Self-denial by shamans promotes perceptions of religious credibility

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Abstract

Religious leaders refrain from sex and food across human societies. Researchers argue that this self-denial promotes perceptions of credibility, invoking such associations in explanations of shamanism and prosocial religion, but few, if any, quantitative data exist testing these claims. Here we show that shamans in a small-scale society observe costly prohibitions and that observers infer three dimensions of credibility – cooperativeness, religious belief, and supernatural power – from shamans' self-denial. We investigated costly prohibitions on shamanic healers, known as *sikerei*, among the rainforest horticulturalist Mentawai people of Siberut Island. We found that shamans must observe permanent taboos on various animals, as well as prohibitions on sex and food during initiation and ceremonial healing. Using vignettes, we evaluated Mentawai participants' inferences about self-denial, testing three mechanisms of religious credibility: cooperative costly signaling, credibility-enhancing displays, and supernatural otherness. We found support for all three mechanisms: Mentawai participants infer self-denying shamans to be (1) cooperative, (2) sincere believers in the religious rules, and (3) dissimilar from normal humans and with greater supernatural powers. These data provide novel, quantitative evidence that self-denial develops to promote perceptions of practitioners' religious credibility.

Introduction

Religious self-denial, whether enforced or apparently voluntary, is ubiquitous. The renunciation of sex, valuable food, or social contact has been practiced by Catholic priests, Buddhist and Jain clergy, Taoist monks and nuns, Christian monastic sects, and many other practitioners who devote themselves to communing with the divine (Bell & Sobo, 2001; Gross, 1992).

Importantly, religious self-denial extends beyond world religions. For example, Winkelman and White (1987) coded ethnographic information about trance practitioners, or shamans (Hultkrantz, 1993; Lewis, 2003; Singh, 2018), in a representative sample of human societies. They found that shamans abstained from food, sex, or social contact in 83% of the societies coded.

Why should religious leaders observe such costly prohibitions, especially given that they can exploit their position to devise self-serving rules (Singh, Glowacki, & Wrangham, 2016; Singh, Wrangham, & Glowacki, 2017)? One common proposal is that leaders' self-denial promotes religious credibility (Henrich, 2009; Norenzayan et al., 2016; Singh, 2018; Sosis & Alcorta, 2003), although such claims remain largely untested. By "credibility", we mean an individual's believability. Credibility is contingent on factors such as trustworthiness and perceived expertise.

In this research, we tested three hypotheses connecting self-denial to credibility: cooperative costly signaling (Sosis & Alcorta, 2003), credibility-enhancing displays (Henrich, 2009), and supernatural otherness (Eliade, 1964; Mauss, 2001). Each of these hypotheses posits that observers infer from religious self-denial some trait about the practitioner – respectively, cooperativeness, religious belief, and supernatural power.

According to the cooperative costly signaling hypothesis, costly behaviors serve as reliable signals of an actor's cooperative intent (Bulbulia & Sosis, 2011; Gintis, Smith, & Bowles, 2001; Irons, 2001; Sosis & Alcorta, 2003). For example, costly behaviors might indicate that an individual is committed to cooperating with members of a particular group (Posner, 2000; Sosis, 2006) or that they believe in a religious system which includes cooperative doctrines (Henrich, 2009). Researchers have examined whether behaviors like possession and donating to charities act as costly signals of cooperativeness (Hall, Cohen, Meyer, Varley, & Brewer, 2015; Power, 2017a, 2017b), but few if any quantitative studies have tested whether this hypothesis explains the ascetic practices of religious leaders.

Aside from broadcasting cooperativeness, self-denial may also indicate the sincerity of one's belief. Developing this intuition, researchers have modeled how costly actions, termed credibility enhancing displays (CREDs), coevolve culturally with certain beliefs (Henrich, 2009; Wildman & Sosis, 2011). CREDs function as cues to social learners that a cultural model (i.e., someone from whom social information is learned) genuinely subscribes to the beliefs he or she espouses. For example, consider a model who tells a learner that it is safe to consume some mushroom. In response to a learner's reasonable apprehension, the model can enhance their credibility by taking a bite of the mushroom – that is, by engaging in a behavior that would be sensible only if the model genuinely believes the beliefs they espouse.

Researchers argue that CREDs culturally evolve to ensure the spread of other beliefs. For instance, recent work suggests that cultural evolution may have favored costly, religious displays to instill stronger beliefs in a powerful, moralizing god (Norenzayan et al., 2016). By this logic,

religious leaders abstain from food and sex because it makes them more effective as transmitters of the faith.

A growing body of research provides evidence for CREDs in different informational and behavioral domains (e.g., Kraft-Todd, Bollinger, Gillingham, Lamp, & Rand, 2018; Willard & Cingl, 2017). When betting on the validity of stories, subjects who witness others put down money are more likely to do the same (Willard, Henrich, & Norenzayan, 2016). US internet-users who recall their caregivers acting according to religious virtues are more likely to believe in God and be certain of that belief (Lanman & Buhrmester, 2017). Despite these advances, no work has tested whether a CREDs model explains the severe, religious restrictions of religious leaders.

Crucially, some behaviors can serve as both CREDs and cooperative costly signals (Bulbulia & Sosis, 2011), such as if a person demonstrates that they believe in a moralistic, punishing god. However, not all cooperative costly signals are CREDs – because a behavior might signal cooperativeness through channels other than belief – and not all CREDs are cooperative costly signals – because, among other reasons, there are many beliefs that a person can hold (such as that a mushroom is safe to eat) that do not make the believer more cooperative.

A third explanation for why practitioners observe costly prohibitions is what we refer to here as supernatural otherness. According to this hypothesis, observers infer that someone who self-denies is different from normal humans. This supposed difference makes it more conceivable that the self-denial has superhuman powers, such as healing or divine contact (Mauss, 2001; Singh, 2018). Researchers have not specified how or why observers should understand self-deniers to be distinct from normal humans, but potential mechanisms include perceptions that deniers have strange preferences or unique cognitive abilities enabling their abstention – or that they undergo some kind of transformation as a result of the denial, such as becoming purer (Smith, 2007).

To test whether any or all of these hypotheses explains why religious leaders observe costly prohibitions, we investigated taboos on shamans among the Mentawai of Siberut Island (Indonesia). Examining these dynamics among the Mentawai offers at least two advantages compared to research in industrialized populations with Abrahamic religions. First, as a belief system including, among other attributes, shamanism and an animist worldview (Loeb, 1929b, 1929c; Schefold, 1988), Mentawai religion shares characteristics with the traditional religions of small-scale societies around the world, especially those of hunter-gatherers (Peoples, Duda, & Marlowe, 2016). Studying Mentawai religion thus permits generalizations to a diversity of contexts, most of which are less relevant when examining the centralized religions of complex societies (Boyer & Baumard, 2016). Second, religious systems include many practices and beliefs, some of them recent variations due to cultural drift, others more functionally important and stable over time (Currie & Mace, 2014; Rogers & Ehrlich, 2008). The unique arrangement of Siberut Island, which contains many cultural regions that differ slightly in their practices and beliefs, allows us to identify those taboos on shamans that are shared across cultural regions and thus more likely to be functionally important.

Mentawai and sikerei

The Mentawai of Siberut Island are forest-dwelling sago-horticulturalists who live in river valleys

separated by hilly expanses of forest (Tulius, 2012) (Fig. 1A). At least 11 major valleys cover the island, each hosting a set of communities who speak their own dialect and decorate themselves with unique tattoo motifs. Throughout the rest of this paper, we refer to the set of communities who reside in the same valley and share a dialect as a cultural region.

Fig. 1. (A) Siberut Island, the largest island of the Mentawai Archipelago (Indonesia). Colored dots represent different study sites; the legend specifies the villages surveyed with the cultural region in parentheses. Indonesia is colored light gray in the inset, while other countries are in dark gray. (B) A Mentawai shaman and his wife.

Missionaries and government programs have transformed the religious lives of people living elsewhere in the Mentawai Archipelago, but dense tracts of forests have hindered these efforts on Siberut (Schefold, 1988). This, in combination with struggles by Mentawai clans to resist these programs, has allowed the traditional religious system to survive relatively intact in the interior of Siberut, bolstered by a strong shamanic institution. Nevertheless, tourism, the spread of Islam, settlement agendas by the government, and the expansion of formal education are rapidly transforming Mentawai social and cultural life (Delfi, 2013, 2017; Hammons, 2010), making ethnographic investigations invaluable.

Mentawai shamans are a class of men believed to possess the unique ability of seeing otherwise invisible spirits (Loeb, 1929c). These spirits include the ghosts of ancestors, deities that cause sickness (e.g., *sikaoinan*, a water-dwelling spirit, sometimes described as a crocodile, who punishes stinginess), and human souls, whose departure from the body manifests as illness. As healers, shamans are experts in herbal medicine and the special songs used for communicating

with various spirits. In some cultural regions, shamans are marked by their continued use of the loincloth and their full-body tattoos (Fig. 1B).

Shamans and their wives are both known as *sikerei*; other individuals are referred to as *simata* (uncooked, unripe, immature). Because only male *sikerei* are believed to see spirits and invited to heal illness during healing ceremonies – and because the term is commonly used to describe those individuals who provide these services – we use *sikerei* to refer to male *sikerei* unless otherwise specified.

Sikerei treat illness in *pabetei*, healing ceremonies that last from one day to a week. Families of sick people invite one to six shamans to administer treatments, which can include providing herbs, sweeping away evil spirits, beckoning a sick person's soul, and summoning the punitive water-spirit and removing it from the house. Shamans enter trance during a special nighttime treatment, known as *lajok simagre*, during which several shamans dance and summon beneficent spirits, some of whom possess the practitioners.

A man hoping to become a shaman can start by erecting and inhabiting a small house in the forest (*pulaeat*), observing taboos while dedicating himself to raising chickens and pigs. After days or weeks there, the novice finds a shaman-guru (*sipauma*) who typically demands pigs, durian trees, coconut trees, and sago. In return, the guru teaches the novice the herbal remedies and songs required for healing while treating the trainee's eyes to help him see spirits. Some initiates do not move to a forest house; instead, their training begins with a severe, untreatable illness, perceived by others as a sign that a person must become a shaman.

The *sikerei* must constantly observe taboos, or *keikei* (Loeb, 1929b; Schefold, 1988). As with shamans around the world (Eliade, 1964; Narby & Huxley, 2001), the Mentawai *sikerei* must abstain from sex and various food items during initiation and ceremonial periods, in addition to permanently refraining from several hunted animals. The severity of sex taboos in particular is captured in the frequent remark that, in becoming a *sikerei*, one's wife becomes one's sister.

We used costly prohibitions on Mentawai shamans (*keikei sikerei*) to evaluate whether and how religious self-denial promotes religious credibility. We first documented those taboos that apply to shamans and investigated the costliness of a subset of those prohibitions. We then used vignettes to probe participants' inferences about self-denying shamans and test the three hypotheses reviewed earlier.

Study 1: What are the taboos on shamans?

We first documented the activities and food items that are tabooed to shamans during initiation, during healing ceremonies, and permanently. By examining which prohibitions are shared across river valleys, we identified the taboos that are most resilient to change and which thus seem most functionally important (Currie & Mace, 2014).

Methods

We interviewed 88 participants about taboos on shamans across four cultural regions of southern Siberut (see Figure 1a; Sabirut: $n = 20$; Sarereiket: $n = 27$; Silaoinan: $n = 21$; Taileleu: $n = 20$), asking about temporary taboos during initiation and healing as well as permanent taboos that

apply through a shaman's lifetime. One participant was excluded from the permanent dietary taboo condition because of admitted ignorance. All participants provided informed consent before the study. The Harvard University Committee on the Use of Human Subjects approved this study and all others described in this paper.

We collected initiation and healing taboos using free-lists. We collected permanent dietary taboos, in contrast, using a checklist of 14 items. We developed the checklist after administering pilot interviews in three cultural regions (Sareireket, Sabirut, Simatalu). Thirteen of the 14 items in the checklist were those mentioned by more than one respondent during pilot interviews. The fourteenth (Mentawai langur, *Presbytis potenziani*) is commonly said to be freely consumed by shamans and was included to both confirm participant comprehension and to discourage participants from assuming that all items in the list were tabooed.

We excluded instances when participants specified that an item on the checklist was tabooed to shamans only during special periods. If a respondent mentioned that an item was permanently tabooed to a shaman but also temporarily tabooed during initiation and healing, we only included it as a permanent prohibition. If a participant listed a permanent dietary taboo but then specified that it only applied during healing ceremonies, we included it only as a periodic taboo during healing. We categorized taboos at two levels, first grouping similar responses and then aggregating those taboos within super-ordinate categories, such as taboos pertaining to sex, eating, and grooming.

We did not use inferential analyses on the free-list data; instead we present the raw frequencies of commonly cited taboos (see Figure 2 and Supplementary Table S1). The checklist data, on the other hand, was analyzed with cultural consensus analyses using the AnthroTools package in R (Purzycki & Jamieson-Lane, 2017).

Results: Taboos during healing and initiation

Figure 2 shows those items that respondents mentioned in at least three cultural regions for at least one of the two categories of prohibition.

Fig. 2. Prohibitions on shamans during initiation and healing ceremonies, according to free-lists by respondents in four cultural regions of southern Siberut. Rows correspond with responses from the regions of Sabirut (SAB), Sarereiket (SAR), Silaoinan (SIL), and Tailelu (TAI). White cells occur when no participants in a cultural region reported a taboo, dark blue cells occur when all participants reported a taboo, and transitional shades denote intermediate frequencies. The free-list response columns only include those taboos that were reported in at least three cultural regions for at least one domain. “Fast intermittently” is labeled with an asterisk because it is a prescription rather than a prohibition. The five aggregated columns refer to super-ordinate categories that contain the responses on the left and others; for example, “Cooking/work” includes “Clear brush for gardening”, “Cut/break”, “Plant”, “Work (general)”, and other work-related prohibitions that were reported in low frequencies. Raw frequencies appear in Supplementary Table S1.

Participants reported 54 taboos on shamans during initiation, 13 of which were mentioned in at least three cultural regions. Seven prohibitions appeared across all of the sites: eating without self-control, eating sour foods, committing adultery, having sex with one’s spouse, having sex with anyone, and doing any kind of work (including hunting, repairing a house, or tending to one’s gardens). To eat with self-control means to eat only when sitting down in a house with others, ideally when the food being served was prepared at an earlier time. To eat without self-control, in contrast, is to eat while walking or casually sitting, or to eat food that has been foraged and immediately prepared, like freshwater fish or taro leaves.

Taboos during healing ceremonies are similar to those observed during initiation. Participants mentioned 52 prescriptions that apply to shamans during healing. No taboos were mentioned in only three cultural regions; nine were mentioned in all study regions. As with taboos on shamans during initiation, taboos during healing ceremonies center on work, food, and sex. Figure 2 displays the frequencies with which participants listed different prohibitions along with aggregated frequencies (see Supplementary Table S1).

Results: Permanent dietary taboos

Using cultural consensus analyses, we determined that five animal species are tabooed in all four cultural regions: eels (*Anguilla bicolor*), flounders (Pleuronectiformes), gibbons (*Hylobates klossii*), the white morph of the simakobu monkey (*Simias concolor*), and three-striped squirrels (*Lariscus obscurus*) (see Fig. 3 and Supplementary Tables S2 and S3). Confirming respondents' honesty and comprehension, only one participant of eighty-seven replied that Mentawai langurs are tabooed, and they specified that this was a special case that required unique circumstances.

Fig. 3. Permanent dietary taboos on shamans (A) and individuals' preferences for those food items (B, C, D). Panel A: Participants in four cultural regions of southern Siberut (Sabirut, Sarereiket, Silaoinan, and Taileleu) answered “yes” or “no” to whether fourteen food items are permanently tabooed to shamans. White cells occur when no participant reported that an item was prohibited, dark blue cells occur when all participants reported a prohibition, and transitional shades denote intermediate frequencies. Cultural consensus analyses identified five food items as being tabooed across all four regions, indicated in colored boxes. The Mentawai langur was included as a control because it is freely and commonly consumed by shamans. Panels B, C, and D: Because of methodological limitations, different tasks were administered to measure how the prohibited foods ranked in people's dietary preferences. Panel B shows respondents' preferences for twenty-four foraged animals, including the three non-aquatic species consistently prohibited to shamans (III: gibbon; IV: simakobu monkey [white morph]; V: three-striped squirrel). Panels C and D show the number of times different river (C) and ocean (D) animals were named as the most preferred and frequently consumed items; the items

tabooed to shamans were mentioned second most frequently (I: eel) and not at all (II: flounder). Raw frequencies appear in Supplementary Table S2.

Study 2: How costly are shamans' dietary taboos?

We found that shamans across southern Siberut observe periodic prohibitions on sex and unconstrained eating, while they are permanently prohibited from five foraged food items. The periodic taboos, especially those on sex, appear decisively costly, but the costliness of the permanent dietary taboos is more unclear. We thus used ranking tasks to establish the relative costs of abstaining from eels, flounders, gibbons, white simakobu monkeys, and three-striped squirrels.

Methods

To detect whether and how costly permanent dietary taboos are for shamans, we conducted two tasks probing Mentawai participants' dietary preferences.

First, we investigated the costs of giving up non-aquatic, tabooed animals. We assembled as exhaustive a list as possible of Mentawai wildlife by consulting the appendix of a conservation plan printed by the Indonesian Ministry of Forestry (PHPA, 1995), collected photographs of each species mentioned in the report, and convened with focus groups of Mentawai participants to determine the edibility and local name of each animal. The compiled list excluded all aquatic species, representing only *iba sibara ka leleu* (meat of the jungle). After incorporating edible insects and mollusks, we concluded with a list of 77 consumed, non-aquatic species (74 species excluding the items commonly tabooed to shamans).

To determine how the three tabooed, non-aquatic food items ranked in comparison with other non-aquatic, foraged animals, we presented non-shamans ($n = 40$) with photographs of 24 animals, 21 randomly drawn from the list of 74 animals alongside the three tabooed species found on land (*Hylobates klossii*, *Simias concolor* [white], *Lariscus obscurus*; see Supplementary Table S4 for a list of the twenty-four animals). All participants gave informed consent. The photographs were presented randomly in a grid of 4 photographs by 6 photographs. Participants divided the 24 items into two groups of 12, one including animals they would never eat again and one including animals they would continue to eat. They sub-divided these groups again, and so on and so forth, until they produced eight piles, producing a ranking of foraged items from "most willing to give up" (ranking = 1) to "least willing to give up" (ranking = 8). We calculated each item's mean ranking.

We targeted willingness-to-give-up because this integrates people's preference for an animal with its availability. For example, denying oneself a high-quality animal that is rarely encountered is less costly than rejecting an item that is of slightly lower quality but frequently encountered. Willingness-to-give-up captures this asymmetry, and participants appeared to consider both their preference for an item and its availability when making their decisions. In contrast, questions about which items participants enjoy the most or find the most delicious are easily swayed by highly-favored items that are frequently tabooed or rarely encountered, distorting estimates of the cost of prohibition.

Because we could not obtain a list of consumed, aquatic species with accompanying photographs, we administered a different task to determine the costs of renouncing eels and

flounders. We asked the same subjects to name six aquatic, foraged animals, selecting three from the river and three from the ocean. We specifically asked participants to consider both the frequency with which they ate those items and their preference for those animals in making their selections. We identified synonyms and determined each item's ranking by counting the number of times it was named.

Results

The items vary considerably in people's self-reported willingness to give them up (Fig. 3B-D). Among the 24 foraged land animals, items tabooed to shamans ranked as tenth (*Hylobates klossii*), sixteenth (*Simias concolor* [white]), and twenty-first (*Lariscus obscurus*) in people's dietary preferences (see mean rankings and standard deviations in Supplementary Table S4).

In naming the river species that they enjoyed the most and consumed most frequently, participants listed the item tabooed to shamans, *Anguilla bicolor*, second, preferring it to all freshwater species aside from shrimp. In marked contrast, no participant mentioned flounders when naming favored saltwater species.

Study 3: What do observers infer about self-denying shamans?

We have established that Mentawai shamans observe costly periodic prohibitions, as well as permanent dietary prohibitions with more ambiguous or varied costs. We therefore conducted an experiment in the field to probe whether self-denial by shamans promotes any dimension of religious credibility, specifically testing the predictions of the cooperative costly signaling, CREDs, and supernatural otherness hypotheses.

Methods: Participants and procedure

Participants (n = 96) were opportunistically recruited in two villages in the interior of Siberut Island. All participants gave informed consent.

We presented each participant with two shamans introduced as pretend characters. We provided background details about the characters (family life and accomplishments) and said that both characters observed all of the shaman taboos. One shaman was described as refraining from either sex or valuable food items, while the other was said to have innocuous food preferences. We counterbalanced the characters' images and details and randomized the category of self-denial (food/sex). In the following example, the first character (Aman Dong Dong) refrains from foraged food items (counter-balanced information is italicized; treatment information is underlined):

Self-denying character: Aman Dong Dong, here, is a shaman. He follows all of the shaman taboos. *He has two children; he is knowledgeable in making canoes.* He does not eat pangolins, Pagai Island macaques, and flying foxes.

Control character: Aman Paule, here, is also a shaman. He follows all of the shaman taboos. *He has three children; he has a lot of gardens.* He does not like to eat chili; he likes to eat cassava leaves.

We specified that the shaman abstains from eating pangolins, Pagai Island macaques, and flying foxes because these animals, like two items tabooed to shamans (gibbons, white simakobu monkeys) and other large animals (e.g., wild pigs, other primates), constitute a class of hunted animals afforded special reverence, known as *matei keccak* (dead soul).

We then asked participants two comprehension questions that also served to prime the relevant information: (1) Food condition: *Who does not eat flying foxes?* // Sex condition: *Who does not sleep with their wife every day?*; (2) *Who does not like to eat chili?* If a participant failed, we re-read the character descriptions. We then asked participants questions about the characters' belief, cooperativeness, power, and similarity to other humans (see Supplementary Materials for the full list of questions). The questions were administered in one of four randomized orders, after which we again asked the comprehension questions.

Methods: Analysis

We conducted the task with 96 participants. To ensure the quality of the data reported, we only analyzed the responses of respondents who passed a series of comprehension and attention checks. First, we excluded subjects who failed the final comprehension check ($n = 12$). Second, we excluded participants whose answers contradicted for at least three of four pairs of questions targeting the same inference (questions *beli1* and *beli3*; *coop1* and *coop2*; *powe1* and *powe2*; *simi1* and *simi2* in the Supplementary Materials) ($n = 11$). Third, we excluded participants who, in their responses, alternated between the characters for at least 13 of the 14 questions ($n = 9$) (e.g., naming the first character, then the second, then the first, and so on). Twenty-six participants failed at least one check (six failed more than one). Two more participants were removed from analyses for experimenter error, yielding a final sample size of 68 respondents. See Supplementary Table S5 for results when including excluded participants; all results remain significant at a level of $p < 0.0001$, although effect sizes are smaller.

We conducted all statistical analyses in R (R Core Team, 2015). The internal reliability was high for three of the four traits (Cronbach's $\alpha > 0.75$ for belief, cooperativeness, and power), but lower for similarity (Cronbach's $\alpha = 0.59$). We created indices for each of the four traits that took values from -1 to 1, the magnitude representing the extent to which a participant inferred the self-denying shaman to exhibit the given trait. Using the *lmer* function of the *lme4* package (Bates, Maechler, Bolker, & Walker, 2015), we ran a linear mixed regression in which the domain of the trait inference was used to predict the magnitude of the score with sex, counterbalanced information, and category of self-denial (food or sex) included as covariates and random effects for participant ID. We used the *lsmeans* package (Lenth, 2016) to (1) produce estimated means; (2) conduct a Wald test (two-sided) testing whether these means differ from 0, adjusting for multiple comparisons using the Holm-Bonferroni method; and (3) test whether the means differed from each other, again using the Wald Test (two-sided) and adjusting for multiple comparisons using Holm-Bonferroni. Significance was defined at an alpha level of 0.05.

To test whether the category of self-denial (food or sex) had an effect on the trait inferences, we ran a second linear mixed regression, identical to the first except with the category of self-denial interacting with the domain of trait inference. We used the *lsmeans* package to compare means between the estimated trait inferences in both categories of self-denial, adjusting

for multiple comparisons using the Holm-Bonferroni method.

Results

Fig. 4 displays the estimated mean scores of the four traits. Respondents rated shamans who self-denied as being stronger believers in Mentawai religious beliefs (regression coefficient [C_R] = 0.59, df = 237.89, 95% CI = [0.41, 0.76]), more cooperative (C_R = 0.46, df = 237.89, 95% CI = [0.29, 0.64]), more supernaturally powerful (C_R = 0.42, df = 237.89, 95% CI = [0.25, 0.59]), and less psychologically and physically similar to normal humans (C_R = -0.40, df = 239.27, 95% CI = [-0.57, -0.22]). We conducted pairwise comparisons among all coefficients to test for differences. The effect size for similarity was significantly different from all inferred traits, which is to be expected given that it is negative. Otherwise, there were no significant differences among the coefficients (see Supplementary Table S6), although the estimated effect for belief is nearly 50% higher than the effect for supernatural power.

Fig. 4. Estimates of inferences about self-denying shamans. Scores of 1 indicate that participants infer self-denying shamans to always exhibit some trait, whereas scores of -1 indicate that participants infer self-denying shamans to never exhibit that trait. Error bars represent 95% confidence intervals. Asterisks denote p-values; *** <0.0001.

We found no effect for the category of self-denial (see Supplementary Table S7). In other words, respondents made similar inferences about shamans who refrained from sex as they did about shamans who refrained from eating various food items.

Discussion

Mentawai taboos impose enduring costs on shamans, barring them from having sex during

healing ceremonies and permanently forbidding them from consuming valued items, among many other prohibitions. We found that participants infer shamans who abstain from food and sex to be more cooperative, sincere in their belief, supernaturally powerful, and psychologically and physically dissimilar. These findings are consistent with the hypothesis that self-denial by religious leaders develops to bolster their credibility.

This research is significant for at least three reasons. First, it represents the first quantitative examination of why religious leaders engage in costly self-denial. Although evolutionary and psychological researchers have studied practices like possession, ritual scarring, and church attendance (Hall et al., 2015; Power, 2017a; Sosis, Kress, & Boster, 2007), and although they commonly posit functional hypotheses for leaders' celibacy and asceticism (Henrich, 2009; Norenzayan et al., 2016; Singh, 2018; Sosis & Alcorta, 2003), no study to our knowledge has tested these accounts. Second, this study provides the first experimental evidence that costly behaviors can simultaneously garner perceptions of supernatural power and difference from normal humans. This is consistent with wisdoms about the metamorphic nature of pain and hardship (Glucklich, 2001; Hoffman & Trawalter, 2016), but it suggests that, whether or not pain and denial *actually* change a person, people's psychological biases predispose them to interpret those behaviors as transformative. Lastly, this research advances our understanding of the origins of institutionalized leadership in human societies. Shamans represent the only professional class in many societies, and their religious authority often translates into leadership roles beyond the supernatural, such as in organizing economic activity or arbitrating conflict (Singh, 2018). This research identifies self-denial as a potential mechanism by which shamans and other practitioners maintain their authority, even in small-scale societies.

Many evolutionary scholars emphasize the costliness of prohibitions (Barker, Power, Heap, Puurtinen, & Sosis, 2019; Sosis, 2006), but our research indicates that other factors might influence prohibition. In line with the emphasis on costliness, we found that shamans are tabooed from sex and freely eating during healing ceremonies and initiations. But we also found that for permanent dietary taboos, cost seems tangential to whether an item is prohibited. Consider eels and flounders, both of which are prohibited to shamans. Eels ranked as the second most frequently-consumed and favored river species. The communities surveyed live along rivers and regularly fish in them, so this suggests a real, appreciable cost. In contrast, no participant named flounders when listing their preferred food items. This is not surprising. The Mentawai living in the interior of Siberut never come into contact with flounders, and in follow-up conversations, several participants admitted to never having eaten one.

Rather than banning especially valuable food items, these permanent dietary taboos instead may target peculiar animals. People regard atypical entities as impure or sacred (Douglas, 2002; Leach, 1964; Sperber, 1996), so rejecting them may enhance perceptions of a practitioner's difference. In fact, all of the foods tabooed to shamans are known as *makatai* (bad, broken, evil), and, with the exception of the three-striped squirrel, all are categorical anomalies. Gibbons are likened to humans (Schefold, 1972, 1982). The flounder is literally regarded as a split fish (*laitak katsila*). The white simakobu is the only white primate on the island. And eels are described as slippery and, in myths, are compared to snakes (Loeb, 1929a).

What explains prohibitions on both beneficial acts (sex, easy eating) and strange animals? There are at least two interpretations. First, different prohibitions may evoke different inferences. For example, the permanent withdrawal from strange animals may serve to indicate an inherent difference from normal people, enhancing perceptions of supernatural power, while

the withdrawal from sex and freely eating might indicate another dimension of religious credibility, such as cooperativeness or belief. Alternatively, different prohibitions may evoke similar inferences that vary along a single dimension of prohibition. For instance, the permanent withdrawal from strange animals may produce the same kinds of inferences as does withdrawal from sex during healing ceremonies.

Our experimental results support the second interpretation: Different prohibitions evoke similar inferences. The evidence is that we found no differences in the inferences participants made about a shaman who refrained from having sex compared to the inferences they made about a shaman who denied himself hunted animals. Moreover, many participants spontaneously referred to the self-denying character as *makeikei* (tabooed), regardless of his taboo. In doing so, they likened the novel forms of self-denial to other taboos, considering the shamans along a single dimension of prohibition. These results suggest that participants' inferences were not unique to the specific items but instead constituted more generalizable perceptions of people who self-deny.

Readers should be aware of at least two limitations of our field experiment. First, the self-denying character engaged in voluntary self-denial beyond the typical restrictions observed by shamans. All shamans are expected to permanently reject eels, gibbons, and so on, as well as sex and uncontrolled eating during healing ceremonies – but the treatment character went beyond these restrictions, abstaining either from other hunted animals or completely from sex. Thus, our experiment risks capturing participants' inferences about additional self-denial rather than inferences about typical prohibitions. Second, and relatedly, the experimental characters rejected items different from those normally forbidden to Mentawai shamans. Rather than rejecting eels, gibbons, and so on, the characters in the food-prohibition condition abandoned flying foxes, pangolins, and Pagai Island macaques. How confident can we be that the inferences people made about these hypothetical forms of self-denial are equivalent to the inferences they make about actual abstinence?

These points are important to consider, and future research should further probe how these variables bias people's inferences. Still, our basic interpretation is justified. The most conservative interpretation, given these limitations, is that Mentawai participants infer several dimensions of religious credibility from shamans who self-deny, regardless of whether the shamans refrain from sex or from eating several notable, large animals.

In sum, we have provided evidence that religious leaders in a small-scale society observe permanent and periodic prohibitions and, in doing so, garner religious credibility and perceptions of supernatural powers. This project helps elucidate why figures across time and space, from the shamans of rainforest horticulturalists to the memorialized prophets of the world's major religions, have rejected sex, food, social contact, and other necessities on their journeys toward religious leadership and apparent divinity.

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Author Contributions: MS and JH designed the study. MS collected and analyzed data. MS wrote the manuscript, and both authors edited it.

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Self-denial by shamans promotes perceptions of religious credibility

SUPPLEMENTARY MATERIAL

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3 July 2019

Experimental Materials

Questions

Question IDs (e.g., beli1, coop1) match those in the dataset

Belief

beli1: *For example, there is a ceremony. Of the two of them here, someone eats sour [the consumption of sour is tabooed during ceremonies and believed to cause misfortune]. Who is it?*

beli2: *According to you, who believes more in arat sabulungan [Mentawai religion]?*

beli3: *According to you, who follows taboos less?*

Cooperativeness

coop1: *According to you, who is a thief?*

coop2: *According to you, who shares meat more?*

coop3: *For example, there is a burning house. Who goes to help?*

trus1: *For example, you are not here because you are working or with family somewhere far. Who do you look for to help take care of your children here?*

trus2: *For example, you need personal advice on a family issue. Who do you ask?*

Power

powe1: *Who has weaker medicine?*

powe2: *Who has stronger medicine?*

powe3: *Who has stronger magic?*

Similarity

simi1: *Whose thoughts are closer to those of a non-shaman?*

simi2: *Whose thoughts are farther from those of a non-shaman?*

simi3: *Whose body is closer to that of a non-shaman?*

Supplementary Tables

Table S1. Raw frequencies with which respondents named taboos on shamans during initiation and healing across four cultural regions. See Fig. 2 and the main text for details.

		FREE-LIST RESPONSES															AGGREGATED				
HEALING	INITIATION		Clear brush for gardening	Cook	Cut/break	Display anger or yell	Eat fern	Eat sour	Eat without self-control	Fast intermittently	Have sex (adultery)	Have sex (spouse)	Have sex (general)	Plant	Shower	Work (general)	Cooking/work	Disturb household	Eat	Groom	Have sex
		SAB	0.00	0.00	0.15	0.05	0.15	0.25	0.40	0.00	0.20	0.20	0.30	0.00	0.00	0.10	0.20	0.05	0.65	0.00	0.55
		SIL	0.14	0.05	0.05	0.24	0.00	0.38	0.10	0.05	0.19	0.29	0.33	0.00	0.14	0.29	0.33	0.24	0.43	0.14	0.57
		SRR	0.12	0.04	0.04	0.04	0.12	0.27	0.15	0.23	0.12	0.19	0.65	0.12	0.12	0.19	0.42	0.04	0.65	0.15	0.88
		TAI	0.05	0.05	0.00	0.05	0.05	0.20	0.30	0.15	0.25	0.25	0.20	0.25	0.05	0.35	0.45	0.05	0.70	0.10	0.55
HEALING		SAB	0.05	0.00	0.05	0.15	0.05	0.10	0.40	0.00	0.05	0.15	0.35	0.05	0.10	0.05	0.15	0.15	0.50	0.10	0.45
		SIL	0.24	0.00	0.00	0.29	0.00	0.10	0.05	0.00	0.14	0.29	0.24	0.05	0.00	0.48	0.67	0.29	0.19	0.10	0.57
		SRR	0.19	0.04	0.08	0.08	0.15	0.12	0.15	0.00	0.19	0.08	0.38	0.04	0.00	0.15	0.46	0.12	0.50	0.00	0.65
		TAI	0.15	0.00	0.10	0.05	0.00	0.05	0.15	0.05	0.15	0.20	0.45	0.15	0.00	0.15	0.35	0.05	0.30	0.00	0.75
			0.15	0.00	0.10	0.05	0.00	0.05	0.15	0.05	0.15	0.20	0.45	0.15	0.00	0.15	0.35	0.05	0.30	0.00	0.75

Table S2. Raw frequencies with which respondents reported dietary taboos on shamans across four cultural regions. See Fig. 3 and the main text for details.

	Eel <i>Anguilla bicolor</i>	Fern <i>Diplazium esculentum</i>	Flounder <i>Pleuronectiformes</i>	Gibbon <i>Hyllobates klossii</i>	Green broadbill <i>Calyptomena viridis</i>	Mentawai squirrel <i>Callosciurus melanogaster</i>	Mushroom Unknown poliphore	Palm hearts {e.g., sago, coconut}	Simakobu (white morph) <i>Simias concolor</i>	Taro leaves <i>Colocasia esculenta</i>	Three-striped squirrel <i>Lariscus obscurus</i>	Turmeric <i>Cucuma longa</i>	Turtle <i>Heosemys spinosa</i>	Mentawai Langur* <i>Potenziani presbytis</i>
SAB	1.00	0.89	0.95	0.89	0.16	0.68	0.42	1.00	1.00	0.58	0.84	0.74	0.79	0.00
SIL	1.00	1.00	0.86	1.00	0.48	1.00	0.19	1.00	0.95	0.24	1.00	0.10	1.00	0.05
SRR	1.00	0.27	0.92	0.85	0.62	0.15	0.08	0.31	0.96	0.19	0.96	0.04	0.23	0.00
TAI	0.95	1.00	0.90	1.00	0.35	0.95	0.90	1.00	0.95	1.00	1.00	0.90	0.95	0.00

Table S3. Probabilities that different items are tabooed in the four cultural regions according to cultural consensus analyses.

	Eel <i>Anguilla bicolor</i>	Fern <i>Diplazium esculentum</i>	Flounder Pleuronectiformes	Gibbon <i>Hylobates klossii</i>	Green broadbill <i>Calypomena viridis</i>	Mentawai squirrel <i>Callosciurus melanogaster</i>	Mushroom Unknown poliphore	Palm hearts {e.g., sago, coconut}	Simakobu (white morph) <i>Simias concolor</i>	Taro leaves <i>Colocasia esculenta</i>	Three-striped squirrel <i>Lariscus obscurus</i>	Turmeric <i>Cucuma longa</i>	Turtle <i>Heosemys spinosa</i>	Mentawai langur* <i>Potenziani presbytis</i>
SAB	>0.99	>0.99	>0.99	>0.99	<0.01	>0.99	0.47	>0.99	>0.99	>0.99	>0.99	>0.99	>0.99	<0.01
SIL	>0.99	>0.99	>0.99	>0.99	0.77	>0.99	<0.01	>0.99	>0.99	<0.01	>0.99	<0.01	>0.99	<0.01
SRR	>0.99	<0.01	>0.99	>0.99	>0.99	<0.01	<0.01	<0.01	>0.99	<0.01	>0.99	<0.01	<0.01	<0.01
TAI	>0.99	>0.99	>0.99	>0.99	<0.01	>0.99	1.00	>0.99	>0.99	>0.99	>0.99	>0.99	>0.99	<0.01

Table S4. The twenty-four nonaquatic, foraged animals presented to subjects. Items tabooed to shamans in all four regions are shaded. See also Fig. 3.

Latin	English	Mentawai	Mean ranking	Standard deviation
<i>Anthracosceros coronatus</i>	Malabar pied hornbill	<i>kailaba</i>	6.46	1.39
<i>Ardea sumatrana</i>	Great-billed heron	<i>meccau</i>	2.28	1.32
<i>Calyptomena viridis</i>	Green broadbill	<i>luikluik</i>	4.59	1.76
<i>Centropus sinensis</i>	Greater coucal	<i>kemut</i>	5.13	1.59
<i>Ceyx erithacus</i>	Three-toed kingfisher	<i>sikoplaitak</i>	1.28	0.60
<i>Cuculux fugax</i>	Hawk-cuckoo	<i>buccit</i>	4.28	1.39
<i>Cuora amboinensis</i>	Box turtle	<i>lokipat</i>	3.10	1.63
<i>Dicaeum cruentatum</i>	Scarlet-backed flowerpecker	<i>ritdit</i>	3.73	1.74
<i>Dicaeum trigonistigma</i>	Orange-bellied flowerpecker	<i>dhadhatdhat</i>	4.36	2.05
<i>Geomyda spinosa</i>	Spiny turtle	<i>toulu</i>	3.70	1.71
<i>Hylarana nicobariensis</i>	Nicobar golden-backed frog	<i>loloakkek</i>	4.05	1.88
<i>Hylobates klossii</i>	Kloss's gibbon	<i>bilou</i>	4.93	1.95
<i>Lariscus obscurus</i>	Three-striped squirrel	<i>soksak</i>	2.50	1.85
<i>Macaca pagensis</i>	Pagai macaque	<i>obaketa</i>	5.88	1.81
<i>Occidozyga laevis</i>	Puddle frog	<i>utetsopak</i>	6.63	1.41
<i>Paradoxurus hermaphroditus siberu</i>	Siberut palm civet	<i>lamusek</i>	3.45	2.18
<i>Phaenicophaeus curvirostris</i>	Chestnut-breasted malkoha	<i>koitkot</i>	5.83	1.41
<i>Pycnonotus melanoleucos</i>	Black-and-white bulbul	<i>pusitattat</i>	4.59	1.87
<i>Pycnonotus plumosus</i>	Olive-winged bulbul	<i>rotidot</i>	5.56	1.70
<i>Rhynchophorus ferrugineus</i>	Sago palm weevil (larvae)	<i>tamara</i>	6.40	2.37
<i>Simias concolor</i>	Simakobu monkey (black morph)	<i>simakobuk</i>	6.90	1.37
<i>Simias concolor</i>	Simakobu monkey (white morph)	<i>simabulau</i>	3.90	1.57
<i>Sturnus sturninus</i>	Daurian starling	<i>ngorut</i>	6.88	1.38
[Tadpole]	Tadpole	<i>kalabbok</i>	1.48	0.75

Table S5. Comparison of coefficients with and without data exclusion. Standard errors are displayed in parentheses. See Supplementary Table 5 and the main text for statistical details. Asterisks denote p-values; *** <0.0001.

	With data exclusion	Without data exclusion
Belief	0.586*** (0.088)	0.446*** (0.075)
Cooperativeness	0.462*** (0.088)	0.368*** (0.075)
Power	0.419*** (0.088)	0.313*** (0.075)
Similarity	-0.397*** (0.089)	-0.341*** (0.076)

Table S6. Pairwise comparisons among coefficients (estimated trait inferences).

	Estimated difference	SE	df	t	p	Adjusted p (Holm)
Belief-Power	0.166	0.113	200.2	1.48	0.45	1.0
Belief-Similarity	0.983	0.113	200.8	8.69	<0.0001	<0.0001
Belief-Cooperativeness	0.123	0.113	200.2	1.10	0.69	1.0
Power-Similarity	0.816	0.113	200.8	7.22	<0.0001	<0.0001
Power-Cooperativeness	-0.043	0.113	200.2	-0.38	0.99	1.0
Similarity- Cooperativeness	-0.860	0.113	200.8	-7.60	<0.0001	<0.0001

Table S7. Estimated differences between trait inferences when self-denial targeted food compared to when it targeted sex.

	Estimated difference	SE	t	p	Adjusted p (Holm)
Belief	-0.081	0.166	-0.49	0.63	0.94
Cooperativeness	-0.212	0.166	-1.28	0.20	0.61
Power	-0.120	0.166	-0.73	0.49	0.94
Similarity	0.243	0.168	1.45	0.15	0.59