

Supernatural Explanations Across the Globe Are More Common for Natural Than Social Phenomena

Joshua Conrad Jackson^{1,2*†}, Danica Wilbanks^{1*}, Brock Bastian³, Joseph Watts^{4,5}, Nicholas DiMaggio¹, & Kurt Gray¹

1. University of North Carolina at Chapel Hill, Department of Psychology and Neuroscience
2. Kellogg School of Management, Northwestern University
3. University of Melbourne, Department of Psychology
4. University of Otago, Religion Programme
5. Max Planck Institute for the Science of Human History

*The first two authors contributed equally

† Correspondence should be addressed to joshcj@live.unc.edu

Acknowledgements. This study was supported by a grant from the John Templeton Foundation to JCJ, BB, JW, and KG. We are grateful for the research assistance of Michael Doucette, Hadden LaGarde, Vishal Easwar, and Susie Webb.

Abstract

Supernatural beliefs are common in every human society, and people frequently invoke the supernatural to explain natural (e.g., storms, disease outbreaks) and social (e.g., murder, warfare) events. However, evolutionary and psychological theories of religion raise competing hypotheses about whether supernatural explanations should more commonly focus on natural or social phenomena. Here we test these hypotheses with a global analysis of supernatural explanations in 109 geographically and culturally diverse societies. We find that supernatural explanations are more prevalent for natural phenomena than for social phenomena, an effect that generalizes across regions and subsistence styles and cannot be reduced to the frequency of natural vs. social phenomena or common cultural ancestry. We also find that supernatural explanations of social phenomena only occur in societies that also have supernatural explanations of natural phenomena. This evidence is consistent with theories that ground the origin of supernatural belief in a human tendency to perceive intent and agency in nature.

Supernatural Explanations Across the Globe Are More Common for Natural Than Social Phenomena

For thousands of years, humans have used religious beliefs to understand the world. Ancient Chinese, Baha'i, and Korean societies used divine intervention to explain and justify dynastic change¹; Egyptians, Aztecs, Celts, and Tiv people used the will of gods to explain celestial cycles²; and Mesopotamians, Ancient Indians, and Persians explained depression, anxiety, and aggression as the result of a person's failing relationship with their deities³. To account for why these supernatural explanations are so common, scholars since Nietzsche and Darwin have posed a "god of the gaps" hypothesis: that humans find religious beliefs—beliefs in supernatural agents and principles—appealing in part because these beliefs fill gaps in knowledge^{4,5}. Yet we still know little about the gaps that people use religion to fill. If religious belief serves as an explanatory system, what does it explain?

One possibility is that people apply supernatural principles mostly to understand and explain the natural world. Claims that religious beliefs focus on natural phenomena can be traced to scholars such as Tylor⁶, Frazer⁷, Muller⁸, and Hume⁹, who argued that early religious systems endowed animals, plants, and even rocks with souls and intentions. More recent psychological studies show that humans^{10–13}—and even some non-human animals^{14,15}—tend to anthropomorphize the natural world and bestow intentionality to natural phenomena such as storms and droughts. As a result of this tendency, humans may infer spiritual intervention during natural events which do not have a clear cause, like a sudden thunderstorm¹⁶. These studies suggest that supernatural explanations should be more common for natural events (where there is no clear causal agent) compared to social events (where events can be attributed to human agency).

In contrast, scholars such as Durkheim¹⁷ and Weber¹⁸ have proposed theories that place the social world at the center of religion^{19–22}. According to these kinds of theories, humans may develop beliefs in witchcraft, sorcery, or spiritual possession to explain why people engage in harmful antisocial behaviors like murder or theft. People may similarly develop beliefs in divinely sanctioned warfare to explain and justify intergroup conflict²³. Such supernatural explanations may bond together social groups because they can codify and reinforce social norms (e.g., punishment for suspected witchcraft). A social model of supernatural explanations makes two predictions. First, supernatural explanations may be more common for social phenomena versus natural phenomena, and second, societies with more supernatural explanations of any kind may show more social cohesion than societies with fewer supernatural explanations. If confirmed, this finding would add to past literature on the social function of religion which has found that—for example—punitive god beliefs can increase people's likelihood of cooperating^{19–21}, and that collective rituals can increase social cohesion^{23,24}.

Past studies have provided support for both natural-focused and social-focused models of supernatural explanation. In support of natural models, studies show that children often attribute supernatural causes to natural events²⁵, that natural disasters can increase religious conviction^{26–28}, and that people are more likely to propose supernatural explanations when a flood is attributed to natural cause rather than human cause¹⁷. In support of social models, cross-cultural studies have found evidence of widespread belief in shamans and witches who possess magical power or special relationships with supernatural agents^{29–32}. People across many societies also believe in spiritual possession, applying these beliefs to explain a broad range of social behaviors^{33–35}.

Despite this large body of research on religious belief, no previous studies have directly examined whether supernatural explanations are more common for natural or social phenomena in a global sample of societies. Global surveys of supernatural explanations have the potential to address different hypotheses about how people develop and apply their religious beliefs. Whereas natural models of religious belief suggest that supernatural explanations should be more cross-culturally prevalent for natural phenomena, social models suggest that these explanations should be more common for social phenomena, and that supernatural explanations of any kind may be linked to higher levels of social cohesion. Testing these hypotheses on a worldwide scale can answer longstanding questions about the foundational concerns of religious systems and the development of religious belief as an explanatory system.

Here we present a global analysis of supernatural explanations in a diverse range of societies in the ethnographic record. We examine ethnographic material from 109 geographically and culturally diverse groups to test how people invoke religion to explain the natural world vs. the social world. We define supernatural explanations as the attribution of an event to supernatural processes, such as the actions of a god, ancestor spirit, or human magical practitioner such as a witch or shaman. Using cross-cultural coding techniques from evolutionary and cultural anthropology^{36,37}, we develop numerical codes indicating whether supernatural explanations are common for events in each society based on anthropologists' qualitative descriptions. We focus on supernatural explanations of harmful events, since past research shows that people develop supernatural explanations more commonly for harmful than helpful phenomena.

Analyzing the ethnographic record means that, in addition to estimating the prevalence of supernatural explanations involving natural and social phenomena, we analyze data on these societies' linguistic, geographic, subsistence, sociopolitical, and ecological characteristics. This allows us to build a comprehensive dataset for testing whether patterns of supernatural explanation generalize across societies from different subsistence styles (e.g., pastoralists, hunter-gatherers) and regions, and whether the frequency of supernatural explanations are tied to differences in the frequency of focal events (e.g., societies with frequent warfare have supernatural explanations of warfare). Meta-data about linguistic characteristics also enable us to use language-based phylogenies to test whether supernatural explanations are distributed based

on patterns of common ancestry. These data ultimately allow us to test why supernatural explanations of natural and social phenomena may be more common in some groups than others.

Method

Data Availability. All data and code to reproduce our results are available at https://osf.io/jsk4t/?view_only=cf5e73d49aa44e9696288a4c4855c979.

Coding Process. We developed our codes using ethnographic data from societies in the “Standard Cross-Cultural Sample”, a geographically and linguistically diverse sample of societies that was developed to minimize cultural independence in cross-cultural research³⁸. We retrieved annotated ethnographic data from the electronic Human Relations Area Files (eHRAF) and used these data to code variables on the nature of supernatural attributions^{37,39}. All data points are justified and linked to ethnographic source materials. We trained two research assistants to identify and code ethnographic text related to supernatural explanations. Research assistants assigned codes indicating whether supernatural explanations were absent (0), present but rare (1), or present and common (2).

We developed codes for six different categories: infectious diseases (pathogens), natural hazards, naturally caused food scarcity (drought or famine), warfare, murder, and theft. We chose these categories because they are commonly described in ethnographies and they are feasible to classify as naturally caused (infectious disease, natural hazard, natural food scarcity) or socially caused (warfare, murder, theft). They are also each harmful events, which allowed us to avoid confounding natural vs. social phenomena with harmful vs. helpful phenomena¹⁶.

Previous cross-cultural coding projects have raised concerns about the difference between coding an event as absent vs. not reported⁴⁰. We were particularly concerned with mistakenly coding supernatural explanations as absent simply because the focal event (a natural hazard) had not occurred in recent memory. To help address this possible confound, we only coded supernatural explanations as absent when there was documentation of the phenomenon, but people in a society had not made a supernatural explanation. For example, theft was mentioned less often than other events across ethnographies, but coding only instances in which theft was mentioned ensured that we did not conflate infrequent mentions of theft as lack of evidence of supernatural explanation. Infectious diseases were recorded in 99% of societies in our sample, natural hazards were recorded in 92%, periods of food scarcity in 90%, intergroup conflicts in 89%, murder in 96%, and theft in 90%. We also performed a further check (described in the section “variables from outside sources”) in which we used exogenous data on frequency of occurrence to test whether ethnographies with frequent mentions of warfare, natural hazards, etc., cited more supernatural explanations of these phenomena.

We applied this procedure to a diverse sample of societies that were well-documented in eHRAF. These societies came from geographically diverse regions and had little contact with one another, minimizing the potential horizontal transfer of information between groups. Two research assistants coded the first 20 societies to establish intercoder reliability. After reliability between codes exceeded an average Krippendorff's α value of .75, research assistants split the remaining societies and each coded half of the sample.

For each society, research assistants provided a recommendation for whether the society had usable data. We started with a sample of 115 societies. However, five societies had insufficient data to make coding decisions. Ethnographic information for one society (the Abipon people) provided by a Christian missionary was strongly biased by racism to the extent that the information in the ethnography was unreliable. For the 109 societies with suitable source materials, research assistants documented evidence of supernatural explanations for each of our six phenomena, provided a summary statement on the prevalence of supernatural explanations for each phenomenon, and then gave a numerical code based on their summary. We coded sources based on whether supernatural explanations were absent (no evidence of supernatural explanation), uncommon (supernatural explanations were held by single people or small groups and were not widely acknowledged in a society), or common (supernatural explanations were widely acknowledged in the society). The second author of this paper checked each coding decision manually. Out of the 654 phenomena across our 109 societies, 391 had supernatural explanations, 353 of which were common. Since "uncommon" explanations were rare, and typically held by single people in a society or were tied to a single instance (e.g., a single story about a shaman who caused a murder in the Ingalik society in the absence of other evidence that people viewed murder as caused by Shamans), we chose to focus on commonly held explanations in our analysis and created dummy variables representing whether a supernatural explanation of a particular explanation was absent or uncommon (0) vs. common (1). All results in this paper replicated if we recoded uncommon explanations as present rather than absent.

Table 1 provides examples of text that we coded as containing supernatural explanations as well as text that we did not code as containing supernatural explanations. We note that there is an ongoing debate about whether universally humans make a distinction between "natural" explanations and "supernatural" explanations⁴¹⁻⁴³. Our study does not address this debate. Instead, we only coded for supernatural explanations without making assumptions about the co-occurrence of natural and supernatural explanations.

Table 1.
Examples of Supernatural Explanations

| Phenomenon | Coded as Supernatural Explanation | Not Coded as Supernatural Explanation |
|------------|-----------------------------------|---------------------------------------|
|------------|-----------------------------------|---------------------------------------|

| | | |
|-------------------------------------|---|---|
| Disease (natural phenomenon) | <p>People fall sick and die because they are attacked by a nggïyúdn who wishes them ill or because they are seduced or “led off” by one who wants them for company. Seduction is accomplished either through invitations to visit a “good country”, where the hunting is good and the honey plentiful, or through sexual stimulation. Klendó almost died because a female nggïyúdn wanted him for a sex companion. (Aweikoma)</p> | <p>When a man is sick, he is !nau, and must look after himself. He mustn't touch anyone with his hands, he mustn't touch cold water or the pots. When the cuts which have been made to inject medicine are healed (/arī), then the person who cut him must clean him with fat and milk mixed with cow dung; then he is taken to the well and has clay rubbed on his legs. He has also to take off all his old clothes, and give them to the one who cuts him. Then they say ‘!anúts ke go’; ‘you are clean.’ (Nama Hottentot)</p> |
| Natural Hazard (natural phenomenon) | <p>Lightning, kū'īdya pīdya, which almost all people seem to recognize in one way or another as directly connected with thunder, is attributed by the Cayapa to the sword-like weapon carried by the Thunder spirit. It is maintained by some that Thunder strikes and kills people with his sword, or at any rate with the glint of it. (Cayapa)</p> | <p>In the fury of the storm, the footsteps of the hunters are not heard by the active yet somnolent animal ere a deadly whack of his short club falls upon his unconscious head. In this way, two Aleutian brothers are known to have slain seventy-eight otters in less than one hour! (Aleut)</p> |
| Murder (social phenomenon) | <p>The whole country is given over to witchcraft. Many fatal illnesses and sudden deaths are due to witchcraft. Witches even kill each other... If a sorcerer's diagnosis or his treatment failed, he was open to the charge of murder by sorcery. Such an idea was never far from the Papago mind. (Papago)</p> | <p>To slay a man for the commission of an offence was considered just and permissible. The reasons for such slayings were: desecration of the conjugal couch, the rejection of betrothal, theft, secret hunting in foreign territory, and sometimes even envy of the advantages of another. Revenge for this went so far that they sometimes killed the wife of the culprit, but children, especially those under age, were always spared. (Aleut)</p> |
| Warfare (social phenomenon) | <p>Men who became especially noteworthy for their success in healing, procuring desired weather conditions, or ensuring a successful chase or war party, came to be singled out as medicine men... Dreams about a successful raid were not deemed necessary as a sanction for starting a war party, but in most cases such dreams were the effective stimulus. (Comanche)</p> | <p>This in turn often precipitates war. Once underway, a war can drag on for years in a series of retaliations, which are also given their financial colorings. The case of hard dealing in connection with a debt mentioned on page 67, which led to the theft of a child and from there to the taking of a head, is an illustration of such a situation. (Alorese)</p> |

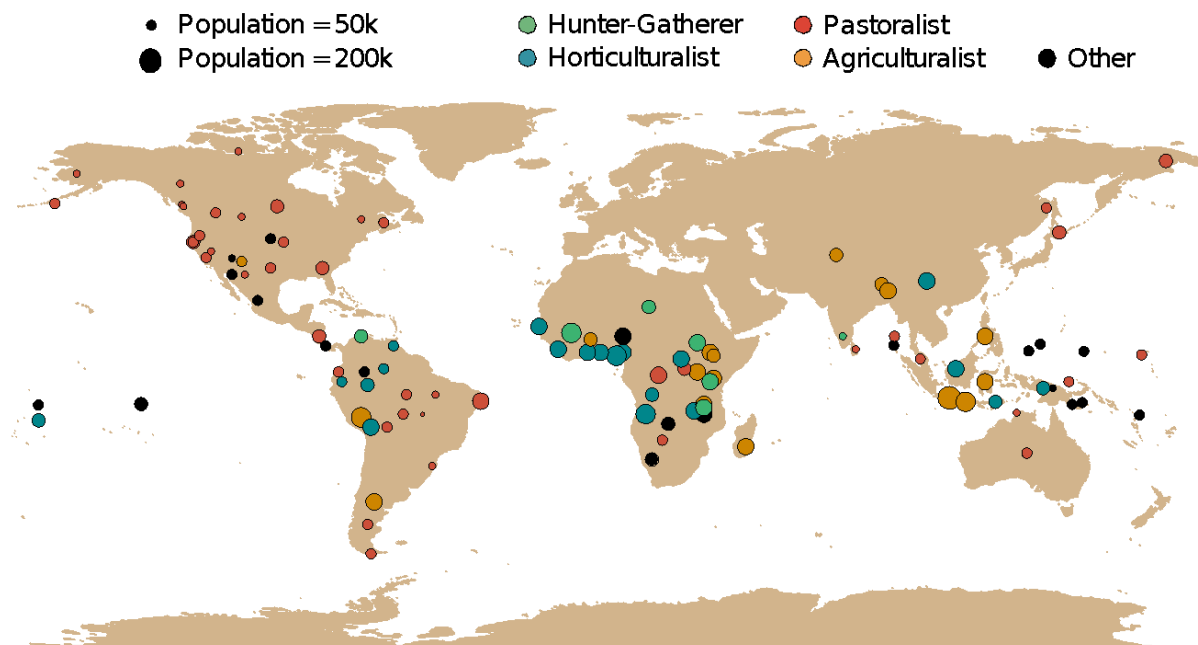


Figure 1. The geographic location of the 109 societies in our sample. Each node represents a society. Node color indicates subsistence style. Node size indicates population size⁴⁴.

Variables from Outside Sources. We collected geography and subsistence style data from eHRAF World Cultures. We measured pathogen prevalence using an index developed by Low⁴⁵ in which seven pathogens were coded on a 1 (absent) to 3 (widespread or endemic) scale. We dummy-coded this scale such that 0 represented societies with absent pathogens and 1 represented reported pathogens, and then summed across the seven pathogens to create a 1-7 scale. We measured natural disasters using data from Ember & Ember⁴⁶, who measured the frequency of natural disasters such as floods, storms, and droughts. We measured natural causes of scarcity using Jackson, Gelfand, and Ember's⁴⁷ food scarcity composite measure adapted from Dirks⁴⁸ and Ember & Ember⁴⁶. We measured prevalence of warfare between polities (independent political groups), and within polities using data from Ross⁴⁹ that used scales from 1 (rare or never) to 4 (occurring at least yearly). We could not find previous studies that had developed cross-cultural codes for the frequency of murder or theft across societies. Ross⁴⁹ coded for conflict in local community and resort to physical force by disputants in settling disputes. But we considered these variables too general to approximate frequency of murder since they could refer to many social conflicts.

We also measured sociopolitical characteristics, which allowed us to test whether supernatural explanations were linked to metrics of social cohesion and social inequality. We identified six variables from Ross⁴⁹ measuring (a) participation in the political process, (b) distribution of political power, (c) loyalty to the society, (d) loyalty to a local community, (e) compliance of individuals with community norms and decisions, and (f) modes of conflict management in the

community. Exploratory factor analysis using maximum likelihood and principal components analysis each had 2-factor solutions in which a “social inequality” factor took loadings of $> .30$ from a-b and a “social cohesion” factor took loadings from c-f (see supplement for details).

Phylogenetic Structure. To test for the effects of common ancestry on our inferences, we paired societies to languages on a global language phylogeny. Language-based phylogenies provide a general proxy for cultural ancestry⁵⁰ and have previously been used to test evolutionary hypotheses about religion and society^{51,52}. The global phylogeny used in this project is based on language classification data from the Glottolog catalogue of world languages⁵³, which contains comprehensive classification data for over 20,000 world languages and dialects. This language classification provides the underlying structure of language phylogenies but does not contain information on the scale of the branches. We developed a method for simplifying the classification scheme of Glottolog and scaling branches according to different potential distances between taxonomic classifications (see supplementary materials). Our approach yielded three simplified phylogenies that provide a proxy for the ancestral relationship between all languages. Our main text uses the first tree (see Figure 2), but our supplemental materials show that findings are largely unchanged across the different phylogenies.

We used this tree to test for phylogenetic patterning of supernatural explanations. Using Fritz and Purvis D statistic to estimate phylogenetic patterning of a binary trait⁵⁴, we tested the null hypotheses that distributions of natural and social supernatural explanations were randomly patterned. These models revealed no significant patterning for supernatural explanations of disease ($p = .58$), food scarcity ($p = .66$), natural hazards ($p = .55$), warfare ($p = .08$), murder ($p = .24$), or theft ($p = .053$). We also created composite variables indicating whether societies had at least one supernatural explanation of a natural phenomenon, or at least one supernatural explanation of a social phenomenon, but neither the natural ($p = .43$) nor social ($p = .38$) variable showed significant patterning. The fact that no forms of supernatural explanations showed phylogenetic patterning suggests that the explanations coded in this study are not tightly coupled with cultural and linguistic histories, meaning that they were relatively evenly distributed across different ancestral groups. It also suggests that associations involving supernatural explanations were unlikely to be confounded by shared ancestry, which is a frequent concern in cross-cultural comparative research⁵⁵. For this reason, our primary analyses do not adjust for phylogeny, but to be as comprehensive as possible, we also present a conservative set of analyses where we adjust for phylogeny even though we did not observe significant patterning.

Results

Prevalence of Supernatural Explanations. Which supernatural explanations are most common around the world? We found that 92% of societies in our sample had supernatural explanations for disease, 84% for natural hazards, and 78% of societies for food scarcity. Supernatural

explanations were less prevalent for social phenomena: 49% of societies had common supernatural explanations of warfare, 45% of societies for murder, and 18% of societies for theft. Supernatural explanations of natural phenomena were therefore more common than supernatural explanations of social phenomena. Figure 2 shows each society's number of documented supernatural explanations of natural and social phenomena in a phylogenetic layout.

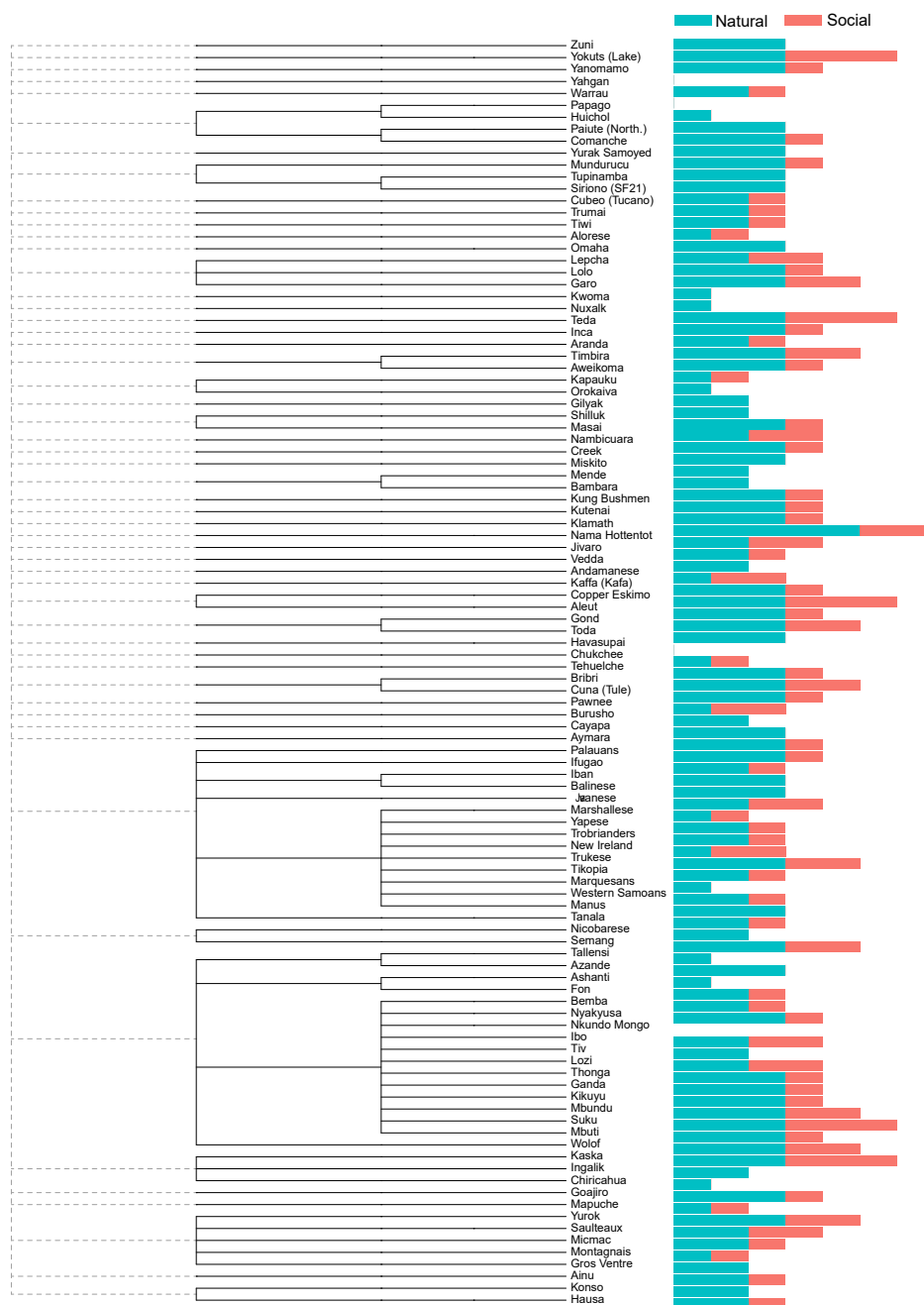


Figure 2. The number of supernatural explanations for natural phenomena (in blue) and social phenomena (in red) across societies in our sample. Society names are listed to the left of the columns, and societies are nested in a language phylogeny. Dashed lines represent uncertain

ancestral branching that we permuted in supplemental analyses to test for the robustness of our results.

Paired sample t-tests showed that societies, on average, had significantly more forms of natural explanations than social explanations, $t(107) = 13.33, p < .001$. We also examined differences between the percent of societies that had at least one supernatural explanation of natural vs. social phenomena. We found that societies were more likely to have supernatural explanations of natural than social phenomena, $t(107) = 6.71, p < .001$. These results were consistent after controlling for shared ancestry. Phylogenetically controlled t-tests replicated the finding that societies had more forms of natural explanations than social explanations, $t(105) = 13.31, p < .001$, and that societies were more likely to have at least one supernatural explanation of a natural phenomenon than at least one supernatural explanation of a social phenomenon, $t(105) = 6.59, p < .001$. This suggests that the gap between supernatural explanations of natural and social phenomena was not an artifact of ancestral interdependence among the societies in our sample.

Prevalence of Supernatural Explanations by World Region and Subsistence Style. There were similar patterns of supernatural explanations across world regions and subsistence styles. Supernatural explanations were more prevalent for natural compared to social phenomena in hunter-gatherers, $t(43) = 9.58, p < .001$, pastoralists, $t(6) = 4.77, p = .003$, horticulturalists, $t(19) = 5.78, p < .001$, and agriculturalists, $t(16) = 3.35, p = .004$. This gap was also robust across geography, replicating in Asia, $t(11) = 3.36, p = .006$, Africa, $t(27) = 6.30, p < .001$, Oceania, $t(21) = 5.70, p < .001$, North America, $t(26) = 7.69, p < .001$, and South America, $t(18) = 6.43, p < .001$. There were no significant regional differences in the prevalence of supernatural explanations across natural vs. social phenomena. Analyzing subsistence style revealed a small effect such that hunter-gatherers had significantly fewer supernatural explanations for social phenomena than agriculturalists, $b = -.50, t = -2.01, p = .048$, but this relationship did not reach significance when controlling for regional differences. Figure 3 shows the proportion of societies with supernatural explanations by continent and subsistence style.

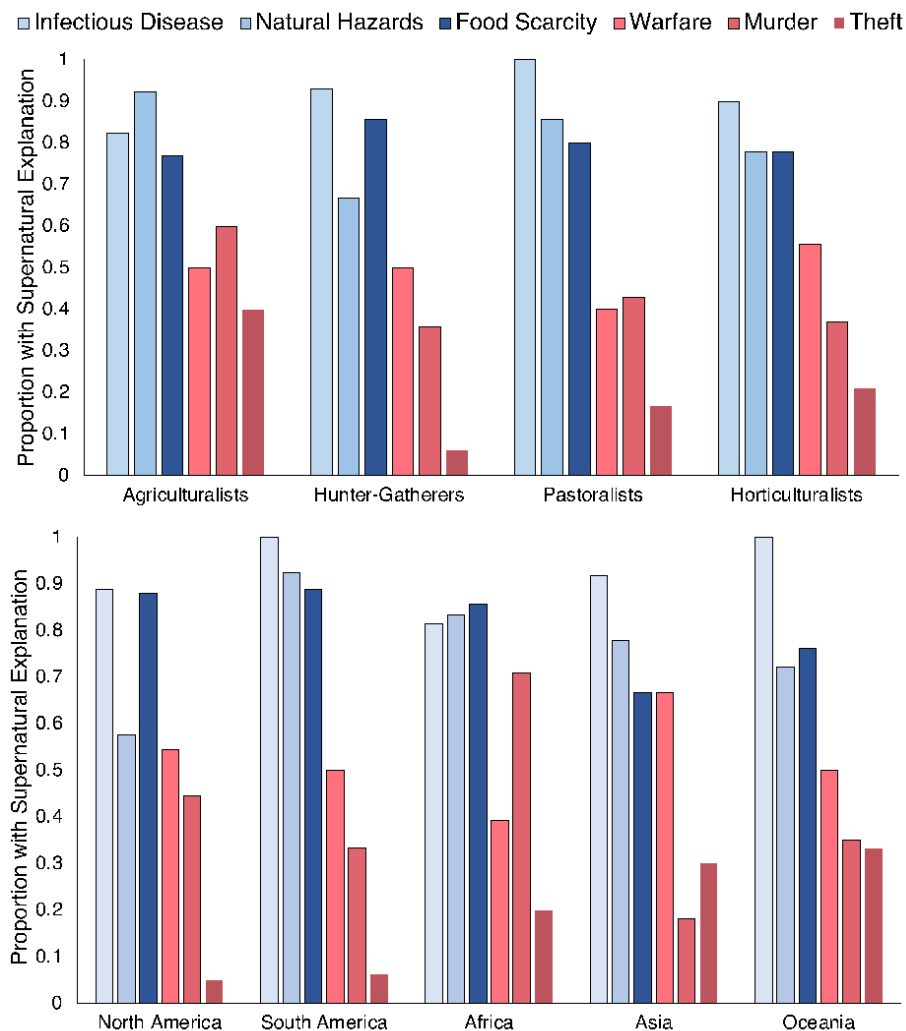


Figure 3. Proportion of societies with supernatural explanations of each phenomenon by (top) subsistence style and (bottom) continent.

These findings raise two questions about variation in supernatural explanations. First, why are supernatural explanations of natural phenomena so much more common than supernatural explanations of social phenomena? And second, why does the prevalence of supernatural explanations for social phenomena vary across societies whereas supernatural explanations for natural phenomena are relatively universal?

Frequency of Phenomena and Frequency of Supernatural Explanation. One reason for the gap between frequency of socially focused and naturally focused supernatural explanations could simply be because events such as disease outbreaks occurred more frequently than events such as warfare. To evaluate this possibility, we ran logistical regression models to test whether the frequency of infectious disease outbreaks, natural hazards, food scarcity, and warfare between and within polities predicted supernatural explanations of these phenomena. None of these

models yielded significant results. Frequency of occurrence was not significantly related to the presence of supernatural explanation for infectious disease, $OR = .97$, 95% CI s [.68, 1.41], natural hazards, $OR = 1.26$, 95% CI s [.57, 2.79], food scarcity, $OR = .85$, 95% CI s [.36, 1.74], and warfare between polities, $OR = 1.08$, 95% CI s [.67, 1.75], or within polities, $OR = .85$, 95% CI s [.53, 1.35]. We could not find data on the frequency of murder and theft across our sample^a, but our available data suggest that the prevalence gap between supernatural explanations for natural and social phenomena cannot be explained by frequency of occurrence, and that our main results are likely driven more by how humans think about the causes of natural vs. social events.

Sources of Variability in Supernatural Explanations. Why did some societies have frequent supernatural explanations of warfare, theft, and murder, whereas other societies did not? We next examined sources of variability in supernatural explanations of social phenomena to understand the possible origin of these explanations. One possibility is that supernatural explanations for social phenomena are tied to explanations of natural phenomena. In support of this possibility, descriptive statistics revealed that there were no societies that had documentation of supernatural explanations for social but not natural events, and the number of supernatural explanations for natural events correlated strongly with the number of supernatural explanations for social events, $r(107) = 0.27$, $p = .005$ (see Figure 4). These analyses were only correlational, but they suggest that societies may be especially likely to develop supernatural explanations of social phenomena when they already have supernatural explanations of natural phenomena.

^a Ross has previously coded for conflict in local community and resort to physical force by disputants in settling disputes. However, we considered these variables too general to approximate the frequency of murder in a community since it could refer to a variety of social conflicts.

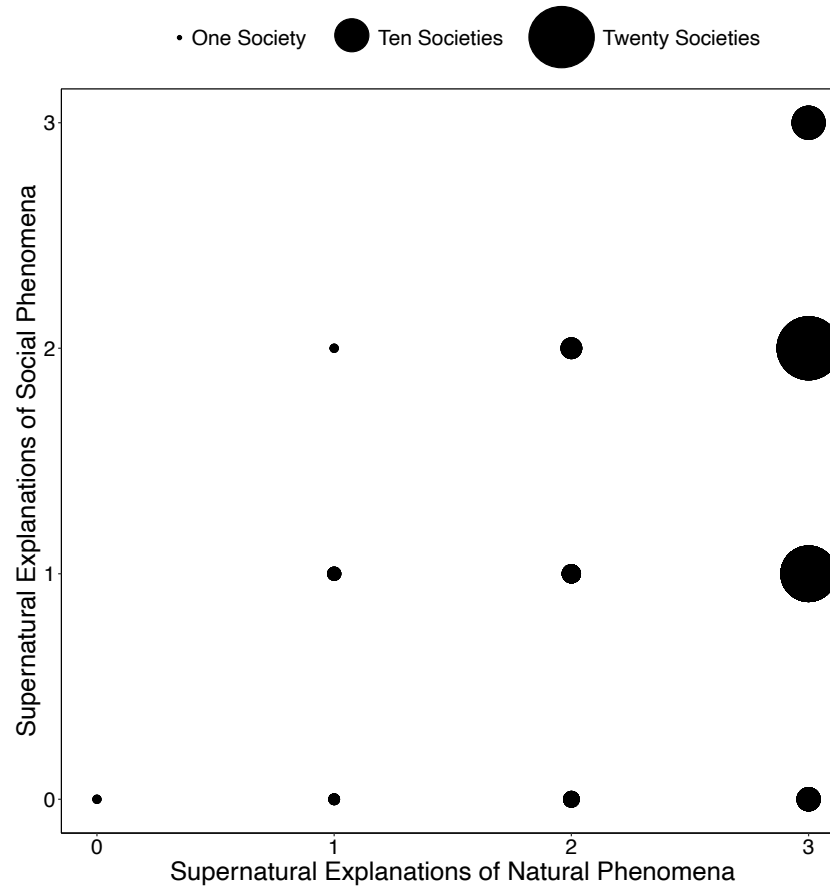


Figure 4. The association between supernatural explanations of natural and social phenomena. Node size indicates number of societies within a datapoint such that larger datapoints contain more societies.

Supernatural explanations of social and natural phenomena could also plausibly covary with social cohesion if they codify and reinforce social norms (e.g., punishment for suspected witchcraft) and could plausibly covary with social inequality if they help political elites justify social systems or conflict. Regressing social inequality on supernatural explanations of natural and social phenomena revealed that more supernatural explanations of natural phenomena was associated with lower social inequality, $b = -.37$, $SE = .16$, $t(61) = -2.35$, $p = .02$. Supernatural explanations of social phenomena were not significantly associated with social inequality, $b = .20$, $SE = .13$, $t(61) = 1.60$, $p = .12$. However, explanations of warfare were significantly linked to higher social inequality, $b = .54$, $SE = .23$, $t(49) = 2.35$, $p = .02$, providing evidence that some forms of social-focused supernatural explanation may be enforced by authorities. Repeating this analysis for social cohesion found no significant effects for supernatural explanations of natural, $b = -.19$, $SE = .12$, $t(61) = -1.60$, $p = .12$, or social phenomena, $b = .16$, $SE = .10$, $t(61) = 1.63$, $p = .11$. In sum, neither kind of supernatural explanation predicted greater social bonding and cohesion, but societies with less social inequality were more likely to have supernatural explanations of natural phenomena, and less likely to have supernatural explanations of warfare.

Finally, we tested whether the socioecological pressures facing societies were associated with the nature of supernatural explanations. For example, a disease outbreak could encourage beliefs that witches are using supernatural forces to harm a community, which would be consistent with past findings that people often mistake illness with invisible supernatural forces of evil⁵⁶. Stepwise models showed mixed evidence of this link. Table 2 displays that pathogen prevalence was not significantly associated with the number of supernatural explanations of social phenomena when only controlling for the number of supernatural explanations of natural phenomena, but this association was stronger and significant controlling for the frequency of warfare, and natural causes of scarcity^b, and remained significant when also controlling for subsistence style differences. However, the link did not remain significant after controlling for shared ancestry in Model 3b, meaning that it was not robust to ancestral interdependence of societies.

| | Societies | R^2 | $b(SE)$ | β | t | p |
|--|-----------|-------|------------|---------|-------|------|
| Model 1 | 105 | .10 | | | | |
| Infectious Diseases | | | .08(.04) | .17 | 1.85 | .07 |
| Natural Phenomena | | | .30(.10) | .29 | 3.11 | .002 |
| Model 2 | 53 | .28 | | | | |
| Infectious Diseases | | | .20(.06) | .43 | 3.50 | .001 |
| Natural Phenomena | | | .40(.15) | .31 | 2.64 | .01 |
| Natural Food Scarcity | | | .07(.12) | .07 | 0.56 | .58 |
| Warfare within Polities | | | -.13(.09) | -.19 | -1.55 | .13 |
| Warfare between Polities | | | .10(.09) | .14 | 1.14 | .26 |
| Model 3 | 41 | .32 | | | | |
| Infectious Diseases | | | .17(.07) | .36 | 2.31 | .03 |
| Natural Phenomena | | | .35(.19) | .25 | 1.84 | .07 |
| Natural Food Scarcity | | | .03(.14) | .03 | 0.23 | .82 |
| Warfare within Polities | | | -.14(.10) | -.19 | -1.31 | .20 |
| Warfare between Polities | | | .08(.10) | .12 | 0.85 | .40 |
| Pastoralists | | | -.30(.47) | -.10 | -0.64 | .52 |
| Horticulturalists | | | -.30(.38) | -.13 | -0.77 | .44 |
| Hunter-Gatherers | | | -.51(.36) | -.28 | -1.41 | .17 |
| Model 3b (Phylogenetic Control) | 41 | .29 | | | | |
| Infectious Diseases | | | .10(.10) | .23 | 1.09 | .28 |
| Natural Phenomena | | | .45(.18) | .43 | 2.45 | .02 |
| Natural Food Scarcity | | | .005 (.15) | .01 | .03 | .97 |
| Warfare within Polities | | | -.07 (.11) | -.11 | -.64 | .52 |
| Warfare between Polities | | | .14 (.11) | .21 | 1.34 | .19 |

^b Adding frequency of natural hazards to this model reduced the degrees of freedom to 19, and so we omitted the variable to preserve the model's statistical power.

| | | | | |
|-------------------|------------|------|-------|-----|
| Pastoralists | -.44 (.58) | -.14 | -.77 | .45 |
| Horticulturalists | -.33 (.32) | -.16 | -1.03 | .31 |
| Hunter-Gatherers | .68 (.37) | -.40 | -1.81 | .08 |

Note. Subsistence group estimates are contrasted against “Agriculturalists” in this model. Models vary in number of societies because of missing data in some variables.

Taken together, these models indicate that societies only have supernatural explanations of social phenomena when they have existing supernatural explanations of natural phenomena. Other factors such as pathogen prevalence could possibly be related to supernatural explanations of social phenomena, but this relationship is not robust to controlling for ancestral interdependence, suggesting that it may not be a meaningful link. Finally, social inequality is linked to supernatural explanations of warfare, perhaps because social elites are more likely to use supernatural explanations to justify warfare in unequal societies. These models cannot make causal claims, but they do show evidence that social-focused and nature-focused supernatural explanations co-occur frequently across societies.

Discussion

Religious beliefs are prevalent in virtually every human society⁵⁷, and may even predate anatomically modern humans^{58,59}. The widespread prevalence of supernatural explanations suggests that explanation is a core property of religious beliefs, and humans may have long used religious beliefs to explain aspects of their natural and social worlds^{4-7,9}. However, there has never been a worldwide survey of supernatural explanations, which has been a barrier to understanding the most frequent ways that people use religious belief as a tool for explanation.

We use a global analysis of societies in the ethnographic record to show that humans are more likely to use supernatural explanations to explain natural phenomena versus social phenomena. Across all world regions and subsistence styles, societies were more likely to attribute natural events like famine and disease to supernatural causes compared to social events such as warfare and murder. This prevalence gap could not be explained by the frequency of phenomena in our analysis (i.e., that disease outbreaks occurred more frequently than warfare).

Our findings support longstanding philosophical and sociological claims that humans have a widespread tendency to imbue spiritual anthropomorphism to the natural world^{6,9}, and more recent cognitive science claims that agency detection may have played a role in the evolution of religious beliefs¹⁰. According to these claims, humans may be especially likely to make supernatural explanations of natural events because natural events have no clear causal agent, leading people to infer supernatural agency. Whereas past studies have shown that individual people are more likely to explain the same events when they are given natural (rather than social) causes¹⁶, we provide society-level evidence that natural phenomena are more commonly explained using supernatural principles than social phenomena. Even among natural phenomena,

we found that supernatural explanations were especially prevalent for illness and disease. This pattern supports theories which claim that pathogen outbreaks encourage beliefs in “moral vitalism”—invisible forces of good and evil^{56,60}—that can manifest through beliefs in evil spirits (e.g., demons) and forces such as the evil eye.

Our global analysis also sheds light on why supernatural explanations of social phenomena vary around the world. For example, we found that all societies with supernatural explanations of social phenomena had at least one supernatural explanation of a natural phenomenon, illustrating that social-focused explanations are strongly tied to natural-focused explanations. This link suggests that supernatural explanations of social events may have grown out of supernatural explanations of natural phenomena, but our correlational data cannot prove this causal path. Some models also suggested that supernatural explanations of social phenomena were most common in societies with high levels of pathogen prevalence, but these findings did not replicate controlling for shared ancestry between societies, suggesting that they may be an artifact of interdependence in datapoints.

Neither supernatural explanations of natural nor social phenomena were linked to higher social cohesion. However, this does not mean that social processes are not important in the cultural evolution of religious beliefs. Rather, we view our findings as consistent with “scaffolding” theories of the evolution of religion, which suggest that people universally developed supernatural beliefs because of an innate tendency to bestow intentionality and agency to the natural world, and that other social properties of religion such as collective ritual and punitive gods then grew out of these supernatural beliefs^{61,62}.

We note two limitations to this study. The first limitation is that our data are based on ethnographers’ interpretations of the societies in our sample. Although eHRAF is one of the best resources available for global cross-cultural research, the ethnographic record is often filtered through a western lens. Although we excluded ethnographies that showed clear problematic biases, our findings may still be impacted by subtler biases, and we encourage future research to scrutinize and re-analyze our publicly accessible codes. The second limitation is that the natural and social phenomena in our study may not always be completely independent. Natural hazards, for example, could cause a famine that leads to war, murder, and theft. To mitigate this limitation, we used multiple regression to control for the covariance between natural and social explanations and phenomena in all our analyses, and we also found that the frequency of events was not related to the likelihood of supernatural explanation. These analyses suggest that it is the way that humans process natural phenomena that elicits supernatural explanation, rather than their frequency or their covariation with social phenomena.

Theories of religious belief and explanation are centuries old, but this study provides a new quantitative window into how people most frequently apply supernatural explanations. Our

global survey shows that societies around the world are more likely to use religion to explain natural phenomena than social phenomena, and that there are key characteristics linked to societies with supernatural explanations of social events. Our open access codes, culturally diverse sample, and multi-method approach foreshadows a scientifically enriched study of religious belief, with implications for how we understand the deep history of religion.

References

1. Zhao, D. The mandate of heaven and performance legitimation in historical and contemporary China. *Am. Behav. Sci.* **53**, 416–433 (2009).
2. Hawkins, G. S. Sun, moon, men, and stones. *Am. Sci.* **53**, 460A–408 (1965).
3. Millon, T. *Masters of the Mind: Exploring the Story of Mental Illness from Ancient Times to the New Millennium*. (John Wiley & Sons, 2004).
4. Nietzsche, F. W. *Thus Spoke Zarathustra: A Book for Everyone and Nobody*. (Oxford University Press, 2005).
5. Darwin, C. *The Descent of Man, and Selection in Relation to Sex*. (Princeton University Press, 2008).
6. Tylor, E. B. *Primitive Culture: Researches into the Development of Mythology, Philosophy, Religion, Art, and Custom*. vol. 2 (J. Murray, 1871).
7. Frazer, S. J. G. *Golden Bough: a Study in Magic and Religion. Abridged Edition*. (Macmillan, 1959).
8. Müller, F. M. *Natural Religion: The Gifford Lectures Delivered Before the University of Glasgow in 1888*. (Longmans, Green, and Company, 1889).
9. Hume, D. *The Natural History of Religion*. vol. 4 (J.J. Tourneisen, 1793).
10. Barrett, J. L. Exploring the natural foundations of religion. *Trends Cogn. Sci.* **4**, 29–34 (2000).
11. Barrett, J. L. *Why Would Anyone Believe in God?* (AltaMira Press, 2004).
12. Boyer, P. *Religion Explained: The Evolutionary Origins of Religious Thought*. (Basic books, 2007).
13. Epley, N., Waytz, A. & Cacioppo, J. T. On seeing human: A three-factor theory of anthropomorphism. *Psychol. Rev.* **114**, 864 (2007).
14. Goodall, J. *In the Shadow of Man*. (Houghton Mifflin Harcourt, 2000).
15. Cheney, D. L. & Seyfarth, R. M. Assessment of meaning and the detection of unreliable signals by vervet monkeys. *Anim. Behav.* **36**, 477–486 (1988).
16. Gray, K. & Wegner, D. M. Blaming God for our pain: Human suffering and the divine mind. *Personal. Soc. Psychol. Rev.* **14**, 7–16 (2010).
17. Durkheim, É. & Swain, J. W. *The Elementary Forms of the Religious Life*. (Courier Corporation, 2008).
18. Weber, M. *The Sociology of Religion*. (Beacon Press, 1993).
19. Johnson, D. *God is Watching You: How the Fear of God Makes Us Human*. (Oxford University Press, 2016).
20. Norenzayan, A. *et al.* The cultural evolution of prosocial religions. *Behav. Brain Sci.* **39**, (2016).
21. Watts, J. *et al.* Broad supernatural punishment but not moralizing high gods precede the evolution of political complexity in Austronesia. *Proc. R. Soc. B Biol. Sci.* **282**, 20142556 (2015).

22. Wilson, D. *Darwin's Cathedral: Evolution, Religion, and the Nature of Society*. (University of Chicago Press, 2010).
23. Sosis, R., Kress, H. C. & Boster, J. S. Scars for war: Evaluating alternative signaling explanations for cross-cultural variance in ritual costs. *Evol. Hum. Behav.* **28**, 234–247 (2007).
24. Whitehouse, H. *et al.* The ties that bind us: Ritual, fusion, and identification. *Curr. Anthropol.* **55**, 674–695 (2014).
25. Kelemen, D. Are children “intuitive theists”? Reasoning about purpose and design in nature. *Psychol. Sci.* **15**, 295–301 (2004).
26. Sinding Bentzen, J. Acts of God? Religiosity and natural disasters across subnational world districts. *The Economic Journal.* 129, 2295–2321 (2019).
27. Zapata, O. Turning to God in tough times? Human versus material losses from climate disasters in Canada. *Econ. Disasters Clim. Change* **2**, 1–23 (2018).
28. Sibley, C. G. & Bulbulia, J. Faith after an earthquake: A longitudinal study of religion and perceived health before and after the 2011 Christchurch New Zealand earthquake. *PLOS ONE* **7**, e49648 (2012).
29. Singh, M. Magic, explanations, and evil: On the origins and design of witches and sorcerers. *Current Anthropology.* **62**, 2–29 (2018).
30. Winkelman, M. *Shamanism: The Neural Ecology of Consciousness and Healing*. (Greenwood Publishing Group, 2000).
31. Winkelman, M. J. A cross-cultural study of the elementary forms of religious life: shamanistic healers, priests, and witches. *Relig. Brain Behav.* **11**, 27–45 (2021).
32. Singh, M. The cultural evolution of shamanism. *Behav. Brain Sci.* **41**, (2018).
33. Cohen, E. *The Mind Possessed: The Cognition of Spirit Possession in an Afro-Brazilian Religious Tradition*. (Oxford University Press, USA, 2007).
34. Keener, C. S. Spirit possession as a cross-cultural experience. *Bull. Biblic. Res.* **20**, 215–235 (2010).
35. Cohen, E. & Barrett, J. L. Conceptualizing spirit possession: Ethnographic and experimental evidence. *Ethos* **36**, 246–267 (2008).
36. Slingerland, E. *et al.* Coding culture: challenges and recommendations for comparative cultural databases. *Evol. Hum. Sci.* **2**, (2020).
37. Ember, C. R. *Cross-cultural Research Methods*. (Rowman Altamira, 2009).
38. Murdock, G. P. & White, D. R. Standard cross-cultural sample. *Ethnology* **8**, 329–369 (1969).
39. Skoggard, I., Ember, C. R., Pitek, E., Jackson, J. C. & Carolus, C. Resource stress predicts changes in religious belief and increases in sharing behavior. *Hum. Nat.* **31**, 249–271 (2020).
40. Beheim, B. *et al.* Treatment of missing data determines conclusions regarding moralizing gods. (2019).
41. Legare, C. H. The contributions of explanation and exploration to children's scientific reasoning. *Child Dev. Perspect.* **8**, 101–106 (2014).
42. Legare, C. H. & Gelman, S. A. Bewitchment, biology, or both: The co-existence of natural and supernatural explanatory frameworks across development. *Cogn. Sci.* **32**, 607–642 (2008).
43. Legare, C. H., Evans, E.M., Rosengren, K.S., & Harris, P.L. The coexistence of natural and supernatural explanations across cultures and development. *Child development.* **83**, 779–793 (2012).

44. Murdock, G. P. & Provost, C. Measurement of cultural complexity. *Ethnology* **12**, 379–392 (1973).
45. Low, B. S. Pathogen stress and polygyny in humans. in *Human Reproductive Behaviour: A Darwinian Perspective* 115–127 (Cambridge University Press, 1987).
46. Ember, C. R. & Ember, M. War, socialization, and interpersonal violence: A cross-cultural study. *J. Confl. Resolut.* **38**, 620–646 (1994).
47. Jackson, J. C., Gelfand, M. & Ember, C. R. A global analysis of cultural tightness in non-industrial societies. *Proc. R. Soc. B* **287**, 20201036 (2020).
48. Dirks, R. Starvation and famine: Cross-cultural codes and some hypothesis tests. *Cross-Cult. Res.* **27**, 28–69 (1993).
49. Ross, M. H. Political decision making and conflict: Additional cross-cultural codes and scales. *Ethnology* **22**, 169–192 (1983).
50. Evans, C. L. *et al.* The uses and abuses of tree thinking in cultural evolution. *Philos. Trans. R. Soc. B Biol. Sci.* **376**, 20200056 (2021).
51. Watts, J., Sheehan, O., Atkinson, Q. D., Bulbulia, J. & Gray, R. D. Ritual human sacrifice promoted and sustained the evolution of stratified societies. *Nature* **532**, 228 (2016).
52. Basava, K., Zhang, H. & Mace, R. A phylogenetic analysis of revolution and afterlife beliefs. *Nat. Hum. Behav.* **5**, 604–611 (2021).
53. Hammarström, H., Forkel, R., Haspelmath, M. & Bank, S. *Glottolog 4.3*. (Max Planck Institute for the Science of Human History, 2020). doi:10.5281/zenodo.4061162.
54. Fritz, S. A. & Purvis, A. Selectivity in mammalian extinction risk and threat types: A new measure of phylogenetic signal strength in binary traits. *Conserv. Biol.* **24**, 1042–1051 (2010).
55. Bromham, L., Hua, X., Cardillo, M., Schneemann, H. & Greenhill, S. J. Parasites and politics: why cross-cultural studies must control for relatedness, proximity and covariation. *R. Soc. Open Sci.* **5**, 181100 (2018).
56. Bastian, B. *et al.* Explaining illness with evil: Pathogen prevalence fosters moral vitalism. *Proc. R. Soc. B* **286**, 20191576 (2019).
57. Brown, D. E. Human universals, human nature & human culture. *Daedalus* **133**, 47–54 (2004).
58. Mithen, S., Morley, I., Wray, A., Tallerman, M. & Gamble, C. The singing neanderthals: the origins of music, language, mind and body. *Camb. Archaeol. J.* **16**, 97–112 (2006).
59. Insoll, T. *Archaeology, Ritual, Religion*. (Psychology Press, 2004).
60. Bever, E. Witchcraft fears and psychosocial factors in disease. *J. Interdiscip. Hist.* **30**, 573–590 (2000).
61. Gervais, W. M. & Henrich, J. The Zeus problem: Why representational content biases cannot explain faith in gods. *J. Cogn. Cult.* **10**, 383–389 (2010).
62. Atran, S. Folk biology and the anthropology of science: Cognitive universals and cultural particulars. *Behav. Brain Sci.* **21**, 547–569 (1998).

Supplemental Materials

Factor Analysis of Social Cohesion and Social Inequality

We factor-analyzed six items measuring social dynamics: (a) participation in the political process, (b) distribution of political power, (c) loyalty to the society, (d) loyalty to a local community, (e) compliance of individuals with community norms and decisions, and (f) modes of conflict management in the community. A maximum likelihood exploratory factor analysis suggested two factors based on eigenvalues, parallel analysis, and an acceleration factor approach. The first factor (Eigenvalue = 1.88) contained loadings from “participation in the political process” (.67) and “perceptions of political leaders' power” (.79). The second factor contained loadings from “loyalty to wider society” (.72), “modes of conflict management in a community” (.43), “compliance with community norms and decisions” (.46) and “loyalty to local community” (.35). We coded the factors so that higher scores on the first factor represented greater inequality, and higher scores on the second factor represented greater group cohesion.

Recoding “Common” to “Present” in Main Analysis of Supernatural Explanations

We reconducted our major analyses to see if our findings replicated when including both supernatural explanations that were common, and supernatural explanations that were present but rare. In the results of the main paper, we only included explanations that were widely believed by the full societies. However, during data collection, we also coded explanations that had evidence of being believed by a single person or were otherwise rare. Here we present our main analyses including rare supernatural explanations:

Prevalence of Supernatural Explanations. 99% of societies in our sample had common or rare supernatural explanations for disease, 96% for natural hazards, and 92% of societies for food scarcity. Supernatural explanations were still less prevalent for social phenomena: 79% of societies had common supernatural explanations of warfare, 67% of societies for murder, and 49% of societies for theft. Paired sample t-tests showed that societies, on average, had significantly more forms of natural explanations than social explanations, $t(107) = 8.77, p < .001$. The number of supernatural explanations for natural events correlated strongly (but not as strongly) with the number of supernatural explanations for social events, $r(106) = 0.23, p = .02$.

Prevalence of Supernatural Explanations by World Region and Subsistence Style. There were similar patterns of supernatural explanations across world regions and subsistence styles. Supernatural explanations were more prevalent for natural compared to social phenomena in hunter-gatherers, $t(43) = 12.95, p < .001$, pastoralists, $t(6) = 5.46, p = .002$, horticulturalists, $t(19) = 7.34, p < .001$, and agriculturalists, $t(16) = 4.64, p < .001$. Supernatural explanations were also more common for natural compared to social phenomena across world regions-- in Asia, $t(11) = 3.36, p = .006$, Africa, $t(27) = 8.04, p < .001$, Oceania, $t(21) = 7.52, p < .001$, North America, $t(26) = 10.61, p < .001$, and South America, $t(18) = 7.64, p < .001$. Societies in Asia had significantly fewer supernatural explanations for natural phenomena than societies in other world regions, $b = .78, t = 3.20, p < .001$.

Frequency of Phenomena and Frequency of Supernatural Explanation. We tested whether the frequency of infectious disease outbreaks, natural hazards, food scarcity, and warfare between and within polities predicted the commonality of their corresponding supernatural explanations. None of these models yielded significant results. Frequency of occurrence was not significantly related to the presence of supernatural explanation for infectious disease, $OR = 3.10$, 95% CI s [.07, 140.13], natural hazards, $OR = 1.01$, 95% CI s [.95, 1.07], food scarcity, $OR = 1.04$, 95% CI s [.98, 1.10], and warfare between polities, $OR = 1.07$, 95% CI s [0.98, 1.17], or within polities, $OR = 1.00$, 95% CI s [.92, 1.09].

Phylogenetic Analyses with Alternative Trees

We tested for phylogenetic patterning of supernatural explanations with two alternative Glottolog trees using Fritz and Purvis D statistics. The null hypothesis was that the distributions of natural and social supernatural explanations were randomly patterned. Like the main paper's findings, these models also revealed no significant patterning for supernatural explanations of disease (Glottolog Tree 2: $p = .91$; Glottolog Tree 3: $p = 0.36$), food scarcity ($p = 0.66$; $p = 0.92$), natural hazards ($p = .90$; $p = .76$), warfare ($p = .84$; $p = .56$), murder ($p = .24$; $p = 0.57$), or theft ($p = .15$; $p = .44$).