



# When Saying “Sorry” Isn’t Enough: Is Some Suicidal Behavior a Costly Signal of Apology?

## A Cross-Cultural Test

Kristen L. Syme<sup>1</sup> · Edward H. Hagen<sup>1</sup> 

Published online: 14 December 2018

© Springer Science+Business Media, LLC, part of Springer Nature 2018

### Abstract

Lethal and nonlethal suicidal behaviors are major global public health problems. Much suicidal behavior (SB) occurs after the suicide victim committed a murder or other serious transgression. The present study tested a novel evolutionary model termed the Costly Apology Model (CAM) against the ethnographic record. The bargaining model (BRM) sees nonlethal suicidal behavior as an evolved costly signal of need in the wake of adversity. Relying on this same theoretical framework, the CAM posits that nonlethal suicidal behavior can sometimes serve as an honest signal of apology in the wake of committing a severe transgression, thereby repairing valuable social relationships. To test this hypothesis, the CAM was operationalized into a set of variables, and two independent coders coded 473 text records on suicidal behavior from 53 cultures from the probability sample of the Human Relations Area Files. The results indicated that in ethnographic accounts of suicidal behavior, transgressions, punishment, and shame were relatively common, supporting the CAM, but explicit motives to apologize and evidence of forgiveness were rare, contrary to the CAM. The theoretical variables of the CAM nevertheless formed a cluster distinct from the BRM, and a subset of cases of suicidal behavior were largely related to transgressions and other CAM variables rather than BRM or other variables. Support for the CAM varied widely across cultures, but there was evidence for it in every major geographical region. Exploratory analyses suggested that the CAM is potentially more likely to occur in response to severe conflicts concerning transgressions committed against nonkin. Furthermore, in text records that involved transgressions, male suicidal behavior was most frequently associated with murder, whereas female suicidal behavior was most frequently associated with sexual transgressions. In conclusion, the results provided mixed support for the hypothesis that some instances of suicidal behavior function to send a costly signal of apology to those harmed by a transgression.

---

**Electronic supplementary material** The online version of this article (<https://doi.org/10.1007/s12110-018-9333-3>) contains supplementary material, which is available to authorized users.

✉ Edward H. Hagen  
[edhagen@wsu.edu](mailto:edhagen@wsu.edu)

Extended author information available on the last page of the article

**Keywords** Suicidal behavior · Cross-cultural analysis · Costly signaling · Bargaining · Mental health · Evolutionary medicine

Suicide is a universal human tragedy. Though rates of suicide vary across populations, no society is immune from it. Given the cross-cultural ubiquity of suicidal behavior (SB), which can include threats and attempts in addition to completions, and the ongoing failure to reduce suicide rates despite decades of research (Nock et al. 2008), it is a scientific imperative to investigate this phenomenon using unexplored theoretical frameworks, such as evolutionary theory (Syme et al. 2016).

One of the first and most influential evolutionary theories of suicide is the inclusive fitness model (IFM; DeCatanzaro 1980, 1991). According to the IFM, suicide is an evolved strategy that increases inclusive fitness when victims (1) have low reproductive potential and (2) impose a substantial fitness cost on kin. For example, in a nomadic population, such as those in which humans evolved, individuals with severe, permanent physical disabilities would be unlikely to reproduce and might require substantial help from close relatives to survive, reducing the reproduction of their relatives. Such individuals could have negative inclusive fitness and would therefore increase their inclusive fitness by removing themselves via suicide, allowing close genetic kin to invest more in their own reproduction. Evidence in support of the IFM includes the facts that suicide rates increase with age as, arguably, reproductive value decreases and burdensomeness on kin increases, and recent psychological theories of suicide emphasize the role of perceived burdensomeness (Joiner 2005).

The IFM, however, faces a theoretical challenge: in numerous species, individuals disperse to avoid competing for resources with, and otherwise imposing costs on, kin (and also to avoid inbreeding; for review, see Ronce 2007). In human groups, individuals who were imposing costs on kin could simply disperse, reducing that cost to zero while preserving some probability of survival and reproduction. If physical disability prevented dispersal, kin could abandon or stop investing in the costly individual, again eliminating their cost without foreclosing any chance of survival and reproduction.

The IFM also faces empirical challenges: In Westernized populations, such as the US, rates of suicide attempts outnumber suicide completions by factors of 10–100 or more (National Center for Injury Prevention and Control 2003); in other words, most suicidal behavior does not result in death, contrary to the IFM. Moreover, attempts are especially common among healthy young adult women, whose reproductive potential would seem to be high (Syme et al. 2016), also contrary to the IFM. The risk of nonlethal suicide attempts by adolescents and young adults is increased by negative life events, such as breakups, rejections, and serious fights with family members, and chronic interpersonal difficulties, such as poor relationships and frequent arguments with authority figures (Johnson et al. 2002). Based on these patterns, scholars in many disciplines have suggested that suicide attempts are often some type of signal of distress or cry for help (Andrews 2006; Farberow and Shneidman 1961; Firth 1936, 1961; Hagen et al. 2008; Hezel 1984; Nock 2008; Rosenthal 1993; Stengel 1956; Watson and Andrews 2002).

Signals can evolve when the information, such as level of need or distress, is known to one party and unknown to other parties (private information), but it would benefit all parties for the information to be shared (for discussion, see Maynard Smith and Harper

2003). A long-standing puzzle is how reliable signals can evolve if signal senders would benefit by deceiving signal receivers. In such situations, senders would evolve to send deceptive signals of, for example, need, and receivers would therefore evolve to ignore the signals (Zahavi 1993).

Costly signals are one solution to the problem of deceptive signals (for review, see Maynard Smith and Harper 2003; Spence 1974; Zahavi 1975). Rosenthal (1993) developed a game-theoretic model of suicidal behavior as a costly and therefore credible signal of need. Senders are in one of two states, known only to them: in need, and not in need.<sup>1</sup> Need is therefore private information. Senders in both states benefit if their social partners provide help. Social partners (signal receivers), however, want to help senders who are in need but not senders who are not in need. Senders choose an attempt (signal) strength, and then survive with a probability that depends on the strength and a chance factor. Social partners observe the attempt strength (not level of need) and then decide whether or not to help the sender. The cost of the attempt is the benefit foregone if the sender dies. Simplifying somewhat, a critical assumption of the model is that for senders in need (but not for senders who are not in need), the benefit of living without getting help is close to zero. Senders in need can therefore afford to attempt suicide (because the cost of dying is low), whereas senders who are not in need cannot afford to attempt suicide (because the cost of dying is high). Receivers can therefore trust that individuals attempting suicide are in genuine need and provide help (for details, see Rosenthal 1993). The stochasticity of outcomes of suicide attempts might actually reduce the average cost of the signal (Meacham et al. 2013).

Hagen and colleagues (Hagen 1999, 2002; Hagen et al. 2008) similarly argued that aspects of major depression, deliberate self-harm (DSH), and suicidal behavior might be bargaining strategies in which a victim puts a cooperative endeavor at risk to credibly signal his or her low valuation of the endeavor, with the aim of achieving mutually beneficial terms of cooperation (see also Andrews 2006; Nock 2008; Watson and Andrews 2002). Some game-theoretic models of bargaining are variants of costly signaling models in which *both* parties can credibly signal their valuation of an endeavor (Ausubel et al. 2002; for reviews, see Kennan and Wilson 1993). We term this the bargaining model (BRM) of suicidal behavior.

In an arranged marriage, for example, a young woman's suicidal behavior credibly signals to her parents that she holds a low valuation of the marriage relative to marrying someone else. The "message" of suicidal behavior in this case is that the value of the arranged marriage is so low that the young woman is (almost) indifferent between marriage and death. The woman's desired outcome is that she survive and her parents allow her to marry a more suitable mate. The parents, in turn, can signal their valuation of their daughter: If they value her, they will agree to let her marry someone else to prevent a future suicide attempt, whereas if they do not value her, they will not agree.

Syme et al. (2016) tested the IFM and BRM by coding every mention of suicidal behavior in the Probability Sample (PSF) of the Human Relations Area Files (HRAF), a database of ethnographic reports. In support of the BRM, most victims of suicidal behavior were powerless (e.g., had little social influence), were in conflict with powerful others (e.g., parents, community leaders), had experienced some type of

<sup>1</sup> Rosenthal uses the terms "depressed" and "not depressed."

adversity that posed a threat to their fitness (e.g., loss of a mate, physical abuse), and, if they survived, often improved their situation.

There was weaker evidence for the IFM, which possibly characterized a small fraction of cases of suicidal behavior in societies in northern latitudes where the environment is harsh, and where the support of noncontributing community members can present an insurmountable burden. These results indicate that a single model does not encapsulate all cases of suicidal behavior, and that the IFM, support for which varies by geographic region, might be best explained by cultural evolution.

## The Costly Apology Model of Suicidal Behavior

Despite the fairly high level of evidence for the BRM, a subset of reports of suicidal behavior in the eHRAF was not easily explained by the original formulation of the BRM or the IFM. These reports involved a severe transgression and subsequent suicidal behavior, along with punishment, shame, and sometimes forgiveness. Malinowski (1926) and Firth (1940, 1961) argued that, in the Trobriand Islands and Tikopia, respectively, suicide following a transgression was a means to expiate the sin, offense, or crime. Hezel (1984), who worked in Chuuk, another Pacific Island culture, also noted a distinct cluster of suicide cases related to transgressions. This raised the possibility that, in some cases, suicidal behavior might not credibly signal need but instead, apology.

Apologies appear to be signals that help maintain cooperative relationships that were harmed by transgressions—acts that violate important social norms and/or impose costs on others (Okamoto and Matsumura 2000; Trivers 1971). Apologies are effective at eliciting forgiveness and avoiding punishment (Fehr et al. 2010), probably because they assure the offended the transgression or harmful behaviors will not happen again (Feinberg et al. 2012; Goffman 1956). Apologies take various forms and incorporate verbal and nonverbal cues. Verbal cues might include saying “excuse me,” giving detailed explanations, accepting responsibility, expressing remorse, showing consideration, begging for forgiveness, and promising future good deeds (Ohbuchi et al. 1989). Nonverbal cues include gaze aversion, smiling, nervous laughter, blushing, and showing other signs of embarrassment (Feinberg et al. 2012; Goffman 1956).

Apologies can be motivated by shame and guilt, emotions that inform the individual that they have either transgressed or imposed costs on others (Fessler 2004), and that might involve distinctive universal expressions (Ekman and Cordaro 2011). Shame, in particular, appears to be caused by self-perceived devaluation by social partners. The behavioral correlates of shame resemble appeasement displays in nonhuman primates, such as lowering the face, gaze aversion, slumping shoulders, and adopting a stooped posture and bent-kneed gait (Fessler 2007), and might function to ameliorate threats to one’s social value (Sznycer et al. 2012, 2017). Guilt is similar to shame but also involves the perception that one has inflicted harm on others (for a discussion of shame vs. guilt, see Fessler 2007).

Ohtsubo and Watanabe (2009) proposed that it might not be clear to those offended by transgressions whether the breach was accidental or deliberate—the motive of the transgressor is unobservable, private information. If the transgression benefited the transgressor, there is a motive for the transgressor to offer a “cheap” but insincere apology so as to further exploit others. For example, Serena borrows Rei’s car,

benefiting herself but hurting Rei by preventing her from getting to work. Serena apologizes. Rei would continue to be Serena's friend if Serena were genuinely sorry and would avoid hurting Rei again for her own benefit, but it is difficult for Rei to know if Serena is genuinely sorry; maybe Serena just wants to keep using Rei's car.

Transgressors who genuinely wish to continue their cooperative relationship with the offended will be willing to make a costly and therefore honest apology because these costs will be repaid by the future cooperation (e.g., reciprocal altruism: Axelrod and Hamilton 1981; Trivers 1971), whereas those who do not desire future cooperation will not make a costly apology (because the lack of future cooperation means the costs of such an apology would not be recouped). Thus, when motives are private information and there are incentives to offer insincere apologies, those harmed by severe transgressions will be more likely to resume cooperation after receiving a costly apology (Ohtsubo and Watanabe 2009).

There is evidence that transgressions are often followed by costly behavioral signals of penance. The Christian sacrament of penance, for example, involves various forms of self-sacrifice from acts of goodwill to self-denial (e.g., fasting), and in some times and places even deliberate self-harm, notably self-flagellation (Zialcita 1986). The Ainu of Japan forced severe transgressors to pay for their crimes by removing their hair and beard, a symbolic and denigrating punishment, in the event that they could not pay direct compensation (Shinichirō and Harrison 1960). Corporal punishment is a cross-culturally common sanction that, besides affording the offended the satisfaction of revenge, can serve to absolve transgressors. In the Hopi language, the term *wuvatota*, or punishment, conveys the dual meanings of flogging and purification (Hieb 1973). In some cases, the costly apology involves the transgressor directly compensating the offended parties. Among the Nuer, for instance, the transfer of cattle serves as a form of direct payment when a man murders someone from an outside clan or village. The payment acts not just as a punishment but as a means of restoring balance between the groups (Howell 1970) and evading retaliation (Johnson 1986).

In war, soldiers kill, or otherwise perpetrate, fail to prevent, bear witness to, or learn about acts that transgress deeply held moral beliefs, which Litz et al. (2009) conceptualize as *moral injury*. As a consequence, many suffer profound shame, guilt, and other forms of psychological distress and often engage in self-harming behaviors such as drug abuse and suicidal behavior. In a section titled "Reparation and Forgiveness," Litz et al. (2009) argue that to repair the moral injury, service members and veterans need to "find decency and goodness and ways of *doing good deeds* as a vehicle to self-forgiveness and repair" (2009:704, emphasis added). Both self-harming behaviors and doing good deeds could be costly apologies.

In laboratory studies, Bottom et al. (2002) found that, following defection in an iterated prisoner's dilemma, substantive (costly) amends had more positive effects than simple explanations in restoring cooperation. Nelissen and Zeelenberg (2009) found that individuals who, according to the condition, committed a wrongdoing and could not directly compensate were more likely to say they would self-punish by forgoing money or other opportunities than those in alternative conditions. Tanaka et al. (2015) found that shame and guilt were associated with self-punishment following an accidental transgression in an experimental modified dictator game. In a control study, Inbar et al. (2013) found that participants who recalled a time in which they experienced guilt for a wrongdoing self-administered shocks of greater intensity compared

with those who recalled either neutral or sad experiences. Moreover, deliberate self-harmers often report self-punishment as one of several motivations (Klonsky 2011). In sum, these studies point to a relationship between transgression-related emotions and various forms of self-punishment, consistent with costly apologies.

Receivers of apology signals, in turn, are sensitive to the costs of the apology. Ohtsubo and Watanabe (2009) tested perceptions of an apologizer's sincerity based on the costs of the apology through the use of vignettes and an experimental dictator game. The results indicated that those offended by a transgression regarded costly apologies as more sincere or honest than no-cost, verbal apologies and were less likely to punish costly apologizers through complaint messages. In the dictator game experiment, the cost of the apology was not transferable; therefore, the offended's willingness to pardon the transgressor was based on the apology, not restitution (Ohtsubo and Watanabe 2009).

### How Costly Does the Apology Need to Be?

Because signal costs serve to discriminate honest from deceptive signalers, if there were no deceptive signalers then apologies for even the most severe transgressions would not need to be costly. Apology costs are therefore not necessarily related to the severity of the transgression—in other words, the harm to the victims. Instead, to be credible, the cost of an apology must exceed the potential benefit to a deceptive signaler. In a formal model of suicide as a costly signal (Rosenthal 1993), a lower bound on the cost of the signal is given by:

$$\alpha \geq (a-b)/a$$

where  $\alpha$  is the probability of suicide (i.e., the signal cost),  $a$  is the benefit to a deceptive signaler if her signal is believed,  $b$  is the benefit to her if her signal is not believed, and  $a > b > 0$  (for details, see Rosenthal 1993). The cost of an honest apology will therefore increase as the potential benefit to deceivers,  $a$ , increases, converging to 1 (certain death). At the same time, for the sincerely remorseful, the benefit of a restored relationship must exceed their cost of sending a costly apology. Thus, high-cost apologies will be offered when the stakes are high for both sincerely and insincerely remorseful transgressors. One example would be apologies for transgressions that have the potential to permanently terminate extremely valuable relationships. For the sincerely remorseful, the benefit of an accepted apology could be, for example, a lifetime of cooperation. For the insincerely remorseful, the benefit of a deceptive apology could be, for example, a future opportunity to exploit a social partner.

Here we propose and test the hypothesis that some suicidal behavior evolved as a costly and therefore credible nonverbal apology for a transgression to either an individual or a social group, which functions to elicit forgiveness from offended parties and restore extremely valuable cooperative social relationships, and avoid ostracism and other punishment. In our data set, many transgressions involved violations of social norms that affected the perpetrator's relationship to large groups, such as kin and community networks or an out-group. In such cases, an apology signal would need to be broadcast widely, and in fact, suicidal acts can be so startling that news spreads quickly. We term this adaptationist model of suicidal behavior the *costly apology model* (CAM).

## The Costly Apology Model vs. the Bargaining Model

Untangling the CAM from the BRM might be difficult in cases that lack critical details because, in both, suicidal behavior is a costly signal that functions to credibly communicate otherwise private information in a context characterized by a conflict, adversity, and close social relationships. The desired outcome in both cases is to successfully influence social partners to improve outcomes for victims. In addition, although transgressors have harmed others, they often face future harm themselves in the form of punishment or ostracism, similar to circumstances proposed to activate the BRM. If the punishment inflicted on the transgressor is disproportionate to the offense and presents a fitness threat (e.g., imprisonment, loss of status, loss of resources) then the transgressor's signal might be aimed at alleviating the punishment, similar to the BRM.

It is therefore important to emphasize that the meaning of suicidal behavior will depend on the context. Someone who attempts suicide after harming others would be signaling an apology (CAM). Someone who attempts suicide after suffering harm would be signaling need (BRM). The CAM signaler's message is: "I am genuinely remorseful for my actions, and you can trust that I will not do it again." The BRM signaler's message is: "My fitness is genuinely being threatened, and I need your support."

### Study Aims and Predictions

Adaptations are typically universal in the species. Many phenomena, however, are specific to one or a few cultures or geographic regions. For instance, the Akan have a norm that military and political leaders must commit suicide following failure (Meyerowitz 1974), and there are other such examples of ritualized suicide (Rohner and Chaki-Sircar 1988). In a handful of cultures, suicide is viewed as a consequence of malevolent ghosts (Aschwanden 1987; Elwin 1943). Support for the IFM increased with increasing latitude (Syme et al. 2016).

The aim of this study was to determine the extent to which hypothesized features of the CAM (Table 1) appear across cultures—in other words, are human universals. Unfortunately, much of the known human cultural diversity, such as Pacific Island chiefdoms and precolonial African states, no longer exists. In the nineteenth and twentieth centuries, anthropologists documented many of these cultures, sometimes by interviewing elderly informants. There are also many descriptions from missionaries, traders, and explorers. The Human Area Relations Files (HRAF) contains more than a million pages of this primary ethnographic source material, spanning several centuries, on nearly 500 different cultures, which comprise more than 40% of all well-described cultures (Ember and Ember 2009).

We aimed to test the CAM by reading and coding all mentions of suicidal behavior in a representative subset of the HRAF. We would judge the CAM to be well supported if (1) there was evidence of its essential features (Table 1) in most cultures (2) regardless of subsistence mode, level of complexity, or geographic region; (3) these essential features tended to co-occur (i.e., were jointly present or absent in a subset of cases of suicidal behavior); and (4) there was evidence that the CAM was distinct from the IFM and BRM. To determine whether the CAM was distinct from the IFM and especially the

**Table 1** Operationalization of the costly apology model of suicidal behavior

Variables name and definition	Examples from data set
Transgression: Did the victim commit or was he/she accused of committing a transgression or wrongdoing?	“being exposed as a liar, a thief, or a witch . . . is unbearable for Dogon and may incite suicide”
Punishment: Did the victim face punishment for a transgression?	“Maclean . . . suppressed the disturbance and ordered that a hundred lashes should be given to each of the chiefs who allowed their people to fight. . . . One of the chiefs who suffered this indignity committed suicide.”
Punishment fitness threat: Did the punishment entail a fitness threat? (i.e., did the punishment have the potential to reduce the recipient’s fitness?)	“It is expected that people will despise a person of arrogance and that there be much hostile gossip about him. The resulting shame has driven a number of persons to suicide.”
Motive apology: Was the motive of suicidal behavior to apologize?	“Two motives must be registered in the psychology of suicide: first there is always some sin, crime, or passionate outburst to to expiate.”
Shame: Did the victim experience shame?	“the woman was so ashamed and frightened by the sin she committed that she killed herself by drinking rat poison.”
Guilt: Did the victim experience guilt?	“‘It is my fault,’ he said, ‘My fault, my fault! But you shall not go alone. I am with you yet.’ And . . . he plunged the knife he still held into his bosom.”
Forgiveness: Did the victim obtain forgiveness such that relationships were repaired?	“If a person struck his father, however, that would be too much. He would be expected to take a canoe and go out to sea, there to be lost—the favourite method of suicide. The father would wait for his son, then go out in search of him. If he found him, he would bring him back.”
Culpable: Was the victim responsible for the transgression?	“For example, a stepfather in a rage killed a young child of his second wife. For several days after that he brooded over the possible consequences of his act, and then suddenly hanged himself.”
*Unjust punishment or accusation: Did the victim see the accusation or punishment as unjust?	“This is the traditional Tikopia method of committing suicide, carried out by a group of people . . . in protest against what they consider to be an unfair accusation.”

\*Evidence of the unjust punishment variable is evidence *against* the CAM

BRM, which it resembles in many respects, we would exactly replicate the analysis of Syme et al. (2016), which tested the BRM vs. IFM, except that we would now include newly coded variables operationalizing the CAM, as described next.

## Methods

Unlike most cross-cultural and cross-national studies on suicide, this study does not aim to explain variation in suicide rates across populations, but instead to test a culturally universal model of suicidal behavior against accounts in the ethnographic record that include information on social contexts of suicidal behavior.

The Washington State University Institutional Review Board certified this research as exempt.

## Data Collection

Data for this study were obtained from an electronic version of the HRAF, the eHRAF, which can be searched via an online interface (Ember and Ember 2009). We limited our searches to the Probability Sample Files (PSF) of the eHRAF—a stratified random sample of the eHRAF collection which divided the world into 60 culture areas and one culture from each area was randomly chosen from a list of societies that met certain data-quality criteria (e.g., the ethnographers stayed for more than a year) (HRAF website).

All paragraphs on suicidal behavior were located by using two search strategies. First, we searched using the keyword “suicid\*,” which located any paragraph containing words such as “suicidal” or “suicides.” Second, we used a unique feature of the HRAF: a paragraph-level index, the Outline of Cultural Materials (OCM), which assigns topic codes to each paragraph in each document. These codes cover hundreds of different topics, including suicide (OCM code 762). We retrieved every paragraph with OCM code 762.

We created a database containing every paragraph identified using either search strategy. Contiguous paragraphs were assigned to a single text record in the database. All text records were classified as “cases” or “cultural models.” Cases were specific accounts of suicidal behavior (e.g., so-and-so killed herself in despair). Cultural models were cultures’ evaluations, explanations, and other various perspectives on suicidal behavior (e.g., suicide in culture X is a form of protest).

The final database of 473 texts came from 213 documents that discussed suicide in 53 cultures (7 of the 60 cultures in the PSF had no texts discussing suicide). The oldest document was published in 1704 and the latest in 2000. The large majority of documents (94%) were published in the twentieth century (median year = 1963.5). The quality of the reports was extremely heterogeneous, ranging from brief asides and footnotes on suicide, sometimes less than one sentence in length, to entire articles and chapters on the topic. Some cultures only had a single report; others had numerous reports. Each report was subdivided into text records based on the appearance of one or more cultural models or one or more cases. For example, if a report described three separate cases of suicide and then offered a general account of suicide, this would generate three cases and one cultural model, for a total of four text records in our database. In addition, there were six exceptionally long documents from five cultures with 129 total accounts of suicidal behavior. To prevent these unusually detailed accounts, including one from Firth and two from Hezel (anthropologists whose work helped motivate the CAM), from biasing our analyses toward the CAM, we analyze them separately in the [ESM](#) (there was little difference).

## Coding

Syme et al. (2016) operationalized the IFM and the BRM with two sets of theoretical variables containing 6 and 13 variables, respectively. The IFM included variables such as low reproductive potential, burdensomeness, and use of highly lethal methods; the

BRM included variables such as high reproductive potential, social conflict, powerlessness, and fitness threat (an event or situation, such as physical abuse or thwarted marriage, that had the potential to reduce the victim's fitness). Syme et al. (2016) also operationalized victims' ages into four categories (child, young adult, adult, and older adult), sex, evidence of mental illness, and marital status. If the text record described conflict, we coded the relationship between the antagonist and the victim as genetic kin, spouses and affines, nonkin, and unknown.

In the present study, we operationalized the costly apology model of suicidal behavior using eight variables (Table 1). In addition, because some ethnographic accounts of suicidal behavior involved *false* accusations of transgressions, for which no apology would be expected, we added an "anti-CAM" variable: unjust punishment or accusation. We then coded each text record in the database on these variables as follows. Evidence of a variable was coded as +1 and no evidence was coded as 0. Two independent coders evaluated each record on each variable.

The coders were not blind to the hypotheses. Because our data set involved hundreds of ethnographic descriptions of societies with a diverse range of subsistence, kinship, descent, and marriage systems, we required coders with an advanced understanding of the anthropology of traditional societies. Of the small pool of qualified coders at WSU, all had some familiarity with the hypotheses of this study. We therefore coded the data using two independent expert coders, both of whom have degrees in anthropology, were experienced with the HRAF database, the ethnography of traditional societies, and with the three theoretical models of suicide.

We illustrate the CAM coding process with the following text record from the Azande, which also serves as a possible example of suicidal behavior as a costly apology:

When it was known what he had done [violated a sexual taboo] he was so humiliated that he told his neighbours he was going to commit suicide. He disappeared for three days and was then discovered in the bush by his friends who brought him home "in honour," and the esteem they showed him wiped out the disgrace. A Zande commented at the time, "A man who really intends to commit suicide does not tell people of his intentions."

The coders coded this extract as evidence (+1) of transgression, shame, and forgiveness, and no evidence (0) for punishment, punishment is a fitness threat, motive apologize, guilt, culpable, or unjustly accused or punished.

## Statistical Analyses

Our statistical analyses had four main goals. First, we wanted to determine how much evidence there was for the individual CAM variables in our data set, especially compared with the IFM and BRM variables we analyzed previously (Syme et al. 2016). To estimate the proportion of text records that provided evidence of each variable, we used generalized linear mixed effects models, with the binomial error family and random effects for document author nested within culture.

Second, we wanted to determine if the CAM variables tended to co-occur within records, as Syme et al. (2016) found for the IFM and BRM variables, and third, if CAM variables were more likely to occur with each other than with variables from either the

IFM or BRM. Our primary data consisted of an  $n \times p$  matrix of 0s and 1s, where  $n$  was the number of text records, each coded on  $p$  variables. In our case,  $n$  was several hundred, and  $p = 32$  (9 CAM variables, 13 BRM variables, 6 IFM variables, and 4 anti-BRM variables; see Syme et al. 2016 for details). A common approach with high-dimensional data is to attempt to reduce the dimensionality. Our hypothesis was that the components in the lower-dimensional representation would correspond closely to each of our theoretical models.

Nonnegative matrix factorization (NMF) (Lee and Seung 1999) is a decomposition method, somewhat analogous to principal components analysis (PCA), that can represent an  $n \times p$  matrix as the product of  $n \times k$  and  $k \times p$  matrices, where typically  $k \ll \min(n, p)$  (Lee and Seung 1999). The  $k \times p$  matrix represents the basis components (i.e., the contribution of each variable to each component), and the  $n \times k$  matrix represents the mixture coefficients (i.e., the contribution of each component to each text record). An advantage of NMF over, for example, PCA, is that because all values in all matrices are nonnegative, each observation can be represented as the sum of positive basis components (in PCA, variables can have a positive or negative contribution to components, which can make interpretation difficult). In document classification analyses, such as ours, the basis components are interpreted as “topics” and each text record is represented as a “mixture” of a small number of topics. The topics, in our case, should correspond to our theoretical models. Previously, we showed that the variables in IFM and BRM each formed distinct “topics” (i.e., primarily contributed to different basis components; Syme et al. 2016). We therefore predicted that, in an NMF analysis, the CAM variables would contribute primarily to a single basis component, distinct from the IFM and BRM components.

Fourth, if suicidal behavior as a costly apology is an evolved adaptation, it should be common across cultures, regardless of geographic region, subsistence type, or cultural complexity. We therefore used generalized linear mixed effect models to determine whether evidence for the CAM varied by geographic region, subsistence type, latitude, or cultural complexity (with culture as a random effect). Subsistence type was that reported by the eHRAF for each culture (hunter-gatherers, horticulturists, pastoralists, intensive agriculturists, other). Cultural complexity was a composite score from the Standard Cross-Cultural Sample for cultures that matched those in the PSF; see Syme et al. (2016) for details. We predicted that these variables would not be strong predictors of support for the CAM.

Finally, we used standard bar plots to explore patterns and types of transgressions, especially in relation to social conflict.

## Results

Inter-rater reliability for the two raters on the CAM variables was first evaluated using percent agreement (the percent of all ratings that were the same), which was 92%, but this statistic does not adjust for the fact that some agreement will be due to chance. We therefore computed two chance-adjusted statistics, which equal 0 when agreement equals that expected by chance and 1 when there is complete agreement. Cohen’s  $\kappa$ , one of the most widely used chance-corrected statistics, was 0.51, but it has several deficiencies, including paradoxically low values despite high agreement in certain

situations, such as when some categories have low prevalence and there are few categories (Bakeman et al. 1997; Feinstein and Cicchetti 1990). Our data had only two categories, one with low prevalence: the proportions of  $\{0,1\}$  were, respectively, 0.92 and 0.08. We therefore also computed the  $B$  statistic (Munoz and Bangdiwala 1997), which behaves better under such asymmetry (Shankar and Bangdiwala 2014):  $B = 0.91$ . To produce a consensus data set used in all subsequent analyses, the authors jointly recoded every record for which there was disagreement, coming to agreement for all values in the data matrix. (For inter-rater reliability of the other variables, see Syme et al. 2016.)

### Support for Variables by Text Records and Culture

Of our 473 text records, 24.9% had evidence of at least one of the eight CAM variables, and 14.2% had evidence of three or more variables. None had evidence of more than five CAM variables.

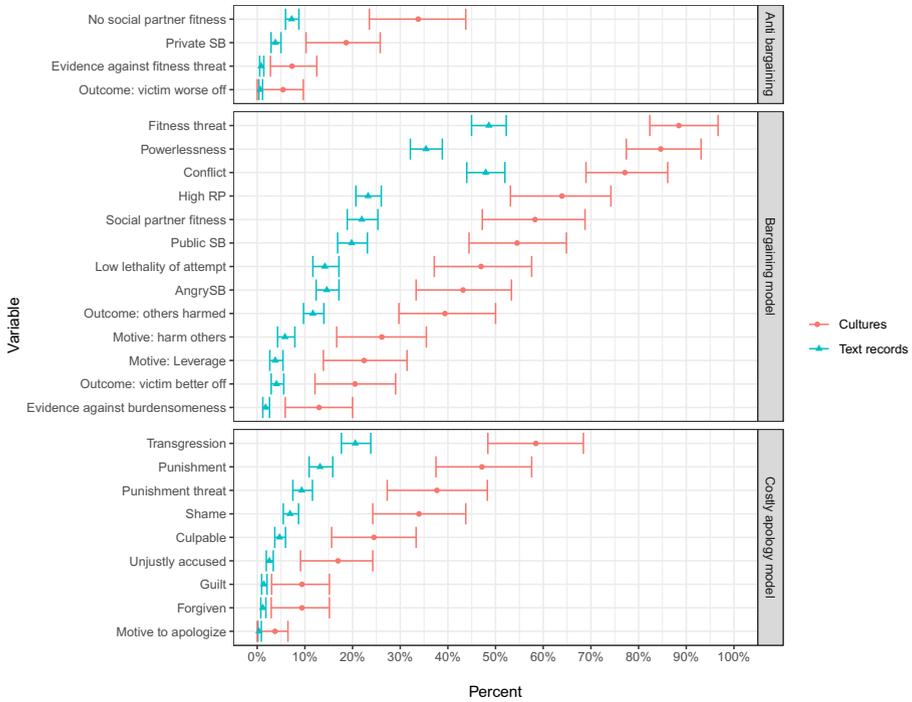
For each of the CAM variables, we computed the percentage of text records that provided evidence of support for that variable, estimating standard errors using a binomial generalized linear mixed effects model with a random intercept for author nested within culture. For each variable, we then computed the percent of cultures that had at least one text record providing support for that variable, estimating standard errors using a cluster bootstrap.

Because we conceived of the CAM as closely related to the BRM, the results for the CAM variables are displayed alongside the original results for the BRM variables (Syme et al. 2016) (see Fig. 1). Compared with the BRM variables, the CAM variables were moderately represented across text records and cultures. Of the CAM variables, transgression was the most commonly occurring variable across cultures and text records. About 60% of cultures had at least one instance of a transgression committed by the victim prior to the suicidal behavior, and 20% of all text records contained evidence of transgression prior to suicidal behavior. About 50% of cultures had at least one instance of evidence of a punishment following a transgression, and about 12% of the text records mentioned a punishment following a transgression; and, there were comparable levels of evidence of the punishment entailing a fitness threat and evidence of shame. There was less evidence of guilt, forgiveness, and a motive to apologize. That some transgressions involved unjust accusations and punishment (Fig. 1) was evidence *against* the CAM but *for* the BRM.

### Nonnegative Matrix Factorization

The data contained 473 text records that were coded for the presence and absence of 32 variables and were therefore represented by a  $473 \times 32$  matrix of 0s and 1s. In Syme et al. (2016), an NMF analysis found that the IFM variables clustered in a single component whereas the BRM variables were hierarchically nested in a second component comprising three subcomponents. Here, we repeated the NMF analysis in Syme et al. (2016) except that we now added the nine CAM variables.

The NMF analysis produced five basis components (Fig. 2a), which we interpreted as “topics,” in two major clusters. The top cluster comprises basis topics 1–4, which consist almost entirely of BRM and CAM variables. The bottom cluster comprises only

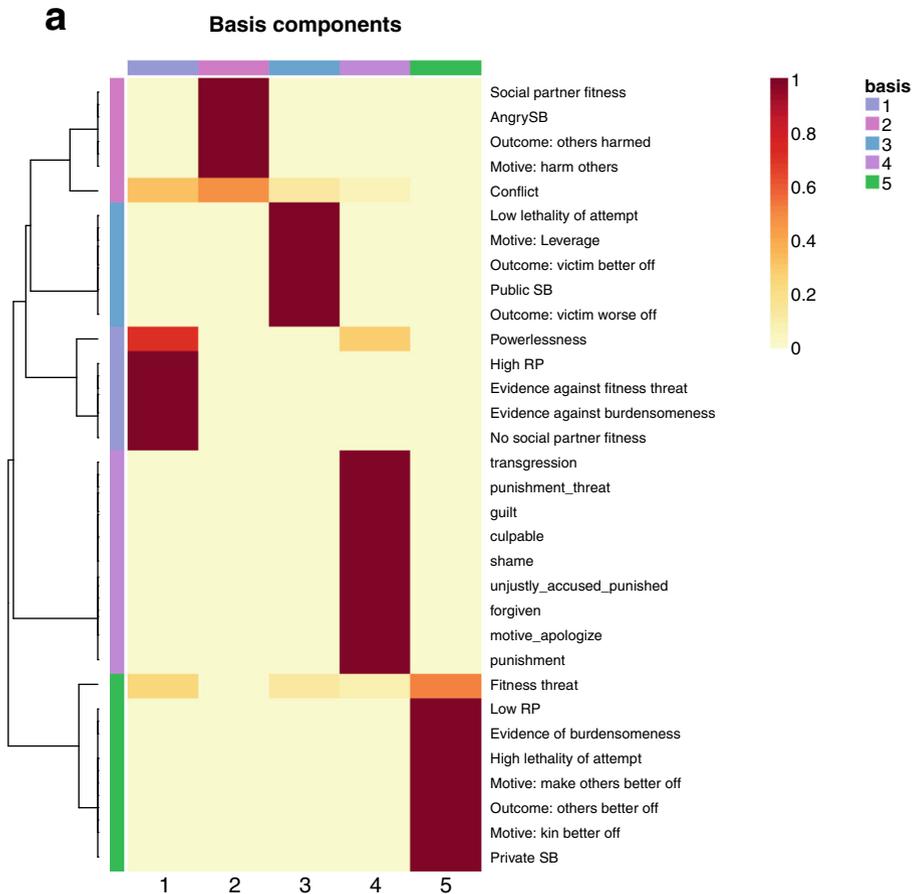


**Fig. 1** Percent of text records (triangles) and cultures (circles) that provided evidence for each of the variables in the CAM and the BRM, as well as four anti-BRM variables. Bars represent SE. Standard errors for text record percentages were estimated using a binomial generalized linear mixed effects model with random intercept for author nested within culture. Standard errors for the culture percentages were estimated with a cluster bootstrap

basis topic 5, which consists of almost only the IFM variables, as also found by Syme et al. (2016). The top cluster has four subclusters, three of which comprise basis topics 1–3 and consist of only the BRM variables, as also found by Syme et al. (2016), and the fourth cluster, topic 4, which consists of the CAM variables. These results suggest that the CAM is closely related to, but distinct from, the BRM, and that each of these differs from the IFM. Note that the *unjustly accused* variable, which is evidence against the CAM, nevertheless clustered with the CAM variables.

There was one important exception to our predictions: fitness threat, a BRM variable, loaded on the IFM, the CAM, and two of the three BRM topics, whereas in Syme et al. (2016), an analysis that did not include the CAM variables, fitness threat only contributed to BRM topics and not to the IFM topic. Powerlessness strongly correlated with one of the BRM topics (1) and moderately correlated with the CAM topic. Conflict correlated with all of the BRM topics and the CAM topic, but not the IFM topic.

The heatmap of the mixture coefficient matrix (Fig. 2b) depicts the mixtures of topics in each text record. The darkest shade indicates text records that contain a single topic, and lighter shades indicate text records that contain a mixture of topics. Text records with information on topic 5, the IFM, tend not to contain information on other topics. Text records with information on topic 4, the CAM, also contain information on the BRM topics, as well as some mixture from the IFM topic.



**Fig. 2** Nonnegative matrix factorization (NMF) of evidence of each of the 32 study variables in 473 text records. **A:** Heatmap of the basis matrix ( $W$ ), clustered using the correlation distance function and complete agglomeration algorithm. Components are interpreted as “topics.” The darkest shading indicates variables that contributed to only one topic; lighter shades indicate variables that contributed to multiple topics. The five topics clustered into two groups (left-hand dendrogram). **B:** Heatmap of the coefficient matrix ( $H$ ). Each column represents one text record. Shading represents the extent to which each of the four basis topics contributed to that record. The darkest shading indicates only one topic contributed to that text record. Lighter shades indicate the proportionate contribution of multiple basis topics to a single text record. The basis annotation track indicates the most-contributing basis topic

The clustering of the basis topics (Fig. 2a) was sensitive to the choice of agglomeration algorithm. We also clustered using “Ward” agglomeration, and although the CAM variables still formed a distinct cluster, this cluster was now on a branch separate from all other variables—in other words, more distant from the BRM variables (Fig. ESM1).

### Cross-Cultural Variation in Support for the CAM

If suicidal behavior as a costly apology is an adaptation, then it should be a human universal—it should be found in all, or nearly all, cultures. We therefore investigated the support for the CAM by culture and continental region as follows. First, we

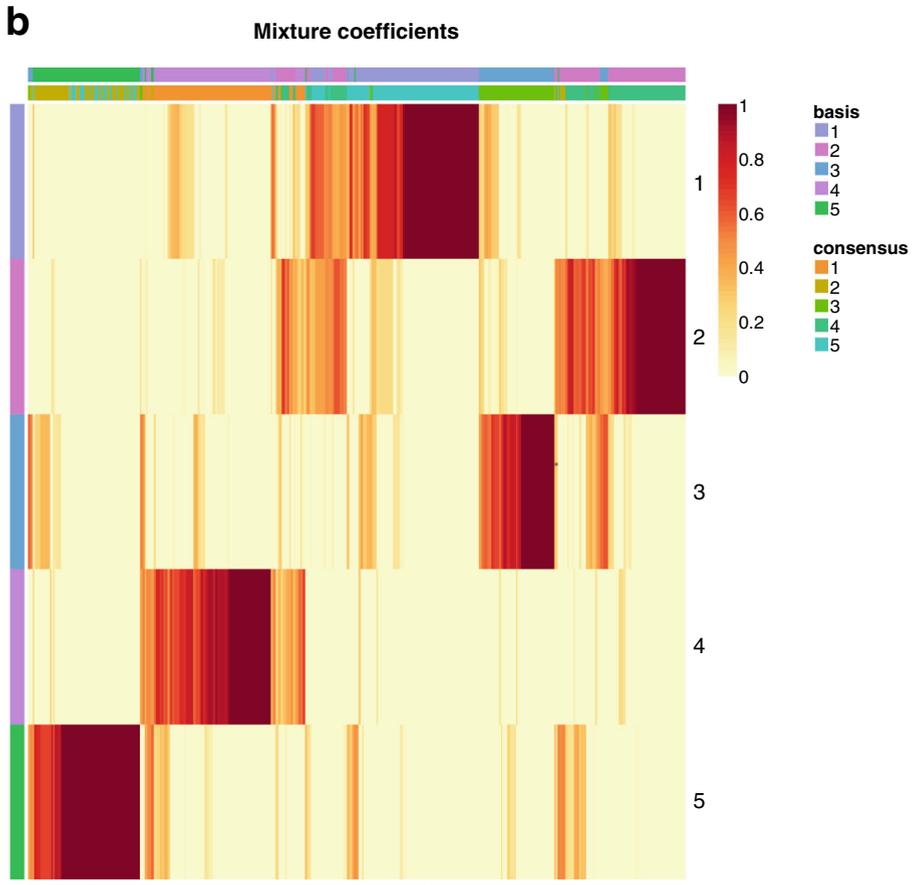


Fig. 2 (continued)

computed a raw model score as the proportion of the eight CAM variables scored as 1 for all text records for each culture (this score did *not* include the *unjustly accused* variable). For example, there were 16 text records on suicide among the Blackfoot. The total number of 1s in these  $16 \times 8 = 128$  cells was 19. The Blackfoot CAM score was therefore  $19/128 = 0.15$ . In general, if there are  $N$  text records for culture  $Y$ , then the mean score for this culture would be

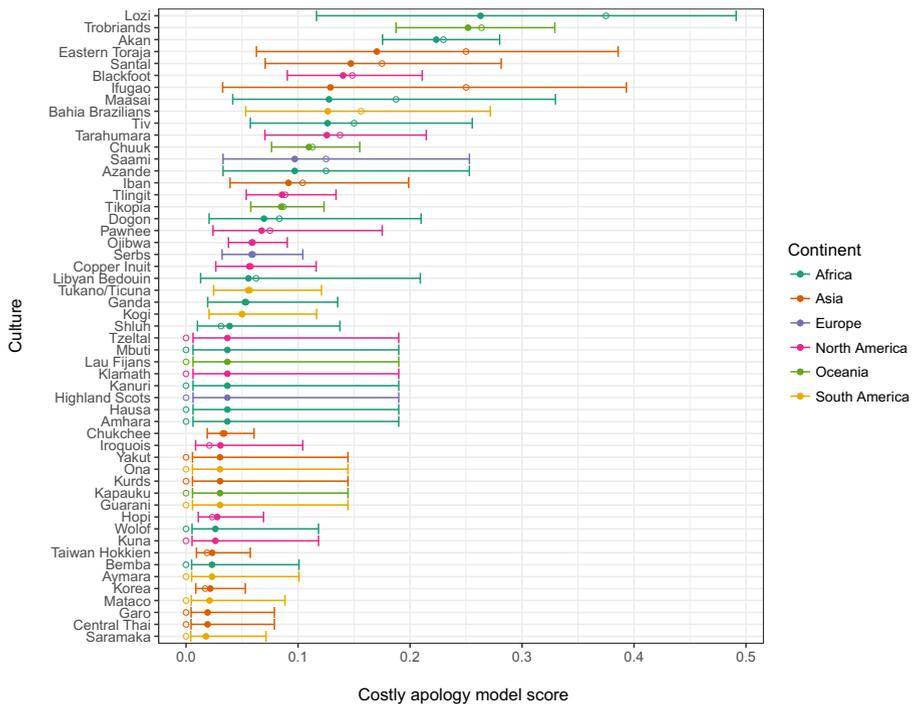
$$\sum_{i=1}^N \sum_{j=1}^8 x_{ij} / 8N$$

where  $x_{ij}$  is the evidence (0 or 1) for variable  $j$  in text record  $i$ .

In cultures with relatively few text records the raw model score is a poor estimate because of the small sample size. For example, nine cultures had only one text record on suicidal behavior; a high or low model score based on a

single text record is not convincing evidence for or against the CAM in that culture. For this reason, we used a binomial generalized linear mixed effects model with the number of text records per culture as a weight, and culture as a random effect, thus taking advantage of partial pooling (as recommended by Gelman and Hill 2007). Partial pooling shrinks the estimates for cultures with few records toward the cross-cultural mean. We fit two models, one with culture as a grouping factor and one with cultures nested within continental regions as grouping factors. According to a likelihood ratio test, the second model did not improve fit over the first model. These results indicate that although substantial cross-cultural variation is evident for the CAM, contrary to the hypothesis of universality, there is little variation in support across continental regions; in other words, level of support for the CAM is similar on every continent, consistent with the universality of this type of suicidal behavior (Fig. 3).

We also tested for variation in support for the CAM by subsistence type, cultural complexity, and latitude. There were no significant effects of any of these variables on support for the CAM (results not reported).



**Fig. 3** The raw CAM score (open dot) and the adjusted CAM score (solid dot) for each culture, identified by continental region plus Oceania and sorted by the adjusted CAM score. Adjusted CAM scores are the random intercepts from a binomial generalized linear mixed effects model with culture as a random effect. Bars represent  $\pm 2$  SE. A score of 0 means there was no evidence for any CAM variable in any text record from that culture. A score of 1 means that there was evidence for all eight CAM variables in every text record from that culture. An intermediate score means that there was evidence for some variables in some text records from that culture

## Exploratory Analyses

Although we did not have a priori predictions regarding the nature of transgressions or the types of relationships between transgressors and the offended, we discovered patterns relevant to the CAM. Overall, a larger number of males than females committed a transgression prior to the suicidal behavior, and males tended to predominate in most of the transgression categories. Murder was the most common transgression and was predominately committed by males. Females outnumbered males only in the domain of sexual transgressions (sexual infidelity and other sexual taboos) and witchcraft (Fig. 4).

We also explored the relationships between transgressors and offended parties, relative to antagonists in the social conflicts that characterize suicidal behavior not involving transgressions. The social antagonist (SA) was the individual(s) with whom the suicide victim was in conflict and was, therefore, only coded when social conflict was specifically mentioned (47.8% of text records had evidence of conflict). We based the categorizations on the relationship of the SA to the suicide victim (e.g., mother, husband, social partner). For the purposes of this exploratory analysis, we recoded the SA as kin or nonkin, with the kin category acting as a proxy for genetic relatedness. However, we recognize that the application of kinship terms does not necessarily denote a genetic relationship (e.g., fictive kin). There was a preponderance of nonkin social antagonists when the conflict centered on a transgression committed by the victim. On the other hand, in conflicts not concerning a transgression, there is about equal representation of kin and nonkin social antagonists (Fig. 5).

## Discussion

This study tested the costly apology model (CAM) of suicidal behavior, which proposes that nonlethal suicidal behavior can function to repair social bonds following a severe transgression by serving as a credible apology. Statistical analyses of 473 cases and cultural models of suicidal behavior in the ethnographic record provided mixed support for the CAM.

Supporting the CAM, transgressions, punishment, and shame were associated with suicidal behavior in 58.5%, 47.2%, and 34% of cultures in our sample, respectively (see Fig. 1). Moreover, the punishments inflicted on the victims prior to suicidal behavior often represented a threat to fitness such as loss of social status and corporal punishment, potentially rendering a costly apology a beneficial course of action. The NMF analysis found that the CAM variables clustered in a single basis component (Fig. 2a, column 4), separate from our other model variables, and that there was a group of text records that predominantly involved the CAM “topic,” albeit with some mixture of other topics (Fig. 2b, row 4). Each result supports the hypothesis that transgression-related suicidal behavior is a coherent phenomenon that is distinct from other types of suicidal behavior (but this cluster also included the *unjustly accused* variable, which was evidence against the CAM). Finally, there was support for the CAM in some cultures in every continental region, and no significant variation by subsistence type, latitude, or cultural complexity, which supports the hypothesis that suicidal behavior as a form of costly apology is a human universal (see Fig. 3).

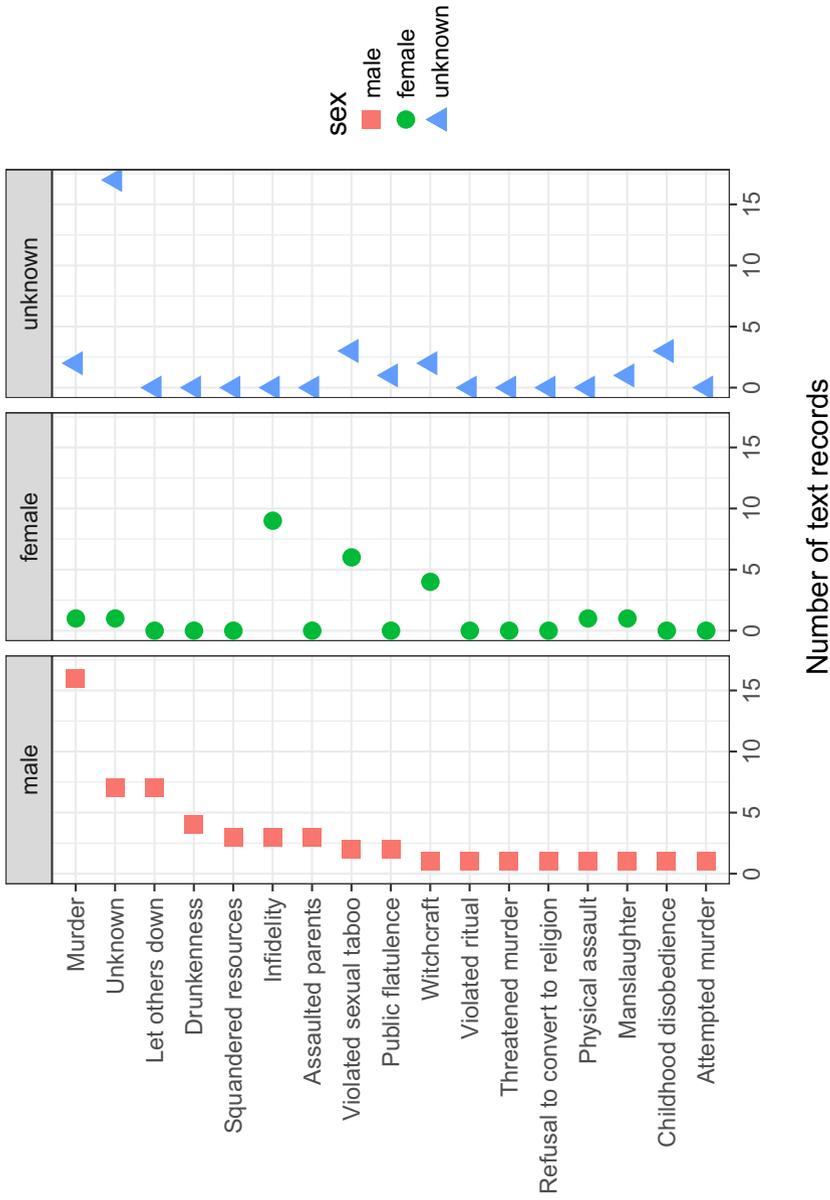
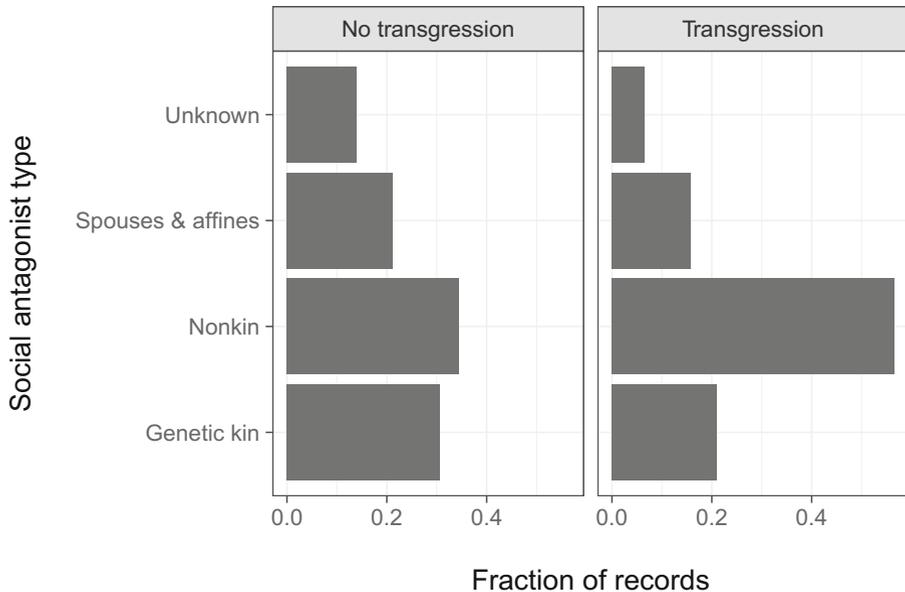


Fig. 4 The number of text records describing each type of SB-associated transgression, by sex



**Fig. 5** Types of social antagonists (SA) in text records involving transgressions vs. those not involving transgressions. In the case of transgressions, the SA is the offended party

Contrary to the CAM, although there was moderate levels of support for it in many cultures, there was little to no evidence of it in many others (Fig. 3). The CAM does not predict that all suicidal behavior serves as a costly apology, however, so it could be that in some cultures this type of suicidal behavior simply never occurred or, more likely, that it wasn't recorded by an ethnographer. Evidence of guilt, forgiveness, and a motive to apologize were also relatively rare in the data set. However, eHRAF ethnographic documents on suicidal behavior seldom discussed victims' internal mental states and also usually ignored the social aftermath of suicidal behavior (see Syme et al. 2016). Hence, the relative rarity of ethnographic evidence of these aspects of the CAM could reflect the fact that very few of the ethnographers were focused specifically on suicidal behavior and therefore usually failed to provide a thorough account of each case. Finally, most cases of suicidal behavior in the ethnographic record are completions, contrary to the CAM, which predicts that most suicidal behaviors would be nonlethal attempts. The ethnographic record of suicidal behavior might be biased toward completions, however, as completions are probably more memorable for ethnographers and their informants than are unsuccessful attempts. None of our results changed significantly after including the 129 records from the exceptionally long documents (compare Figs. ESM2 and ESM3 with Figs. 1 and 3).

The following example from the Tikopia (Firth 1940:309–10) illustrates suicidal behavior as a costly apology (and perhaps also as bargaining):

A person who had committed some very grave offence or who had taken umbrage at some offence thought to have been committed against him, placed himself beyond reach of the community by evasion. If he was fortunate, this evasion would lead him to another land. If not, he perished at sea. But his canoe flight also served the purpose of expiation. If he was brought back by a searching

party, or indeed if he returned of his own free will, his offence was not further brought up against him. He made his apology to his chief in particular, and by implication to the community at large, and was once more accepted as a fully functioning member of the society.

## Exploratory Results

Although we did not have a priori predictions about the frequencies of the different types of transgressions or the types of social antagonists that would be most common in suicidal behavior cases with transgressions versus those without, the patterns we discovered in exploratory analyses of our data have a straightforward interpretation under the CAM.

### Social Antagonists

Models of costly apologies are based on maintaining cooperation following transgressions in prisoner dilemma (PD) type scenarios—in other words, in dyadic reciprocal relationships with nonkin (Ohtsubo and Watanabe 2009). Cooperation with close genetic kin, in contrast, is based on inclusive fitness. If suicidal behavior is a costly apology, then it should occur more often when transgressions occur against nonkin than when transgressions occur against genetic kin, who should be more tolerant of transgressions. We found that when suicidal behavior followed a transgression, the injured party was much more commonly nonkin than kin, consistent with PD models; in contrast, for suicidal behavior without transgression the social antagonist was almost equally likely to be kin as nonkin (see Fig. 4).

Spouses and other affines were about equally as likely to be the social antagonist for suicidal behavior following transgressions as for suicidal behavior not following transgressions (Fig. 4). Spouses and affines are not genetic kin, so this pattern would seem to contradict the CAM. However, spouses and affines often have an enduring mutual interest in offspring that is not predicated on PD-like interactions. Hence, suicidal behavior as bargaining (the BRM) would be as likely to occur among spouses as would costly apologies.

### Transgression Types

Murder and sexual infidelity were the most commonly occurring transgressions in our data set. In line with the CAM, these transgressions often impose severe costs on others that are difficult or impossible to repay over the short term but might be possible to repay via a lifetime of valuable cooperation that would follow a successful apology.

Exploratory analysis of the transgression types by sex suggests that sex differences in the types of transgressions committed prior to suicidal behavior probably reflect the divergent reproductive constraints of males and females. Overall, a larger proportion of males were associated with transgressions than females in the context of suicidal behavior. Males exhibiting suicidal behavior were more likely to have committed murder or let others down. Male reproduction is constrained by access to mates, and high-status males tend to have higher reproductive success than low-status males (von Rueden and Jaeggi

2016). In polygynous societies with a balanced sex ratio, there is increasing variation in males' reproductive success as the rate of polygyny rises owing to the monopolization of females by fewer high-status males (Betzig 2012). Repercussions from a transgression could entail status loss; therefore, risking suicide in order to repair one's social standing might have a fitness payoff, a hypothesis to test in future studies.

Females exhibiting suicidal behavior were more likely to have committed or been accused of sexual infidelity, violating another sexual taboo, or practicing witchcraft. The female bias in sexual transgressions might be a consequence of the sexual double standard. Cross-culturally, females are subjected to more restrictions on sexual behavior than males and face greater social sanctions for perceived promiscuity. These are perhaps cultural manifestations of an adaptive problem faced by human males. Unlike mothers, fathers cannot identify their offspring with absolute certainty in species that have unobservable fertilization. Because paternal investment is high in humans, males risk mistakenly investing in another man's offspring (Daly et al. 1982). Males have evolved psychological mechanisms to defend against cuckoldry. For instance, males tend to exhibit greater degrees of sexual jealousy (Buss et al. 1992; Sagarin et al. 2003) and outward aggression toward a cheating mate or a sexual rival (Paul and Galloway 1994; Wilson and Daly 1992). Reviews of legal codes across ancient and modern societies reveal an imbalanced focus on the extradyadic amorous entanglements of wives compared with husbands, the former of whom are often lawfully regarded as the property of the latter (Bullough 1976; Daly et al. 1982; Hadjiyannakis 1969). If females are exposed to greater levels of social recourse for sexual behaviors, they might be more likely to resort to costly signals of apology. On the other hand, the association of females with sexual infidelity and other sexual taboos might correspond to the BRM if, rather than signaling an apology for a sexual indiscretion, females are signaling their desired choice of mate. Only with full knowledge of the details surrounding such cases could we decipher the possible meaning of the signal.

The skew toward females in the area of witchcraft might be due to women being the primary targets of witchcraft accusations. Witchcraft accusations might be a form of indirect aggression widely used by, and against, women (Fry 1992; Hess and Hagen 2006). However, there are as of yet no systematic cross-cultural investigations of sex differences in witchcraft accusations. The ethnographic record indicates that witchcraft accusations often arise in the context of social conflict. Given the existing relationship between suicidal behavior and social conflict, witchcraft accusations likely represent a corollary.

## Limitations

First, with a few exceptions, most of the ethnographers were not investigating suicidal behavior. Consequently, much information that is of interest to our research questions are scarcely reported in the documents, including victims' psychological states, motivations, and the responses of kin and social partners. Second, there is a bias in the ethnographic record toward suicide completions, which is likely an artifact of the attentional bias of the ethnographers and their informants. If circumstances surrounding attempts, which are the focus of the BRM and CAM, differ dramatically from those surrounding completions, our results would be misleading. Finally, the coders were not blind to the hypotheses under investigation, which could have biased their coding of the text records. For further discussion of the limitations of our data and analyses, such as

demographic differences between our sample and other cross-cultural samples, and the fact that most of our documents were compiled during periods of dramatic culture change, see Syme et al. (2016).

## Future Directions

A substantial subset of cases of suicidal behavior involve transgressions. The impact of the behavior on the offended, however, is much less clear. Although there was some evidence that transgressors were forgiven following such behavior, in most cases in the ethnographic record there is very little information on the social consequences of nonlethal suicidal behavior. To determine if suicidal behavior is a signal of some sort, much more research is needed on whether social partners come to learn more about the victim's state of mind following the behavior. More research is also needed on the state of mind of transgressors; for example, how important it is to them to be forgiven, and what "price" they would pay to redeem themselves. Finally, if, like suicidal behavior, depression has elements of bargaining (Hagen 2003), then it might also sometimes serve as a costly apology for transgressions.

According to Litz et al. (2009), many US military veterans suffer moral injury from perceived transgressions, either during combat or by failing to engage in combat. US veterans also currently exhibit a higher suicide rate than the US civilian population (Kang et al. 2015). Under the CAM, it is conceivable that some veterans' suicidal behavior is motivated by moral injury, a topic for future research.

## Conclusion

All social relationships, including those with close genetic kin such as parents and offspring, are fraught with potential conflicts of interest of varying degrees of severity. Transgressions can precipitate or exacerbate these conflicts, disrupting cooperative relationships and potentially causing the offended to doubt the trustworthiness of the transgressor. Syme et al. (2016) found that across cultures interpersonal conflict is a common antecedent of suicidal behavior. The BRM and the CAM represent possible strategies to resolve conflicts and keep exploitation in cooperative relationships in check.

This study found that transgressions, punishment, and shame were common themes in a significant minority of cases of suicidal behavior in the ethnographic record that were distinct from other cases. Evidence of motives to apologize and obtain forgiveness, however, was rare but not unknown. Although support for the CAM varied widely across cultures, there was evidence for it in cultures on every continent. This study thus provides mixed support for the CAM as a distinct type of suicidal behavior. If the CAM is correct, it would only apply to a minority of cases of suicidal behavior in the ethnographic record, with most other cases being better explained by the BRM.

**Acknowledgments** This project was funded by NSF-BCS #1355469. We thank Caitlyn Calsbeek for assistance coding the text records, and Paul Andrews, Andy Thomson, Benjamin Gelbart, and one anonymous reviewer for numerous useful comments and suggestions.

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

## References

- Andrews, P. W. (2006). Parent-offspring conflict and cost-benefit analysis in adolescent suicidal behavior: Effects of birth order and dissatisfaction with mother on attempt incidence and severity. *Human Nature, 17*, 190–211.
- Aschwanden, H. (1987). *Symbols of death: An analysis of the consciousness of the Karanga*. Gweru, Zimbabwe: Mambo Press.
- Ausubel, L. M., Cramton, P., & Deneckere, R. J. (2002). Bargaining with incomplete information. In R. J. Aumann & S. Hart (Eds.), *Handbook of game theory with economic applications* (Vol. 3, pp. 1897–1945). Amsterdam: North-Holland.
- Axelrod, R., & Hamilton, W. D. (1981). The evolution of cooperation. *Science, 211*(4489), 1390–1396.
- Bakeman, R., McArthur, D., Quera, V., & Robinson, B. F. (1997). Detecting sequential patterns and determining their reliability with fallible observers. *Psychological Methods, 2*(4), 357–370.
- Betzig, L. (2012). Means, variances, and ranges in reproductive success: Comparative evidence. *Evolution and Human Behavior, 33*(4), 309–317.
- Bottom, W. P., Gibson, K., Daniels, S. E., & Murnighan, J. K. (2002). When talk is not cheap: Substantive penance and expressions of intent in rebuilding cooperation. *Organization Science, 13*(5), 497–513.
- Bullough, V. (1976). *Sexual variance in history and society*. New York: John Wiley and Sons.
- Buss, D. M., Larsen, R. J., Westen, D., & Semmelroth, J. (1992). Sex differences in jealousy: Evolution, physiology, and psychology. *Psychological Science, 3*(4), 251–255.
- Daly, M., Wilson, M., & Weghorst, S. J. (1982). Male sexual jealousy. *Ethology and Sociobiology, 3*(1), 11–27.
- DeCatanzaro, D. (1980). Human suicide: A biological perspective. *The Behavioral and Brain Sciences, 3*, 265–290.
- DeCatanzaro, D. (1991). Evolutionary limits to self-preservation. *Ethology and Sociobiology, 12*(1), 13–28.
- Ekman, P., & Cordaro, D. (2011). What is meant by calling emotions basic? *Emotion Review, 3*(4), 364–370.
- Elwin, V. (1943). *Maria murder and suicide*. Bombay: Oxford University Press.
- Ember, C. R., & Ember, M. (2009). *Cross-cultural research methods*. Lanham: Altamira Press.
- Farberow, N. L., & Shneidman, E. S. (1961). *The cry for help*. New York: McGraw-Hill.
- Fehr, R., Gelfand, M. J., & Nag, M. (2010). The road to forgiveness: A meta-analytic synthesis of its situational and dispositional correlates. *Psychological Bulletin, 136*(5), 894–914.
- Feinberg, M., Willer, R., & Keltner, D. (2012). Flustered and faithful: Embarrassment as a signal of prosociality. *Journal of Personality and Social Psychology, 102*(1), 81–97.
- Feinstein, A. R., & Cicchetti, D. V. (1990). High agreement but low kappa, part I: The problems of two paradoxes. *Journal of Clinical Epidemiology, 43*(6), 543–549.
- Fessler, D. M. (2004). Shame in two cultures: Implications for evolutionary approaches. *Journal of Cognition and Culture, 4*(2), 207–262.
- Fessler, D. M. (2007). From appeasement to conformity. In J. L. Tracy, R. W. Robins, & J. P. Tangney (Eds.), *The self-conscious emotions: Theory and research* (pp. 174–193). New York: Guilford.
- Firth, R. (1936). *We, the Tikopia: Kinship in primitive Polynesia*. Boston: Beacon.
- Firth, R. (1940). *The work of the gods in Tikopia*. London: The London School of Economics and Political Science.
- Firth, R. (1961). Suicide and risk-taking in Tikopia society. *Psychiatry, 24*(1), 1–17.
- Fry, D. P. (1992). Female aggression among the Zapotec of Oaxaca, Mexico. In K. Björkqvist & P. Niemelä (Eds.), *Of mice and women: Aspects of female aggression* (pp. 187–199). San Diego: Academic Press.
- Gelman, A., & Hill, J. (2007). *Data analysis using regression and multilevel hierarchical models* (Vol. 1). New York: Cambridge University Press.
- Goffman, E. (1956). Embarrassment and social organization. *American Journal of Sociology, 62*(3), 264–271.
- Hadjiyannakis, C. (1969). Les tendances contemporaines concernant la répression du délit d'adultère: Étude de droit français et de droit comparé. University of Renne, France.
- Hagen, E. H. (1999). The functions of postpartum depression. *Evolution and Human Behavior, 20*, 325–359.
- Hagen, E. H. (2002). Depression as bargaining: The case postpartum. *Evolution and Human Behavior, 23*, 323–336.

- Hagen, E. H. (2003). The bargaining model of depression. In P. Hammerstein (Ed.), *Genetic and cultural evolution of cooperation* (pp. 95–123). Cambridge: MIT Press.
- Hagen, E. H., Watson, P. J., & Hammerstein, P. (2008). Gestures of despair and hope: A view on deliberate self-harm from economics and evolutionary biology. *Biological Theory*, 3, 123–138.
- Hess, N. H., & Hagen, E. H. (2006). Sex differences in indirect aggression: Psychological evidence from young adults. *Evolution and Human Behavior*, 27(3), 231–245.
- Hezel, F. X. (1984). Cultural patterns in Trukese suicide. *Ethnology*, 23, 193–206.
- Hieb, L. A. (1973). The Hopi ritual clown: Life as it should not be. PhD dissertation, Princeton University. Ann Arbor: University Microfilms.
- Howell, P. P. (1970). *A manual of Nuer law: Being an account of customary law, its evolution and development in the courts established by the Sudan government*. Oxford: Oxford University Press.
- Inbar, Y., Pizarro, D. A., Gilovich, T., & Arieli, D. (2013). Moral masochism: On the connection between guilt and self-punishment. *Emotion*, 13(1), 14–18.
- Johnson, D. H. (1986). Judicial regulation and administrative control: Customary law and the Nuer, 1898–1954. *Journal of African History*, 27(1), 59–78.
- Johnson, J. G., Cohen, P., Gould, M. S., Kasen, S., Brown, J., & Brook, J. S. (2002). Childhood adversities, interpersonal difficulties, and risk for suicide attempts during late adolescence and early adulthood. *Archives of General Psychiatry*, 59(8), 741–749.
- Joiner, T. E. (2005). *Why people die by suicide*. Cambridge: Harvard University Press.
- Kang, H. K., Bullman, T. A., Smolenski, D. J., Skopp, N. A., Gahm, G. A., & Reger, M. A. (2015). Suicide risk among 1.3 million veterans who were on active duty during the Iraq and Afghanistan wars. *Annals of Epidemiology*, 25(2), 96–100.
- Kennan, J., & Wilson, R. (1993). Bargaining with private information. *Journal of Economic Literature*, 31, 45–104.
- Klonsky, E. (2011). Non-suicidal self-injury in United States adults: Prevalence, sociodemographics, topography and functions. *Psychological Medicine*, 41(09), 1981–1986.
- Lee, D. D., & Seung, H. S. (1999). Learning the parts of objects by non-negative matrix factorization. *Nature*, 401(6755), 788–791.
- Litz, B. T., Stein, N., Delaney, E., Lebowitz, L., Nash, W. P., Silva, C., & Maguen, S. (2009). Moral injury and moral repair in war veterans: A preliminary model and intervention strategy. *Clinical Psychology Review*, 29(8), 695–706.
- Malinowski, B. (1926). *Crime and custom in savage society*. New York: Harcourt, Brace.
- Maynard Smith, J., & Harper, D. (2003). *Animal signals*. New York: Oxford University Press.
- Meacham, F., Perlmutter, A., & Bergstrom, C. T. (2013). Honest signalling with costly gambles. *Journal of the Royal Society Interface*, 10(87), 20130469.
- Meyerowitz, E. L.-R. (1974). *The early history of the Akan states of Ghana*. London: Red Candle Press.
- Munoz, S. R., & Bangdiwala, S. I. (1997). Interpretation of Kappa and B statistics measures of agreement. *Journal of Applied Statistics*, 24(1), 105–112.
- National Center for Injury Prevention and Control, Centers for Disease Control and Prevention (producer) (2003). Web-based Injury Statistics Query and Reporting System (WISQARS) [Online]. <http://www.cdc.gov/ncipc/wisqars>
- Nelissen, R., & Zeelenberg, M. (2009). When guilt evokes self-punishment: Evidence for the existence of a dobbie effect. *Emotion*, 9(1), 118.
- Nock, M. K. (2008). Actions speak louder than words: An elaborated theoretical model of the social functions of self-injury and other harmful behaviors. *Applied and Preventive Psychology*, 12(4), 159–168.
- Nock, M. K., Borges, G., Bromet, E. J., Cha, C. B., Kessler, R. C., & Lee, S. (2008). Suicide and suicidal behavior. *Epidemiologic Reviews*, 30(1), 133–154.
- Ohbuchi, K.-i., Kameda, M., & Agarie, N. (1989). Apology as aggression control: Its role in mediating appraisal of and response to harm. *Journal of Personality and Social Psychology*, 56(2), 219–227.
- Ohtsubo, Y., & Watanabe, E. (2009). Do sincere apologies need to be costly? Test of a costly signaling model of apology. *Evolution and Human Behavior*, 30(2), 114–123.
- Okamoto, K., & Matsumura, S. (2000). The evolution of punishment and apology: An iterated prisoner's dilemma model. *Evolutionary Ecology*, 14(8), 703–720.
- Paul, L., & Galloway, J. (1994). Sexual jealousy: Gender differences in response to partner and rival. *Aggressive Behavior*, 20(3), 203–211.
- Rohner, R. P., & Chaki-Sircar, M. (1988). *Women and children in a Bengali village*. Hanover: University Press of New England.
- Ronce, O. (2007). How does it feel to be like a rolling stone? Ten questions about dispersal evolution. *Annual Review of Ecology, Evolution, and Systematics*, 38, 231–253.

- Rosenthal, R. W. (1993). Suicide attempts and signalling games. *Mathematical Social Sciences*, 26(1), 25–33.
- Sagarin, B. J., Becker, D. V., Guadagno, R. E., Nicastle, L. D., & Millevoi, A. (2003). Sex differences (and similarities) in jealousy: The moderating influence of infidelity experience and sexual orientation of the infidelity. *Evolution and Human Behavior*, 24(1), 17–23.
- Shankar, V., & Bangdiwala, S. I. (2014). Observer agreement paradoxes in 2×2 tables: Comparison of agreement measures. *BMC Medical Research Methodology*, 14(1), 100.
- Shinichirō, T., & Harrison, J. A. (1960). The Ainu of northern Japan: A study in conquest and acculturation. *Transactions of the American Philosophical Society*, 50(4), 1–88.
- Spence, M. (1974). *Market signaling*. Cambridge: Harvard University Press.
- Stengel, E. (1956). The social effects of attempted suicide. *Canadian Medical Association Journal*, 74(2), 116–120.
- Syme, K. L., Garfield, Z. H., & Hagen, E. H. (2016). Testing the bargaining vs. inclusive fitness models of suicidal behavior against the ethnographic record. *Evolution and Human Behavior*, 37(3), 179–192.
- Szymer, D., Takemura, K., Delton, A. W., Sato, K., Robertson, T., Cosmides, L., & Tooby, J. (2012). Cross-cultural differences and similarities in proneness to shame: An adaptationist and ecological approach. *Evolutionary Psychology*, 10(2), 352–370.
- Szymer, D., Al-Shawaf, L., Bereby-Meyer, Y., Curry, O. S., De Smet, D., Emmer, E., et al. (2017). Cross-cultural regularities in the cognitive architecture of pride. *Proceedings of the National Academy of Sciences*, 114(8), 1874–1879.
- Tanaka, H., Yagi, A., Komiya, A., Mifune, N., & Ohtsubo, Y. (2015). Shame-prone people are more likely to punish themselves: A test of the reputation-maintenance explanation for self-punishment. *Evolutionary Behavioral Sciences*, 9(1), 7.
- Trivers, R. L. (1971). The evolution of reciprocal altruism. *Quarterly Review of Biology*, 46(1), 35–57.
- von Rueden, C. R., & Jaeggi, A. V. (2016). Men's status and reproductive success in 33 nonindustrial societies: Effects of subsistence, marriage system, and reproductive strategy. *Proceedings of the National Academy of Sciences*, 113(39), 10824–10829.
- Watson, P. J., & Andrews, P. W. (2002). Toward a revised evolutionary adaptationist analysis of depression: The social navigation hypothesis. *Journal of Affective Disorders*, 72, 1–14.
- Wilson, M. I., & Daly, M. (1992). Who kills whom in spouse killings? On the exceptional sex ratio of spousal homicides in the United States. *Criminology*, 30(2), 189–216.
- Zahavi, A. (1975). Mate selection—a selection for a handicap. *Journal of Theoretical Biology*, 53, 205–214.
- Zahavi, A. (1993). The fallacy of conventional signalling. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 340(1292), 227–230.
- Zialcita, F. N. (1986). Popular interpretations of the passion of Christ. *Philippine Sociological Review*, 56–62.

**Kristen Syme** is a PhD candidate in anthropology at Washington State University, where she completed her MA in 2014. She studies suicidal behavior and other mental health issues in an evolutionary framework.

**Edward Hagen** is a professor of anthropology at Washington State University. He specializes in evolutionary medicine, with a focus on substance use, depression, and other topics in mental health.

## Affiliations

Kristen L. Syme<sup>1</sup> · Edward H. Hagen<sup>1</sup>

<sup>1</sup> Department of Anthropology, Washington State University, Pullman, WA, USA