







Resource Stress Predicts Changes in Religious Belief and Increases in Sharing Behavior

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Abstract

We examine and test alternative models for explaining the relationships between resource stress, beliefs that gods and spirits influence weather (to help or harm food supply or punish for norm violations), and customary beyond-household sharing behavior. Our model, the resource stress model, suggests that resource stress affects both sharing as well as conceptions of gods' involvement with weather, but these supernatural beliefs play no role in explaining sharing. An alternative model, the moralizing high god model, suggests that the relationship between resource stress and sharing is at least partially mediated by religious beliefs in moralizing high gods. We compared the models using a worldwide sample of 96 cultures from the Standard Cross-Cultural Sample (SCCS), newly coded data on supernatural involvement with weather, and previously coded data on food and labor sharing. We conducted three types of analysis: multilevel and society-level regressions, and mediational path modeling using Monte Carlo simulations. Resource stress shows a robust effect on beliefs that high gods are associated with weather (and the more specific beliefs that high gods help or hurt the food supply with weather), that superior gods help the food supply through weather, and that minor spirits hurt the food supply through weather. Resource stress also predicts greater belief in moralizing high gods. However, no form of high god belief that we test significantly predicts more sharing. Mediational models suggest the religious beliefs do not significantly explain why resource stress is associated with food and labor sharing. Our findings generally accord with the view that resource stress changes religious belief and has a direct effect on sharing behavior, unmediated by high god beliefs.

Keywords Resource stress · Moralizing high gods · Cooperation · Sharing · Belief that gods control weather

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s12110-020-09371-8>) contains supplementary material, which is available to authorized users.

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Across the ethnographic record, gods are believed to either help or hurt food supply by controlling the weather; in some cases, moral intent is ascribed to such divine acts (Roncoli et al. 2009). However, the belief in gods' involvement with weather is not universal, so this variation is in need of explanation. We argue and test for the idea that resource stress may explain greater belief in both supernatural involvement with weather and moralizing high gods. Also, given that resource stress predicts more customary beyond-household seasonal sharing (Ember et al. 2018), we test a broader model that resource stress may explain both beliefs in supernatural involvement with weather as well as more beyond-household seasonal sharing (henceforth, "sharing").

Because sharing is a major form of cooperation, we refer to the extensive literature on human cooperation, in particular the theory that moralizing high gods promote cooperation, especially in complex societies (Atkinson and Bourrat 2011; Johnson 2016; Johnson and Bering 2006; Norenzayan 2013; Norenzayan et al. 2016; Purzycki et al. 2016; Roes and Raymond 2003). Accepting the link between moralizing high gods and cooperation, some scholars have identified environmental stressors that increase the likelihood of belief in moralizing high gods and cooperative behavior (Botero et al. 2014; Hayden 1987; Snarey 1996). Based on this literature, we investigate the following questions across a worldwide sample: "Are people in societies facing serious resource stress more likely to believe that their gods and spirits (1) are responsible for weather, (2) use weather to help or hurt people's food supply, and (3) punish people for bad behavior with weather?" Our final question is "Do beliefs in moralizing high gods help us explain why resource stress predicts more sharing?"

Environmental Stress and Religious Belief

In trying to explain the universality of religious belief in human societies, scholars such as Malinowski (1939, 1954) have suggested that inevitable stresses of life give rise to the need to find comfort and relief from anxiety caused by death, illness, and natural disasters, and that religion provides this comfort and relief. If religion does provide this function, it follows that more stressful situations should increase religiosity, people facing more life stressors should be more religious, and societies with more stressors should be more committed to religious practices. In support of this possibility, various studies have found higher religiosity in either earthquake-prone or drought-affected regions, or associated with more risk-filled subsistence practices (Bentzen 2015; Gibson and Connell 2015; Poggie et al. 1976; Shannonhouse et al. 2019; Sibley and Bulbulia 2012). Moreover, Barber (2011, 2013, 2015) found that increased material security was linked to country-level and state-level declines in religiosity.

If religion does help relieve anxiety, it may partly do so by providing an explanation for such events as the illness or death of a loved one, natural hazards, or failure to have an adequate food supply. Commonly, natural forces beyond human control are ascribed to anthropomorphized supernatural agents who can act helpfully and/or harmfully, and humans try to influence these agents through propitiation, magic, or collective ritual (Evans-Pritchard 1937; Fortes 1987; Guthrie 1993; Malinowski 1954). Alternatively, the character and behavior of religious agents might be a reflection, or projection, of the stresses that people in society actually face. For example, psychological theories postulate that conceptions of supernatural beings are reflections of typical parent-

child relationships or, more generally, a projection of conflicts and anxieties faced by individuals as a result of common experiences. Consistent with this idea, scholars found that punitive child-rearing practices predict the presence of gods who tend to be aggressive and malevolent (Lambert et al. 1959; Spiro and d'Andrade 1958). Some of these findings are paralleled by research that found folktales had more capricious aggression in societies that faced more natural hazards (Cohen 1990).

In this paper, our particular concern is with resource stress, and we ask whether more stress will be associated with the greater likelihood that supernatural beings are thought to be involved with weather or to affect food supply by means of weather. Based on theories that religion helps comfort in the face of stress, or the psychological idea that conceptions of the supernatural reflect experienced trauma, we expect resource stress to predict more belief that gods are involved with weather that can hurt or harm the food supply.

Religion and Cooperation

Much has been written on the evolution of human cooperation and adaptive effects of religion in extending prosocial instincts and consciousness beyond the small group (Atkinson and Bourrat 2011; Atkinson and Whitehouse 2011; Boehm 2012; Norenzayan 2013; Norenzayan et al. 2016; Purzycki et al. 2016; Richerson and Boyd 2005; Willard 2018). Many perspectives argue that religion as a moral system of sanctions and rewards dampens intragroup aggression and competition and promotes trust and cooperation (Alexander 1987). Experiments using economic games have shown that religious priming engenders generosity and helps curtail free-rider problems (Shariff and Norenzayan 2007; Shariff et al. 2016). Scholars point to the belief in moralizing high gods as omniscient, omnipresent, and omnipotent supernatural entities who keep watch on everyone to ensure cooperation and punish noncooperators (Johnson et al. 2015; Norenzayan and Shariff 2008; Peoples and Marlowe 2012; Purzycki et al. 2016). Also, gods can be the focus of cults and rituals, which scholars argue heighten and extend shared sentiments that promote solidarity, trust, and cooperation (Argyle 2002; Boehm 2008; Boyd and Richerson 2009; Bulbulia 2004; Fehr et al. 2002; Goldschmidt 2006; Power 2017; Rappaport 1999; Sosis and Ruffle 2003).

Punishment is recognized as an effective second-order mechanism extending cooperation beyond the small group (Boyd and Richerson 1992; Gneezy and Fessler 2012); however, the genetic cost to third-party enforcers remains a problem (Egas and Riedl 2008). Fear of supernatural punishment offers a unique solution by displacing the role of punishing agent onto imaginary supernatural beings, especially moralizing high gods (Atkinson and Bourrat 2011; Brown and Eff 2010; Johnson 2005, 2016; Johnson and Bering 2006; McNamara et al. 2016; Purzycki et al. 2016; Roes and Raymond 2003; Schloss and Murray 2011), albeit lesser gods can also have moral concerns and punish transgressors (Purzycki and Arakchaa 2013; Purzycki et al. 2016; Watts et al. 2015).

Models of Resource Stress, Supernatural Beliefs, and Sharing Behavior

Based on theory and research discussed above, we examine two different theoretical models that suggest how resource stress, sharing behavior, and

supernatural beliefs are related. Both of these models predict that resource stress should predict religious beliefs, such as the belief in gods associated with the weather and beliefs in moralizing high gods. However, the models diverge in their prediction for how religious beliefs and resource stress should predict sharing. Our own model—the resource stress model shown in Fig. 1, on the left—postulates a positive causal relationship between resource stress and beyond-household sharing based on the previous findings and reasoning of Ember et al. (2018). More specifically, Ember et al. (2018) argue that, in the face of resource stress, sharing is postulated to be an adaptive mechanism to spread risk and build social capital (Cashdan 1980; Draper 1978; Hames 1990; Jaeggi and Gurven 2013; Kaplan et al. 1990; Smith 1988; Winterhalder 1986, 1990). In addition, the resource stress model postulates a positive causal relationship between resource stress and certain supernatural beliefs. As discussed above, the connection between resource stress and supernatural involvement in weather is argued to be either a psychological reflection of the anxiety surrounding resource stress or a mechanism for people to try to ameliorate that anxiety. However, this model postulates no direct effect of religious beliefs on sharing.

In contrast, in our rendition of the moralizing high god model (depicted in Fig. 1, on the right), we test an alternative explanation adapted from the literature on moralizing high gods and cooperation. Our model postulates that supernatural agents, especially moralizing high gods, are important for promoting cooperation, particularly in more complex societies. Here we focus on sharing, a major form of cooperation. In this model, food and labor sharing are believed to be particularly important when resources are stressed or unpredictable; hence the model has a causal arrow between resource stress and moralizing high god beliefs, and a causal arrow between moralizing high god beliefs and sharing. Because the moralizing high god model is agnostic about whether resource stress should only predict sharing by virtue of its shared relationship with belief in moralizing high gods, or whether resource stress should also have a direct effect between resource stress and sharing after controlling for moralizing high god belief, we leave the arrow unfilled. We note that in our analysis we allow for a direct relationship between resource stress and sharing.

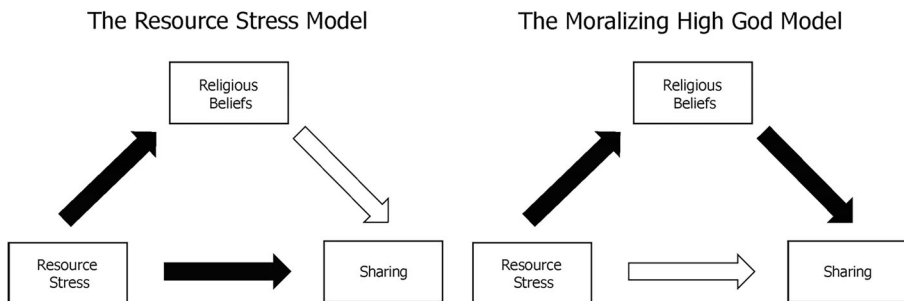


Fig. 1 Visual representation of the resource stress and moralizing high god models. Black-filled arrows represent theorized paths. Unfilled arrows represent paths that are not specifically theorized from the models

Methods

Sample

Our starting sample is the widely used Standard Cross-Cultural Sample (SCCS) of 186 mostly nonindustrial societies, constructed to maximize historical independence of cases (Murdock and White 1969). Each society has a specified time and place focus (an “ethnographic present”); most of the societies (86%) have foci that range from the 1860s to the 1960s. Many of the variables of interest to us have been coded for this sample: most importantly, three measures of resource stress—natural hazards that seriously impact food supplies, famine, and chronic scarcity (Ember and Ember 1992a, 1992b)—and measures of beyond-household food and labor sharing (Ember et al. 2018). Our study, including our new coding of beliefs that gods and spirits are involved with weather, is limited to the 96 cases for which food-destroying natural hazards were more reliably coded by Ember and Ember (1992b) for a 25-year period (−15 years to +10 years around the ethnographic present).¹ Societies range from hunter-gatherers to intensive agriculturalists and from autonomous communities to complex states. Consistent with common practice we have controlled for the highest-level language family in a multilevel analysis, but we found no significant effect of language family on major results relating resource stress to beliefs that gods/spirits are involved with weather. In the ESM, § 5, we have listed the language families that were included in each multilevel model and the parameters regarding language family.

Measures of Supernatural Involvement with Weather

Our coding of gods and spirits’ involvement in weather is based mainly on ethnographic documents in eHRAF World Cultures (<http://ehrafworldcultures.yale.edu>). For those SCCS cases not yet in eHRAF, we used library sources that match the time and place foci used for coding resource stress (Ember and Ember 1992b) and beyond-household sharing (Ember et al. 2018). The documents in the HRAF collections that match the time/place focus of the SCCS are identified in Ember et al.’s (1992) concordance of cross-cultural samples. (The documents that match the SCCS sample in eHRAF are now identified at <http://hraf.yale.edu/resources/reference/sccs-cases-in-ehraf>.)

Data Collection

We collected information using an advanced search in eHRAF World Cultures, which allowed us to use Boolean operators that combined individual subjects from the *Outline of Cultural Materials (OCM)*, such as ethnometeorology, disasters, gods and spirits, and religious offenses, with keywords for specific weather events, such as storm, frost, flood, hurricane, tornado, typhoon, tsunami, rain, and drought. The formula we used for each search was one *OCM* subject “AND” all the keywords using the “OR” operation.

¹ We follow Ember and Ember (1992b) in using reliability scores of 5 or less for resource stress measures. We also excluded two societies—Hebrews and Babylonians—that did not have information on sharing from Ember et al. (2018).

For example, one search involved the subject “disasters” AND all the keywords with the operator “OR.” We saved pertinent data that conformed to the SCCS place and time foci in a notes file for each culture.

Data Coding

Once notes were compiled, we used a predesigned presence-absence coding scheme to code the data. We followed these steps in coding:

1. Check for presence or absence of spiritual entities that are involved with weather.
2. If present, place each of these entities within a basic “hierarchy” of spirits based on the extent of their power: high gods, superior gods, and minor spirits. We used Swanson’s (1964) definition of a high god (HG) as the sole creator or governor of the universe. High gods may or may not be actively involved in the world, and if the former, may or may not be concerned with human morality. Our definition of superior gods (SG) differs somewhat from Swanson’s (1964). Superior gods represent large communal groups such as clans that encompass many local groups or regions and, following Swanson (1964), specialized communal activities, such as war, hunting, and farming. Minor spirits (MS) are ancestral, guardian, or place spirits that may affect individuals or small groups (e.g., families and households). The coders resolved these decisions before moving onto the next step.
3. When there was no information in our search about high gods’ involvement with weather, we did not want to assume that a high god was absent; a high god could be present but not concerned with weather. Since the presence or absence of a high god (and whether the high god was otiose or actively involved with human affairs) was already coded in the *Ethnographic Atlas* (variable 34: High Gods; Murdock 1967), the coders consulted the *Atlas* during the coding process to confirm that high gods were either absent, present, or present and otiose—that is, not involved in human affairs.²
4. If a particular type of god or spirit was deemed to be present, coders assigned the presence or absence of four supernatural actions based on textual ethnographic evidence. These were the general “associated with weather,” and more specifically, “associated with weather that hurts food supply,” “associated with weather that helps food supply,” and “weather actions deemed punitive (with respect to moral transgressions).”

Coding of Divine Weather Actions

A “helpful” supernatural disposition would be characterized by evidence of actions having a beneficial environmental influence on the food supply, such as bringing needed rain. Hurtful actions are environmentally influential actions that would have a

² In response to reviewers’ comments, we subsequently reviewed the ethnographic evidence for Murdock’s (1967) codes on high gods to see if we were in agreement. After this review we removed one case (Koreans) for which there was contradictory information. The Database of Religious History (DRH) (<https://religiondatabase.org/landing/>) was also used for reviewing the presence or absence of high gods.

harmful effect on the food supply (such as withholding rain, or causing a killing frost). Note that the “helpful” and “hurtful” codes do not require moralistic or punitive intent; such acts might include harmful spiritual actions that directly affect human subsistence but have no clear logic or relationship to human actions. Their actions would be described in the literature as “malevolent,” “mischievous,” or “capricious,” but not “punitive.” The fourth category, “punitive,” separately captures elements of moralistic punitive intention within spiritual action affecting weather which may or may not affect food supply. All of these codes were assigned independently (see ESM, Figure S1 for a diagram of the relationship between various supernatural actions with regard to weather). For example, if a high god was sometimes helpful with weather and sometimes hurtful, the help and hurt categories would both be coded as present. The variable “associated with weather” is a general category that includes any of the above three actions, or merely identification of a supernatural agent with a weather event, if no actions were specified in the ethnography. For example, a god or spirit may be identified with the wind, but there is no further account of possible effect of wind on food supply. Note that gods associated with plant fertility or pests, but not weather, were not included in our coding even though they could affect food supply. “Punitive with weather” includes two types of actions: in response to moral transgressions, (1) gods/spirits hurt food supply with weather and (2) god/spirits did not destroy food supply but were destructive in other ways, such as lightning strikes or storms that adversely affect travel, hunting, or fishing expeditions. Coders were instructed not to assume any information about the data unless explicitly stated. For example, if a god is associated with a storm, coders did not assume the storm was destructive or beneficial unless specified by the ethnographer. For a godly action to be deemed “punitive,” the ethnographer had to explicitly state that the action was in response to a moral offense or taboo violation. Some coding examples are given in Table 1. In ESM § 3, Table S1 gives frequencies of the different types of gods and spirits and their associated supernatural actions with regard to weather.

Moralizing High Gods

Since most of the literature discusses the importance of moralizing high gods in fostering cooperative behavior, we also use a dichotomized variable following Botero et al.’s (2014) procedure to document a presence or absence of moralizing high gods based on data from the *Ethnographic Atlas*. High Gods (variable 34 in the *Atlas*; Murdock 1967)³ was recoded as “A high god present, active, and specifically supportive of human morality” (category C) versus “A high god not supportive of human morality, otiose, or a high god is absent or not reported” (all other categories: B, A, and O, respectively). Note that this variable includes cases with a high god absent, whereas our coded variables relating to high god involvement with weather only pertain to societies with high gods present. To construct a moralizing high god variable that is more comparable to our variable, we created a second dichotomized variable for moralizing high gods (again, using variable 34 from Murdock 1967), recoded as moralizing high god (category C) versus otiose high god or high god not supportive

³ D-PLACE (<https://d-place.org/>) was used for cases not found in Murdock (1967).

Table 1 Examples of Coding

Deity Name	Deity Type	Deity Action	Coding Decision				Reference
			Regarding Food Supply	Regarding Punitive Actions	Culture (SCCS ID)		
Allah	HG	A good harvest is a sign of Allah's approval and a storm that destroys the villagers' crops, a sign of Allah's disapproval.	Harmful and helpful	Punitive	Fellahin (43)	Ammär	1954
Tirawahat	HG	Tirawahat was ever present in all things, especially the storm. He acted through the Wonderful Being, who sends the storm to cool the fields and cause the corn and timber to grow, and also produces rain, streams, and rivers.	Helpful, but not harmful	Not punitive	Pawnee (142)	Chamberlain	1982
Gods of Wind and Thunder	SG	The gods do not allow an evil deed go unpunished and send storms, a scarcity of fish and fowl, diseases, and other misfortunes.	Harmful	Punitive	Nivkh (119)	Shternberg et al.	1933
Nagawonyi	SG	Nagawonyi, the goddess of hunger, was thought to be able to end drought or famine by means of her influence with the gods Musoke and Gulu.	Helpful	Not punitive	Ganda (12)	Roscoe	1911
Nats (spirits)	MS	An executed man became a nat and, in anger, prevented rain from falling. This nat was eventually pacified, and it was he who taught the people that rain could be induced by a tug-of-war that invokes a special nat to bring rain.	Harmful and helpful	Not punitive	Burmese (71)	Spiro	1978

HG = High God; SG = Superior God; MS = Minor Spirit

of morality (categories A and B, but excluding societies where a high god is absent or not reported in substantial descriptions of religious beliefs [category O]).

Beyond-Household Sharing

Our dependent variables from Ember et al. (2018) are the presence or absence of types of customary food and labor sharing beyond the typical household. Following Ember et al. we define beyond-household food and labor sharing as the uncoerced giving of aid from one or more household members to one or more individuals within other households. In this paper, we focus on “seasonal food sharing” and “seasonal labor sharing,” both of which were strongly predicted by resource stress (Ember et al. 2018). “Seasonal food sharing” is food shared outside the typical household during certain seasons—in other words, during harvest or fishing season. “Seasonal labor sharing” is labor shared outside the household on a seasonal basis—for example, helping to hunt migratory animals or at harvest time.

Resource Stress

Our first three independent variables measuring resource stress come from Ember and Ember (1992a, 1992b). Below is an abbreviated coding scale:

Chronic scarcity (1) food abundant year round, (2) some “hungry times,” (3) some members of the population usually do not have enough to eat, (4) most members usually do not have enough to eat.

Famine (1) low threat, (2) moderate threat—no famine, but ethnographer reports ever present threat of famine, (3) moderately high threat (one famine in 25-year period), (4) high threat (two or more famines in 25-year period.)

Natural hazards Defined as the incidence of severe weather or pest problems that destroy food resources: (1) low threat, (2) moderate threat—no hazard, but ethnographer reports ever-present threat of hazard, (3) moderately high threat (one hazard in 25-year period), (4) high threat (two or more hazards in 25-year period). Note that in Ember and Ember (1992a, 1992b) the term “natural (weather or pest) disaster” was used.

The resource stress measures are based on information obtained by ethnographers from observation and interviewing, but we also wanted some etic measures of environmental conditions that might reflect the lack of likely resource stress over a broader time span. Employing the same variables used by Botero et al. (2014), we recalculated factor loadings for the SCCS sample (using imputation procedures for four of the 11 variables; see EMS, § 4). As did Botero et al. (2014), we labeled the resulting factor scores as “climate stability” and “resource abundance.” Resource abundance was highly weighted on plant and animal richness, annual mean precipitation, and precipitation predictability. We expected resource abundance to reflect the likely absence of resource stress. We did not have any explicit expectations for how climate stability would affect supernatural beliefs with regard to weather.

Social Complexity

Some scholars argue that the moralizing god hypothesis pertains particularly to larger, more complex societies (Norenzayan and Shariff 2008; Peoples and Marlowe 2012; Roes and Raymond 2003); therefore, we controlled for social complexity in analyses involving that hypothesis.⁴ For social complexity we used Murdock and Provost's (1973) score based on a summary of 10 variables (retrieved from Divale 2004 as variable 158.1).

Analysis Plan

Our hypotheses required two sets of analyses. First, we sought to test whether societies with high levels of resource stress are more likely to believe that gods and spirits are associated with the weather (including gods/spirits who harmed the food supply with weather, gods/spirits who helped the food supply with weather, gods/spirits who morally punish with weather), and moralizing high gods as suggested by both the resource stress model and the moralizing high god model shown in Fig. 1. Second, we sought to test whether these beliefs about high gods could explain or mediate the relationship between resource stress and food and labor sharing (consistent with the moralizing high god model), or whether the link between resource stress and food and labor sharing could not be explained by high god beliefs (consistent with the resource stress model). These analyses are described below. All analyses were conducted in R (see the specific programs used in the sections below). All R code is included in a supplementary file and is available at <http://hrafarc.org/>.

Resource Stress and Religious Belief Analysis

We employed multiple regressions for our first set of analyses, in which we tested for the linear association between resource stress and different forms of religious belief. We also built these regression models to address two concerns. First, analyzing each form of resource stress (chronic scarcity, reverse-coded abundance, famine, and natural hazards) separately could result in biased estimates due because it involves multiple comparisons. Multiple comparisons can lead to type I error if each comparison is testing the same hypothesis. To address this issue, we constructed a multilevel model where different forms of resource stress were nested within societies. This allowed us to analyze resource stress as a single variable, while also modeling variation across different forms of resource stress. Since there was a high intercorrelation between different forms of resource stress ($\alpha = 0.75$), it made sense to treat each variable as an indication of each society's underlying state of resource stress. We also summarize individual analyses for each form of resource stress in the ESM (§ 6). These analyses show that different forms of resource stress had very similar predictive effects on our religious belief variables.

⁴ Although the temporal ordering of moral high gods and complexity is controversial (Beheim et al. 2019; Slingerland et al. 2019; Whitehouse et al. 2019), there is broad agreement that complexity and moral high gods are correlated.

Second, since some of our societies belonged to the same language family, we pursued methods of controlling for the relationship between cases in our analyses. We initially did this by adding language family as a third level of our multilevel models. However, since our samples were relatively small and only a small subset of societies belonged to the same language family, most three-level models did not converge. Instead, we added language families involving multiple societies as dummy-coded fixed effects to our models. The ESM (§ 5) details the language families controlled for and the effects of language families. This fixed-effects approach is functionally equivalent to a random effects approach involving three-level models. Both approaches free the standard errors from bias associated with nonindependent effects. Results from this fixed-effects model were substantially similar (i.e., no significant effects became nonsignificant when dummy-coded language families were added) to our general linear models.

Resource Stress, Religious Belief, and Sharing Analysis

Our second set of analyses concerned the interplay between resource stress, religious belief, and sharing. Because different forms of resource stress showed similar predictive effects in our first set of analyses, we averaged our resource variables into a single metric for this second set of analyses. We then used a set of society-level regressions—once more controlling for language family—to test for the relationship between various forms of religious belief and sharing behavior. Our resource stress model hypothesizes that resource stress predicts sharing behavior, and that this relationship cannot be reduced to shared variance with religious belief. The moralizing high god model predicts that high god belief—especially belief in moralizing high gods—predicts sharing behavior, and it makes no direct prediction for how resource stress should predict sharing behavior after controlling for high god belief. We focused on high god belief in this analysis (rather than superior god or minor spirit belief) since it is the focus of most theories of moralizing religion (Norenzayan et al. 2016; Schloss and Murray 2011; Swanson 1964).

Finally, we entered the coefficients from both sets of analyses into a set of Monte Carlo simulations, which estimated the likelihood of mediational path models by resampling and simulating effects 20,000 times. These simulations cannot establish causality, but they can compare the plausibility of alternative causal models (Hayes 2009; Holland 1988). Specifically, we used Monte Carlo simulations to test for the likelihood of a resource stress → high god belief → sharing model derived from the moralizing high god model and compared it with the likelihood of the resource stress → sharing model and resource stress → high god belief derived from the resource stress model.

We note that all analyses involving the “moralizing high gods” variable controlled for social complexity since socially complex societies are more likely to have both moralizing high gods, and as noted above, some theories suggest that moralizing gods may be most functional for preserving cooperation among large-scale, complex societies. Our effects maintained the same direction regardless of whether we controlled for social complexity, and there were no significant results that become nonsignificant (or vice versa) after controlling for social complexity.

Reproducibility Statement

All data and code are available at <http://hrafarc.org/> so that others can reproduce our analyses. We used the packages `lme4` and `lmerTest` to run multilevel models (Bates et al. 2015; Kuznetsova et al. 2017). We used the `plyr` package for data transformation, and the `lm.beta` package to extract standardized betas for cases where we report effect sizes (Behrendt 2014; Hadley 2011). We estimated standardized betas for multilevel models by reestimating models with standardized variables. We used the `MASS` package for Monte Carlo simulations (Venables and Ripley 2002).

Results

Resource Stress and Religious Belief

We first tested whether societies experiencing resource stress showed greater belief in gods or spirits that are (a) associated with weather, (b) helping food supply with weather, (c) harming food supply with weather, (d) morally punitive with weather, and (e) more likely to have moralizing high gods. Tables 2, 3 and 4 show results for the god/spirit weather variables we coded for high gods, superior gods, and minor spirits, respectively. Table 5 shows results for moralizing high gods. In all these models, we independently regressed resource stress on each form of religious belief, controlling for language family (Tables S3–S6 in the ESM show results for each of the language family controls in these models). The first line of each table row shows the overall prediction of resource stress, and the lines below show individual effects of the different religious belief variables in the models.⁵ In § 6 of the ESM, we show the separate effects of each of the resource stress measures (still controlling for language family).

Resource stress showed a robust effect on high god belief, predicting gods associated with the weather (Model 1), gods that harm food supply with the weather (Model 2), and gods that help food supply with the weather (Model 3). At first, it seems strange that resource stress would predict both helpful and harmful gods, but these forms of religious belief were highly correlated ($r = .92$), suggesting that a particular high god does not specialize in harming or helping food supply with weather but may do either action at different times and circumstances. When the two forms of belief were modeled together (Model 5), the “help” variable’s effect remained robust whereas the “harm” variable’s effect disappeared. “Help” was marginally significant, but this was likely due to the multicollinearity of Model 5 ($VIF_{\text{help}} = 6.15$; $VIF_{\text{harm}} = 6.82$) and the reduced power of the model (89 cases instead of 116 in Model 3), rather than a decrement in effect size.

Resource stress was also associated with some superior god beliefs. As with high gods, resource stress predicted superior gods who helped food supply with weather (Table 3, Model 8), but superior gods were not robustly related to being associated with weather (Model 6) or harming food supply with weather (Model 7). However, a very

⁵ In our first set of models, religious belief variables were predictors and resource stress was an outcome. Models were organized in this way because dependent variables in multilevel models must vary at each level of analysis.

Table 2 Resource Stress and High God's (HG) Associations with Weather

	Cases	Societies	R ²	<i>b</i> (SE)	<i>t</i>	<i>p</i>
Model 1	155	46	0.22			
HG Associated with Weather				0.70(0.25)	2.79	0.008
Model 2	104	32	0.43			
HG Harms Food Supply with Weather				1.19 (0.39)	3.59	0.001
Model 3	116	36	0.42			
HG Helps Food Supply with Weather				0.94 (0.27)	3.51	0.002
Model 4	124	38	< 0.01			
HG Punitive with Weather				0.29(0.30)	0.98	0.34
Model 5	89	28	0.41			
HG Helps Food Supply with Weather				1.30(0.71)	1.82	0.09
HG Harms Food Supply with Weather				-0.13(0.78)	-0.17	0.87

Note: R^2 values for all tables in this paper are at the society level. There are more cases than societies in our first set of models because we nested different forms of resource stress within societies

different pattern of results emerged for minor spirits: resource stress primarily predicted minor spirits that harmed food supply with weather (Table 4, Model 11), and minor spirits that are deemed punitive with weather (Model 13). This suggests that, in times of hardship, people may view high gods and superior gods as potential sources of salvation while viewing minor spirits as the causes of hardship.

Resource stress was also associated with greater belief in moralizing high gods. Our models (Table 5, Models 14 and 15) showed that resource stress was associated with both the presence of moralizing high gods (whether or not there was a high god who was actively concerned with morality) and the moralization of high gods (whether or not a present high god was concerned with human morality).

Resource Stress, Religious Belief, and Sharing

Did resource stress or high god belief better predict sharing? Our second set of multiple regressions predicting food sharing is summarized in Table 6, and multiple regressions

Table 3 Resource Stress and Superior Gods' (SG) Associations with the Weather

	Cases	Societies	R ²	<i>b</i> (SE)	<i>t</i>	<i>p</i>
Model 6	207	65	0.01			
SG Associated with Weather				0.56(0.41)	1.34	0.19
Model 7	126	38	0.06			
SG Harm Food Supply with Weather				0.40 (0.27)	1.50	0.14
Model 8	125	40	0.21			
SG Help Food Supply with Weather				0.72 (0.30)	2.42	0.02
Model 9	138	43	< 0.01			
SG Punitive with Weather				-0.09(0.26)	-0.34	0.74

Table 4 Resource Stress and Minor Spirits' (MS) Associations with the Weather

	Cases	Societies	R ²	<i>b</i> (SE)	<i>t</i>	<i>p</i>
Model 10	177	56	<0.01			
MS Associated with Weather				0.02(0.41)	-0.04	0.97
Model 11	80	25	0.51			
MS Harm Food Supply with Weather				0.89(0.31)	2.87	0.01
Model 12	100	32	<0.01			
MS Help Food Supply with Weather				0.40(0.35)	1.13	0.27
Model 13	107	33	0.20			
MS Punitive with Weather				0.60 (0.29)	2.06	0.049

involving labor sharing are summarized in Table 7. In the eight relationships examined between high god belief and food or labor sharing, no high god belief predicted increased sharing. The only high god belief variable significantly related to food sharing is “HG Harms Food Supply with Weather.” However, as depicted in Model 18 (Table 6), the presence of high gods who harm food supply with weather is associated with *less* food sharing. Neither food nor labor sharing were significantly associated with belief in moralizing high gods, high gods who helped food supply with the weather, or high gods who morally punished with the weather.

Even though resource stress positively predicted sharing behavior, the association between resource stress and sharing only reached significance in three of the eight models controlling for high god belief. There are two possible reasons for this. The first is that resource stress really did share meaningful variance with high god belief, and that the effect size of resource stress was meaningfully impacted by controlling for various forms of high god belief. A second possibility, however, is that there were simply fewer cases in the models including high god beliefs, and that the reduced power in these models led to nonsignificant effects of resource stress. To adjudicate between these possibilities, we plotted the effect sizes of resource stress and high god beliefs on food and labor sharing (Fig. 2). This plot clearly demonstrates that the effect size of resource stress repeatedly emerged as approximately 0.27–0.62 across our analyses, while the effects of high god beliefs varied considerably—often negative in food sharing models, positive in labor sharing models, but never approaching significance in the expected direction.

It is possible that moralizing high god belief only promotes labor and food sharing in complex societies, in which defection is easier and moralizing gods are more essential

Table 5 Resource Stress and Presence of Moralizing High God (MHG)

	Cases	Societies	R ²	<i>b</i> (SE)	<i>t</i>	<i>p</i>
Model 14	366	160	0.17			
MHG Presence				0.40(0.16)	2.48	0.01
Model 15	241	100	0.16			
MHG Presence in Societies with High Gods				0.47 (0.18)	2.55	0.01

Table 6 Resource Stress, High God (HG) Belief Involving Weather, and Food Sharing

	Societies	R ²	<i>b</i> (SE)	<i>t</i>	<i>p</i>
Model 16	63	0.14			
Resource Stress			0.24 (0.07)	3.25	0.002
Model 17	26	0.15			
Resource Stress			0.23(0.11)	2.19	0.04
HG Helps Food Supply with Weather			-0.30(0.20)	-1.48	0.16
Model 18	24	0.33			
Resource Stress			0.29(0.10)	2.97	0.006
HG Harms Food Supply with Weather			-0.69(0.22)	-3.15	0.006
Model 19	26	0.16			
Resource Stress			0.21(0.11)	1.90	0.07
HG Punitive with Weather			-0.39(0.23)	-1.69	0.107
Model 20	36	0.11			
Resource Stress			0.19(0.10)	1.93	0.07
Moralizing High Gods			-0.29(0.18)	-1.55	0.13

Note: R² values have been adjusted for multiple predictors

to promote prosociality (Norenzayan and Shariff 2008). If this were the case, the presence of moralizing high god belief may not directly predict labor or food sharing, but it may interact with social complexity to predict labor or food sharing. However, an additional interaction term of social complexity and moralizing high god belief did not significantly predict food sharing ($b = 0.02$, $SE = 0.01$, $t = 1.46$, $p = .16$) or labor sharing

Table 7 Resource Stress, High God (HG) Belief, and Labor Sharing

	Societies	R ²	<i>b</i> (SE)	<i>t</i>	<i>p</i>
Model 21	72	0.11			
Resource Stress			0.23(0.08)	2.86	0.006
Model 22	27	0.03			
Resource Stress			0.18(0.15)	1.16	0.26
HG Helps Food Supply with Weather			0.09(0.28)	0.32	0.76
Model 23	21	0.12			
Resource Stress			0.26(0.16)	1.64	0.12
HG Harms Food Supply with Weather			0.16(0.43)	0.37	0.72
Model 24	27	0.14			
Resource Stress			0.19(0.13)	1.52	0.14
HG Punitive with Weather			0.09(0.24)	0.38	0.71
Model 25	43	0.16			
Resource Stress			0.28(0.12)	2.26	0.03
Moralizing High Gods			0.19(0.16)	1.15	0.26

Note: R² values have been adjusted for multiple predictors

($b = 0.02$, $SE = 0.02$, $t = 1.20$, $p = .24$) in our models. This interaction suggests that the effect of moralizing high god belief on labor and food sharing did not vary significantly in its magnitude with varying degrees of complexity.

Monte Carlo Simulations

Does resource stress or religious beliefs drive food and labor sharing? To estimate the contributions of these factors, we estimated a mediational model in which resource stress predicted religious beliefs, which in turn predicted sharing behavior. The moralizing high god model (that high god beliefs should at least partially predict sharing) was not supported, largely because no moralizing high god belief variables significantly predicted increased sharing behavior. Note that the indirect effect of resource stress on food sharing through harmful high god belief is significant, but in the negative direction. Belief in a high god that harms food supply predicts *less* food sharing, which is contradictory to what our version of the moralizing high god model would predict.

In contrast, the resource stress model (that there would be a positive link between resource stress and food/labor sharing) was supported by the total effects in our models. We note that the direct effect of resource stress on sharing controlling for high god belief did not always reach significance. However, this direct effect was always positive, and our previous analysis suggests that reduced power—rather than shared variance with high god belief—accounted for this lack of statistical significance. Each of the analyses is displayed as mediational models in Fig. 3.

Summary of Results

Resource stress showed a robust effect on beliefs that high gods are involved with weather; the involvement of superior gods and minor spirits is more limited. Resource stress was also associated with greater belief in moralizing high gods. When considering sharing along with resource stress and supernatural belief, we found that having no high god beliefs predicted an increase in food or labor sharing even when including an interaction term of social complexity and moralizing high god belief. In our Monte Carlo mediational tests there was support for the resource stress model, whereas the

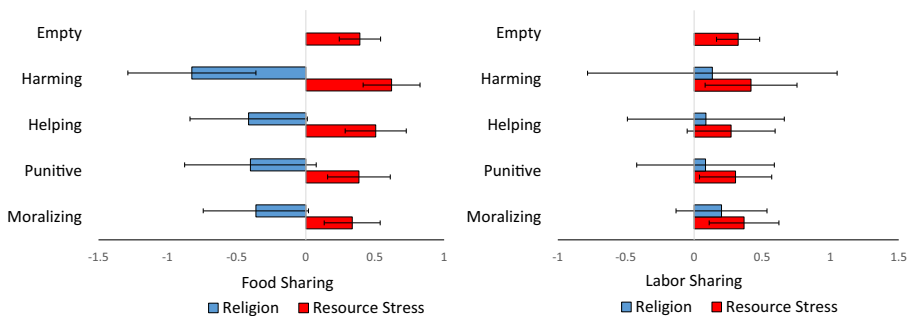


Fig. 2 Effect sizes (standardized betas) of resource stress and various high god beliefs on food sharing (left) and labor sharing (right). Each line represents a different model, and the line is named for the high god variable that the model included. The “empty” (zero-order) model was the association between resource stress and sharing controlling for language family but not high god belief. The error bars represent 95% confidence intervals

moralizing high god model was not supported, largely because no moralizing high god belief variables significantly predicted increased sharing behavior.

Discussion

Our findings are generally consistent with our resource stress model, which postulates that resource stress is a causal driver of both (a) more customary seasonal beyond-household sharing and (b) beliefs that supernatural beings are involved with weather,

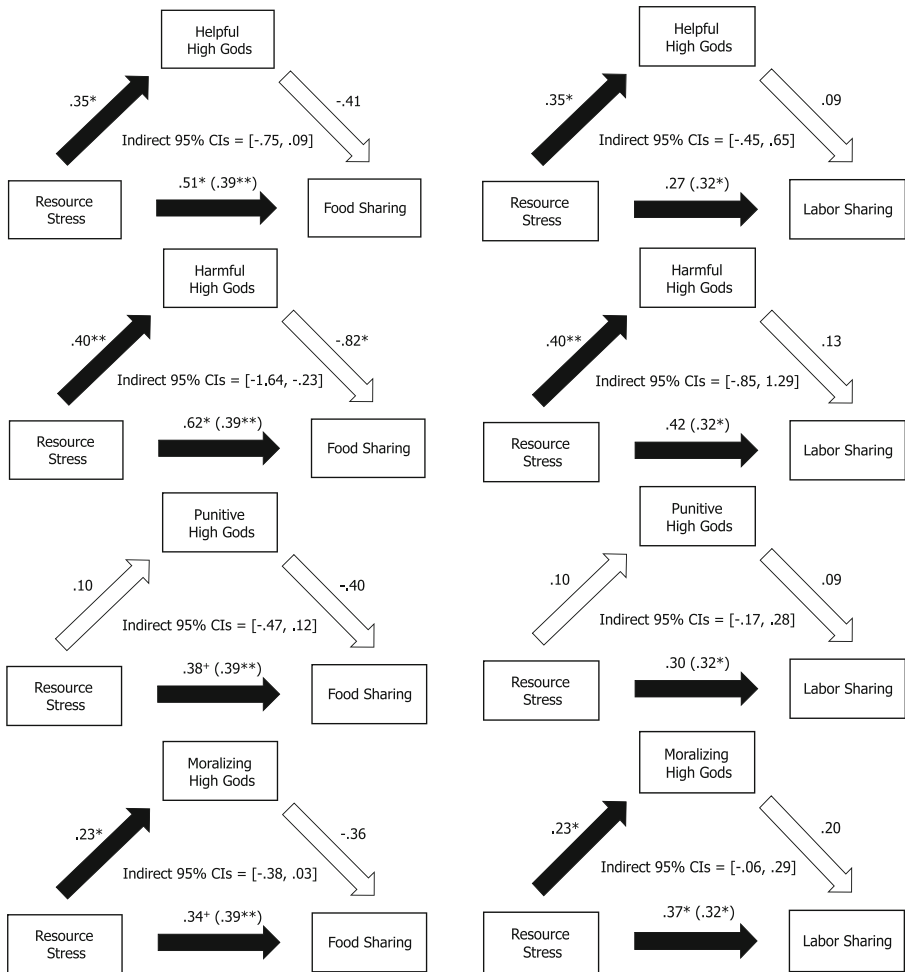


Fig. 3 Visual representation of how resource stress and various forms of high god beliefs predict sharing. Indirect effects come from a Monte Carlo simulation of the models' effects and variances. Inside the square brackets are the estimates of the upper and lower bounds of the effect of resource stress on food/labor sharing through high god beliefs. Black arrows indicate significant effects in the predicted direction. Unfilled arrows represent effects that did not reach significance in the predicted direction. The effect in the parenthesis is the total effect of resource stress on food sharing. The effect beside the parenthesis is the effect of resource stress on sharing controlling for high god belief. All effects have been standardized so that they can be interpreted as effect sizes

but such god/spirit beliefs do not directly influence sharing. We suggest that the existential risk of resource stress may give rise to cognitive conceptions of godly involvement with weather, indicating the need to relieve anxiety and uncertainty, or reflecting the harsh conditions of life. The fact that belief in high gods who help the food supply by sending good weather is more predictive of resource stress than belief in those who hurt the food supply by sending bad weather suggests to us that the anxiety-relief principle may be more important. Nevertheless, it is common for high god beliefs to include both helpful and harmful behaviors. The traumas of resource stress themselves may produce the idea of capricious god and spirit behavior consistent with Cohen's (1990) finding that folktales had more capricious aggression in societies that faced more natural hazards.

The predictions we derived from our moralizing high god model suggest that the relationship between resource stress and sharing would be at least partially mediated by religious beliefs in moralizing high gods. However, no form of high god belief, including the belief in a moralizing high god, significantly predicts an increase in labor or food sharing. Furthermore, our mediational models suggest that these religious beliefs do not significantly explain why resource stress is associated with more food and labor sharing. To be sure, we have only looked at a subset of small-scale cooperative practices: seasonal food and labor sharing. It is possible that supernatural agents may act in other ways to enhance other forms of cooperation, especially large-scale cooperation found in more complex societies.

The emphasis in the literature is generally on the role of gods and spirits as third-party punishers—a quality that is believed to enhance cooperation and enforce social norms (Johnson and Bering 2006; Norenzayan et al. 2016; Purzycki et al. 2016; Schloss and Murray 2011). While many of the gods and spirits in the ethnographic record are believed to play a morally punitive role with regard to weather (see Table S1), we find it interesting that, at least with respect to high or superior gods, helping or harming the food supply (without moral judgment by the gods) is more characteristic of our sample societies. Also, the belief that gods can help food supply with weather is slightly more common than the belief that gods can harm food supply with weather, and when the two forms of belief are modeled together (Model 5), the “help” variable's effect remains robust whereas the “harm” variable's effect disappears.

One interesting exception though has to do with minor spirits. Whereas for high gods and superior gods, helping food supply with weather is the strongest result, and punitive with weather the weakest, the opposite is true for minor spirits; harming the food supply with weather and punishment with weather are the strongest. This intriguing difference requires further research.

Are gods necessary to promote cooperation in the face of hazards and other resource stressors? The results presented here are limited to seasonal food and labor sharing, but they do suggest that resource stress supersedes the supernatural in promoting these forms of cooperation. This foray into using the worldwide ethnographic record to test theories on cooperation related to religious beliefs and practices is, we believe, a necessary test of how supernatural beliefs predict *in situ* cooperative practices. Worldwide tests maximize the chances that these findings are generalizable. It is also possible that other forms of religious belief and ritual or general religiosity not tested here promote cooperation. Future research would need to evaluate other types of cooperative behavior and other kinds of supernatural punishment or rewards, such as bringing

sickness or restoring health, accidents or good fortune, and providing a bad or good existence in the afterlife.

Acknowledgments IS and CC conceived and designed the experiments. IS, CC, and EP collected and coded the data. EP and JCJ analyzed the data. CRE, EP, and JCJ contributed reagents/materials/analysis tools. IS, CRE, EP, and JCJ wrote and revised the paper. This material is based upon work supported by the National Science Foundation under Grant Number SMA-1416651 awarded to the Human Relations Area Files for the research project titled “IBSS: Natural Hazards and Cultural Transformations.” We thank the reviewers for their constructive comments and suggestions.

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