we found that the facets from the AWE-S correlate with a direct question asking participants whether they experienced awe, but that the "wow" reaction may not be a strong indicator of awe. Additionally, we found that high science curiosity significantly predicted experiencing awe from reading the science story, but it did not consistently moderate the relationship between condition—i.e., which story the participants were randomly assigned to read—and their experiences of awe.

Connectedness and Vastness are the Facets Most Strongly Associated with Awe

The original AWE-S developed by Yaden et al. (2019) has six facets, five of which were examined in this study. All five facets of awe were significantly and positively associated with the direct awe item. The two facets with the strongest relationship with the direct awe item were connectedness and vastness. This is notable as definitions of awe vary in which facets they reference, and experiencing awe may mean different things to different people. For our participants, their conceptions of awe seemed most closely linked with connectedness and vastness[2], though, Graziosi and Yaden (2021) state that the two definitional features of awe are vastness and accommodation (pg. 263). It is also possible that to experience awe is to engage in a process in which the different facets occur in a chain. As McPhetres (2019) suggests, perceptions of vastness may precede need for accommodation as participants become aware of what they don't know (i.e., "knowledge gaps") and, thus, seek out experiences or learning opportunities (i.e., go to a science museum). Future research ought to consider whether the different facets of awe co-occur in one's experience or whether they make up different components of a process.

The "Wow" Reaction is Not a Good Indicator that Participants Experienced Awe

Recent news stories about Facebook have explained that, starting in 2017, the new reactions were given five times the weight of the original "like" (thumbs up) reaction (Merrill and Oremus 2021). The "wow" reaction has been explained in a variety of different ways including shock or surprise (Moreau 2021), impressed (Betters 2016), and even disdain and skepticism (Dewey 2016). Some marketers assumed that the wow reaction means "awe" or "mindblown" ("How to use Facebook", n.d.). Indeed, findings from qualitative academic research suggests that such "paralinguistic digital affordances" carry different meanings for different users and across different platforms (e.g., Hayes, Carr, and Whon 2016). Our professional collaborators were curious whether they could interpret readers' choosing of the "wow" reaction as an indicator that those readers experienced awe when evaluating the impact of their journalism using social media metrics. Although most participants chose the "wow" reaction most frequently (over the other five options), participants' likelihood of choosing that reaction decreased as their experiences of awe increased. This was true even for the direct rating of awe. Therefore, journalists and

audience analysts ought to think twice before using the "wow" reaction as an indicator that participants experienced awe. Future research can continue to consider ways in which science journalists and audience analyst teams can use accessible metrics (like paralinguistic digital affordances) to better understand their audiences' reactions to content.

Being Science Curious is Positively Associated with Experiencing Greater Awe

Though condition manipulation (stories expected to elicit awe versus stories written in the "business-as-usual" format) did predict experiencing awe, the stronger predictor was participants' science curiosity. This may not be too surprising; science curiosity, as it was measured in this study, is the disposition to seek science media for one's own personal enjoyment (Kahan et al. 2017). Perhaps science curiosity influences awe, which in turn influences seeking out science media; it is possible that science curious individuals are more motivated to seek out science media because they have stronger emotional reactions to it. One study that measured *dispositional* awe (as opposed to experiencing the *state* of awe), found a positive association between awe (which they characterize as an epistemic emotion) and people's self-rated curiosity (Anderson et al. 2020). The authors suggest that awe may influence curiosity which in turn may influence academic outcomes such as self-efficacy, behavioral engagement, and work ethic (Anderson et al. 2020). Other researchers separate perceived knowledge gaps and need for accommodation from the experience of awe and hypothesize that curiosity occurs when one perceives gaps in their own knowledge, whereas awe occurs when one feels a need for accommodation (when new information cannot simply be assimilated) that emerges from that perceived knowledge gap (Valdesolo, Shtulman, and Baron 2017). Future research could aim to disentangle the relationship between awe and (science) curiosity.

Limitations

This study, like many others, is not without its limitations. For one, we only examined five of the six facets of awe because we had intended to follow-up with a psychophysiological study that would have captured actual physical responses to media (as opposed to self-reported ones). However, our ability to conduct in-lab research was thwarted by COVID-19 pandemic precautions. Future studies ought to examine psychophysiological correlates with experiencing awe as such measurements would capture real time data during media consumption as opposed to asking participants to reflect on their experiences after the fact.

Furthermore, it is highly likely that experiences of awe are dependent on the stimuli selected. First, it was not guaranteed that what the science journalists found to be awe-inducing would be awe-inducing in a general population. Afterall, what was awe-inspiring to one of the science journalists on our project team was not necessarily awe-inspiring to another science journalist on the team. Yet, science journalists are likely to draw upon their own intuition of what is awe-inspiring when they aim to write in a way to evoke this emotion in their role as knowledge broker and translator of scientific information for lay audiences (Gesualdo, Weber, and Yanovitzky 2020). Our study took

what science journalists found awe-inspiring and measured whether these stories did inspire awe (along those five dimensions proposed by Yaden et al. 2019) among general audiences.

Second, while our science journalist collaborators aimed to select a variety of stories that they expected would elicit awe from readers, we still were only able to use seven example stories.[3] Anecdotally, the stories that appeared to elicit the greatest "awe" scores overall were the ones that were sad (e.g., *Orca*, *Death*, *Bison*). In some ways, this is surprising given that all but one of the dimensions of awe[4] were associated with having a more positive reaction to the story (positive emotional valence, SAM item). However, awe has been described as a complex emotion with both positive and negative affective components (Arcangeli et al. 2020). It is possible that there are more uplifting stories that may also elicit awe in audiences, and it is possible that they may vary from the sad ones. Future research could investigate this.

Third, in retrospect, we also believe it would have been useful to use multiple examples of business-as-usual stories as we had multiple examples of awe-eliciting ones. It is not that we didn't think of this at the time, we were restricted in the number of participants that we could pay, and our science journalists collaborators felt that there was more diversity in the types of stories that elicit awe than the ones that would not.

Conclusions and Implications for Practice

This study examined how (and for whom) the emotion of awe is experienced when reading science stories. Journalists, including science journalists, often aim to elicit emotional responses in their audiences, encouraging them to think more deeply about their world and their place in it (Lünenborg and Maier 2018), which could foster greater public engagement with science. This makes it worthwhile to investigate the conditions in which the "knowledge emotion" of awe is experienced. These findings have implications for science journalism and how awe is studied as an effect of mediated communications. For one, we find that the AWE-S formulated by Yaden et al. (2019) replicates in the context of written science journalism and can be used in future research about awe responses for other types of science media/journalism. However, the "wow" Facebook reaction may not be a good indicator of audiences' awe when reading a science story, so newsrooms monitoring social media analytics should be cautious about relying on it or other reactions (likely due to audiences' different interpretations of paralinguistic digital affordances like social media reaction icons and emoji). Finally, our finding that science curiosity is a strong predictor of awe in our study has implications for how science media can elicit positive emotions.

These findings are just the first step into investigating the potential role of awe in science journalism and identifying important implications for the practice. Future research will aim to pinpoint specific characteristics or features of science journalism that trigger dimensions of awe and will investigate whether desired media effects (e.g., engagement, learning, persuasion) are more common for articles that inspire awe (and along what dimensions). Though research is still ongoing, science journalism offers a promising platform for cultivating awe (and science curiosity) in public audiences.

Notes

1. We use the term "facets" as this was the term used in the Yaden et al. (2019) article.
2. Notably, a recent study that referenced the AWE-S (Yaden et al. 2019) only used the dimensions of connectedness and vastness to measure awe (van Houwelingen-Snippe, van Rompay, and Ben Allouch 2020).
3. We also should have asked whether audiences had seen the stories before, as they all were previously published. Though, we were not too concerned with this as the readership for the original articles was relatively limited.
4. The self-diminishment facet of awe was not significantly associated with the SAM valence item.

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