

Explaining the Existential: Functional Roles of Scientific and Religious Explanation

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Abstract

Questions about the origins of life and the universe seem to call out for explanation, with science and religion offering candidate answers. These answers clearly differ in content, but do they also differ in psychological function? In Study 1 (N=501) participants on Amazon Mechanical Turk rated scientific and religious answers to existential questions on dimensions related to epistemic functions (e.g., “This explanation is based on evidence”) as well as moral/social/emotional functions (e.g., “If everyone believed this, the world would be a more moral place”; “This explanation is comforting”). For non-religious participants, only scientific explanations were assigned high values along epistemic dimensions; For religious participants, only religious explanations were assigned high values along non-epistemic dimensions. In Study 2 (N=130), priming a non-epistemic need boosted religious participants’ evaluation of the quality of religious (vs. scientific) explanations. These findings shed light on the functions of scientific and religious cognition and raise new questions about explanatory co-existence and the origins of religious belief.

Keywords: explanation; science; cognitive science of religion; religiosity; epistemic needs; emotional needs; social needs

How did the universe come to exist? Why is there suffering in the world? What happens after we die? Questions like these seem to call out for explanation. Science and religion offer candidate answers, and many people endorse elements of both (Legare et al., 2012). Yet it’s not obvious what makes an answer to such questions appropriate and satisfying (e.g., Parfit, 1998). Scientific explanations with good epistemic credentials – those supported by evidence and argument – might not address the existential concern that prompts such questions in the first place. Explanations that are comforting, on the other hand, may be epistemically weak. How do people satisfy both epistemic and non-epistemic explanatory goals?

We explore the hypothesis that scientific and religious explanations are tuned to different functions, with the former oriented towards epistemic functions (e.g., tracking evidence), and the latter towards more social and emotional functions (e.g., providing comfort and community). To satisfy both epistemic and non-epistemic goals, people could endorse both scientific and religious explanations (Shtulman & Lombrozo, 2016), or imbue their favored explanation with additional characteristics: religious believers could judge religious explanations epistemically strong, and non-believers could find scientific explanations emotionally uplifting (e.g., Rutjens & Preston, in press). Below, we first review the literature on the role of scientific and religious

explanatory frameworks in fulfilling epistemic and non-epistemic functions. We then report two novel studies that investigate the perceived epistemic and non-epistemic features of scientific and religious explanations. In the General Discussion, we turn to broader implications for theories of scientific and religious cognition.

Distinct Functional Roles for Explanations

Although people often appeal to science and religion under different circumstances (see Lupfer, Tolliver, & Jackson, 1996), or use science and religion to explain different aspects of the same phenomenon (e.g., Legare, Evans, Rosengren, & Harris, 2012), existential questions, such as those concerning the origins of life or the consequences of death, often fall under the purview of both science *and* religion (see Legare & Visala, 2011 for a review).

While co-existence between scientific and religious explanations is pervasive (Legare & Visala, 2011; Shtulman & Lombrozo, 2016), prior work investigating scientific and religious explanations finds that in this region of shared explanatory space, explanations sometimes compete. For example, Preston and Epley (2008) found that highlighting the power of science in explaining the origins of the universe led to lower (implicit) valuation of religion, and that highlighting “gaps” in scientific explanations led to a more positive (implicit) valuation of religion (see also Preston, Ritter, & Hepler, 2013). These effects suggest that science and religion can sometimes satisfy the same need, such that an adequate explanation within one domain obviates the need for an alternative.

Importantly, this work on attribution and competition does not identify the specific needs that motivate a search for explanations, nor the dimensions along which explanations compete. It’s plausible that explanations serve epistemic needs (e.g., accurately representing the world), emotional needs (e.g., offering comfort), and/or social needs (e.g., supporting community), and competition occurs only when the same need is under consideration. Below, we review evidence to suggest that both scientific and religious explanations can potentially satisfy all three of these needs, but scientific explanations may be better aligned with epistemic goals, and religious explanations with social/emotional goals.

Epistemic Needs

Evidence suggests that science and religion differ in their relationship to evidence and inquiry. For example, Shtulman (2013) found that while both scientific and religious beliefs

are often justified by appeal to others (experts or texts), scientific beliefs are more often justified by appeal to evidence. Metz, Weisberg, and Weisberg (2018) report that those who endorse an evolutionary explanation for human origins (vs. creationism) are more likely to invoke scientific evidence, and less likely to invoke criteria such as what they feel in their heart. Finally, Liquin, Metz, and Lombrozo (2018) found that American adults judge science questions to be in greater need of explanation than religious questions, and are more willing to accept “it’s a mystery” as an answer to questions about religion than science.

These results suggest a closer alignment between science (vs. religion) and epistemic goals, such as tracking evidence and revising beliefs through ongoing inquiry. However, these effects could be moderated by religiosity. For instance, believers might treat considerations like what one feels in one’s heart as a *source* of evidence. Moreover, Liquin et al. (2018) found that for religious believers, the gap between ratings of need for explanation and mystery acceptability for science vs. religion was attenuated.

Emotional Needs

Both science and religion can support a psychological need for order and control. For example, Kay et al. (2008) found that threat to control contributed to an increase in belief in God when God was presented as intervening and controlling, but not when God was presented as non-intervening and working in “mysterious ways” (see also Khenfer et al., 2017). Van der Pligt and van Harreveld (2010) found that participants more often preferred the theory of intelligent design to evolution when the evolutionary account emphasized chaotic and unpredictable processes, but not when it emphasized order and predictable processes.

Under some conditions, science and religion can both also mitigate anxiety and stress. Norenzayan and Hansen (2006), for example, found that increased attention to mortality increased belief in the existence of God. Farias and colleagues (2013) found that in a relatively secular sample, increased attention to mortality increased “faith” in science.

These results, among others (see Rutjens & Preston, in press) suggest that the content of a claim, rather than its scientific or religious designation per se, determines its potential to meet emotional needs. Yet content will tend to vary systematically across domains: it may well be that religious explanations more characteristically feature elements that satisfy emotional needs, even if science – under some conditions – can do so as well.

Social Needs

On one account, natural and supernatural explanations are the outcomes of distinct learning systems: one focused on figuring out physical causal regularities and mechanisms, and another focused on learning and transmitting social norms (Whitehouse, 2011). Indeed, some evidence suggests a close link between supernatural / religious belief and social considerations. For instance, in addition to religious involvement playing a role in social integration (see for

example, Cadge & Ecklund, 2006 showing patterns of religious service attendance among immigrants), religious belief itself may serve as a catalyst for belonging to a community and signaling social commitments. For example, in recent work, Cui et al. (2019) have shown that within a religious minority group in China, the development of children’s religious beliefs closely follows the patterns observed among their parents, whereas there is no relation between children’s and parents’ beliefs among the mainstream secular group. This context-dependent pattern provides evidence for the role of religious belief as a marker, catalyst, or even “glue” for community ties and social identity, especially when observed among persecuted groups, such as religious communities within Mainland China.

The role of scientific belief as a social catalyst is more debatable. Kahan and colleagues (2017) argue that scientific beliefs can, under certain politicized circumstances, function as social signals (see also Kahan, 2012). Again, content and context seem to matter here, although it is possible that religious explanations more readily offer contents that are amenable to social needs (e.g., Wilkins, 2018).

Current Project

The goal of the current project is to systematically investigate the (perceived) functional roles of scientific and religious explanations. We focus on existential questions that support explanations from both domains (e.g., “How did the universe come to exist?”), and on explanations that are representative of those endorsed in our target population (see Stimulus Generation below).

Our studies are designed to test two predictions: (1) that on average, scientific explanations will be attributed more features linked to epistemic functions and religious explanations more features linked to non-epistemic functions, and (2) that these effects will be moderated by participant religiosity.

In Study 1, we investigated the (perceived) epistemic and non-epistemic features of religious and scientific explanations. In Study 2, we manipulated epistemic and non-epistemic need and measured the perceived quality of religious and scientific explanations.

Study 1

Method

Stimulus Generation

Participants recruited through Amazon Mechanical Turk (MTurk) were presented with one of the following questions and asked to provide a “good explanation”: “How did the universe come to exist?”, “Why is there suffering in the world?”, or “What happens after we die?”. These explanations were then presented to another group of participants who classified them as scientific, religious, neither, or both. We repeated this process until we obtained 10 explanations per question rated by 75% or more as religious and 10 rated by 75% or more as scientific, yielding a total set of 60 explanations.

Examples for the final stimuli set include the following scientific and religious explanations for the universe and suffering questions, respectively: “by the big bang, a massive explosion that created all matter in the universe. This happened many billions of years ago”; “The universe was created by God in 6 days. He created everything out of nothing by his own will. The last thing that he created was man, before he rested on the 7th day. Nothing came into existence by itself since you need life to create life”; “Because not everyone has the same access to resources. Also because some areas are more developed than others. In addition there are many unfair things about living in areas without having the financial resources to better oneself”; “Because there is free will in the world. God doesn't like suffering, but when man has free will there will be suffering”.

Participants 501 adults (320 female, 175 male, 6 non-binary, $M_{Age} = 37$ years) were recruited on MTurk. Participation was restricted to workers with an IP address within the United States and an approval rating of at least 95% based on at least 500 prior tasks. An additional 168 participants were excluded for failing preregistered attention checks (described below).

Procedure

Participants first consented to participate and pledged to pay attention and answer questions carefully. After completing a short training on how to use the response scale (which doubled as an attention check), they were randomly assigned to one of six conditions based on the corresponding question (How did the universe come to exist? Why is there suffering in the world? What happens after we die?) and domain of the explanation (Scientific, Religious), and randomly received one of the 10 explanations within the corresponding set. Each unique explanation was rated by 7-12 participants.

Rating explanations on their functional roles. Participants saw their question and the corresponding explanation at the top of the page and rated statements about it (see Table 1) from 1 (“Strongly Disagree”) to 5 (“Strongly Agree”). These statements were designed to measure attributes related to epistemic as well as non-epistemic psychological functions. Two attention checks were also included (e.g., “select the middle option”). The order of statements and attention checks was randomized.

Demographics. Before concluding the study and being debriefed, participants answered a number of demographic questions, including a 4-point measure of religiosity: (1) not religious at all, (2) slightly religious, (3) moderately religious, (4) very religious. 36%, 19%, 28%, and 16% of participants identified themselves at each level of religiosity from “not at all” to “very”, respectively. Data was not available for one participant.

Results

Exploratory Factor Analysis on Explanation Ratings

We conducted an exploratory factor analysis over the explanation rating items, using the *GPArotation* (Barnaards & Jenrich, 2005) and *psych* (Revelle, 2018) packages in R

(Core Team, 2019). To determine the number of factors, we used the Parallel Analysis method (Horn, 1965) using the *fa.parallel* function from *psych*, specifying the minimum residual approach to account for assumed correlations between components. We also inspected the scree plot, which suggested a range of 5-7 factors. Finally, we used the *fa* function from the *psych* package, specifying an oblique rotation and the minimum residual method and modeled 5- to 7-factor solutions. The 7-factor solution achieved simple structure (no item loaded on more than one dimension) and suggested good fit to the data, based on model parameters ($RMSR = 0.02$, $RMSEA = 0.04$, $Tucker\ Lewis\ Index = 0.96$, $p < 0.01$ compared to 6-factor model). Thus, we extracted 7 factors (see Table 1 for items loading on each factor). Prior to investigating the EFA patterns, we decided on eliminating items with factor loadings less than 0.4.

The resulting structure was highly interpretable, and a good match to the functional roles identified in the introduction (see Table 1). We created average composite scores for each factor (function), yielded by the EFA, based on the items that loaded on the corresponding factor. This resulted in seven average composite scores.

Table 1: Explanation rating items clustered by factor. Statements with asterisks loaded negatively and were reverse-scored in composite scores.

Statement	EFA Factor
<ul style="list-style-type: none"> ▪ This explanation is based on evidence. ▪ This explanation is based on logic ▪ This explanation is based on facts that aren't supposed to be questioned. ▪ This explanation is based on expert knowledge. ▪ this explanation offers a clear cause-and-effect mechanism or pathway 	Epistemic (Objectivity)
<ul style="list-style-type: none"> ▪ We'll never know whether this explanation is right or wrong ▪ This explanation is right for some people, but it is not the right explanation for everyone. 	Epistemic (Subjectivity)
<ul style="list-style-type: none"> ▪ This explanation tells me something important about who I am. ▪ This explanation helps me understand my true self. ▪ This explanation offers insight into my feelings and subjective experiences. 	Self & Identity
<ul style="list-style-type: none"> ▪ If everyone believed this, the world would be a more moral place. ▪ If everyone believed this, the world would be a kinder place. 	Moral (Positive)
<ul style="list-style-type: none"> ▪ If everyone believed this, there would be no accountability for people's actions. ▪ This explanation is harmful for the world. 	Moral (Negative)
<ul style="list-style-type: none"> ▪ This explanation offers peace of mind.* ▪ This explanation is comforting.* ▪ This explanation is unsettling. ▪ This explanation provokes anxiety. 	Emotional (Negative)
<ul style="list-style-type: none"> ▪ Shared belief in this explanation can foster a feeling of personal connection. ▪ Disagreeing about this explanation can threaten social bonds. ▪ This is the sort of explanation that brings people closer together. ▪ People typically learn this explanation from other. 	Social

Effects of Domain and Religiosity

To investigate whether religious and scientific explanations differed in their functional profiles (as reflected in composite function scores), we conducted linear regression models with each of the seven composite scores as the dependent variable and Domain (religious, scientific) as a predictor (see Figure 1).

Because we were additionally interested in moderating effects of religiosity, we also included individuals' level of religiosity and an interaction term (Domain x religiosity). Finally, to control for effects of Question (Universe, Suffering, Death) and Question by Domain interactions, these terms were also included in the final model, wherever significant (in the interest of space, we do not report effects of Question here).

Epistemic Considerations Controlling for a significant main effect of Question, objective epistemic considerations were rated higher for scientific explanations than for religious explanations ($B = 2.11, SE = 0.18, t = 11.42, p < 0.001$). Controlling for a significant main effect of Question, subjective epistemic considerations showed the reverse pattern ($B = -0.82, SE = 0.21, t = -3.88, p < 0.001$, respectively). These effects, however, were moderated by Religiosity. For objective epistemic considerations, less religious participants rated scientific explanations more objective than religious explanations, but more religious participants did not (Religiosity X Condition: $B = -0.57, SE = 0.07, t = -7.80, p < 0.001$; see Figure 2A).

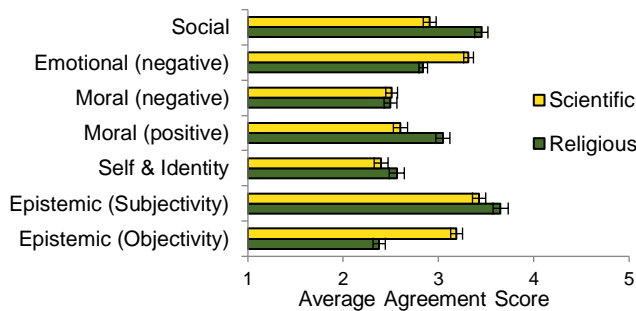


Figure 1: Mean composite score for each factor by Domain, collapsed across the three questions. Error bars indicate +/-1 SEM.

For subjective epistemic considerations, less religious participants rated religious explanations more subjective than scientific explanations, but more religious participants did not (Religiosity X Condition: $B = 0.26, SE = 0.08, t = 3.10, p < 0.01$; see Figure 2B).

Non-epistemic considerations

Self & Identity. Religious and scientific explanations differed with respect to Self & Identity ($B = 1.24, SE = 0.21, t = 6.00, p < 0.001$). This effect was also moderated by Religiosity ($B = -0.62, SE = 0.08, t = -7.50, p < 0.001$). Less religious

participants provided low ratings for both religious and scientific explanations, whereas more religious participants rated religious, but not scientific, explanations high on these functions (see Figure 2C).

Positive moral. Positive moral considerations were rated higher for religious explanations than for scientific explanations ($B = 0.79, SE = 0.22, t = 3.49, p < 0.001$), but this effect was moderated by Religiosity ($B = -0.54, SE = 0.09, t = -6.03, p < 0.001$). Less religious individuals rated both religious and scientific explanations low on positive moral functions, whereas more religious individuals rated religious, but not scientific, explanations high on these functions (see Figure 2D).

Negative moral. Controlling for a significant main effect of Question, scientific explanations were higher than religious explanations on negative moral considerations ($B = -1.25, SE = 0.22, t = -5.61, p < 0.001$), but this was moderated by Religiosity ($B = 0.57, SE = 0.09, t = -6.42, p < 0.001$). Less religious individuals provided low ratings for both types of explanation, while religious individuals rated scientific, but not religious, explanations high (see Figure 2E).

Emotional. Controlling for a significant interaction between Question and Domain, scientific explanations were rated higher on negative emotions compared to religious explanations ($B = -0.48, SE = 0.23, t = -2.12, p = 0.03$), but this effect was moderated by Religiosity ($B = 0.35, SE = 0.07, t = 4.66, p < 0.001$). Less religious individuals rated both scientific and religious explanations high, whereas more religious individuals rated religious, but not scientific, explanations low on negative emotions (see Figure 2F).

Social Considerations. Controlling for a significant interaction between Question and Domain, there was no main effect of Domain ($B = -0.26, SE = 0.18, t = -1.44, p = 0.15$) and no moderating effect of Religiosity ($B = -0.08, SE = 0.06, t = -1.32, p = 0.19$).

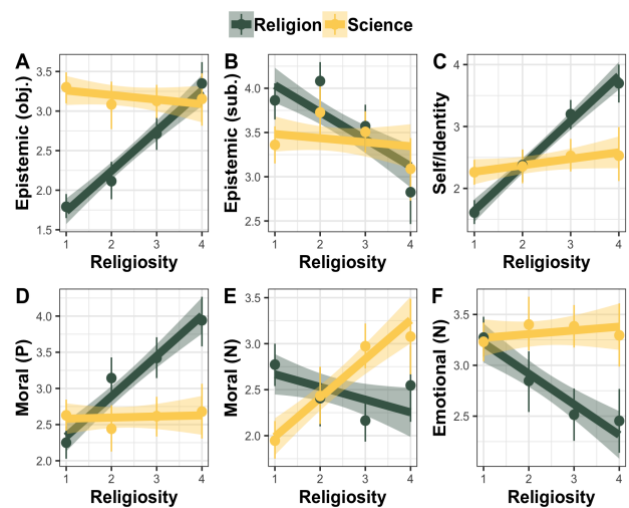


Figure 2: Moderating effects of religiosity on Domain in Study 1.

Study 2

In Study 2, we primed epistemic or non-epistemic needs and measured participants' ratings of the quality of religious and scientific explanations. Based on the findings from Study 1, we predicted that for religious participants, a non-epistemic prime would boost the perceived quality of religious (vs. scientific) explanations.

Method

Participants 133 adults (65 female, 68 male, $M_{Age} = 38$ years) were recruited on MTurk as in Study 1. An additional 30 participants were excluded for failing attention checks similar to those in Study 1.

Procedure

After an initial consent and pledge, participants were randomly assigned to the epistemic or non-epistemic condition. In both conditions, we aimed to prime a need by having participants reflect on a situation in which they tried –but failed – to solve a personal problem. To manipulate the nature of the need, participants in the epistemic prime conditions were asked to consider a problem for which they tried to take an objective stance, reason logically, and rely on evidence. To prime a non-epistemic need, we asked participants to consider a problem for which they tried to foster personal connection to others, achieve emotional comfort, and have peace of mind. Participants were then presented with a set of four scientific or religious explanations for the question of how the universe came to exist (selected from the stimulus set for Study 1) and were asked to rate how good they found each explanation, on a scale from 1 (very bad) – 7 (very good). These “goodness” ratings were introduced as “part of a different project.” Lastly, all participants completed the same *demographics* survey as in Study 1. And 48%, 16%, 23%, and 13% identified as not at all, slightly, moderately, and very religious, respectively.

Results

We conducted mixed-effects linear regression analyses, using the *nlme* package, on ratings of “goodness” with Prime (Epistemic, Non-epistemic), Domain (of explanation: science, religion), Religiosity, and all interactions as fixed effects, and Explanation as a random effect. This analysis revealed a significant three-way interaction between Religiosity, Prime, and Domain ($B = -1.17$, $SE = 0.44$, $t = -2.68$, $p < 0.01$).

To understand this interaction, we looked at effects of prime for each type of explanation separately (see Figure 3). With greater religiosity, the non-epistemic prime (relative to the epistemic prime) increased the perceived quality of religious explanations ($B = 0.77$, $SE = 0.27$, $t = 2.89$, $p < 0.01$) while it followed a declining pattern (although non-significant) in the perceived quality of scientific explanations ($B = -0.40$, $SE = 0.35$, $t = -1.14$, $p = 0.26$). Figure 3 shows these observed patterns.

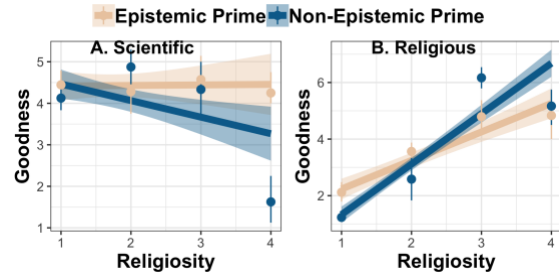


Figure 3: Moderating effects of religiosity on “goodness” ratings of (A) scientific and (B) religious explanations in each priming condition of Study 2.

Discussion

Across two studies, we find that scientific and religious explanations are differentially attributed properties that correspond with epistemic versus non-epistemic functions. In Study 1, participants who identified as religious rated both scientific and religious explanations as high on objective and low on subjective epistemic characteristics, but only religious explanations were attributed features associated with identity and self-insight, positive moral characteristics, and a reduction in negative moral and emotional implications. For participants who identified as low on religiosity, only scientific explanations were attributed high objective and low subjective epistemic features, and religious explanations were not judged more favorably along any dimensions. So, while participants at all levels of religiosity systematically differentiated the religious and scientific explanations, the basis for differentiation varied with religiosity.

In Study 2, priming a non-epistemic need (vs. an epistemic need) primarily affected the group of participants who shared a relevant demographic variable with those who recognized non-epistemic values in Study 1: namely religious participants. With greater religiosity, the non-epistemic prime increased the perceived quality of the religious (relative to the scientific) explanations. This suggests that explanatory needs are malleable, and that priming a need can result in higher evaluations of explanations that satisfy that need (cf. Preston & Epley, 2009).

In addition to documenting the role of different needs in appealing to scientific and religious explanations, these patterns inform theories about the coexistence of religious and scientific explanatory frameworks (Legare et al., 2012; Shtulman & Lombrozo, 2016). Specifically, across various cultural and social groups, children and adults have been shown to coherently appeal to both natural and supernatural conceptions of existential matters, such as death (Astuti & Harris, 2008; Gimenez & Harris, 2005) or the origins of life (Legare, Evans, Rosengren, & Harris, 2012; Evans, 2001). Why might natural or scientific and supernatural or religious explanations both make sense and provide value for the same individual, despite the two explanatory frameworks making potentially conflicting claims about how things work? Our data suggest that these different types of explanations for the same phenomena can both provide functional value because

they are primarily concerned with different aspects of inquiry. Scientific explanations satisfy the need to grasp evidential, objective, and causally coherent truths, whereas religious explanations, at least for some, provide additional value in response to needs such as relief from existential anxiety. This proposal, supported by patterns reported here, raises new questions about the *ways* in which scientific and religious explanations co-exist in individuals' minds. It is possible, for instance, that for a religious individual who believes in creationism, integrating this religious explanation with a scientific one is very likely if an epistemic need arises to reason about the origins of the universe based on objective evidence. If, however, for this same individual, the belief in creationism serves non-epistemic functions (e.g., establishes a sense of order and control), then integrating a creationist explanation with a scientific one may be less likely. That is, when scientific and religious explanations that make conflicting claims serve the same function for a given individual, they may cognitively coexist in a coherently integrated framework, whereas when they serve different functions, they may coexist in compartmentalized schemas.

Our findings also bear on accounts of the origins of religious belief. Some have posited that religion emerges in part as a response to an explanatory need (e.g., Tyler, 1871; Snow, 1922); others (Boyer, 2007) question the prevalence of explanatory drives and existential quandaries outside highly specialized circumstances. While our findings cannot speak to the prevalence with which people experience or pursue "existential curiosity," they do point to various possibilities about the relationship between explanatory needs and religiosity. The association of non-epistemic attributes with religious explanations for existential matters suggests that the reflection of our emotional, social, and moral needs in religious explanations for existential quandaries may have contributed to the cultural transmission of religious beliefs and the global pervasiveness of supernatural conceptions of life and death. Yet, it remains a question whether, in the cultural evolution of religious belief as well as within individual minds, valuing non-epistemic considerations supports religious belief or if religious belief increases the perceived explanatory value of non-epistemic considerations. Moreover, a third possibility would be that both non-epistemic considerations and religious belief are the result of one or more common early-developing abilities or cognitive constraints (see Boyer, 1994).

Our finding that more religious participants do not discriminate between scientific and religious explanations along epistemic dimensions also raises new questions about the role of evidence in navigating religious belief. How do religious participants understand the role of evidence across domains? Recent data show that what is perceived as justification or reason for belief varies based on religious belief. For instance, the beliefs of loved ones or of religious authorities, as well intuitive knowledge "of the heart," are seen by US adults who believe in creationism as being legitimate bases for belief (Metz, Weisberg, & Weisberg, 2018). Moreover, children from a particularly religious

community in China refer to the source of their beliefs about religious entities (e.g., angels) as justification for knowing that these entities exist (Davoodi et al., 2020).

Turning to our non-religious participants, we might wonder whether they place low value on non-epistemic considerations quite generally, or rather identify and value them in contexts beyond those investigated here. Given prior findings suggesting that scientific beliefs can sometimes play social/emotional roles (Kahan et al., 2017, Farias et al., 2013), it seems plausible that scientific explanations that offer a more structured and predictable world, that are used to mark identity-relevant group boundaries, or that induce a sense of awe might be perceived to have more social-emotional functions (see Johnson et al., 2019). These are important questions for future research.

In summary, the data presented here provide initial support for the proposal that scientific and religious explanations are associated with different psychological functions. Yet, specific patterns of coexistence in relation to functional roles, the conditions under which epistemic and non-epistemic functions are highlighted and served by various explanations for given individuals, and the role of these functions in the cultural transmission of belief remain to be investigated.

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References

- Astuti, R., & Harris, P. L. (2008). Understanding mortality and the life of the ancestors in rural Madagascar. *Cognitive Science*, 32, 713-740.
- Bernaards, Coen A. and Jennrich, Robert I. (2005) Gradient projection algorithms and software for arbitrary rotation criteria in factor analysis. *Educational and Psychological Measurement*, 65, 676-696.
- Boyer, P. (2007). *Religion explained: The evolutionary origins of religious thought*. Basic books.
- Boyer, P. (1994). *The naturalness of religious ideas: A cognitive theory of religion*. University of California Press.
- Cadge, W., & Ecklund, E. H. (2006). Religious service attendance among immigrants: Evidence from the New Immigrant Survey-Pilot. *American Behavioral Scientist*, 49(11), 1574-1595.
- Cui, Y. K., Clegg, J. M., Yan, E. F., Davoodi, T., Harris, P. L., & Corriveau, K. H. (2019). Religious testimony in a secular society: Belief in unobservable entities among Chinese parents and their children. *Developmental Psychology*.
- Davoodi, T., Cui, K. Y., Clegg, J. M., Yan, F. E., Payir, A., Harris, P. L., & Corriveau, K. H. (2020). Epistemic justifications for belief in the unobservable: The impact of minority status. *Cognition*.

- Davoodi, T., Jamshidi-Sianaki, M., Abedi, F., Payir, A., Cui, Y. K., Harris, P. L., & Corriveau, K. H. (2019). Beliefs About Religious and Scientific Entities Among Parents and Children in Iran. *Social Psychological and Personality Science, 10*, 847-855.
- Evans, E. M. (2001). Cognitive and contextual factors in the emergence of diverse belief systems: Creation versus evolution. *Cognitive Psychology, 42*, 217-266.
- Evans, E. M. (2008). Conceptual change and evolutionary biology: A developmental analysis. *International handbook of research on conceptual change*, 263-294.
- 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*(6), 1210-1213.
- Giménez, M., & Harris, P. (2005). Children's acceptance of conflicting testimony: The case of death. *Journal of Cognition and Culture, 5*, 143-164.
- Harris, P. L., Corriveau, K. H., Pasquini, E. S., Koenig, M., Fusaro, M., & Clément, F. (2012). Credulity and the development of selective trust in early childhood. *Foundations of metacognition*, 193-210.
- Harris, P. L., Pasquini, E. S., Duke, S., Asscher, J. J., & Pons, F. (2006). Germs and angels: The role of testimony in young children's ontology. *Developmental Science, 9*, 76-96.
- Horn, J. L. (1965). A rationale and test for the number of factors in factor analysis. *Psychometrika, 32*, 179-185.
- Johnson, K. A., Moon, J. W., Okun, M. A., Scott, M. J., O'Rourke, H. P., Hook, J. N., & Cohen, A. B. (2019). Science, God, and the cosmos: Science both erodes (via logic) and promotes (via awe) belief in God. *Journal of Experimental Social Psychology, 84*.
- Kahan, D. M. (2012). Ideology, motivated reasoning, and cognitive reflection: An experimental study. *Judgment and Decision making, 8*, 407-24.
- Kahan, D. M., Landrum, A., Carpenter, K., Helft, L., & Hall Jamieson, K. (2017). Science curiosity and political information processing. *Political Psychology, 38*, 179-199.
- Kay, A. C., Gaucher, D., Napier, J. L., Callan, M. J., & Laurin, K. (2008). God and the government: testing a compensatory control mechanism for the support of external systems. *Journal of personality and social psychology, 95*, 18-35.
- Khenfer, J., Laurin, K., Tafani, E., Roux, E., & Kay, A. C. (2017). Interventionist external agents make specific advice less demotivating. *Journal of Experimental Social Psychology, 73*, 189-196.
- 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.
- Legare, C. H., & Visala, A. (2011). Between religion and science: Integrating psychological and philosophical accounts of explanatory coexistence. *Human Development, 54*, 169-184.
- Liquin, E., Metz, S. E., & Lombrozo, T. (2018). Explanation and its limits: Mystery and the need for explanation in science and religion. *Proceedings of the 40th Annual Conference of the Cognitive Science Society*.
- Lupfer, M. B., Tolliver, D., & Jackson, M. (1996). Explaining life-altering occurrences: A test of the 'god-of-the-gaps' hypothesis. *Journal for the Scientific Study of Religion, 379*-391.
- Metz, S. E., Weisberg, D. S., & Weisberg, M. (2018). Non-Scientific Criteria for Belief Sustain Counter-Scientific Beliefs. *Cognitive Science, 42*, 1477-1503.
- Norenzayan, A., & Hansen, I. G. (2006). Belief in supernatural agents in the face of death. *Personality and Social Psychology Bulletin, 32*, 174-187.
- Parfit, D. (1998). Why anything? Why this? *The London Review of Books, 20*, 24-7.
- Preston, J., & Epley, N. (2009). Science and God: An automatic opposition between ultimate explanations. *Journal of Experimental Social Psychology, 45*, 238-241.
- Preston, J. L., Ritter, R. S., & Hepler, J. (2013). Neuroscience and the soul: Competing explanations for the human experience. *Cognition, 127*, 31-37.
- R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.
- Revelle W (2019). *psych: Procedures for psychological, psychometric, and personality research*. Northwestern University, Evanston, Illinois. R package version 1.9.12, <https://CRAN.R-project.org/package=psych>
- Rutjens, B., & Preston, J. (2019). Science and religion: a rocky relationship shaped by shared psychological functions. *The Science of Religion, Spirituality, and Existentialism, 373*-385. Elsevier.
- 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.
- Shtulman, A. (2013). Epistemic similarities between students' scientific and supernatural beliefs. *Journal of Educational Psychology, 105*, 199.
- Shtulman, A., & Lombrozo, T. (2016). Bundles of contradiction: A coexistence view of conceptual change. In *Core knowledge and conceptual change*, 49-67. Oxford.
- Snow, A. J. (1922). A psychological basis for the origin of religion. *The Journal of Abnormal Psychology and Social Psychology, 17*, 254-260.
- Tylor, E. B. (1871). *Primitive culture: researches into the development of mythology, philosophy, religion, art, and custom*. J. Murray.
- Whitehouse, H. (2011). The coexistence problem in psychology, anthropology, and evolutionary theory. *Human Development, 54*, 191-199.
- Wilkins, J. S. (2018). Why do believers believe silly things? Costly signaling and the function of denialism. In *New Developments in the Cognitive Science of Religion*, 109-129. Springer, Cham.