

Emotion

Awe and Scientific Explanation

Piercarlo Valdesolo, Jun Park, and Sara Gottlieb

Online First Publication, August 15, 2016. <http://dx.doi.org/10.1037/emo0000213>

CITATION

Valdesolo, P., Park, J., & Gottlieb, S. (2016, August 15). Awe and Scientific Explanation. *Emotion*. Advance online publication. <http://dx.doi.org/10.1037/emo0000213>

BRIEF REPORT

Awe and Scientific Explanation

Piercarlo Valdesolo
Claremont McKenna CollegeJun Park
Yale UniversitySara Gottlieb
University of California, Berkeley

Past research has established a relationship between awe and explanatory frameworks, such as religion. We extend this work, showing (a) the effects of awe on a separate source of explanation: attitudes toward science, and (b) how the effects of awe on attitudes toward scientific explanations depend on individual differences in theism. Across 3 studies, we find consistent support that awe decreases the perceived explanatory power of science for the theistic (Study 1 and 2) and mixed support that awe affects attitudes toward scientific explanations for the nontheistic (Study 3).

Keywords: awe, religion, science, explanation

Supplemental materials: <http://dx.doi.org/10.1037/emo0000213.supp>

Religious experience has been associated with awe and wonder (James, 1902/1987), and empirical work has shown that manipulations of awe can increase reported religiosity (Valdesolo & Graham, 2014) and spirituality (Van Cappellen & Saroglou, 2012). Awe involves an “immediate failure to assimilate information into existing mental structures” (Keltner & Haidt, 2003; Shiota, Keltner, & Mossman, 2007), and accompanying states of uncertainty trigger motivations for explanation and meaning-making. Religious and supernatural frameworks are one means of satisfying these motives, allowing individuals to explain environmental occurrences via the causal power of supernatural agents (Atran, 2002; Inzlicht, Tullett, & Good, 2011a, 2011b; Kay, Whitson, Gaucher, & Galinsky, 2009).

But science can also serve as a strong source of meaning and explanation (e.g., Dawkins, 1998; Sagan, 2006). Indeed, affinity for secular and supernatural explanations for the world share motivational similarities (Preston, 2011), and if awe increases the general motivation to find order and explanation, then the means through which that is achieved (e.g., belief in supernatural agents or affirming a scientific worldview) could be secondary (cf. Rutjens, van der Pligt, & van Harreveld, 2010). The present studies build from these theories to test whether awe might influence attitudes toward scientific explanations.

Some work suggests that religious and scientific explanations are in opposition, such that belief in one automatically decreases affinity for the other (Preston & Epley, 2009). On this account, if awe increases belief in supernatural forces (Valdesolo & Graham, 2014), it might correspondingly decrease affinity for science. But the relationship between awe and these ultimate explanations might be more complicated. Studies have shown the anxiety-reducing role of accepting scientific explanations, but exclusively among *secular* populations (Farias, Newheiser, Kahane, & de Toledo, 2013; Rutjens et al., 2010; Rutjens, van Harreveld, van der Pligt, Kreemers, & Noordewier, 2013), suggesting that awe-induced attraction toward scientific versus supernatural explanations might depend on existing levels of theism. Awe might preferentially drive theists toward supernatural sources of explanation and order, and nontheists preferentially toward scientific ones.

At the same time, research has shown that individuals can simultaneously endorse both natural and supernatural explanations (Evans, 2001; Evans & Lane, 2011; Legare, Evans, Rosengren, & Harris, 2012), and that even nontheists demonstrate intuitive affinities for supernatural and purpose-driven explanations (Banerjee & Bloom, 2015; Järnefelt, Canfield, & Kelemen, 2015). This suggests that the kinds of explanations awe attracts individuals toward might not be straightforwardly predicted by theism. The motives for order and meaning elicited by awe might preferentially drive theists to supernatural explanations and away from scientific ones, but nontheists might be drawn toward either supernatural or scientific explanations.

The current studies draw upon this literature to explore the effect of awe on attitudes toward science as a function of individual differences in theism. Studies 1 and 2 tested the effects of theism and manipulated awe (compared with neutral and amuse-

Piercarlo Valdesolo, Department of Psychology, Claremont McKenna College; Jun Park, School of Management, Yale University; Sara Gottlieb, Department of Psychology, University of California, Berkeley.

Correspondence concerning this article should be addressed to Piercarlo Valdesolo, Department of Psychology, Claremont McKenna College, 850 Columbia Avenue, Claremont, CA 91711. E-mail: pvaldesolo@cmc.edu

ment conditions) on attitudes toward scientific explanations. Study 3 tested the effects of theism and manipulated awe (compared with neutral condition) on attitudes toward versions of scientific theories emphasizing randomness versus order. This work would be the first to show a relationship between awe and attitudes toward scientific explanation, while also further elucidating the relationship between awe and theism.

Study 1

Study 1 tested the effect of awe and theism on a measure of *belief in science*.

A total of 158 college students (97 women, $M_{\text{age}} = 19.66$) participated in a computer-based study in return for course credit (sample size determined in advance, with a target of 50 participants per cell). Participants were randomly assigned to one of three conditions: awe, amusement, or neutral.

Procedure

Participants first answered seven questions, adapted from previous research, measuring religiosity (Shenhav, Rand, & Greene, 2012) and supernatural beliefs (Kay et al., 2009), including the target question measuring general theism (6 point scale ranging from *confident atheist* to *confident believer*). Participants then watched either a neutral nature video, an awe-inducing nature video, or an amusing nature video (both previously shown to be effective in eliciting awe and amusement, respectively; see Valdesolo & Graham, 2014, for full details). All videos were in the content domain of nature to avoid potential confounds associated with merely priming nature concepts.

Participants then answered the 10-item “belief in science” scale measuring their epistemic beliefs regarding science “as a superior, even exclusive, guide to reality, and as possessing unique and central value” (cf. Farias et al., 2013). Responses were reported on 6-point scales from 1 = “*strongly disagree*” to 6 = “*strongly agree*”; example item: “We can only rationally believe in what is scientifically provable”). Finally, participants completed an eight-item emotion manipulation check measuring a variety of emotional states on 7-point scales from 1 = “*not at all*” to 7 = “*extremely*” (see online supplemental materials for full details of methodology across all studies).

Results and Discussion

Thirty-one participants were removed from analyses. A programming error for the first 28 participants resulted in incomplete data, and an additional three participants were removed because of patterns of responding indicating low attention, leaving us with a final sample of 127.

Manipulation checks confirmed that videos influenced the intended emotions across comparison conditions (see online supplemental materials).¹ There were no differences across conditions in levels of theism ($M_{\text{awe}} = 3.38$, $SD_{\text{awe}} = 1.29$, $M_{\text{amuse}} = 3.51$, $SD_{\text{amuse}} = 1.35$, $M_{\text{Neut}} = 3.73$, $SD_{\text{neut}} = 1.3$); $F(2,124) = .763$, and theism correlated significantly with reported belief in science across all experimental conditions, $r(127) = -.46$, $p < .001$. Furthermore, theism did not moderate the effect of condition on reported awe ($p = .736$). These patterns held across all studies.

Responses on the scale of belief in science were averaged to form the *belief in science* index ($\alpha = .873$), and responses did not vary by experimental condition ($M_{\text{awe}} = 3.56$, $SD_{\text{awe}} = 1.13$; $M_{\text{amuse}} = 3.65$, $SD_{\text{amuse}} = .88$; $M_{\text{Neut}} = 3.65$, $SD_{\text{neut}} = .79$; $F = .126$). Of primary interest, we conducted a Condition \times Theism multiple regression predicting participants’ belief in science scores. Theism ratings were mean-centered as recommended by Aiken, West, and Reno (1991) and entered in Step 1 along with emotion condition (neutral, amusement, and awe) contrast coded as -1 , -1 , and 2 , respectively. In Step 2, we entered the interaction term Condition \times Theism. There was no main effect of condition ($b = -.057$, $\beta = -.085$, $p = .29$), but there was a significant main effect of theism ($b = -.332$, $\beta = -.467$, $p < .001$). As predicted, we found a significant interaction ($b = -.116$, $\beta = -.224$, $p = .005$, 95% confidence interval [CI] = $[-.196, -.037]$) suggesting that theism moderates the effect of condition on attitudes toward science. Effect size attributable to the addition of the interaction: Cohen’s $f^2 = .053$. Examining simple slopes at ± 1 SD from the mean revealed that theists showed lower belief in science in the awe condition compared with amusement and control conditions, $b = -.221$, $\beta = -.329$, $p = .005$, 95% CI = $[-.373, -.069]$, whereas emotion condition had no effect on nontheists. In sum, awe decreased belief in science for theists, but did not affect attitudes toward science for nontheists.

These data support the possibility of an automatic opposition between scientific and religious explanations for theists. However, data for nontheists fit with research showing the coexistence of scientific and supernatural explanations (Jarnefelt et al., 2015). In short, nontheists might not show a preference for scientific explanations after awe because they also seem to be intuitively inclined toward supernatural and purpose driven explanations. However, this null effect might be because of the dependent variable. The belief in science measure may best capture epistemic evaluations of scientific truth (e.g., “Science provides us with a better understanding of the universe than does religion”) as opposed to the ability of science to provide explanation and order. Past studies have shown how nontheists’ motives for understanding and meaning lead to unique effects on endorsement of scientific theories framed as orderly and predictable as opposed to random and unpredictable (Rutjens et al., 2010, 2013). Awe might influence nontheists’ valuations of science but only when it is explicitly perceived to provide explanatory order. To test this possibility, we replicated our study, replacing the measure of belief in science with a measure designed to more directly assess participants’ attitudes toward science as providing explanation and order to the world.

Study 2

Study 2 used an online sample from Amazon Mechanical Turk. Four hundred thirteen participants (221 women, $M_{\text{age}} = 35.6$; target sample size determined by 2.5x sample of Study 1, cf.

¹ Though other significant differences in reported emotions did emerge across conditions (consistent with previous use of these kinds of manipulations) in both this study as well as in Studies 2 and 3, none of these other states were consistently related to the experimental conditions across the studies. Furthermore, the strongest effects across all studies were consistently in reported awe.

Simonsohn, 2015) participated for \$1.00 and were randomly assigned to one of three conditions: neutral, amusement, and awe.

Procedure

The procedure was identical to Study 1 except we replaced the belief in science scale with a measure of belief in *scientific order*. Participants indicated how likely the following statements were to be true on 1–6 scales ranging from *not at all likely* to *extremely likely*: “the events that unfold in this world can be entirely explained by science,” “the principles of science provide order and predictability to the world,” and “the course of evolution follows certain paths, and is not just the result of random processes.”²

Results and Discussion

Forty-nine participants were removed from analysis because of patterns indicating low attention leaving a final sample of 364. Manipulation checks confirmed that videos influenced the intended emotions across comparison condition. Responses on two of our measures of scientific order were averaged to form the *scientific order* index ($\alpha = .69$), and responses did not vary by experimental condition ($M_{awe} = 4.09$, $SD_{awe} = 1.36$; $M_{amuse} = 4.13$, $SD_{amuse} = 1.22$; $M_{Neut} = 4.22$, $SD_{neut} = 1.19$; $F = .344$).³ An emotion Condition \times Theism multiple regression showed no main effect for condition ($b = -.017$, $\beta = -.019$, $p = .67$), a significant main effect of theism ($b = -.401$, $\beta = -.532$, $p < .001$), and replicating Study 1, a significant interaction ($b = -.055$, $\beta = -.104$, $p = .019$, 95% CI = $[-.102, -.009]$). Effect size attributable to the addition of the interaction: Cohen’s $f^2 = .011$. Theists (defined at 1 SD above the mean in theism) showed lower belief in science in the awe condition compared with amusement and control conditions, $b = -.122$, $\beta = -.109$, $p = .05$, 95% CI = $[-.218, .00]$. Simple effect for nontheists (defined at 1 SD below the mean) were not statistically significant, though were in the direction of awe increasing affinity for scientific order, $b = .084$, $\beta = .075$, $p = .18$, 95% CI = $[-.035, .186]$.

Study 3

The results of Study 1 and 2 provide support for the effect of awe on theists’ attitudes toward science, but no support for nontheists’ attitudes. Study 3 was designed as a final test of awe’s effects on attitudes toward science across levels of theism, but measuring attitudes toward scientific theories explicitly framed as either orderly or random.

Evolutionary theory emphasizes the importance of randomness in the process of natural selection, and as a result can be perceived as existentially threatening (Brem, Ranney, & Schindel, 2003). Indeed, manipulating feelings of control changes nontheists’ preferences for different variants of evolutionary theory (Rutjens et al., 2010), with preferences for versions emphasizing order (vs. randomness) increasing after feelings of lost control. We tested whether awe, compared with a neutral state, would increase preference for orderly theories of evolution across theism.

A total of 161 participants (81 women, $M_{age} = 37.5$; 80 per cell sample size determined in advance) completed an online study conducted on Amazon Mechanical Turk in exchange for \$1.00. Participants were randomly assigned to one of two conditions: awe and neutral.

Procedure

The procedure replicated Study 1 with the exception that the “belief in science” scale was replaced by a measure of participants’ preferences for orderly versus random scientific theories. This task was adapted from Rutjens et al. (2010) and was framed as a reading comprehension test in which participants would be presented with two scientific theories about which they would later need to recall information. Participants in all conditions were presented with two descriptions of evolutionary theory, one of which emphasized the necessary role of randomness and unpredictability in the theory (Theory 1), the other of which emphasized the role of order and structure (Theory 2). Participants were asked to select the theory that “provides the best framework to explain the origin of life on this planet” as well as to rate each theory on the degree to which it fit with their views on the origin of life (rated from 1 = “not at all” to 7 = “extremely”).

Results and Discussion

Twenty-four participants were removed for failing comprehension checks, leaving a final sample of 137. Manipulation checks confirmed that videos influenced the intended emotions across comparison condition. A generalized linear model predicting theory choice (Theory 1 or Theory 2) from condition, theism and their interaction revealed no main effect for condition ($b = .472$, odds ratio [OR] = 1.603, $p = .22$) but a significant main effect of theism ($b = .510$, OR = 1.665, $p < .001$), and a significant interaction $\chi^2(1,133) = 4.544$, $p = .03$. Awe increased preference for the orderly version of evolution for nontheists but had no effect on theory preference for theists. Analysis of continuous attitudes toward theories were consistent with this effect. We examined simple slopes in each condition at 1 SD above and below the mean for the theism variable. Nontheists showed higher ratings of perceived fit for Theory 2 in the awe condition compared with the control condition, ($b = 1.083$, $\beta = .332$, $p = .004$) whereas emotion condition did not affect theists’ rating (see online supplemental material for full results).

Conclusion

This work shows a relationship between awe and attitudes toward science and adds complexity to the study of how awe influences reliance on different explanatory frameworks. We found a consistent decrease in theists’ attitudes toward science and scientific order after experiencing awe (Study 1 and 2), and mixed support for our predictions regarding the effect of awe on nontheists’ scientific beliefs. While awe did not increase nontheists’

² This study also moved the measure of *supernatural control* (c.f. Valdesolo & Graham, 2014) from pre- to postmanipulation. We do not report results for these items, but the effect of emotion condition on supernatural control was significant, replicating this previous work ($p = .041$). We also included two items adapted from previous research (Laurin, Kay, & Moskovitch, 2008) meant to measure motives of compensatory control as a potential mediator of the effects of awe on attitudes towards scientific explanations. We found no effect of condition or theism on these items, and the role of this mechanism in mediating the effect of awe on explanation requires further research.

³ Responses to the item describing evolution as following certain paths were excluded from analysis because of poor reliability.

valuation of science “as a superior, even exclusive, guide to reality” (Study 1) or ratings of *scientific order* (Study 2), we did find that awe influenced preferences for a version of evolutionary theory that construes it as a predictable and orderly process (Study 3). These findings suggest that awe drives theists’ away from scientific explanations (and correspondingly toward supernatural explanation; cf. Valdesolo & Graham, 2014), but only tentatively suggests that awe drives secular individuals toward science. Indeed, it seems that awe attracts nontheists to scientific explanations to the extent that science is framed as explicitly providing order and explanation and eschewing the importance of randomness in the process (disconcerting to those interested in promoting an accurate understanding of evolution).

There is much more work to be done on this topic, particularly given the mixed results we present here. It seems clear, however, that the effect of awe on explanation is not limited to the domain of the supernatural, and that existing differences in theism matter in determining what kinds of explanations experiences of awe motivate.

References

- Aiken, L. S., West, S. G., & Reno, R. R. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park, CA: Sage.
- Atran, S. (2002). *In gods we trust: The evolutionary landscape of religion*. New York, NY: Oxford University Press.
- Banerjee, K., & Bloom, P. (2015). “Everything happens for a reason”: Children’s beliefs about purpose in life events. *Child Development, 86*, 503–518. <http://dx.doi.org/10.1111/cdev.12312>
- Brem, S. K., Ranney, M., & Schindel, J. (2003). Perceived consequences of evolution: College students perceive negative personal and social impact in evolutionary theory. *Science Education, 87*, 181–206. <http://dx.doi.org/10.1002/sce.10105>
- Dawkins, R. (1998). *Unweaving the rainbow: Science, delusion and the appetite for wonder*. Boston, MA: Houghton Mifflin.
- Evans, E. M. (2001). Cognitive and contextual factors in the emergence of diverse belief systems: Creation versus evolution. *Cognitive Psychology, 42*, 217–266. <http://dx.doi.org/10.1006/cogp.2001.0749>
- Evans, E. M., & Lane, J. D. (2011). Contradictory or complementary? Creationist and evolutionist explanations of the origin(s) of species. *Human Development, 54*, 144–159. <http://dx.doi.org/10.1159/000329130>
- Farias, M., Newheiser, A. K., Kahane, G., & de Toledo, Z. (2013). Scientific faith: Belief in science increases in the face of stress and existential anxiety. *Journal of Experimental Social Psychology, 49*, 1210–1213. <http://dx.doi.org/10.1016/j.jesp.2013.05.008>
- Inzlicht, M., Tullett, A. M., & Good, M. (2011a). The need to believe: A neuroscience account of religion as a motivated process. *Religion, Brain, & Behaviour, 1*, 192–212.
- Inzlicht, M., Tullett, A. M., & Good, M. (2011b). Existential neuroscience: A proximate explanation of religion as flexible meaning and palliative. *Religion, Brain, & Behaviour, 1*, 244–251.
- James, W. (1987). *The varieties of religious experience: A study in human nature*. New York, NY: Library of America. (Original work published 1902)
- Järnefelt, E., Canfield, C. F., & Kelemen, D. (2015). The divided mind of a disbeliever: Intuitive beliefs about nature as purposefully created among different groups of non-religious adults. *Cognition, 140*, 72–88. <http://dx.doi.org/10.1016/j.cognition.2015.02.005>
- Kay, A. C., Whitson, J. A., Gaucher, D., & Galinsky, A. D. (2009). Compensatory control achieving order through the mind, our institutions, and the heavens. *Current Directions in Psychological Science, 18*, 264–268. <http://dx.doi.org/10.1111/j.1467-8721.2009.01649.x>
- Keltner, D., & Haidt, J. (2003). Approaching awe, a moral, spiritual, and aesthetic emotion. *Cognition and Emotion, 17*, 297–314. <http://dx.doi.org/10.1080/026999303022297>
- Laurin, K., Kay, A. C., & Moscovitch, D. A. (2008). On the belief in God: Towards an understanding of the emotional substrates of compensatory control. *Journal of Experimental Social Psychology, 44*, 1559–1562. <http://dx.doi.org/10.1016/j.jesp.2008.07.007>
- Legare, C. H., Evans, E. M., Rosengren, K. S., & Harris, P. L. (2012). The coexistence of natural and supernatural explanations across cultures and development. *Child Development, 83*, 779–793. <http://dx.doi.org/10.1111/j.1467-8624.2012.01743.x>
- Preston, J. L. (2011). Religion is the opiate of the masses (but science is the methadone). *Religion, Brain & Behavior, 1*, 231–233.
- Preston, J. L., & Epley, N. (2009). Science and God: An automatic opposition between ultimate explanations. *Journal of Experimental Social Psychology, 45*, 238–241. <http://dx.doi.org/10.1016/j.jesp.2008.07.013>
- Rutjens, B. T., van der Pligt, J., & van Harreveld, F. (2010). Deus or Darwin: Randomness and belief in theories about the origin of life. *Journal of Experimental Social Psychology, 46*, 1078–1080. <http://dx.doi.org/10.1016/j.jesp.2010.07.009>
- Rutjens, B. T., van Harreveld, F., van der Pligt, J., Kreemers, L. M., & Noordewier, M. K. (2013). Steps, stages, and structure: Finding compensatory order in scientific theories. *Journal of Experimental Psychology: General, 142*, 313–318. <http://dx.doi.org/10.1037/a0028716>
- Sagan, C. (2006). *The varieties of scientific experience: A personal view of the search for God*. New York, NY: Penguin.
- Shenhav, A., Rand, D. G., & Greene, J. D. (2012). Divine intuition: Cognitive style influences belief in God. *Journal of Experimental Psychology: General, 141*, 423–428. <http://dx.doi.org/10.1037/a0025391>
- Shiota, M. N., Keltner, D., & Mossman, A. (2007). The nature of awe: Elicitors, appraisals, and effects on self-concept. *Cognition and Emotion, 21*, 944–963. <http://dx.doi.org/10.1080/02699930600923668>
- Simonsohn, U. (2015). Small telescopes: Detectability and the evaluation of replication results. *Psychological Science, 26*, 559–569. <http://dx.doi.org/10.1177/0956797614567341>
- Valdesolo, P., & Graham, J. (2014). Awe, uncertainty, and agency detection. *Psychological Science, 25*, 170–178. <http://dx.doi.org/10.1177/0956797613501884>
- Van Cappellen, P., & Saroglou, V. (2012). Awe activates religious and spiritual feelings and behavioral intentions. *Psychology of Religion and Spirituality, 4*, 223–236. <http://dx.doi.org/10.1037/a0025986>

Received May 17, 2015

Revision received May 27, 2016

Accepted June 21, 2016 ■