Evolution and Human Behavior xxx (xxxx) xxx

Contents lists available at ScienceDirect

Evolution and Human Behavior

journal homepage: www.elsevier.com/locate/ens

The impact of gossip, reputation, and context on resource transfers among Aka hunter-gatherers, Ngandu horticulturalists, and MTurkers

Nicole H. Hess *, Edward H. Hagen

Department of Anthropology, Washington State University, United States of America

ARTICLE INFO

Keywords:
Resource competition
Reputation
Cooperation
Gossip
Hunter-gatherers
Horticulturalists

ABSTRACT

Theoretical models of gossip's role in the evolution of cooperation in ancestral human communities, and its role in within-group competition for resources, require gossip to cause changes in individuals' reputations, which then cause changes in the likelihood of their receiving benefits. However, there is scant experimental evidence from small-scale societies supporting such causal relationships. There is also little experimental evidence that, when making decisions about the transfer of resources, gossip receivers weigh gossip according to its relevance to the social context in which such transfers occur. Using an experimental vignette study design, in a sample from MTurk ($N = 120$) and another sample from a remote horticultural population, the Ngandu of the Central African Republic (CAR) ($N = 160$), we test whether positive and negative gossip increase and decrease the likelihood of transferring resources, respectively, mediated by their effects on reputation. We also test whether gossip that is relevant to the context of the resource transfer has a larger impact on reputation than other gossip. We found strong significant, context-relevant effects of gossip on participant willingness to transfer benefits, mediated by gossip's effects on reputation. Then, in an exploratory observational study of Aka hunter-gatherers of CAR using peer-reports ($N = 40$), we investigate whether providing benefits to the group (such as working hard, parenting or alloparenting, or sharing) and genetic relatedness to the group, were associated with reputations and receiving benefits. We found that, although having a good reputation was associated with receiving more benefits, there was a stark sex difference, with almost all women scoring higher than almost all men on a dimension involving better parenting, good reputations, and receipt of more benefits.

1. Introduction

Humans evolved in groups that cooperated to obtain food, defend themselves from predators and other humans, and care for children, the injured, and the sick (Martin, Ringen, Duda, & Jaeggi, 2020; Ringen, Duda, & Jaeggi, 2019; Sugiyama, 2004). Some benefits, such as defense from predators and enemies, were non-excludable public goods – all group members would necessarily obtain the benefit. Other benefits, though, such as food and care, were potentially excludable – they could be distributed unequally to group members. Successful hunters could provide more meat to their wives and children, for instance, although the extent to which this happens in contemporary foraging societies is fiercely debated (Blurton Jones, 1987; Hawkes, O'Connell, & Blurton Jones, 2014; Jaeggi & Gurven, 2013; Ringen et al., 2019; Stibbard-Hawkes, 2019; Stibbard-Hawkes, Attenborough, Mabulla, & Marlowe, 2020; Wood & Marlowe, 2013). As another example, Rucas, Gurven, Kaplan, and Winking (2010) found that Tsimane women excluded resources from women with whom they had disputes or conflicts compared to favored female neighbors or desired friends. Studies in high income countries find that individuals perceived as lazy are seen as less deserving of resource transfers, such as welfare payments, than are victims of misfortune, and these perceptions influence social policies (Jensen & Petersen, 2017; Petersen, 2012).

Inclusive fitness is a compelling explanation for the provisioning of excludable benefits within families, such as food, alloparenting, and care of the sick and injured. Indeed, intergenerational transfers of material, embodied, and relational wealth within families establish and maintain inequality in a wide range of small-scale societies (Mulder et al., 2009). Yet levels of inequality in foraging and horticultural societies, specifically, are relatively low (Mulder et al., 2009). This is despite the fact that relatedness within such communities, which comprise a fluid mix of genetic kin, affines, and unrelated adults, is generally low (Dyble et al., 2015; Hill et al., 2011).

A diverse group of theories has been proposed to explain the

* Corresponding author.
E-mail address: nicolehess@wsu.edu (N.H. Hess).

https://doi.org/10.1016/j.evolhumbehav.2023.02.013
Received 14 September 2022; Received in revised form 6 February 2023; Accepted 24 February 2023
1090-5138/© 2023 Elsevier Inc. All rights reserved.

willingness to provide resources to unrelated community members, including reciprocal altruism (Allen-Arave, Gurven, & Hill, 2008; Jaeggi & Gurven, 2013), investing in those who provide valuable group benefits (Gurven, Allen-Arave, Hill, & Hurtado, 2000; Sugiyama, 2004; Sugiyama & Chacon, 2000; Sugiyama & Sugiyama, 2003), providing resources to others as a costly signal of quality (the 'show-off' models) (Bliege Bird & Smith, 2005; Gintis, Smith, & Bowles, 2001; Hawkes & Bliege Bird, 2002; Stibbard-Hawkes, 2019), risk-buffering and fitness interdependence (Aktipis et al., 2018; Smith et al., 2019), and indirect reciprocity (Alexander, 1986; Balliet, Wu, & van Lange, 2020; Leimar & Hammerstein, 2001; Nowak & Sigmund, 2005).

In several of these theories, in order to receive benefits from others, individuals must have a "good" reputation. Reputation is based on information about one's traits, behaviors, intentions, abilities, and culturally-relevant competencies. A study of 153 cultures in the ethnographic record investigated the evidence for 20 domains of reputation identified in the theoretical literature. Domains that were widely supported across cultures included cultural conformity (conforming to cultural norms or excelling in culturally-valued skills), being knowledgeable, intelligent, prosocial, and industrious, and having social status. These domains formed clusters, with the most cross-cultural evidence for cultural group unity (e.g., cultural conformity, prosociality, and industriousness), social and material success (social and material capital and status), and neural capital (knowledgeable, oratory skill) (Garfield et al., 2021).

1.1. Gossip, reputation, and cooperation

Information on the degree to which individuals in one's community excel or fall short on each of these reputational domains or contexts can be obtained via direct observation, or from other individuals in the community, i.e., gossip. Several theories have been put forward for the evolution of gossip, including 'cultural learning'; 'social learning,' such as learning norms or one's place in a group or acquiring new and important knowledge; strategy learning; social comparison; a mechanism for showing off one's social skill and connections, and therefore one's mate value; norm learning and enforcement; sanctioning, social control, or 'policing'; a means to maintain the good reputations of allies; and as a means to maintain the unity, morals, and values of social groups (reviewed in Hess & Hagen, 2019). One early attempt to explain the relationship between gossip and cooperation comes from Dunbar (1996), who suggested that because grooming would be too time-consuming in the large groups that are typical of humans, gossip replaced it as a means to create and maintain social bonds. However, a recent study found no support for the 'vocal grooming' hypothesis as a less time-consuming means of bonding (Jaeggi et al., 2017).

The key role of gossip and reputation in the evolution of human cooperation, especially via indirect reciprocity, is starting to receive considerable attention (Balliet et al., 2020; Wu, Balliet, & Van Lange, 2016b). Gossip has been demonstrated to increase cooperation via indirect reciprocity in experimental economics games (e.g., Sommerfeld, Krambeck, Semmann, & Milinski, 2007) where reputational information impacts contributions to a shared pool of resources (e.g., Beersma & Van Kleef, 2011), or where information about the past behaviors of cooperative partners impacts participants' inclinations to engage in future cooperation (e.g., Feinberg, Willer, & Schultz, 2014). Cooperators in public goods games, in turn, transmit more honest gossip (Giardini, Vilone, Sánchez, & Antonioni, 2021). Gossip was found to be more effective and efficient than punishment in promoting and maintaining cooperation in a public goods game (Wu, Balliet, & Van Lange, 2016a), and gossip also increases cooperation in the dictator and ultimatum games (Wu, Balliet, Kou, & Van Lange, 2019). However, a confederate's negative gossip about a third party did not enhance participant cooperation in a prisoner's dilemma game (De Backer, Larson, Fisher, McAndrew, & Rudnicki, 2016). In addition, agent-based simulations have explored how varying the quantity and quality of gossip impacts cooperation (Giardini, Paolucci, Villatoro, & Conte, 2014; Giardini & Vilone, 2016).

1.2. Gossip and within-group competition for resources

When reputation mediates access to group resources, competition for those resources by group members will often take the form of gossip that aims to increase one's reputation relative to that of competitors. A considerable body of evidence from industrialized populations demonstrates that gossiping is a key strategy in indirect aggression, the suite of behaviors that are used to harm others but that do not involve hitting or other types of physical force (for reviews, see Archer & Coyne, 2005; Hess & Hagen, 2019). Ethnographic studies of gossip find that it is often used in reputation management, i.e., maintaining and improving one's reputation relative to others (Hess, 2017). In a study among Aka, for example, a Congo Basin hunter-gatherer population, peer-rated gossiping was strongly positively correlated with peer-rated anger for both women and men, confirming that Aka perceive gossip as aggressive (Hess, Helfrecht, Hagen, Sell, & Hewlett, 2010). Several studies with US, multinational online, and non-Western samples have also found that gossip is used to either obtain or defend social resources, such as friends and mates (Fisher & Cox, 2011; Krems, Williams, Aktipis, & Kenrick, 2020; Rucas, 2017; Rucas et al., 2006; Stone, 2015; Sutton, 2014; Sutton & Oaten, 2017). Regarding material resources, an experimental vignette study with an MTurk sample found competition for a limited material resource increased gossip, especially negative gossip (Hess & Hagen, 2021), and among North American women a resource scarcity prime increased rival derogation (Arnocky, Davis, & Vaillancourt, 2022).

Campbell (1999) proposed that because the costs of physical aggression are higher for women, female aggression is more likely to take the form of indirect aggression, such as negative gossip. Influenced by Campbell, many evolutionary studies of gossip and competition have therefore focused on women (for reviews, see Fisher, 2017; McAndrew, 2017; Reynolds, 2022). However, the link between indirect aggression and female competition specifically is complicated by the finding that there are few sex differences in indirect aggression (Archer & Coyne, 2005).

Alternatively, Hess and Hagen (2019) proposed that in competition over resources within interdependent groups, negative gossip is more effective than physical aggression for both sexes because one can reduce resource transfers to a competitor by harming his or her reputation, thereby increasing resource availability for oneself, without impairing the competitor's physical ability to continue contributing to the group. Positive gossip by either sex could increase transfers to a relative, or ally by improving his or her reputation. This perspective does not predict sex differences in within-group competitive gossip.

Because individuals' reputations can differ in different social contexts (Garfield et al., 2021), reputation-based decisions to gossip about others, or to provide benefits, should be sensitive to the context in which competition or help is occurring. To influence resource transfers within families, for instance, one should relay gossip that is relevant to family members, and to influence resource transfers within communities, one should relay gossip that is relevant to community members. In an experimental study involving competition over limited resources in a family vs. work context, Hess and Hagen (2021) found, as predicted, that individuals transmitted more family gossip in a family context and more work gossip in a work context.

The theoretical models of the role of gossip in the evolution of cooperation in ancestral human communities require gossip to cause changes in individuals' reputations,which then cause changes in the likelihood of providing benefits to them. However, there is scant evidence from small-scale societies of such causal relationships. There is also no evidence that, when making a decision about the transfer of resources, gossip receivers weigh gossip according to its relevance to the social context.

2. Study aims

Here, using an experimental vignette study design that can provide evidence of causation, in a sample from MTurk and another sample from a remote horticultural population, the Ngandu of the Central African Republic (CAR), we test the following hypotheses:

1. Increasingly positive or negative gossip about a target individual causes greater or lesser likelihood of transferring benefits to them, respectively.
2. The impact of gossip on the transfer of benefits to a target is mediated by the effect of gossip on impression of the target (reputation).
3. The relationship between gossip and impressions are context-relevant, e.g., work gossip will be weighted more heavily in work contexts, and family gossip more heavily in family contexts.

We also conjectured that positive or negative gossip might influence perceptions that the target was a threat or competitor to the participant, and that this might increase or decrease the likelihood of providing a benefit to the target.

Then, in an exploratory observational study of Aka hunter-gatherers of CAR, we investigate the following:

4. Are peer-ratings of behaviors related to common aspects of reputation, i.e., work effort (industriousness), sharing (prosociality), anger (violating cultural conformity), and the quality of (allo)parenting, associated with peer-rated impressions of camp members?
5. Are peer-rated impressions of camp members associated with peer-rated receipt of benefits?
6. Is genetic relatedness to group members positively associated with participants' receipt of benefits?

The studies were not preregistered because all studies were conducted in 2011–2012, prior to the widespread use of preregistration in the social sciences.

3. Ethics

All studies were approved the Washington State University Human Research Protection Program, and all participants provided informed consent.

4. Study 1: MTurk experiment

There is ongoing research on the quality of data from MTurk vs. other samples, with most studies finding that data from MTurk data are equivalent or superior in quality to those collected from other popular sources (briefly reviewed in Chmielewski & Kucker, 2020). In vignette studies, used here, MTurk data quality also compares favorably to that from much more expensive population-based samples (Weinberg, Freese, & McElhattan, 2014). Chmielewski and Kucker (2020) found evidence that MTurk data quality decreased markedly around the summer of 2018. Our MTurk data were collected in 2011, however (MTurk was founded in 2005).

4.1. Methods

Causation can be demonstrated by experimental study designs in which participants are randomized into treatment and control conditions. Unfortunately, such randomization is difficult or impossible for many social situations of interest. Experimental vignette studies are one alternative. These studies, which employ a short, carefully constructed description of a person, object, or situation, aim to approach the ecological validity of observational studies of real-life behaviors by presenting participants with rich, real-world scenarios. At the same time, they allow researchers to randomize participants into conditions in which theoretically relevant dimensions of the vignettes are systematically manipulated, thus enabling robust causal inferences (Atzmüller & Steiner, 2010). Experimental vignette studies are conducted in a broad range of disciplines, including anthropology, psychology, economics, sociology, management studies, political science, and education (Aguinis & Bradley, 2014; Atzmüller & Steiner, 2010; Gaffney, Adams, Syme, & Hagen, 2022).

4.1.1. MTurk vignettes

Participants were randomly assigned to read either a work vignette or a family vignette. In both vignettes, participants read about a same-sex target (a worker that the participant supervises or a cousin of the participant) to whom the participant could allocate a valuable resource (a raise or a valuable painting). All female participants read vignettes with only female targets, and all male participants read vignettes with only male targets.

Work vignette: Imagine you work in an office where you supervise 10 employees, half men and half women. Your office is one division of a company that has done well in the last year, and the company gave you a 20% raise. The company has also authorized you to give a 20% raise to one of the employees you supervise. Dave/Elizabeth is one of the employees that you supervise. Here are some of the things that you know about Dave/Elizabeth [positive and negative gossip statements follow].

Family vignette: Imagine you have 10 cousins, half men and half women. Your wealthy grandmother has just died and you are the executor of her will. Your grandmother owned two valuable paintings that she wanted to remain in the family, and she left you one of them. Her will instructs you to give the other painting to one of your 10 cousins. Dave/Elizabeth is one of your cousins. Here are some of the things you know about Dave/Elizabeth [positive and negative gossip statements follow].

After reading a vignette, participants read 16 "gossip" statements about the target, which we operationalized as true information about the behaviors and traits of the target. Nine gossip statements were relevant to the work environment and seven to the family environment (for details about the selection of these statements, see Hess & Hagen, 2021). We refer to statements that matched the content of the vignette (e.g., work gossip for participants who read the work vignette) as congruent gossip, and those that did not match (e.g., work gossip for participants who read the family vignette) as incongruent gossip. Each participant read either a positive or negative version of each statement. We manipulated the number of positive statements relative to negative ones, i.e., some participants read all positive versions of each statement, some all negative versions, and some with varying proportions of positive vs. negative versions. The number of positive family statements is the *family gossip* score, and the number of positive work statements is the *work gossip* score.

Example work gossip statements (positive and negative versions):

- Dave/Elizabeth [works/does not work] well under pressure.
- Dave/Elizabeth is [willing/unwilling] to work late to finish a project on time.

Example family gossip statements (positive and negative versions):

- Dave/Elizabeth [loves/hates] his/her siblings.
- Dave/Elizabeth [is/is not] good with children.

Our main dependent/outcome variable was how likely the participant was to allocate the valuable resource (a raise or a valuable painting) to the same-sex target in the vignette. After reading the vignette and the positive and negative work and family gossip statements, participants were asked how likely they were to allocate the valuable resource to the target: "How likely would you be to give the [raise/painting] to [Dave/Elizabeth]?" on a 1–9 Likert scale. Our predicted mediating variable was *impression*: "What is your impression of Dave/Elizabeth?".

We also asked some exploratory questions regarding competition with the target, e.g., "How competitive do you feel with Dave/Elizabeth?"

For the full stimuli and questions, see Section 1.1 in the SI.

4.1.2. Statistical analysis

We tested our primary hypotheses with a basic linear regression path model of *impression* as a mediator of the effects of *family_gossip* and *work_gossip* on *give_benefit* (Baron & Kenny, 1986):

$$\text{give\_benefit} = \beta_0 + \beta_1 \text{impression} + \beta_2 \text{work\_gossip} + \beta_3 \text{family\_gossip} + \epsilon \quad (1)$$

$$\text{impression} = \beta_0 + \beta_1 \text{work\_gossip} + \beta_2 \text{family\_gossip} + \epsilon \quad (2)$$

Separate path models were fit for the work and family conditions using the lavaan package (Rosseel, 2012).

We tested the context relevance hypothesis in three ways. First, we tested if there was an interaction of work vs. family condition on the effects of work gossip vs. family gossip on impression, predicting evidence for positive interaction coefficients, $\beta_4 > 0$ and $\beta_5 > 0$:

$$\begin{aligned} \text{impression} \quad &= \beta_0 + \beta_1(\text{condition}_{\text{work}}) + \beta_2(\text{work\_gossip}) + \beta_3(\text{family\_gossip}) + \\ &\beta_4(\text{condition}_{\text{work}} \times \text{work\_gossip}) + \beta_5(\text{condition}_{\text{work}} \times \text{family\_gossip}) + \epsilon \end{aligned} \quad (3)$$

Second and third, we compared the magnitudes of the gossip coefficients in linear regression models of *impression*, predicting larger coefficients for gossip that was congruent with the context (e.g., work gossip in the work condition) than for gossip that was not congruent (e.g., family gossip in the work condition).

In order to further explore the structure of our data, such as the relationship between gossip, competition, and transfer of benefits, we also fit a Gaussian graphical model (GGM) to all study variables using the graphical lasso (glasso) and qgraph packages (Borsboom et al., 2021; Epskamp, Cramer, Waldorp, Schmittmann, & Borsboom, 2012; Friedman, Hastie, & Tibshirani, 2019). In GGMs, the nodes are the variables and the edges are partial correlation coefficients (Borsboom et al., 2021). The graphical lasso estimates a sparse GGM solution using penalized regression. Penalized regression techniques were developed for situations where the number of parameters is large relative to the number of observations. These techniques include an additional penalty term, λ, that helps prevent overfitting (variance), albeit at the cost of some underfitting (bias). The insight of developers of penalized regression methods is that by underfitting (increasing bias), the model will perform better out of sample (have lower variance). One popular version, lasso regression, has the property that some coefficients are set to zero, thereby serving as a form of variable selection (Tibshirani, 1996). In the graphical lasso, a sparse graph is estimated by applying the lasso penalty to the inverse covariation matrix (Friedman et al., 2019); we chose the optimal tuning parameter using the Extended Bayesian Information Criterion provided in the qgraph package (Epskamp et al., 2012). We also performed Principle Components Analyses (PCA).

4.2. Results

Data collection started on July 29, 2011 at 9:58 am PST. All but one participant finished by 10:13 am. Of the 120 participants in the study, 56 were women, 64 were men, 61 were from the US, 45 were from India, and the remaining were mostly from various European and Asian countries. Participants had a diverse range of occupations, and 82 had office experience. For summary statistics by condition, see Table 1. Indian participants were younger than US participants, on average, and generally perceived greater competition with the fictional target of gossip (for comparison of US vs. Indian participants, see Table S1).

All variables were converted to *Z*-scores prior to analyses.

4.2.1. Gossip, reputation, and resource transfers

Two path models were fit with the lavaan package, one for the work condition, and one for the family condition. In both, the randomized work and family gossip scores had a positive effect on *impression*, and *impression* was positively associated with *give benefit*. The direct effects of gossip scores on *give benefit* were smaller, and not significant for three of four effects. See Fig. 1.

4.2.2. Three tests of gossip context relevance

First, in a linear model of *impression* as a function of work gossip and family gossip, and interactions terms with both for condition (Eq. 3), the work gossip score had a larger coefficient in the work than family conditions, and family gossip score had a larger coefficient in the family than work conditions, i.e., the two interaction terms were in the predicted directions and statistically significant. This model explained 56% of the variance in *Impression*. See Fig. 2 and Table S3, model 1.

Second, in a linear regression model of *impression* fit on data from the work condition only, the coefficient of the work gossip score was significantly larger than the coefficient of the family gossip score by a *Z*-test, $\beta_{work} = 0.7 > \beta_{family} = 0.33$, $Z = 3.5$, $p = 5.5 \times 10^{-4}$. In a linear

Table 1
Summary statistics for the MTurk study, by family vs. work conditions; Cohen's 'd' is the standardized mean difference between conditions.

	Family			Work				
Variable	N	Range	Mean (SD)	N	Range	Mean (SD)	d	p-value
Time to complete (seconds)	61	66–546	213 (105)	59	39-508	218 (104)	-0.050	0.69
Age (years)	61	18–68	34.2 (12.4)	59	18-65	33.4 (10.7)	0.071	0.91
Work gossip score	61	0–9	3.98 (3.13)	59	0-9	4.07 (3.05)	-0.027	0.86
Family gossip score	61	0–7	3.61 (2.29)	59	0-7	3.36 (2.46)	0.11	0.59
Impression of target	61	1–9	5.18 (2.59)	59	1-9	4.83 (2.23)	0.145	0.45
Provide benefit to target	61	1–9	4.59 (2.8)	59	1-9	4.44 (2.74)	0.054	0.79
Perceived friendliness	61	1–9	5.16 (2.34)	59	1-9	5.1 (2.21)	0.027	0.85
Perceived competition	61	1–9	3.75 (2.95)	59	1-8	4.07 (2.33)	-0.12	0.20
Get your job	61	1–9	3.77 (2.6)	59	1-9	3.66 (2.49)	0.043	0.87
Criticize behind back	61	1–9	5.41 (2.35)	59	1-9	5.03 (2.4)	0.16	0.37
Interfere with work/family relationships	61	1–9	5.23 (2.34)	59	1-9	4.9 (2.11)	0.15	0.44
Perceived physical threat	61	1–9	3.31 (2.45)	59	1-8	3.25 (1.88)	0.026	0.53

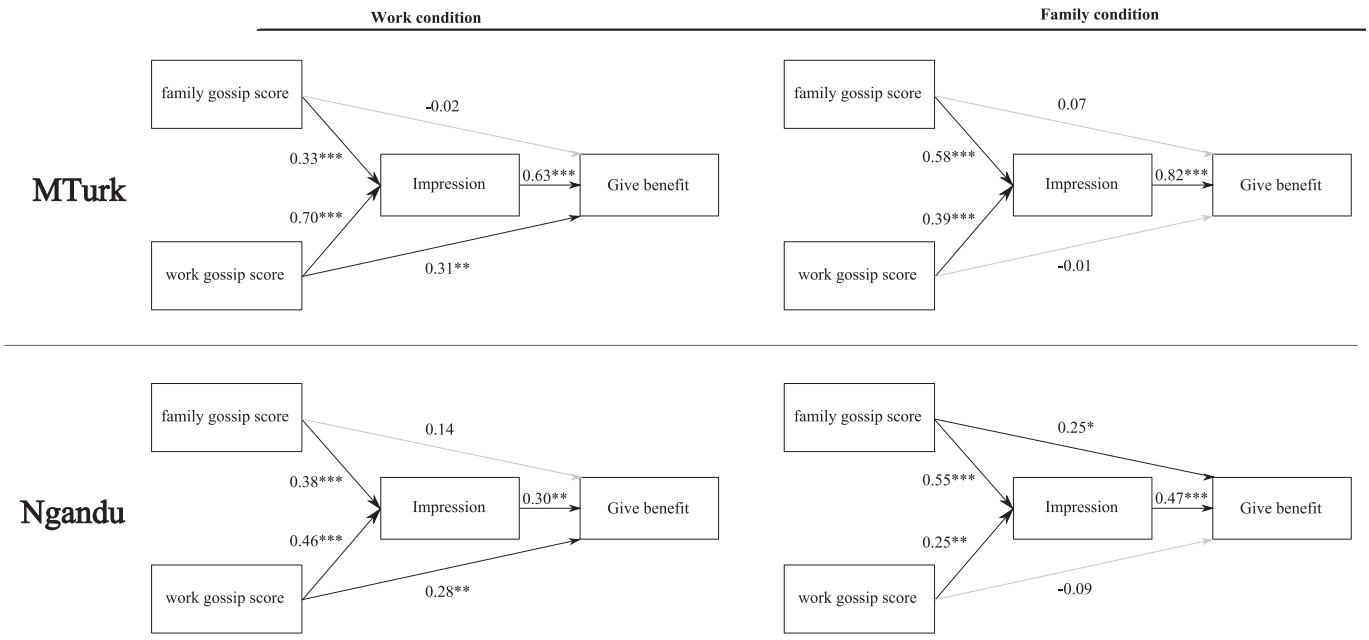

Fig. 1. Path models of reported likelihoods of transfering benefits as a function of family and work gossip, mediated by impression. Top: MTurk study. Bottom: Ngandu study. Models fit by lavaan (Rosseel, 2012). All predictors and outcome standardized. For full model statistics, see Table S2 and Table S4.

regression model of impression fit on data from the family condition only, on the other hand, the coefficient of the family gossip score was not significantly larger than the coefficient of the work gossip score, $\beta_{family} = 0.58 > \beta_{work} = 0.39$, $Z = 1.5$, $p = 0.14$.

Third, data were recoded with a *congruent gossip score* equaling the work gossip score in the work condition and the family gossip score in the family condition; and an *incongruent gossip score* equaling the work gossip score in the family condition and the family gossip score in the work condition. In a linear regression of *impression* as a function of these two gossip scores, the coefficient of the *congruent gossip score* was significantly larger than the coefficient of the *incongruent gossip score* by a Z-test, $\beta_{congruent} = 0.63 > \beta_{incongruent} = 0.36$, $Z = 3.1$, $p = 0.0019$.

4.2.3. Exploratory analyses

We conjectured that positive or negative gossip might influence perceptions that the target was a threat or competitor to the participant, and that this might change the likelihood of providing a benefit to the target. Our measures of threat and competition were *afraid*, *get_your_job*, *competition*, *interference*, and *criticize*. We did not have clear predictions about the direction of any such effects (e.g., negative gossip might make the target seem more threatening, positive gossip might make the target seem more formidable, and either could have a positive or negative effect on providing the benefit). To simplify this exploratory analysis, we computed a *total_gossip* score as the sum of congruent and incongruent gossip, and then investigated these possibilities with a correlation matrix and PCA of all study variables, and an exploratory Gaussian graphical model (Borsboom et al., 2021).

All variables were positively correlated to various degrees, except for *interference* and *criticize*, which were negatively correlated with most variables except *afraid* and *competition*. See Fig. S1. In the exploratory GGM (based on the correlation matrix), as in the path model (Fig. 1), the effect of *total_gossip* on *give_benefit* was via *impression*. These variables were mostly independent of the competition variables *afraid*, *competition*, and *criticize*, although there was a small negative effect of *total_gossip* on *interference*. The association of the competition variables on *give_benefit* was mostly via their association with *get_your_job*. See Fig. S2.

In the PCA, the largest loadings on PC1 were *impression* and *give_benefit*, and *total_gossip* also loaded positively, as did *get_your_job* and *competition*. In contrast, three of the four threat/competition variables loaded strongly and positively on PC2 (*get_your_job* was the exception) and *total_gossip* loaded negatively. See Fig. S3 and Fig. S4. Taken together, these results indicate that positive gossip had little effect on perceived competition, and that, controlling for the other variables, the competition variables had little association with *give_benefit*.

We also explored possible effects of sex and age. We found no significant main effects of sex, or interactions with congruent or incongruent gossip (results not reported). We did find a significant interaction of age with incongruent gossip, such that increasing age was associated with a decreasing effect of *incongruent gossip* on *impression*. See Fig. S5, and Table S3, model 5.

We then investigated if there were interactions between work and family gossip in their effect on impression, or between congruent and incongruent gossip. The interaction terms were small and not significant (results not reported). Finally, we fit a model of *impression* as a function of *congruent* and *incongruent* gossip, with interaction terms for nation (India and the US only). There was a main effect of nation, with the US participants reporting lower mean *impression*, but neither interaction term was significant. See Table S3, model 6.

4.3. Discussion

This study provided strong evidence that differences in levels of positive gossip cause differences in rated willingness to *give benefits*, largely mediated by their effects on *impression*. Moreover, there was fairly consistent evidence that the impact of gossip is context relevant, with family gossip having a larger impact in family contexts than work contexts, and work gossip having a larger impact in work contexts than family contexts. More generally, congruent gossip had bigger impact on *impression* than incongruent gossip. These results align with Hess and Hagen's (2021) finding that increasing competition for resources increased (mostly negative) gossip transmission by participants in a context relevant manner, i.e., they transmitted more gossip that was relevant to the context of competition. Among US and Indian participants, these relationships were not significantly moderated by nationality.

Overall, although these results are consistent with several theories of reputation and transfer of benefits, they arguably best support theories highlighting investment in individuals who provide valuable benefits to

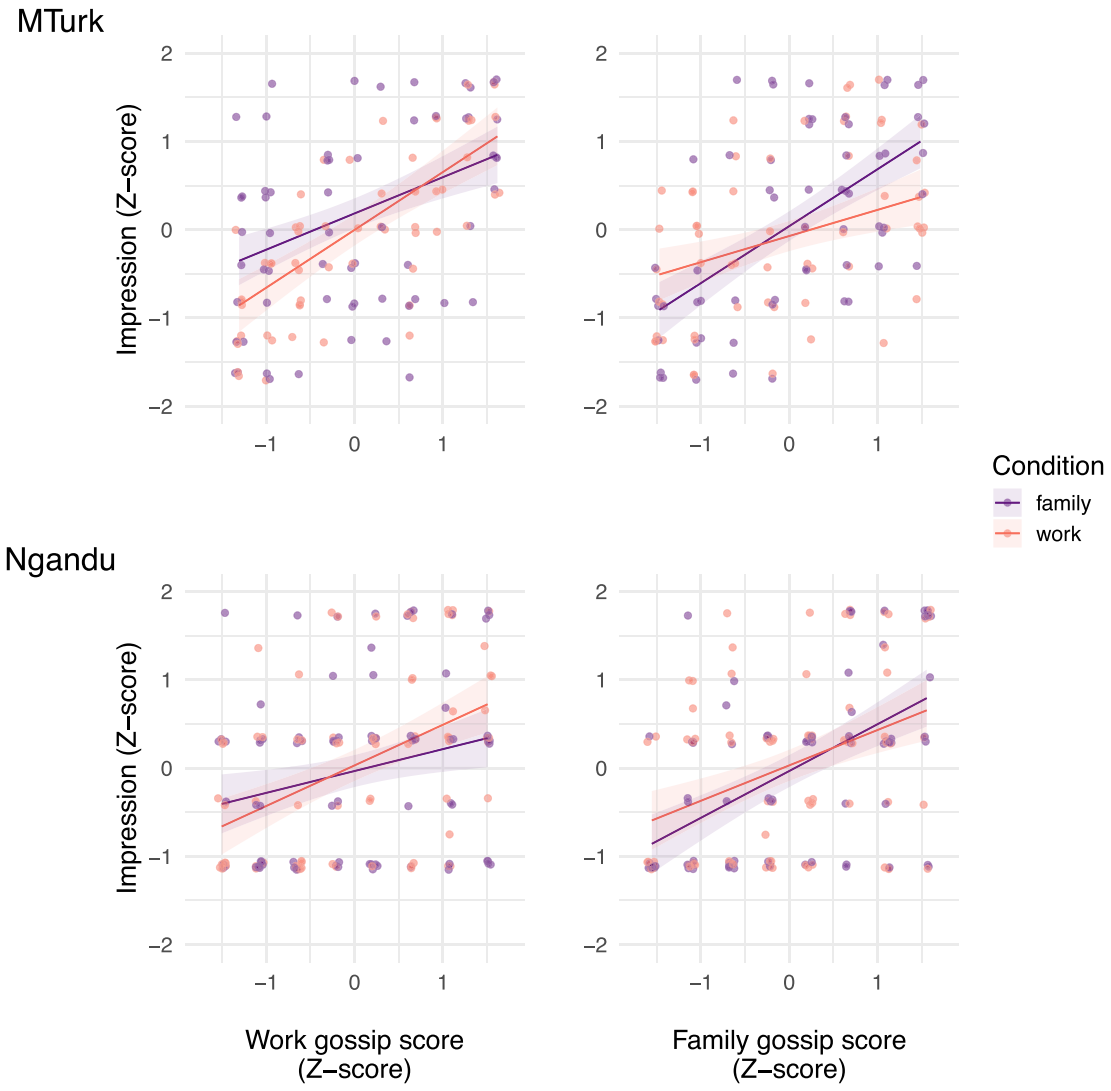

Fig. 2. Effects plots of impression vs. work gossip and family gossip. The work vs. family experimental condition significantly moderated the impact of gossip scores on impression in MTurk study, but not in Ngandu study. Top: MTurk. Bottom: Ngandu. Points are original data with a small amount of jitter added to reveal overlapping values.

their families or to the broader community (Gurven et al., 2000; Sugiyama, 2004; Sugiyama & Chacon, 2000; Sugiyama & Sugiyama, 2003).

5. Study 2: Ngandu horticulturalist experiment

The Ngandu in this study are slash and burn horticulturalists who live in a small village in the southwestern part of CAR, alongside a logging road. They subsist on manioc, corn, plantains, and other crops grown in extensive gardens surrounding the village. There is some market integration, with families selling surplus crops, for example, and producing coffee for sale on international exchanges. The Ngandu speak diNgandu, a Bantu language, along with Sango, the national language of CAR, and many men speak French. Social relations are hierarchically organized by age and sex, with a few formal status roles, such as the village mayor. Polygyny is common, and co-wives often compete for resources (Boyette, 2013).

The Ngandu value a reputation for generosity, and resource transfers among paternal and maternal relatives are routine. Like similar ethnic groups around the world, witchcraft accusations play an important role in Ngandu life, generally revolve around jealousy over accumulations of material wealth, and are a constant source of gossip. In this regard, witchcraft accusations might encourage generosity and serve as a leveling mechanism (Boyette, 2013). The Ngandu regularly hire Aka hunter-gatherers to work in their gardens in exchange for food, money, and tobacco (see Section 7 for more on the Aka).

Shortly before this study was conducted, diamonds and gold were discovered in the region, and jobs at the mines dramatically increased cash flowing into the village. A few months after this study, CAR plunged into a civil war that, at the time of this writing, is ongoing.

5.1. Methods

To replicate the MTurk Study with the Ngandu, we worked with local informants to determine Ngandu cultural equivalents to the work and family vignettes and gossip statements. We then screened the positive and negative work and family gossip statements with 39 Ngandu raters to confirm that positive statements were viewed positively, and negative ones negatively (see Fig. S6). For more details on this process, see Section 2 in the SI. Statistical methods are the same as those described in Section 4.1.2 for the MTurk study.

5.1.1. Ngandu vignettes

Participants were randomized into either the work or family

condition, and then listened as that vignette was read to them in Sango by one of our research assistants.

English translations of each vignette:

Work: Imagine that you have several Aka workers for your manioc plantation, and you have worked with these Aka women/men for a long time. But a new worker has arrived from the Congo because s/he married an Aka man/woman from [this village]. Manioc has become very expensive because the rainy season started too early. A big buyer comes from Bangui [the Capitol] and he wants to pay you 5000 francs. He has also brought many shirts as a gift because you give him a good price on manioc. You are deciding whether to share the shirts with one Aka worker, Male/Malassa [Male and Malassa are common Aka female and male names, respectively]. Listen to these things the people have been saying about Male/Malassa.

Family: Imagine you have five brothers/sisters, and you spent the last year working in Bangui [the Capital]. You have not seen your brothers/sisters for the last year, and your mother/father has just died. You are the Executor and your mother/father gave you two very expensive Italian suits[men]/dresses made in the Congo Kinshasa [women]. When your mother/father was alive s/he told you when s/he dies you keep one, and give the other one to Michael/Marie or one of your other brothers/sisters. Listen to these things about Michael/Marie that you have heard. [Michael and Marie are common Ngandu female and male names, respectively].

After listening to one of the vignettes, participants listened to 7 work and 7 family gossip statements about the target. As in the MTurk study, each participant heard either a positive or negative version of each statement. The number of positive relative to negative statements was randomized between participants. The number of positive family statements is the *family gossip* score, and the number of positive work statements is the *work gossip* score.

Example family gossip statements (positive and negative versions):

- Male/Malassa is [good/bad] with children.
- Michael/Marie [has/does not have] a lot of debt.

Example work gossip statements (positive and negative versions):

- Male/Malassa [does/does not] step on the plants when she/he works.
- Michael/Marie [does/does not] shout at her/his bosses.

Our outcome variable was how likely the participant was to allocate the valuable resource to a same-sex target in the vignette. We also asked several exploratory questions about perceived competition with the target. For the full survey, see Section 2.2 in the SI.

We recruited 160 adult Ngandu participants from the village. Participants came to our location individually (a few women brought their infants). After giving oral informed consent, our local research assistant translated and read our vignettes in the language the participant selected (mostly Sango, with a few selecting French or another language). After responding to our questions, Ngandu participants were thanked and paid.

5.2. Results

There were 84 women in the study, and 76 men. See Table 2.

Two path models were fit with the lavaan package, one for the work condition, and one for the family condition. In both, the randomized work and family gossip scores had a positive effect on *impression*, and *impression* was positively associated with *give benefit*. The direct effects of gossip scores on *give benefit* were smaller, and not significant for two of four effects. See Fig. 1.

5.2.1. Three tests of context-relevance

Although the linear regression model of *impression* as a function of work and family gossip (Eq. 3) explained 34% of the variance, the work vs. family condition did not significantly moderate the relationships between work and family gossip and *impression*, i.e., neither interaction term was statistically significant (unlike the MTurk study). See Fig. 2 and Table S5, model 1.

Like the MTurk study, on a regression model fit on data from the family condition only, the coefficient of the family gossip score was significantly larger than the coefficient of the work gossip score, $\beta_{family} = 0.55 > \beta_{work} = 0.25, Z = 2.3, p = 0.02$. In a regression model fit on data from the work condition only, on the other hand, the coefficient of the work gossip score was not significantly larger than the coefficient of the family gossip score, $\beta_{work} = 0.46 > \beta_{family} = 0.38, Z = 0.63, p = 0.53$.

Like the MTurk study, in a linear regression of *impression* as a function of congruent and incongruent gossip scores, the coefficient of the *congruent gossip score* was significantly larger than the coefficient of the *incongruent gossip score*, $\beta_{congruent} = 0.51 > \beta_{incongruent} = 0.31, Z = 2.2, p = 0.031$.

5.2.2. Exploratory analyses

We found no significant main effects of sex or age on *impression*, or their interactions with congruent or incongruent gossip. There was a modest significant positive interaction between *congruent* and *incongruent* gossip, however, such that positive or negative values on one increased or decreased the effect of the other on *impression*. See Table S5, model 6.

The threat variables – *afraid*, *argue*, and *criticize* – were moderately correlated with each other, all loading strongly on PC2 (and not on PC1), and not correlated with the *total_gossip*, *impression*, and *give_benefit* variables, which all loaded strongly on PC1 (and not PC2). See Fig. S7, Fig. S9, and Fig. S10.

A subset of Ngandu participants ($N = 66$) were asked how much they believed the positive gossip and how much they believed the negative gossip. In a linear model of *impression* as a function of *work gossip*, *family gossip*, *believe positive gossip* and *believe negative gossip*, all coefficients

Table 2
Summary statistics for the Ngandu study, by family vs. work conditions; Cohen's 'd' is the standardized mean difference between conditions.

	Family			Work				
Variable	N	Range	Mean (SD)	N	Range	Mean (SD)	d	p-value
Age (years)	78	18–62	30.9 (11.1)	81	18–81	31.3 (12.6)	−0.037	0.92
Work gossip score	78	0–7	3.53 (2.31)	82	0–7	3.48 (2.36)	0.021	0.89
Family gossip score	78	0–7	3.58 (2.34)	82	0–7	3.43 (2.17)	0.067	0.68
Perceived friendliness	78	1–5	2.37 (1.53)	82	1–5	2.35 (1.43)	0.008	0.79
Perceived threat	78	1–5	2.99 (1.83)	82	1–5	3.11 (1.85)	−0.067	0.57
Target will argue	78	1–5	3.63 (1.58)	82	1–5	3.1 (1.8)	0.32	0.13
Criticize behind back	78	1–5	4.49 (1.15)	82	1–5	4.38 (1.19)	0.089	0.32
Impression of target	78	1–5	2.53 (1.41)	82	1–5	2.57 (1.41)	−0.025	0.86
Provide benefit to target	78	1–5	3.36 (1.84)	82	1–5	3.45 (1.8)	−0.051	0.70
Believe positive gossip	31	1–5	3.45 (1.82)	35	1–5	3.49 (1.8)	−0.019	0.97
Believe negative gossip	31	1–5	3.32 (1.94)	35	1–5	2.66 (1.91)	0.35	0.17

were statistically significant, with *believe positive gossip* positively associated with *impression*, and *believe negative gossip* negatively associated with *impression*. See Table S5, model 5.

5.2.3. Combined MTurk and Ngandu analysis

We combined the MTurk and Ngandu data and fit several models investigating potential differences in parameters by population (i.e., including various population interaction terms), but did not find any evidence that the relationship between gossip and impression differed by population. Table S6, model 1 shows that in a model of *impression* as a function of *congruent* and *incongruent* gossip, the population interaction terms were not significant (other models with insignificant population interaction terms not reported). It also shows that the coefficient of the *congruent gossip score* was significantly larger than the coefficient of the *incongruent gossip score*, $\beta_{congruent} = 0.65 > \beta_{incongruent} = 0.35$, $Z = 3$, $p = 0.0025$.

5.3. Discussion

The Ngandu results, like the MTurk results, showed that increasingly positive gossip caused an increase in reported likelihood of transferring resources to the target, an effect mediated by the effect of gossip on the *impression* of the target. The evidence for the impact of the relevancy of context, was weaker, however, as there was no significant interaction between work and family condition of the effect of gossip on impression, perhaps because work and family contexts are more intertwined in this population than in the MTurk sample. In support of the relevancy of context, the coefficient of congruent gossip was significantly larger than the coefficient of incongruent gossip, as also seen in the MTurk study.

The GGM and PCA analyses showed even less connection between gossip, the competitive variables, and transferring resources in this study than in the MTurk study. Finally, and importantly, in the model of *impression* using the combined data, the population variable (MTurk vs. Ngandu) had no significant main effect nor significant interactions with congruent or incongruent gossip, thus not supporting any important population differences in the relationships between gossip, impression, and transferring resources. Like the MTurk study results, the Ngandu results therefore arguably best support theories highlighting investment in individuals who provide valuable benefits to their families or to the broader community.

6. Study 3: Aka forager exploratory observational study

Genetic evidence indicates that Congo Basin foragers are one of three major lineages of modern humans, the other two being south African foragers (San) and everyone else (there is also evidence of a fourth ghost lineage); in the Congo Basin foragers there are Western and Eastern clades (Lipson et al., 2020, 2022). Aka (members of the Western clade) are highly mobile foragers who, like most other rain forest foragers, obtain many of their calories from starchy plant foods grown by neighboring farmers in exchange for labor, meat, honey, and other forest products (Takeuchi, 2014). Aka live in small camps along trails that radiate from farming villages into the forest, where women and men both participate in collective net hunting of smaller forest animals, mainly duikers (forest antelopes). Both sexes also gather plant foods, but only men collect honey (Hewlett, 1996). The Aka, like many foraging populations, tend to be more egalitarian than non-foraging populations, lack gender and intergenerational inequality, and maintain this ethic through prestige avoidance, demand sharing (demanding that someone share food, tobacco, or other valuable resources), and rough joking (Hewlett, 1991). For a comprehensive introduction to Congo Basin foragers, see Hewlett (2014).

The Aka in this study live in camps on two adjacent trails that terminate in the Ngandu village described above. Aka speak a Bantu language, which, though different from that of Ngandu or other neighboring Bantu farmers, nevertheless indicates a long association with farming groups. Similar to many forager and farmer groups throughout the Congo Basin, relations between Aka and Ngandu involve a complex mix of cooperation and conflict, disdain and awe. Ngandu regard Aka as a species intermediate between humans and wild animals, and Aka regard Ngandu as lazy and wild subhumans. At the same time, both groups believe that the other possesses great supernatural powers (Takeuchi, 2014).

This study aimed to explore the relationship between individuals' peer-rated contributions to their group, costs imposed on the group, and reputations and receipt of benefits from the group. Contributions to the group were assessed by peer-ratings of working hard, sharing, and parenting/alloparenting. A previous study in this population found that peer-rated anger was associated with hitting and was viewed negatively (Hess et al., 2010). We therefore assessed peer-rated anger as a measure of costs imposed on the group. Because inclusive fitness is an important possible explanation for resource transfers, we measured average relatedness to the group. Finally, we investigated whether there were sex or age differences in reputation or receiving benefits. The study was exploratory and observational, i.e., we did not have specified a priori predictions nor did we experimentally manipulate our independent variables,

6.1. Methods

All 40 adult Aka residents of two adjacent trails agreed to participate in the study and were photographed. Ages were estimated by Ngandu research assistants with whom Aka participants had lifelong relationships. Each individual was then interviewed separately with an Ngandu translator who also spoke French or English. Each Aka participant viewed the photos, one by one in random order, and was asked to rate, on a five-point scale, each pictured individual on traits relevant to reputation and receipt of benefits: −2 (much less than other Aka), −1 (a little less than other Aka), 0 (the same as other Aka), 1 (a little more than other Aka), 2 (a lot more than other Aka). To reduce the burden on participants, and to minimize spurious correlation among traits due ratings by the same raters, each rater rated all their peers on only a random subset of these traits, with 7–9 peer-raters for each trait. We did not anticipate high interrater reliability for these traits because individual relationships would undoubtedly strongly influence ratings, but we did expect that mean ratings would nevertheless be informative. In all, 29 Aka rated 40 Aka on 6 traits: 11 raters rated only 1 trait, 16 raters rated 2 traits, and 2 raters rated 3 traits. The 6 reputation-relevant traits were:

- *Works hard*: Does this person work more or less than other Aka?
- *Share*: Does this person share more or less than other Aka?
- *Parenting/alloparenting*: Is this person a better or worse parent than other Aka? (For individuals without children, this question was modified to ask about care of children)
- *Angry*: Is this person more or less angry than other Aka?
- *Reputation*: When people talk about this person, do they say more good things or more bad things?
- *Receive benefits*: Do other Aka share more or less with this person?

To estimate genetic relatedness, each participant provided the names of their two parents and their four grandparents. Parent and grandparent names were double-checked with a senior *kombeti* (camp leader).

6.2. Statistical analyses

The Aka study differed substantially from the MTurk and Ngandu studies. The latter studies involved individuals responding to experimentally manipulated gossip about a fictional character, whereas the Aka study was an observational study of adults, many of whom were biological relatives and all of whom had extensive real-life relationships, rating each other on multiple traits. Hence, there were likely to be

Table 3
Summary statistics of the Aka sample.

Variable	N	Range	Mean (SD)
Age (years)	40	18–50	30.7 (6.6)
Works hard	40	−0.714-1.64	0.33 (0.68)
Shares with others	40	−1.11-1.22	0.023 (0.54)
Gets angry	40	−0.625-1.38	0.15 (0.50)
Reputation	40	−1.62-1.62	0.21 (0.79)
Others share with	40	0–1.38	0.63 (0.38)
Average relatedness	40	0–0.0714	0.034 (0.023)

complex relationships among all the variables. We therefore took an exploratory (i.e., data driven) approach, performing a PCA on all study variables, and fitting a GGM.

6.3. Results

Our sample of Aka had 21 women and 19 men, each of whom resided with an average of 7.6 biological kin in the sample. The average relatedness to one's biological kin in the sample was 0.3, whereas the average relatedness to the sample as whole was 0.034 (12 participants had no biological kin in the sample). See Table 3.

The PCA provided important insights. An initial PCA revealed that the *kombeti* (camp leader) was an extreme outlier. We therefore performed PCA with this individual removed, and then plotted all individuals, including the *kombeti,* using the resulting PC1 x PC2 coordinates (see Fig. 3, A,B). The first 3 PCs accounted for 65% of the variance, with PC1 and PC2 accounting for approximately equal percentages. PC2 was readily interpretable as the predicted association between *reputation* and *receiving benefits*, with *parenting* loading positively on this component, and *angry* loading negatively. PC1, with positive loadings from *work hard*, *age*, and *avg relatedness*, could be interpreted as investing in kin, as could PC3, with positive loadings from *share* and *avg relatedness*.

Remarkably, almost all women had positive values on PC2 whereas almost all men had negative values. We interpret this as a sexual division of labor, with women investing more in parenting than men, and receiving more benefits (presumably from male surplus production). The GGM (which we also fit with the *kombeti* removed) provided additional insights. *Reputation* was associated with *receive benefits*, as was female sex (but sex was not associated with *reputation*). Interestingly, although *sharing*, a core Aka value, and *avg relatedness* were positively associated with each other, neither was directly linked to *reputation* or *receiving benefits*. *Work hard* also had an enigmatic positive association with *angry*. It should be noted that fitting a GGM involves setting some hyperparameters, and adjusting these gave somewhat different results. Thus, the GGM reported here is clearly exploratory.

6.4. Discussion

There was a dramatic sex difference in the clustering of participants in the PCA, with almost all women having positive values on PC2, interpretable as the relationship between parenting, reputation, and receiving benefits, and all men (except the *kombeti)* having low or negative values. Specifically, the PCA and GGM (which investigated pairwise partial correlations, conditional on all other variables) supported 4 of the 6 predictions in the Study Aims, albeit with relatively weak associations: *parenting* and *work hard* were positively associated with *reputation*, *angry* was negatively associated, and *reputation* was positively associated with *receiving benefits*. Somewhat surprisingly, two predictions were not supported: *share*, a core Aka value, was not associated with *reputation* or *receive benefits* in the GGM (i.e., coefficients were shrunk to 0). *Avg relatedness* was also not associated with *receive benefits*, probably because juveniles were not included in the study. *Avg relatedness* was positively associated with *share*, however, and both loaded on PC3. *Work hard* might be associated with *angry* because hard workers were physically stronger, and thus more likely to use anger (Hess et al., 2010) and/or that hard workers were angry at those who worked less hard.

Taken together, these results support the prediction that good reputations are associated with the receipt of benefits, and that reputations are positively influenced by contributions to the family (parenting) and

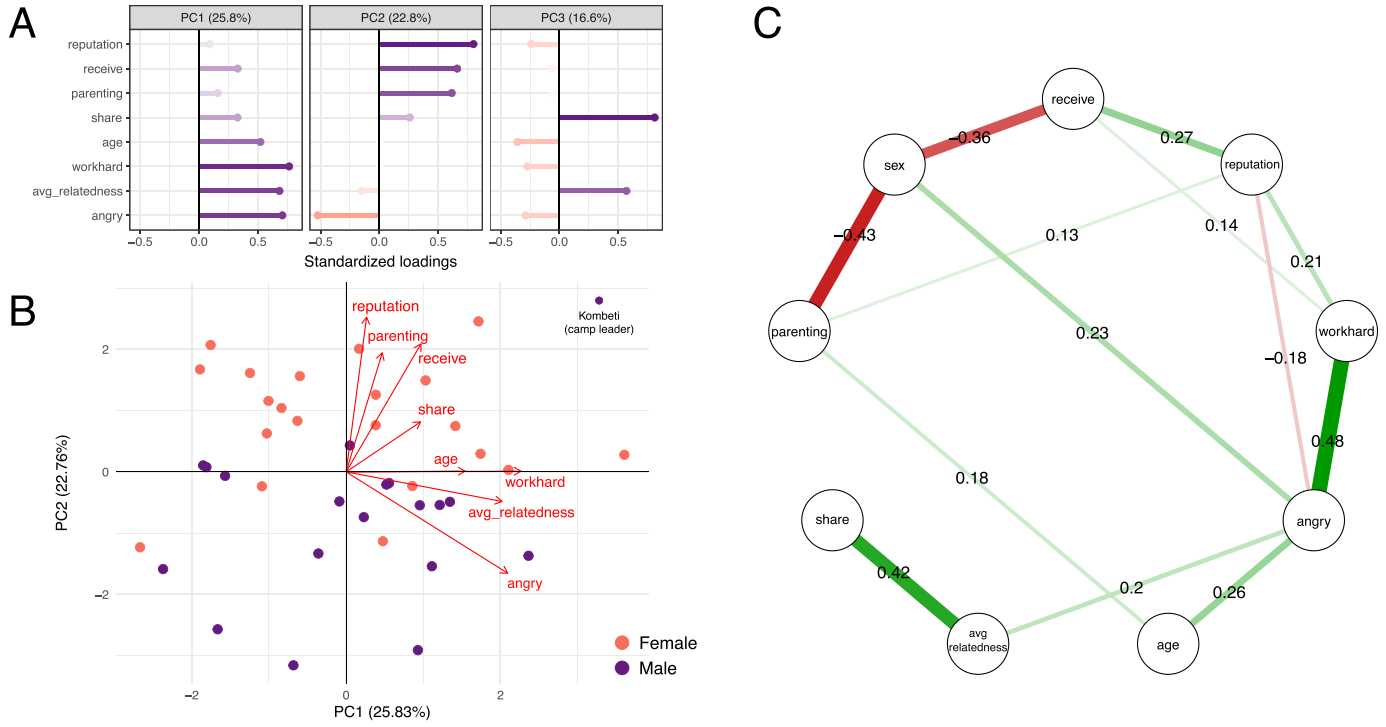

Fig. 3. PCA and GGM of Aka study variables. A: PCA variable loadings. B: PCA biplot. C: Gaussian Graphical Model (GGM). Edge weights are partial correlation coefficients. Females were coded as 0 and males as 1, so negative coefficients for sex indicate a female bias, and positive coefficents a male bias.

by contributions to kin and/or the community (work hard), although the associations were relatively weak. The results also support the inclusive fitness prediction that genetic relatedness helps explain the transfer of resources to others (sharing). Finally, results show clear evidence for a sex difference, perhaps due to a sexual division of labor, with women rated as better parents than men, and also as receiving more benefits than men.

7. Limitations

The MTurk and Ngandu studies traded the ecological validity of real-world observations of individuals gossiping with their social partners for the experimental control afforded by the vignette design. The Aka study, on the other hand, although having high ecological validity, was observational, preventing robust causal interpretations. The Aka study was limited by its small sample size, which increased the risk of overfitting the data. It was also impossible to determine the role of the immediate social context in the results of the Aka study, which was conducted after the camp members had just returned from an extended stay in the forest collecting caterpillars, but also at a time when wage labor opportunities from mining jobs were increasing.

8. General discussion

The experimental MTurk and Ngandu vignette studies found strong, consistent evidence that negative and positive gossip caused lower and higher likelihood of transferring benefits to a fictional target of the gossip, respectively, an effect that was largely mediated by the effect of gossip on impressions of the target. The effect of gossip was also context relevant, with gossip that was congruent with the context (e.g., family-related gossip in a situation involving intergenerational transfer of resources) having a greater impact on impressions than incongruent gossip. This pattern did not differ between the two major subpopulations of MTurk participants (US and India), nor between MTurk and Ngandu participants in the combined analysis.

These results provide strong support for reputation-based theories of resource transfers in both small- and large-scale societies, which include indirect reciprocity (Alexander, 1986; Balliet et al., 2020; Leimar & Hammerstein, 2001; Nowak & Sigmund, 2005), costly signaling (Bliege Bird & Smith, 2005; Gintis et al., 2001; Hawkes & Bliege Bird, 2002; Stibbard-Hawkes, 2019), and investing in those who provide valuable benefits to the family or community (Gurven et al., 2000; Sugiyama, 2004; Sugiyama & Chacon, 2000; Sugiyama & Sugiyama, 2003). While our results do not rule out any of these, our gossip stimuli did not emphasize sharing with others, which is the basis of indirect reciprocity (although they did include gossip about behaviors that are beneficial to others). Our stimuli also did not emphasize risky behaviors, the basis of costly signaling, and the few such behaviors that were included, such as gambling and drinking, were viewed negatively. Our gossip stimuli instead emphasized providing benefits to one's family (such as loving one's siblings or being good with children), or benefits to work (such as working well under pressure and working late), and avoiding imposing costs (such incurring debt or stealing corn).

Our Aka results similarly showed that contributions to family and community were associated with a good reputation, a reputation in turn associated with receiving benefits (though the associations were small). The strong female bias in parenting and receipt of benefits is consistent with a sexual division of labor in which men's surplus production is transferred to women, who invest the surplus in offspring, a pattern seen in other small-scale societies (e.g., Hooper, Gurven, Winking, & Kaplan, 2015). Thus, our results align most closely with theories proposing that resources are transferred to individuals who provide benefits to their families or communities and who avoid imposing costs on their families and communities.

Taken together, these results provide an empirical foundation for competitive gossiping. Although congruent and incongruent gossip both strongly influenced the transfer of benefits, mediated by their effects on impression, congruent gossip had a greater effect. This helps explain why, in a competitive context, individuals relay more congruent gossip, i.e., gossip that is relevant to the competitive context, than incongruent gossip: competitors and allies are targeting the rationales for resource transfers, and resource holders are paying close attention (Hess & Hagen, 2021).

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data and scripts are available here: https://github.com/grasshoppermouse/resourcetransfer and here: https://doi.org/10.5281/zenodo.7080492

All analyses conducted with R version 4.2.1 (2022-06-23).

Acknowledgements

We thank the Editors and anonymous reviewers for their helpful feedback. Funding provided by Washington State University College of Arts and Sciences.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.evolhumbehav.2023.02.013.

References

Aguinis, H., & Bradley, K. J. (2014). Best practice recommendations for designing and implementing experimental vignette methodology studies. *Organizational Research Methods, 17*(4), 351–371. https://doi.org/10.1177/1094428114547952

Aktipis, A., Cronk, L., Alcock, J., Ayers, J. D., Baciu, C., Balliet, D., … Winfrey, P. (2018). Understanding cooperation through fitness interdependence. *Nature Human Behaviour, 2*(7), 429–431. https://doi.org/10.1038/s41562-018-0378-4

Alexander, R. D. (1986). Ostracism and indirect reciprocity: The reproductive significance of humor. *Ethology and Sociobiology, 7*(3–4), 253–270.

Allen-Arave, W., Gurven, M., & Hill, K. (2008). Reciprocal altruism, rather than kin selection, maintains nepotistic food transfers on an Ache reservation. *Evolution and Human Behavior, 29*(5), 305–318. https://doi.org/10.1016/j.evolhumbehav.2008.03.002

Archer, J., & Coyne, S. M. (2005). An integrated review of indirect, relational, and social aggression. *Personality and Social Psychology Review, 9*(3), 212–230. https://doi.org/10.1207/s15327957pspr0903_2

Arnocky, S., Davis, A. C., & Vaillancourt, T. (2022). Resource scarcity predicts Women's Intrasexual competition: The role of trait and state envy. *Evolutionary Psychological Science*, 1–13.

Atzmüller, C., & Steiner, P. M. (2010). Experimental vignette studies in survey research. *Methodology: European Journal of Research Methods for the Behavioral and Social Sciences, 6*(3), 128–138.

Balliet, D., Wu, J., & van Lange, P. A. M. (2020). Indirect reciprocity, gossip, and reputation-based cooperation. In *Social psychology* (p. 23).

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173.

Beersma, B., & Van Kleef, G. A. (2011). How the grapevine keeps you in line: Gossip increases contributions to the group. *Social Psychological and Personality Science, 2*(6), 642–649. https://doi.org/10.1177/1948550611405073

Bliege Bird, R., & Smith, E. A. (2005). Signaling theory, strategic interaction, and symbolic capital. *Current Anthropology, 46*(2), 221–248. https://doi.org/10.1086/427115

Blurton Jones, N. G. (1987). Tolerated theft, suggestions about the ecology and evolution of sharing, hoarding and scrounging. *Social Science Information, 26*(1), 31–54. https://doi.org/10.1177/053901887026001002

Borsboom, D., Deserno, M. K., Rhemtulla, M., Epskamp, S., Fried, E. I., McNally, R. J., et al.others. (2021). Network analysis of multivariate data in psychological science. Nature Reviews Methods Primers, 1(1), 1–18.

Boyette, A. H. (2013). *Social learning during middle childhood among Aka foragers and Ngandu farmers of the Central African Republic (PhD thesis)*. Washington: Washington State University.

Campbell, A. (1999). Staying alive: Evolution, culture, and women's intrasexual aggression. *Behavioral and Brain Sciences, 22*(2), 203–214.

Chmielewski, M., & Kucker, S. C. (2020). An Mturk crisis? Shifts in data quality and the impact on study results. *Social Psychological and Personality Science, 11*(4), 464–473. https://doi.org/10.1177/1948550619875149

De Backer, C. J., Larson, C., Fisher, M. L., McAndrew, F. T., & Rudnicki, K. (2016). When strangers start to gossip: Investigating the effect of gossip on cooperation in a prisoner's dilemma game. *Evolutionary Psychological Science, 2*, 268–277.

Dunbar, R. I. M. (1996). *Grooming, Gossip and the Evolution of Language*. Harvard University Press.

Dyble, M., Salali, G. D., Chaudhary, N., Page, A., Smith, D., Thompson, J., … Migliano, A. B. (2015). Sex equality can explain the unique social structure of hunter-gatherer bands. *Science, 348*(6236), 796–798. https://doi.org/10.1126/science.aaa5139

Epskamp, S., Cramer, A. O. J., Waldorp, L. J., Schmittmann, V. D., & Borsboom, D. (2012). Qgraph: Network visualizations of relationships in psychometric data. *Journal of Statistical Software, 48*(4), 1–18.

Feinberg, M., Willer, R., & Schultz, M. (2014). Gossip and ostracism promote cooperation in groups. *Psychological Science, 25*(3), 656–664. https://doi.org/10.1177/0956797613510184

Fisher, M. (Ed.). (2017). *The Oxford handbook of women and competition*. Oxford University Press.

Fisher, M., & Cox, A. (2011). Four strategies used during intrasexual competition for mates. *Personal Relationships, 18*(1), 20–38.

Friedman, J., Hastie, T., & Tibshirani, R. (2019). Glasso: Graphical Lasso: Estimation of Gaussian graphical models. Retrieved from https://CRAN.R-project.org/package=glasso.

Gaffney, M. R., Adams, K. H., Syme, K. L., & Hagen, E. H. (2022). Depression and suicidality as evolved credible signals of need in social conflicts. *Evolution and Human Behavior, 43*(3), 242–256. https://doi.org/10.1016/j.evolhumbehav.2022.02.004

Garfield, Z. H., Schacht, R., Post, E. R., Ingram, D., Uehling, A., & Macfarlan, S. J. (2021). The content and structure of reputation domains across human societies: A view from the evolutionary social sciences. *Philosophical Transactions of the Royal Society, B: Biological Sciences, 376*(1838), 20200296. https://doi.org/10.1098/rstb.2020.0296

Giardini, F., Paolucci, M., Villatoro, D., & Conte, R. (2014). Punishment and gossip: Sustaining cooperation in a Public Goods Game. In B. Kaminski, & G. Koloch (Eds.), *Advances in social simulation* (p. 107).

Giardini, F., & Vilone, D. (2016). Evolution of gossip-based indirect reciprocity on a bipartite network. *Scientific Reports, 6*(1), 37931. https://doi.org/10.1038/srep37931

Giardini, F., Vilone, D., Sánchez, A., & Antonioni, A. (2021). Gossip and competitive altruism support cooperation in a Public Good game. *Philosophical Transactions of the Royal Society, B: Biological Sciences, 376*(1838), 20200303. https://doi.org/10.1098/rstb.2020.0303

Gintis, H., Smith, E. A., & Bowles, S. (2001). Costly signaling and cooperation. *Journal of Theoretical Biology, 213*(1), 103–119. https://doi.org/10.1006/jtbi.2001.2406

Gurven, M., Allen-Arave, W., Hill, K., & Hurtado, M. (2000). "It's a wonderful life": Signaling generosity among the Ache of Paraguay. *Evolution and Human Behavior, 21*(4), 263–282. https://doi.org/10.1016/S1090-5138(00)00032-5

Hawkes, K., & Bliege Bird, R. (2002). Showing off, handicap signaling, and the evolution of men's work. *Evolutionary Anthropology, 11*(2), 58–67. https://doi.org/10.1002/evan.20005

Hawkes, K., O'Connell, J. F., & Blurton Jones, N. G. (2014). More lessons from the Hadza about men's work. *Human Nature, 25*(4), 596–619. https://doi.org/10.1007/s12110-014-9212-5

Hess, N. H. (2017). Informational warfare: Coalitional gossiping as a strategy for within-group aggression. In *Oxford library of psychology. The Oxford handbook of women and competition* (pp. 223–246). New York, NY, US: Oxford University Press.

Hess, N. H., & Hagen, E. H. (2019). Gossip, reputation, and friendship in within-group competition: An evolutionary perspective. In *The Oxford handbook of gossip and reputation* (pp. 274–302). https://doi.org/10.1093/oxfordhb/9780190494087.013.15

Hess, N. H., & Hagen, E. H. (2021). Competitive gossip: The impact of domain, resource value, resource scarcity and coalitions. *Philosophical Transactions of the Royal Society, B: Biological Sciences, 376*(1838), 20200305. https://doi.org/10.1098/rstb.2020.0305

Hess, N. H., Helfrecht, C., Hagen, E., Sell, A., & Hewlett, B. S. (2010). Interpersonal aggression among Aka hunter-gatherers of the Central African Republic: Assessing the effects of sex, strength, and anger. *Human Nature, 21*(3), 330–354. https://doi.org/10.1007/s12110-010-9094-0

Hewlett, B. S. (1991). *Intimate fathers: The nature and context of Aka pygmy paternal infant care*. University of Michigan Press.

Hewlett, B. S. (1996). Cultural diversity among African pygmies. In S. Kent (Ed.), *Cultural diveristy among twentieth-century foragers: An African perspective* (pp. 215–244). Cambridge University Press.

Hewlett, B. S. (Ed.). (2014). *Hunter-gatherers of the Congo Basin: Cultures, histories and biology of African Pygmies*. New Brunswick, NJ: Transaction Publishers.

Hill, K. R., Walker, R. S., Bovzivcević, M., Eder, J., Headland, T., Hewlett, B. S., … Wood, B. (2011). Co-residence patterns in hunter-gatherer societies show unique human social structure. *Science, 331*(6022), 1286–1289. Retrieved from http://www.sciencemag.org/content/331/6022/1286.short.

Hooper, P. L., Gurven, M., Winking, J., & Kaplan, H. S. (2015). Inclusive fitness and differential productivity across the life course determine intergenerational transfers in a small-scale human society. *Proceedings of the Royal Society B: Biological Sciences, 282*(1803), 20142808.

Jaeggi, A. V., & Gurven, M. (2013). Natural cooperators: Food sharing in humans and other primates. *Evolutionary Anthropology: Issues, News, and Reviews, 22*(4), 186–195. https://doi.org/10.1002/evan.21364

Jaeggi, A. V., Kramer, K. L., Hames, R., Kiely, E. J., Gomes, C., Kaplan, H., & Gurven, M. (2017). Human grooming in comparative perspective: People in six small-scale societies groom less but socialize just as much as expected for a typical primate. *American Journal of Physical Anthropology, 162*(4), 810–816.

Jensen, C., & Petersen, M. B. (2017). The deservingness heuristic and the politics of health care. *American Journal of Political Science, 61*(1), 68–83. https://doi.org/10.1111/ajps.12251

Krems, J. A., Williams, K. E., Aktipis, A., & Kenrick, D. T. (2020). Friendship jealousy: One tool for maintaining friendships in the face of third-party threats? *Journal of Personality and Social Psychology, 120*(4), 977.

Leimar, O., & Hammerstein, P. (2001). Evolution of cooperation through indirect reciprocity. *Proceedings of the Royal Society of London. Series B: Biological Sciences, 268*(1468), 745–753. https://doi.org/10.1098/rspb.2000.1573

Lipson, M., Ribot, I., Mallick, S., Rohland, N., Olalde, I., Adamski, N., … Reich, D. (2020). Ancient West African foragers in the context of African population history. *Nature, 1–6*. https://doi.org/10.1038/s41586-020-1929-1

Lipson, M., Sawchuk, E. A., Thompson, J. C., Oppenheimer, J., Tryon, C. A., Ranhorn, K. L., … Prendergast, M. E. (2022). Ancient DNA and deep population structure in sub-Saharan African foragers. *Nature, 603*(7900), 290–296. https://doi.org/10.1038/s41586-022-04430-9

Martin, J. S., Ringen, E. J., Duda, P., & Jaeggi, A. V. (2020). Harsh environments promote alloparental care across human societies. *Proceedings of the Royal Society B: Biological Sciences, 287*(1933), 20200758. https://doi.org/10.1098/rspb.2020.0758

McAndrew, F. T. (2017). How "the gossip" became a woman and how "gossip" became her weapon of choice. In *The Oxford handbook of women and competition* (pp. 191–205).

Mulder, M. B., Bowles, S., Hertz, T., Bell, A., Beise, J., Clark, G., … Wiessner, P. (2009). Intergenerational wealth transmission and the dynamics of inequality in small-scale societies. *Science, 326*(5953), 682–688. https://doi.org/10.1126/science.1178336

Nowak, M. A., & Sigmund, K. (2005). Evolution of indirect reciprocity. *Nature, 437*(7063), 1291–1298. https://doi.org/10.1038/nature04131

Petersen, M. B. (2012). Social welfare as small-scale help: Evolutionary psychology and the deservingness heuristic. *American Journal of Political Science, 56*(1), 1–16. https://doi.org/10.1111/j.1540-5907.2011.00545.x

Reynolds, T. A. (2022). Our grandmothers' legacy: Challenges faced by female ancestors leave traces in modern women's same-sex relationships. *Archives of Sexual Behavior, 51*(7), 3225–3256. https://doi.org/10.1007/s10508-020-01768-x, 2022 Oct. Epub 2021 Jan 4. PMID: 33398709.

Ringen, E. J., Duda, P., & Jaeggi, A. V. (2019). The evolution of daily food sharing: A Bayesian phylogenetic analysis. *Evolution and Human Behavior, 40*(4), 375–384. https://doi.org/10.1016/j.evolhumbehav.2019.04.003

Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling. *Journal of Statistical Software, 48*, 1–36.

Rucas, S. L. (2017). Cooperation drives competition among Tsimane women in the Bolivian Amazon. In *The Oxford handbook of women and competition*.

Rucas, S. L., Gurven, M., Kaplan, H., & Winking, J. (2010). The social strategy game. *Human Nature, 21*(1), 1–18.

Rucas, S. L., Gurven, M., Kaplan, H., Winking, J., Gangestad, S., & Crespo, M. (2006). Female intrasexual competition and reputational effects on attractiveness among the Tsimane of Bolivia. *Evolution and Human Behavior, 27*(1), 40–52.

Smith, D., Dyble, M., Major, K., Page, A. E., Chaudhary, N., Salali, G. D., … Mace, R. (2019). A friend in need is a friend indeed: Need-based sharing, rather than cooperative assortment, predicts experimental resource transfers among Agta hunter-gatherers. *Evolution and Human Behavior, 40*(1), 82–89. https://doi.org/10.1016/j.evolhumbehav.2018.08.004

Sommerfeld, R. D., Krambeck, H.-J., Semmann, D., & Milinski, M. (2007). Gossip as an alternative for direct observation in games of indirect reciprocity. *Proceedings of the National Academy of Sciences, 104*(44), 17435–17440. https://doi.org/10.1073/pnas.0704598104

Stibbard-Hawkes, D. N. E. (2019). Costly signaling and the handicap principle in hunter-gatherer research: A critical review. *Evolutionary Anthropology, 28*(3), 144–157. https://doi.org/10.1002/evan.21767

Stibbard-Hawkes, D. N. E., Attenborough, R. D., Mabulla, I. A., & Marlowe, F. W. (2020). To the hunter go the spoils? No evidence of nutritional benefit to being or marrying a well-reputed Hadza hunter. *American Journal of Physical Anthropology, 173*(1), 61–79. https://doi.org/10.1002/ajpa.24027

Stone, E. A. (2015). *Sex ratio and women's aggressive competition in the outer islands of Yap (PhD thesis)*. Utah: University of Utah.

Sugiyama, L. S. (2004). Illness, injury, and disability among Shiwiar forager-horticulturalists: Implications of health-risk buffering for the evolution of human life history. *American Journal of Physical Anthropology, 123*(4), 371–389. https://doi.org/10.1002/ajpa.10325

Sugiyama, L. S., & Chacon, R. (2000). Effects of illness and injury on foraging among the Yora and Shiwiar: Pathology risk as an adaptive problem. In L. Cronk, N. Chagnon, & W. Irons (Eds.), *Adaptation and human behavior* (pp. 371–391). Routledge.

Sugiyama, L. S., & Sugiyama, M. S. (2003). Social roles, prestige, and health risk: Social niche specialization as a risk-buffering strategy. *Human Nature, 14*(2), 165–190. https://doi.org/10.1007/s12110-003-1002-4

Sutton, K. (2014). *An exploration of gossip as an intrasexual competition strategy* (Doctoral dissertation, Macquarie University).

Sutton, K. A., & Oaten, M. (2017). Women's talk? Exploring the relationships between gossip, sex, mate competition, and mate poaching. In *The Oxford handbook of women and competition* (pp. 207–221).

Takeuchi, K. (2014). Interethnic relationships between pygmies and farmers. In *Hunter-gathers of the Congo basin* (pp. 299–320). Routledge.

Tibshirani, R. (1996). Regression shrinkage and selection via the lasso. *Journal of the Royal Statistical Society: Series B: Methodological, 58*(1), 267–288.

Weinberg, J. D., Freese, J., & McElhattan, D. (2014). Comparing data characteristics and results of an online factorial survey between a population-based and a crowdsource-recruited sample. *Sociological Science, 1*.

Wood, B. M., & Marlowe, F. W. (2013). Household and kin provisioning by Hadza men. *Human Nature, 24*(3), 280–317. https://doi.org/10.1007/s12110-013-9173-0

Wu, J., Balliet, D., Kou, Y., & Van Lange, P. A. M. (2019). Gossip in the dictator and ultimatum games: Its immediate and downstream consequences for cooperation. *Frontiers in Psychology, 10*.

Wu, J., Balliet, D., & Van Lange, P. A. M. (2016a). Gossip versus punishment: The efficiency of reputation to promote and maintain cooperation. *Scientific Reports, 6*(1), 23919. https://doi.org/10.1038/srep23919

Wu, J., Balliet, D., & Van Lange, P. A. M. (2016b). Reputation, gossip, and human cooperation. *Social and Personality Psychology Compass, 10*(6), 350–364. https://doi.org/10.1111/spc3.12255