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Sex differences in costly signaling in rural Western China

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ABSTRACT

Costly rituals convey commitment to communities and advertise trustworthiness and cooperativeness to peers, which might explain why humans perform costly religious rituals. Here, we compare the efficacy of occasional public displays versus regular but less public acts for prestige enhancement. We collected data on religious behaviors ranging from daily low-cost practices to infrequent high-cost pilgrimages to distant locations among residents of an agricultural Tibetan village, as well as their reputational standings. We find that religious practices are mediated by demographic factors such as wealth, age and gender. Women perform more daily religious activities, but men engage more in distant pilgrimages. Participation in distant pilgrimages increases the perception of all prosocial characteristics. In contrast, daily practices are positively associated with nominations for devoutness but not for other qualities. Devoutness is sometimes negatively associated with other reputational qualities, suggesting that religiosity might be not only about signaling prosociality.

1. Introduction

Costly Signaling Theory (CST) was developed to explain exaggerated characters or displays observed in certain animals that seemed to be harmful to their reproductive success (J.M. Smith & Harper, 2003). Costly displays are suggested to be a way for individuals to honestly communicate information on competitiveness and other qualities (Higham, 2014; Rendall, Owren, & Ryan, 2009; J.M. Smith & Harper, 2003). These signals emerge and persist if they boost their carriers' reproductive success over their whole life cycle (Palmer & Begley, 2015).

Anthropologists have employed CST to explain costly displays observed in many domains of human society that are seemingly unexplained by standard evolutionary models (Bird & Smith, 2005; Roberts et al., 2021; Shaver & Bulbulia, 2016; Sosis, 2006). These include altruistic behaviors – philanthropic gifts, self-sacrificial acts, etc. – which will never be reciprocated directly by the receivers (McAndrew, 2019). Empirical studies have revealed that individuals convey their commitment to the social group, signal themselves to be reliable cooperation partners, and advertise their desirable personal resources through behaviors that seemingly entail a waste of time and energy (Darimont, Coddington, & Hawkes, 2017; Nowak & Sigmund, 2005;

Számadó, Samu, & Takács, 2022; Zahavi, 1977). For instance, the Hadza of Tanzania and the Ache of Paraguay expend a great deal of energy hunting animals in excess of their own families' nutritional requirements and give large amounts of hunted meat to other families in the community (Gurven & Kim Hill, 2000). These displays are suggested to convey information regarding the sender's qualities as a potential food foraging partner to signal recipients. In the Meriam of Torres Strait, Australia, the ability to provide turtle meat for funeral banquets is seen as a reliable indicator that the donor is a skilled hunter, since catching turtles requires not just physical agility but also specific prosocial traits (E.A. Smith & Bliege Bird, 2000). Hawkes et al. (Hawkes, O'Connell, & Blurton Jones, 2001a, 2001b) argue that the function of hunting by men in certain forager societies is to provide the community with periodic bonanzas that display their talents and maybe result in benefit through increased reputation (Stibbard-Hawkes, 2019). Men known as skilled hunters are preferred as campmates and are more frequently named as friends or partners for cooperative hunting (Bird, Smith, & Bird, 2001; Bliege Bird & Power, 2015; Hawkes & Bird, 2002; E.A. Smith, Bliege Bird, & Bird, 2003), which may contribute to greater reproductive success (Hill & Hurtado, 1996; E.A. Smith, 2004). Lab experiments have shown that men were more likely to volunteer for some physically costly activities (e.g. actions requiring pain endurance, high-risk adventures)

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(Farrelly, Lazarus, & Roberts, 2007) or very altruistic behaviors (e.g. generous donations in public goods game) when such behaviors are conspicuous and can be recognized by the spectators or when attractive members of the opposite sex are present, suggesting that men's generosity may have evolved as a mating signal (Bereczkei, Birkas, & Kerekes, 2010; Iredale, Van Vugt, & Dunbar, 2008; van Vugt & Hardy, 2010). As a result, those who engage more in such activities often receive higher rewards and are more likely to be selected as partners by their peers (McAndrew & Perilloux, 2012).

Being among the most pervasive costly behaviors in human societies, religious beliefs and practices typically involve significant time consumption (e.g., meditation, chanting), energy costs (e.g., worship, pilgrimages), monetary expenditure (e.g., offerings, donations), and sometimes physical harm or pain (e.g., ascetic practices, blood sacrifices, and genital mutilations), energy that could have been used to rear offspring. Some argue that these behaviors may be seen as reliable signs of devotion to the community, given that only individuals who are really dedicated to the group's values are prepared to pay such high costs (Sosis & Alcorta, 2003; Sterelny, 2020; Xygalatas et al., 2021). Some studies have shown that those who regularly participate in collective rituals are perceived to be more trustworthy (Purzycki & Arakchaa, 2013); those costly signals of religious commitment can increase trust within or even across religious faiths (Hall, Cohen, Meyer, Varley, & Brewer, 2015). Some findings from economic games show that individuals who report higher levels of religious commitment behave more generously (Ge, Chen, Wu, & Mace, 2019; Soler, 2012). Ethnographic research from a religious community in south India reveals that individuals who participate more in religious life are more likely to be seen as having a variety of prosocial features, which leads villagers to develop mutually beneficial interactions (Power, 2017, 2018; Power & Ready, 2018). Other studies also indicate that religious rites function to foster social cohesion and facilitate cooperation within groups (Bulbulia, 2004; Irons, 2001; Sosis & Alcorta, 2003; Wilson, 2002; Xygalatas et al., 2013).

A prosocial reputation may increase an individual's attractiveness and help them obtain more social resources (Barclay, 2004; Bulbulia, 2004; Cottrell, Neuberg, & Li, 2007; Hardy & Van Vugt, 2006; Lyle & Smith, 2014; G.F. Miller, 2007). People often take part in religious practices as costly signals to convey their commitment to religious beliefs. Their peers discern such signals and combine them with information obtained from other prosocial behaviors to assess what specific qualities an individual possesses. Men and women often differ in the religious practices they perform (Power, 2017; Xygalatas et al., 2021). For example, possessions by a god during annual festivals in South India is generally performed by women (Power, 2017). Somatically costly body piercing during collective rituals in Mauritius and in the South-eastern Tibetan area are practiced exclusively by men (Stuart, Banma-dorji, & Huangchojia, 1995; Xygalatas et al., 2021). The fact that only men engage in body piercing at collective rituals suggests that this ritual may function as a display of mating qualities – health, strength, power – or a way for men to compete for status. It is also likely that social norms and physical characteristics prevent women from performing dramatic acts at collective rituals (Xygalatas et al., 2021). Others have shown that some religious acts may be negatively correlated with prosocial qualities (Power, 2017). Several studies have shown that women are generally more religious than men (Beit-Hallahmi & Argyle, 1997; Flere, 2007; Heyer-Gray, 2000; A.S. Miller & Hoffmann, 1995; Roth & Kroll, 2007; Stark, 2002; Vardy et al., 2022; Walter & Davie, 1998), but none of these studies were dedicated to examining gender differences in reputation for prosociality in the light of costly signaling theory.

Here, to bridge this gap, we collected data from one village in western China by undertaking an in-depth ethnographic study of costly religious behaviors in a Tibetan Buddhist community and evaluating the signal content of routine and low-frequency high-cost religious actions, i.e. pilgrimages to distant destinations. We investigate how participation in religious rituals is linked to socio-economic factors and examine the different efficacy of engaging in distant pilgrimages versus routine

religious acts on perceived prosocial qualities.

2. Material and methods

2.1. Ethnographic setting

The village in our study is located in the Amdo area of the Tibetan Plateau and consists of four communities with long history (Tso wa, མོ་བ། see Supplementary Materials for more details) with a total of 121 households and 557 individuals, including 289 adult residents. The majority of residents are Tibetans, whereas others are Han Chinese or Tu (a Mongol group). Virtually all residents are devout adherents of the Gelug sect; this is the most popular form of Tibetan Buddhism and is also known as “Yellow Hat” after the headdress worn by its monks (Powers, 2007a). Income varies widely among households. Most residents are farmers; only a small proportion of residents hold positions in local government institutions or schools. As is common in these mostly agricultural villages, half of the residents usually grows highland barley, oilseed rape and some cash crops like leeks, cabbages, potatoes, etc., whereas others, who are not in permanent employment, earn their living by digging wild cordyceps (a medicinal fungus) or doing manual labor in slack season (March–May). A few residents support their families by producing *thangka*, traditional Tibetan Buddhist paintings.

Residents invest a considerable amount of time in several different religious practices. Pilgrimages (མཇུག་ལྟོན་པ།) are common and have long constituted an essential aspect of Tibetan life (Jansen, 2018; Buffetrille, 2003; Donnelly, 2018; Kapstein, 2013; Powers, 2007b). These journeys to sacred places are deemed to be the best way to express a person's devoutness to the Buddha (Huber, 2002). In our study site, many villagers made often very long pilgrimages to monasteries located all over the Tibetan plateau. Some elderly villagers have made pilgrimages to distant destinations with their family members from an early age. Households vary greatly in the number of pilgrimages their members have undertaken, with some having travelled to sacred places multiple times and others hardly ever. Individuals who have completed a long and arduous pilgrimage to a faraway destinations (distant pilgrimages) are greatly admired by their communities (Donnelly, 2018; Lopez & Donald, 2007).

In addition to pilgrimages, residents also perform a range of daily religious practices, including chanting sutras (ཁོ་རྟོན་འདོན་པ།; *ka dun dhoun bha*), counting prayer beads (ཕྱིར་བཀྟོན་པ།; *changh nwa dgan bha*), turning prayer wheels (མ་རྟི་བསྟོར་པ།; *mah neig kor wa*), and prostrating (kowitz) to Buddha images at home (ལྷག་འཚལ་བ།; *sheh tsa wa*). Moreover, households regularly smolder highland barley flour together with cypress branches on propitious days and during festivals to beseech the mountain gods to bestow upon them a bountiful harvest and a smooth business (Stuart et al., 1995). Some villagers regularly spend several hours making short-distance pilgrimages to the local monastery (local pilgrimages). Here they circum-perambulate around the whole monastery or one of the stupas, turn prayer wheels, or both. Other villagers, especially women, practice fasting from sunrise to sunset on propitious days. All these practices above signal their devotion to the Buddha and do not entail large financial expenditure (See Supplementary Materials for more details).

2.2. Data collection

We collected demographic data from 557 individuals in 121 households, including basic individual information such as name, gender, age, ethnicity, whether being a monk or not, marital status, birthplace, number of siblings and children (living in the household or elsewhere), and occupation, as well as financial situation (monthly income and source of revenue). All questions were asked by CRDZ, a native Tibetan speaker. Additionally, a survey on reputational nomination and engagement of religious practices was conducted by 289 adult residents.

2.3. The measure of religious practice

Interviewees were asked about the nature, frequency and location of their religious practices. We divided the religious practices into two categories, distant pilgrimage and daily routine practices (local pilgrimage, counting beads, prostrating, aromatic plant burning, and fasting). Individual differed in the frequency of participation to pilgrimages and in the destination chosen. We categorized pilgrimages into “local pilgrimages” and “distant pilgrimages”, according to whether the pilgrimage sites were located inside the local region or outwith, respectively. While villagers generally participate more frequently in local pilgrimages – owing to the destination being closer geographically and the financial expenses lower – they often express the desire to visit more distant and more important monasteries or pilgrimage sites like Lhasa. Although they are costly, participation in distant pilgrimage is highly valued among villagers. To quantify the extent to which each resident invests in distant pilgrimage, we divided distant pilgrimages into seven classes according to the locations of the monasteries, because costs are significantly influenced by the geographic distance between the destination and the pilgrim’s residence (Table S2). We use a questionnaire following Power’s (2017) methods for measuring religiosity, which covers all types of pilgrimage. Respondents scored each act from 1 (low) to 5 (high) in terms of monetary expenditure, time consumption, and physical costs. Ninety-seven adults completed the ranking task (stratified by gender). We performed a consensus analysis on these rankings using “AnthroTools” package in R; the independent weighting scores for each costly behavior are obtained in three dimensions (Table S2), which are then summed up for calculating a total value for each type of distant pilgrimage activity. The frequency of seven classes of pilgrimages was recorded. The score for each class of daily religious acts is denoted by the sum of a series of binary scores where one represents whether the focal resident regularly undertakes the corresponding daily religious practice – that is, whether they regularly engage in a pilgrimage to the local monastery, whether they regularly prostrate, whether they regularly count prayer beads or chant sutras.

2.4. The measure of reputational evaluation

The evaluation of reputation is obtained by collecting nominations on four different qualities (being devout, hardworking, generous, of good character) from every adult respondent living in the focal village. Respondents were asked to freely list up to five individuals in the village whom they felt had the corresponding quality. Each of the character traits described above are locally noticeable and recognized, determined through in-depth interviews, and tested with pilot fieldwork.

2.5. Covariates

We control for gender, age cohort, and the number of consanguineous relatives in the village. We use a dichotomous variable to record if the individual has ever held a position in a local government body, measuring in this way their political prominence. The factors mentioned above are all individual-level and may influence the probabilities of being nominated. As far as the household level factors are concerned, the wealth of each family may also influence reputation. Wealth ranking of households was conducted by one senior person who was very familiar with every household in this village. The households were divided into three categories: rich, medium, and poor, each of which was further divided into three categories, for a total of nine household categories: very rich (1) to very poor (9). Additionally, we also recorded the corresponding communities to which each household belongs. Basic descriptive statistics of all relevant variables are included in Table S1.

2.6. Data analysis

We first predicted that greater investment in the religious life of the

village would correlate with increased recognition as being devout and prosocial. For all reputational qualities, many individuals are never named, while a few individuals are named many times. To account for this skew, we used hurdle models (Cameron & Trivedi, 2013; Hofstetter, Dusseldorp, Zeileis, & Schuller, 2016; Mullahy, 1986), which specify two components: a binomial model predicting if a response will be zero or greater than zero, and a truncated count component (with a negative binomial distribution) predicting the number receiving nominations. Therefore, four models were built, differentiated by the reputational quality considered (Devout; Generous; Hardworking; Good Character respectively). Hurdle models were constructed in R (R Core Team, 2022) using the hurdle function in the “pscl” package (Jackman, 2010; Zeileis, Kleiber, Jackman, & Jackman, 2008).

We then modeled the reputational nomination ties to examine the effect of the religious costs using exponential random graph models (ERGMs). ERGMs can predict the probability of a tie, allowing for the inclusion of node-level (individual), dyad-level (interpersonal), and network-level (structural) components in the model. In addition to various node-level covariates (individual (node), age, gender, wealth), interpersonal (dyad) gender homophily, community homophily, kinship, affinal kinship, and reciprocity are also considered due to their significant influence on the nomination. The religiosity measures are included as a node-level attribute for incoming ties only, meaning that the effect of religiosity is only being evaluated for the effect it has on others naming the person as devout or prosocial. The networks used here are treated as directed and unweighted. Further details on the ERGMs can be found in Supplementary Materials. The reputation nomination networks were constructed in R using the “igraph” package and analyzed with the “statnet” suite of packages.

3. Results

3.1. Descriptive statistics

3.1.1. Religious acts

Investment in religiosity is mediated by demographic factors. Residents with a higher wealth rank have higher mean scores for distant pilgrimages (Fig. 1). As far as gender is concerned, women participate more in daily religious acts (Fig. 2), whereas men are consistently involved in more distant pilgrimages (Fig. S1). The older the residents are, the higher the investments to daily acts (Fig. S2).

3.1.2. Reputation nomination

Two-hundred and eighty-nine individuals acted as nominators, and 246 people received at least one nomination among all the four aspects of reputational qualities. The descriptive statistics for nominations are shown in Table S3. The nomination network of all reputational qualities by gender are shown in Fig. 4 (see Fig. S5, S6, S7 and S8 for networks for each of the four reputational qualities, by gender). Overall, interviewees named an average of 7.7 people for an average of 9.9 times, each villager was named an average of 11.6 times by 9 individuals, though there is substantial variance, with many people named only a few times and a few individuals named many times (Fig. S3 and Fig. S4). The correlation between different domains of reputation shows that being nominated as generous and having good characters are strongly positively correlated. However, the qualities of devoutness and being hardworking as well as generosity seem to belong to independent domains, as suggested by the correlated coefficients (Fig. 3).

Frequencies of nominations by villagers regarding these four reputational qualities are shown in Fig. S4. Men get more nominations than women among all the nominations. In addition, consistent with findings in other studies of reputational nominations (Power, 2017), the data distribution shows that a few individuals get numerous nominations, whereas many others barely get any nominations (Fig. S3 & Table S3).

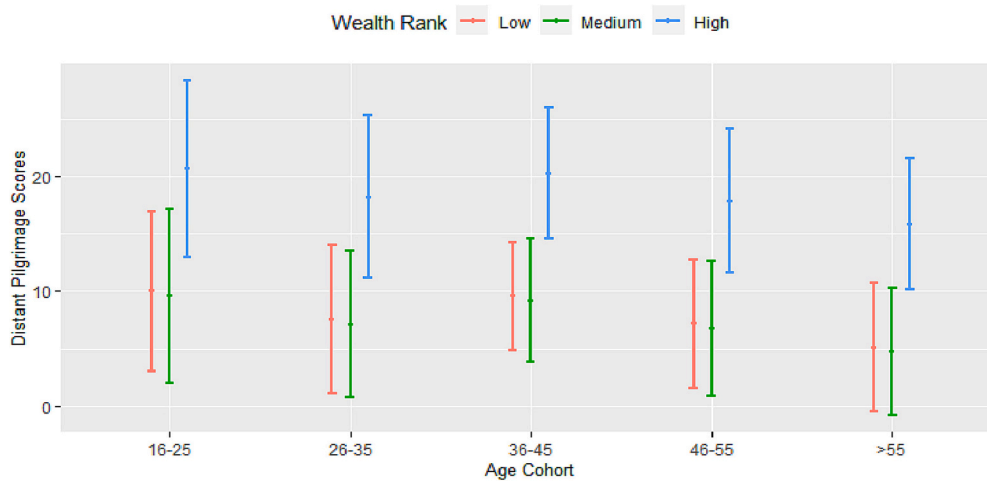


Fig. 1. Distribution of distant pilgrimage scores classified by wealth rank (The error bar represents 95% CI).

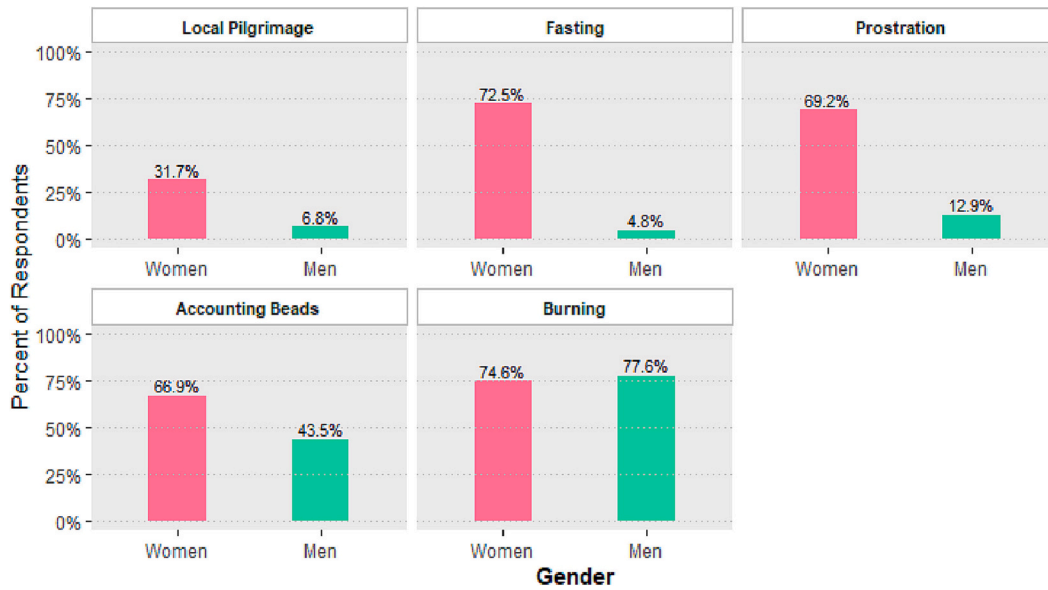


Fig. 2. Percentage of individuals engaging in daily religious activities, classified by gender.

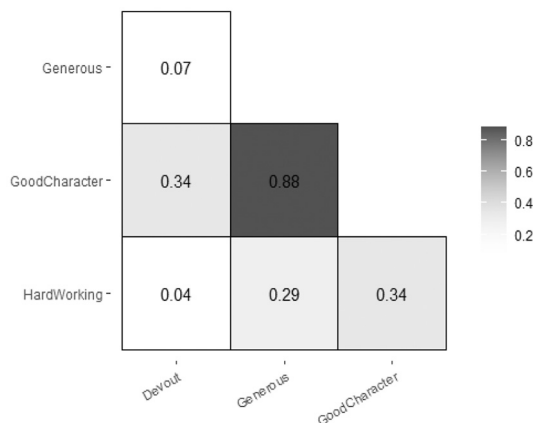


Fig. 3. Bivariate correlations between reputational qualities. Numbers within the squares are Pearson correlation coefficients. The darker the color, the stronger the positive correlation.

3.2. Reputational nomination and religiosity

The zero components predict the probabilities that a resident is nominated at all as having a given quality, where the count components predict the frequency of being nominated.

Table 1 shows the association between religious investments and reputational nomination after controlling for confounding factors, suggesting that daily acts are associated with increased expected frequency of being nominated as devout for those receiving at least one nomination. In addition, the costs of distant pilgrimages are also positively associated with the probabilities of being nominated as devout. On average, increasing the score for distant pilgrimage by one SD unit increases the log-odds of being nominated for devoutness by 0.39, while increasing the score for daily religious acts by one SD unit increases the log-odds by 0.88. In contrast, the efforts put into pilgrimage do not have any significant effect on the frequency of nomination of devoutness. Taken together, as far as the perception of devoutness is concerned, investments in low-cost but frequently repeated religious acts show a more substantial effect than participation in costly pilgrimages, suggesting that perhaps the former one is a more valuable way of signaling devoutness.

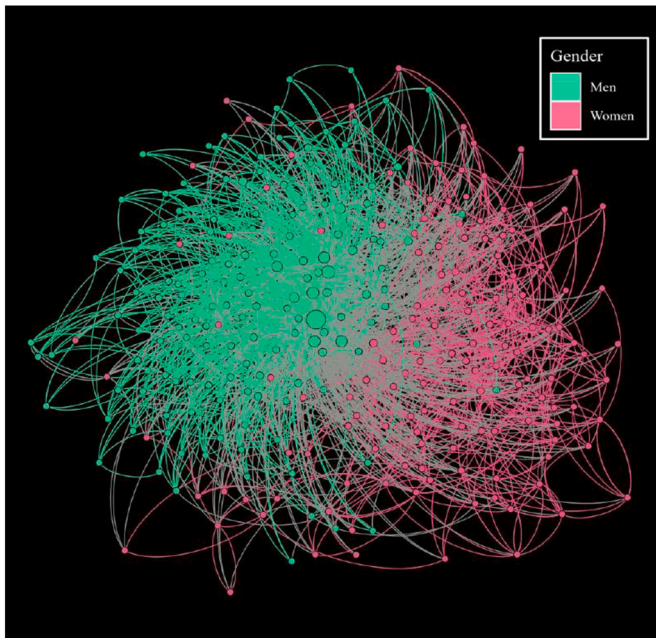


Fig. 4. Nomination network for all qualities, sized by degree and colored by gender (green = male, red = female). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 1

Estimates for the religiosity terms from the hurdle models predicting each reputational quality. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$. (Note: the values showed below are odds ratios).

Reputation	Zero components		Count components	
	Daily score	Pilgrimage score	Daily score	Pilgrimage score
Devout	0.88***	0.39*	0.87***	-0.04
Generous	0.30	0.21	-1.60***	0.29***
Good	0.37*	0.19	0.06	0.01
Character				
Hard working	0.17	-0.04	-0.17***	0.09***

However, it seems that individuals that put more effort toward daily religious acts receive fewer nominations for being generous and hardworking, even after adjusting for gender, but are seen as being of good character. In contrast, among those nominated as being generous or of good character, a higher investment into distant pilgrimages is associated with a significant increase in the expected number of nominations, suggesting that people who invest more in distant pilgrimages are usually recognized by their peers as having other types of prosocial qualities. In comparison to other villagers who must perform heavy daily labor or farm work to maintain their families, villagers of high financial status do not need to engage in such harsh manual labor, which may lead the other villagers to perceive them as not being hardworking. This may also explain why the correlation between performing distant pilgrimages and a reputation for being hardworking is quite weak.

Displays of the full model's specifications (Table S4) suggest that men get more nominations than women for all prosocial qualities. Compared to individuals in the ">55 years old" age cohort, those who are younger are consistently less likely to receive nominations, as well as being nominated fewer times. However, we did not find that the scores of daily religious investment and distant pilgrimage have significantly different associations with the reputational scores in older and younger age groups (Table S5).

Wealth rank is also significantly associated with nominations. People

from households with medium and low wealth ranks are only half as likely to receive nominations as those with a high wealth rank. Being from a low-ranking household also dramatically decreases the expected number of nominations for all qualities. However, as far as being considered hardworking is concerned, wealth rank does not have a significant effect in zero components and smaller coefficients in count components. Interestingly, those with a greater number of relatives seem to receive fewer nominations. Compared to models with only covariates (Table S4), models with the two variables quantifying religious costs fitted better to our data.

3.3. Reputation nomination networks

By using ERGMs, we built the reputation nomination networks to examine which factors influence the probability that A nominates B as having a given prosocial quality. Homophily in gender and community is significantly positive; this suggests that people tend to give nominations to those of the same gender and from the same community. Consanguineous kinship and affinal kinship networks also play substantial roles in building ties for reputational nominations. These multivariate networks reveal that nominations are more likely to happen between relatives. Consistent with the results from our hurdle models, Table S6 shows that older villagers are more likely to receive nominations than younger ones. With high wealth rank as the reference, villagers from other lower wealth ranks are more willing to give nominations but less likely to be nominated by others, which indicates that poorer people are more likely to nominate richer ones. As far as the network structure term is concerned, we find that mutual nominations occur, suggesting that the nominator has a higher probability of being nominated by the nominated person. Crucially, performing distant pilgrimages increases the probability of being nominated as having at least one type of prosocial quality. A negative estimate is obtained for the score of daily religious acts, indicating lower probability of connecting nomination ties.

By analyzing the four nomination networks for each quality, we found that the higher the score for distant pilgrimage, the higher the probability of the focal person being nominated as being devout, generous, of good character as well as hardworking. Despite the positive effect of daily religious acts on the nomination for devoutness, daily acts are negatively associated with people being nominated as having the other three prosocial qualities. We further explored our data by performing separate hurdle models for men and women (Table S8). We found that participation in distant pilgrimages is associated with increased nomination for two prosocial qualities (good character, hardworking) for men, but not for women. For both genders, participation in daily practices is associated with increased nominations for devoutness, but the association is stronger for men than for women.

Together, results from the hurdle models and exponential random graph models consistently suggest that infrequent but costly religious behaviors substantially increase an individual's chances of being nominated as having a number of reputational qualities. The fact that engagement in persistent daily religious acts contributes to an individual being perceived as devout is perhaps not surprising; however, an individual's peers do not recognize them as having prosocial qualities and engaging in daily religious behaviors can decrease the probability of being nominated for other prosocial qualities. Gender differences were also present. Men participated more in low-frequency high-cost religious practices (pilgrimages), and men were also more likely to receive nominations for all prosocial traits. Women participated more in daily religious practices, which is positively associated with nomination for devoutness but negatively associated with nomination for their prosocial traits.

4. Discussion

Residents of the Tibetan village we studied appear to be using the

religious practices performed by their peers to discern their religious commitment and to infer a series of reputational qualities. The findings presented here show that the frequency of religious practices differs between genders. Men tend to take part in distant pilgrimages, whereas women engage more in daily religious rituals. Participation in distant pilgrimages is generally associated with greater recognition of all kinds of reputational qualities. In contrast, religious practices performed on a regular basis are linked to devoutness but are associated with lower scores on other prosocial traits. Women have to work harder than men for recognition of positive character traits.

Studies in Hindu and Christian villages in south India (Power, 2017) show that villagers who invest more in long-term regular worship and participate in costlier ritual acts are not only seen as being more devout, but also as having other prosocial traits. Individuals who perform occasional dramatic religious acts during festivals show a slight increase in recognition for being physically strong and hardworking. Together, these results suggest that persistent signals result in more reputational benefits than dramatic ones. Our results consistently revealed that individuals who participated more in dramatic religious acts like distant pilgrimage are more likely to be considered as possessing a series of prosocial traits, whereas investment in daily religious rituals is negatively associated with nomination for other prosocial qualities. One possible reason may be that daily religious practices require time and energy consumption to a large extent, rather than monetary expenses; this may lead the signal receivers to recognize that the signal senders are more devout than they are generous. But why are villagers still willing to endure the time and energy cost of these religious acts given their negative influence on other traits? In a religious population, the devoutness may be more important than other qualities. One explanation could be that participation in daily religious rituals may earn more significant benefits to its practitioners in subsequent cooperative interactions compensating costs of other qualities. Future research is needed to examine this hypothesis. Those with more relatives receive fewer nominations, possibly because nominators know them too well and do not think much of them. Families of lower socioeconomic status tended to nominate higher socioeconomic families more.

The meaning of a signal depends on its specific content, and how this content corresponds to differences in quality and hence costs. In costly signaling terms, both distant pilgrimages and generosity could be signals of wealth. Distant pilgrimages require large financial expenditure, thus wealthier individuals can more easily afford to undertake distant pilgrimages. They can also afford to be more generous, and their status or power can be increased as a result of being generous. On the other hand, villagers may not be willing to cooperate with a wealthy but stingy villager, as it is hard to gain support or obtain benefits from those individuals. Villagers would be more willing to cooperate with a generous person, even if they are not wealthy. Thus, both distant pilgrimages and generosity are not only signals of the underlying quality of wealth, but also signals of the intention to cooperate.

Low-frequency dramatic signals may be more effective in attracting new sexual and cooperation partners (E.A. Smith et al., 2003), whereas routine signals can better ensure the authenticity of the information conveyed by the signals, indicating that signal senders are more willing to express trust and commit to long-term relationships. For instance, women in some hunter-gatherer societies share food with other women for a long time, and the more generous women signal their cooperativeness or other prosocial traits to other people by sharing food persistently and reaping benefits in subsequent social interactions (Bird, Ready, & Power, 2018). On the other hand, short-term, spectacular religious behaviors often play a role in updating information on other individuals' prosocial qualities, and younger villagers tend to have less empirical knowledge. Participation in spectacular practices in south India often plays a more important role in updating the prosocial traits for younger villagers than older ones (Power, 2017).

Participation in religious practices varies widely across age, gender, and financial status. Men are inclined to participate more in distant

pilgrimages, and women participated more in routine daily practices. Elders are more likely to engage in daily practices, whereas those with a higher wealth rank participate more in distant pilgrimages. Individuals embedded in the capital status of reputational nomination networks are usually those of higher wealth rank, indicating social status is often related to prestige. There are some parallels here with the results of a study of cooperative networks in Mosuo farmers in southwestern China: the poor were more likely to help the rich than vice versa, and residents were more ready to help their kin (Thomas et al., 2018).

In Tibetan Buddhism, men tend to play central roles in collective religious rituals (Makley, 2007; Nietupski, 1999). In the region where our village is located, women abstain from visiting the chapels of protective deities in Holy Temple of the village when annual religious rites are held. In the male-dominant religious communities of Amdo, the kinship system is patrilineal (Du & Mace, 2019; Du, Thomas, Bårdsen, Mace, & Næss, 2019; Wu, Ji, He, Du, & Mace, 2015) and patriarchal. Men control family wealth, which leads to most women participating in fewer long distant pilgrimages, which are financially costly. Younger women are occupied in daily agricultural production, housework, and labor more than men are (Chen, Ge, Zhou, Du, & Mace, 2023) and so they are unable to participate in religious practices that take place far from home, whereas elderly women's main task is taking care of the younger generations (Du & Mace, 2019). Thus, most women only participate in religious acts close to their home, and men participate in distant pilgrimages because they can afford them, as they are the sex who control wealth. In this patriarchal society, it seems that substantial time and energy investment in daily religious acts is not rewarded with as much reputational gains as the spectacular investments that can be afforded by men. A pattern of men nominating more men, and women nominating both men and women is similar to what Micheletti et al. (Micheletti, Ruxton, & Gardner, 2020) call a 'boys club' pattern of altruism: this can evolve when there is female dispersal at marriage and a history of intergroup warfare, as was historically the case for the areas we studied.

In addition, daily religious practices require a large time investment but a lower financial expenditure. The villagers who perform most daily routine practices are elders (Fig. S2). They can dedicate plenty of time to carrying out these daily practices, thus reducing their effort on other labors and making them less likely to be seen as generous and hardworking. This may explain why engagement in daily practices has a negative association with nominations for generosity and hard work for both genders. Our models (Table S8) also showed that women's daily practices only increase nominations for devoutness, not for other prosocial qualities; this may be partially because women who engage in such practices may have less time for household work as a result, leading to them being perceived as less hardworking.

For women especially, trying to increase their status by being devout may not greatly enhance their reputation for prosocial qualities, suggesting that advertising prosociality cannot fully explain the high levels of religious investment in certain communities. Villagers do some daily rituals in private, possibly to safeguard their personal and their immediate family's well-being. These practices are not "prosocial" in the specific sense of being directed at the larger community, but they may be perceived by others as showing devotion to close kin. On the one hand, this is probably a positive virtue in a kin-based society such as this one; on the other hand, given competition between kin groups, it may be seen as "selfish" by non-kin members of the community. This might also explain why villagers who invest more in daily rituals are less likely to be nominated by other villagers as being generous, of good character, and hardworking. More research is needed to fully understand the signaling content of these daily routine practices.

Author's contributions

Study and hypotheses designed by CRDZ., E.G., J.D. and R.M.; Data collected by CRDZ.; Data analyzed by E.G.; Manuscript co-wrote by

CRDZ., E.G., J.D. and R.M.; and all authors contributed substantially to revisions.

Research ethics

Everyone freely and voluntarily signed the consent information form. This study received ethical clearance from Lanzhou University. Permission to perform this study was obtained from each local town government where the investigation was conducted.

Code availability

Code is available at Github: <https://github.com/CairangDongzhi/Se-x-Differences-in-Costly-Signaling-in-Rural-Western-China>

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Declaration of Competing Interest

We declare we have no competing interests.

Data availability

Data is available at dryad: doi:<https://doi.org/10.5061/dryad.pvmcvdnmw>.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.evolhumbehav.2023.02.009>.

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