

In need-based sharing, sharing is more important than need

Aaron D. Lightner^{a,b,*}, Anne C. Pisor^b, Edward H. Hagen^b

^a Department of the Study of Religion, Aarhus University, Aarhus, Denmark

^b Department of Anthropology, Washington State University, Pullman, WA, USA

ARTICLE INFO

Keywords:

Evolution of cooperation
Need-based sharing
Pastoralists
Risk
Maasai

ABSTRACT

Cooperative resource sharing is widespread across cultures, and it was likely critical during much of human evolutionary history for pooling risk. Need-based sharing specifically pools risk by following two cooperative rules: help others when asked, and only request help when in need. In a two-part study, we first expanded an agent-based model of need-based sharing partnerships, adding two types of defection and varying partnership sizes. We show that refusing to help always has a long-term cost, which increases with larger partnerships. In contrast, “greedy” requests that are not based on survival risk carry little-to-no cost. We then conducted an experimental vignette study of osotua, a need-based sharing tradition, with Tanzanian Maasai pastoralists. We found that participants generally complied with osotua requests, but shared larger amounts for requests that were based on survival risk. We conclude by proposing an expanded framework for evolutionary models involving need and fitness interdependence, where the cost asymmetry among types of defection generally favors a decision heuristic where individuals prefer sharing with those in need, but err on the side of generosity when need is uncertain.

1. Introduction

Humans everywhere share resources to manage risk in uncertain and changing environments (Cronk et al., 2019). Food sharing specifically has been a critical part of our evolutionary past and cross-cultural present, and it likely has shaped much of our cooperative psychology and social organization (Jaeggi & Gurven, 2013). Human groups frequently occupy high-risk foraging niches, for example, where individuals buffer their risk of food shortfalls by redistributing surpluses to those who need them. Assuming that each individual is vulnerable to shortfall due to varying foraging success over time, this surplus redistribution effectively functions as an insurance system that dramatically reduces the risk of starvation for those who participate (Gurven, Allen-Arave, Hill, & Hurtado, 2000).

Need-based sharing, as we will discuss further below, refers to cooperative sharing behavior that is conditional on a recipient’s need (Hruschka, 2010; Smith et al., 2019). Whether or not a recipient is in a state of need is an important feature of many different models of cooperation across the biological world; for example, need is a feature of any model of cooperation that considers the relative benefits of the receiver vs. the giver, like inclusive fitness, reciprocity, partnership, and friendship (Wilkinson, 1984; Maynard, 1991; Eshel & Shaked, 2001;

Johnstone & Grafen, 1992; Hruschka, 2010; Aktipis et al., 2018; Dyble, Gardner, Vinicius, & Migliano, 2018). Unlike strict reciprocity, however, need-based sharing often involves long-term benefits, obviating the necessity for account-keeping and building fitness interdependence between partners (Aktipis et al., 2018) – meaning that each individual has a stake in the fitness of others (Roberts, 2005). Other models of cooperation do the same, where the continued existence of the receiver benefits the giver (e.g., pseudo-reciprocity, kith selection, group augmentation) (Connor, 1986; Tooby & Cosmides, 1996; Kokko, Johnstone, & Clutton-Brock, 2001; Queller, 2011). In short, theories of need-based sharing channel many existing models that incorporate need and fitness interdependence in the cooperation literature.

A lack of account-keeping and freerider punishment has been documented ethnographically among need-based sharing systems (Cronk & Aktipis, 2021). In past observations among Dobe !Kung foragers, for example, meat sharing was not necessarily reciprocated, and there is little-to-no “scorekeeping” among producers who share their surpluses with those who need it (Howell, 2010:188). No scorekeeping often means no punishment: among Dobe !Kung, it was uncommon for individuals to punish able-bodied foragers who regularly consumed more than their share, while failing to produce enough to share with others was also relatively uncommon (see Wiessner, 2005). Bliege Bird,

* Corresponding author at: Department of the Study of Religion, Aarhus University, Aarhus, Denmark.

E-mail address: adlightner@cas.au.dk (A.D. Lightner).

<https://doi.org/10.1016/j.evolhumbehav.2023.02.010>

Bird, Smith, & Kushnick (2002) observed similar trends among Meriam foragers, where most food sharing partnerships between households involve one-way, unreciprocated resource flows. For Meriam and for Ik foragers, this appeared to be associated with cultural norms encouraging food sharing as an inherently desirable practice rather than one that requires repayment (Townsend, Aktipis, Balliet, & Cronk, 2020).

Cultural institutions, or sets of such norms and rules, often manage risk through need-based sharing, especially when resource challenges are unpredictable (Cronk, 2007; Cronk & Aktipis, 2021; Cronk, Beltrán, Mercado, & Aktipis, 2021; Lee, 1979; Smith, Bliege Bird, & Bird, 2003; Wiessner, 2002). Many foraging groups, for example, use central place provisioning to pool and redistribute their resources. These are cases where interdependence can emerge through (centralized) need-based sharing: individual foragers disperse, collect varying amounts of food, and, upon returning to camp, divide their total foraged amount among individuals (Marlowe, 2006). Other cases are more decentralized. Decentralized need-based sharing is especially common among nomadic and semi-nomadic pastoralists who rely on livestock sharing friendships, where partners exchange food resources after disasters, such as droughts and cattle disease outbreaks (Dyson-Hudson, 1966; Gulliver, 2013; Iyer, 2016).

Regardless of the underlying social organization of a need-based sharing system, individuals are ultimately able to reduce their risks of a shortfall, thereby providing each other with a safety net for those who, at any given time, might have been unlucky or unable to acquire the resources needed for continued survival. As a consequence, participating individuals become strongly interdependent – a dynamic that likely played a key role in the evolution of human cooperation (Tomasello, Melis, Tennie, Wyman, & Herrmann, 2012; Jaeggi & Gurven, 2013).

1.1. Maasai osotua as a case of need-based sharing

A paradigmatic example of a decentralized system of need-based sharing is *osotua* among Maasai pastoralists. Although Maasai do recognize debt and account-keeping (*esile*) in certain exchange-relevant contexts, a type of partnership where Maasai pastoralists and neighboring Samburu share valuable resources (e.g., cattle and livestock) with kin and non-kin, often without an apparent expectation of reciprocity (Jacobs, 1965; Spencer, 1965; Perlov, 1987; Cronk, 2007). In Maa language, *osotua* literally translates to “umbilical cord,” metaphorically capturing how resources are freely shared from one individual to another based on need (Hollis, 1910). Obligations to help an *osotua* partner are “heavy” (Cronk, 2007), and *osotua* can sometimes connote real and/or fictive kinship (Jacobs, 1965; Spencer, 1965).

Using *osotua* as an illustrative example of need-based sharing, formal models have demonstrated that need-based sharing is mutually beneficial specifically because it pools risk among interdependent partners (Aktipis et al., 2016; Aktipis, Cronk, & de Aguiar, 2011). Stated another way, agents benefit by keeping needy partners alive who are then able to return the favor in the future. Many of these models use dyadic partnerships for simplicity, although ethnographic data on need-based sharing institutions often indicate that partnerships can have multiple members and may be better conceptualized as network-level or even community-level institutions (Spencer, 1965; Perlov, 1987; Spear & Waller, 1993).

Need-based sharing in *osotua* has been observed to follow two simple rules: (1) only ask for help when in need, and (2) when asked for help, share what you can if you are able (Aktipis et al., 2016; Aktipis et al., 2011; Cronk, 2007). Hence, using the terminology of Claessens, Ayers, Cronk, and Aktipis (2021), defection can occur either when recipients ask for help when they are not genuinely in need (*greedy* defection), or when donors reject a request for help when they are able to share (*stingy* defection).

In formal models, a recipient’s “genuine need” typically refers to a relatively low probability of continued survival compared to the

potential donor, usually due to resource scarcity (Aktipis, 2015; Aktipis et al., 2016; Aktipis et al., 2011; Kayser, 2018). This not only applies to models of *osotua* and other human need-based sharing institutions, but to need-based helping partnerships more generally in the evolutionary biological literature (Wilkinson, 1984; Johnstone & Grafen, 1992; Eshel & Shaked, 2001; Garay, 2009; Maynard-Smith & Harper, 2003). Because a reduced probability of survival implies a reduction in future fitness benefits, this formal definition makes need-based sharing relevant for understanding the evolution of cooperation (Aktipis, 2015; Aktipis et al., 2016; Aktipis et al., 2011; Eshel & Shaked, 2001).

1.2. Is need always about survival?

This framing of “genuine need” as a reduced probability of survival is restrictive and might not always generalize to need-based sharing institutions in the real world. Consider, for example, a “greedy” defector who signals that they need help when their survival is not actually at risk. If they are able, a donor might minimize the prevalence of this cheating behavior by critically evaluating requests and deciding whether or not they should comply, basing their judgments on whether or not the signaler’s request reflects a threat to survival (and hence, a threat to fitness). However, even when this is possible, the signaler can make a case to the donor for why they should be considered “genuinely needy” in a more colloquial sense. The donor’s criteria for evaluating what does (or does not) constitute a convincing case can vary strongly across individuals, situations, and cultural contexts (Mercier & Sperber, 2017). Hence, in real-world scenarios, the criteria that a donor uses to evaluate a potential defector’s need-based request might not reliably conform to the narrow survival criteria implied by formal need-based sharing models. Requests may be deemed acceptable in a given situation or culture, but, if they are mapped onto a need-based sharing model, deemed frivolous or greedy from a researcher’s perspective.

To illustrate, consider a polygynous herder who makes a need-based request to potential donor. His request to replace cattle lost after a drought aims to improve his (otherwise low) chances of survival and fitness, and it clearly conforms to formal definitions of need-based requests (e.g., in evolutionary models). Lacking subsistence-related resources due to unexpected misfortune is a risk to survival, so no greedy defection has occurred. We will refer to such justifications for making a need-based request as *survival need*. Alternatively, the herder might say that, to acquire an additional spouse, he needs cattle to pay bridewealth. Here, conferring cattle would increase the recipient’s fitness, despite the recipient lacking a relative survival disadvantage. In a formal model of need-based sharing, this behavior would be indistinguishable from greedy defection. We will refer to such justifications for a need-based request as *non-survival need*. If a need-based sharing institution mandates that acceptable requests must be based on survival need, then a request based on non-survival need should be rejected.

The conundrum this creates is that different ways of *conceptualizing* need might legitimize requests based on non-survival need. In theory, these “greedy” requests could potentially undermine the long-term success of need-based sharing institutions. Yet, a key feature of need-based sharing institutions is that they are interdependent, i.e., individuals should generally avoid cheating because undermining the success of one’s partner also undermines one’s own success over time (Roberts, 2005; Tomasello et al., 2012; Aktipis et al., 2018). If a cultural institution bears the signs of interdependence, risk pooling, and need-based sharing, but if the individuals in that culture do not strictly avoid rule violations that could threaten its persistence (e.g., if a behavior that the theoretical literature would consider cheating is actually culturally permissible), then this indicates that either the institution has failed, or that we should revise our assumptions about the consequences of apparently greedy behavior in need-based sharing.

This raises empirical questions about the boundary conditions for need-based sharing institutions: If institutions like *osotua* serve to pool risk *because they are based on need* (Aktipis et al., 2011), and if “need”

refers to relative survival prospects, would permitting “greedy” requests – those not based on survival needs – undermine risk pooling, thereby jeopardizing the survival of group members? Or can “greedy” requests sometimes be socially permitted because they do not seriously undermine risk-pooling? If the latter is the case, perhaps we should refine our understanding of need-based sharing or provide clarifications about how need-based sharing manages risk in real-world settings.

1.3. Study aims

The present study seeks to answer these questions in the context of osotua among Maasai pastoralists using both modeling and empirical data. Osotua is often treated as a quintessential example of a need-based sharing institution (Aktipis et al., 2016; Aktipis et al., 2011; Cronk, 2007; Cronk & Wasielewski, 2008; Perlov, 1987), so by studying osotua we are returning to the roots of the need-based sharing literature to assess the relevance of survival need in sharing decisions.

In the modeling part of this study, we asked how the long-term benefits of need-based sharing might change as greedy and/or stingy defection become increasingly common, and how increasingly sizeable partnerships might influence these changes. We therefore assessed the boundary conditions of need-based sharing by extending an existing agent-based model (ABM) of osotua by Aktipis et al. (2011) that examines survival outcomes among individuals who cooperate in need-based sharing partnerships. Their ABM found that need-based sharing can improve survival by pooling risk, and we asked how strictly individuals must adhere to the need-based sharing rules for these risk-pooling benefits to persist.

In the empirical part of this study, we used field data to examine how important survival need-based requests are among osotua partners in a real-world setting, and to assess the extent to which osotua is a dyadic partnership vs. a community-level institution. We tested a preregistered hypothesis that, when given an osotua request, Maasai participants would respond more generously to requests based on survival need than they would to requests based on non-survival need (analogous to the greedy requests in the ABM).

2. The agent-based model

In the original ABM by Aktipis et al., 2011, agents represented herders paired into dyads ($N = 2$ agents), each with the same initial number of livestock. In each time step (representing 1 year) each agent’s herd was increased by the same fixed growth factor. Each herd was also subject to an environmental shock with low but non-zero probability that reduced it by a random but possibly substantial amount. When an agent’s herd size fell below a fixed survival threshold, they made a need-based request to their partner for an amount equal to their deficit below the threshold. Partners shared the lesser of either the requested amount, or their surplus above the threshold. Agents whose herd sizes fell below the survival threshold for two consecutive time steps died. Hence, in this mutually cooperative scenario, each agent followed the rules of need-based sharing: (1) request resources only if you are in need, and (2) if you receive a request, share what you can without becoming needy. In this model, a greater number of agents survived at each time step compared to a model with no transfers.

Aktipis et al. also investigated models with “probabilistic asking,” in which a fixed request for cattle is made at a fixed rate, regardless of need (and there are no need-based requests), and “probabilistic giving,” in which a fixed amount is provided in response to any request, regardless of the giver’s herd size. In these models using these rules, survival was similar to or worse than a model with no exchange.

We extended and modified the need-based sharing ABM by Aktipis et al. in two ways. First, we included two possible defection strategies. The *greedy strategy* violates the first need-based sharing rule by feigning survival need. This strategy differs from the Aktipis et al. “probabilistic asking” rule in that [greedy] requests are made by agents without need

but, importantly, [survival] requests are still made by agents in need. The *stingy strategy* violates the second rule by refusing to share livestock upon request. This strategy differs substantially from the Aktipis et al. “probabilistic giving” rule in that transfers are still made according to need-based sharing rules, but with a transfer probability $0 \leq p \leq 1$. Specifically, at each time step, each agent below the threshold made a need-based request, as in the original model, but agents above the threshold could commit each type of rule violation based on a probability parameter that was set prior to each simulation run (p_G for greedy defection and p_S for stingy defection). These parameters dictated how all agents in the partnership would behave. That is, in a given simulation run, each agent might be a pure strategy defector ($p_S = 1$ and/or $p_G = 1$), or each agent could be a mixed strategy defector ($0 \leq p_S < 1$ and/or $0 \leq p_G < 1$). The amounts of greedy requests were randomly drawn from the empirical distribution of need-based requests. In the [Supplementary Materials](#), we also investigated the consequences of reduced need-based requests (i.e., we vary p_{NBR} , the probability of making a need-based request when herd size falls below the survival threshold, $0 \leq p_{NBR} \leq 1$).

Second, we investigated larger completely connected partnerships, $2 \leq N \leq 16$. We assessed each strategy’s long-term survival after $t = 50$ years – roughly a single generation.¹ The higher the fraction of agents surviving, the greater the strategy’s *survival* outcome (Aktipis et al., 2016; Aktipis et al., 2011; Kayser and Armbruster, 2016).

2.1. Protocol per time step

In our replication of Aktipis et al., agents represent herders with herd size x . Survival, as we discuss further below, requires that herd size remain above a minimum, $x > x_{min} = 64$. Each run of the simulation involved $N = 100000$ agents organized into groups ranging in size from 2 (as in Aktipis et al.) to 16. Agents remained in the same group throughout a run, which was 50 time steps. Each agent at each time step, t , followed a basic protocol consisting of 4 phases: growth, shock, transfer, and viability checks. The parameters are from (Aktipis et al., 2016; Aktipis et al., 2011) unless otherwise stated, many of which (e.g., growth rates, disaster probabilities), are from empirical data on annual herd dynamics (Dahl & Hjort, 1976). As we outline next, the protocol per time step for growth, shock, and viability check phases is identical to Aktipis et al., but the transfer phase is not.

At initialization, each agent starts with a herd size of $x_0 = 70$. At each time step, each agent’s herd size grows by $x_{i,t+1} = x_{i,t} + x_{i,t}g_{i,t}$, where $g_{i,t} \sim \mathcal{N}(0.034, 0.0253)$. (Note that this distribution implies that “negative growth” is possible, but rare.) Losses occur at each time step for each agent with probability of 0.1, $x_{i,t+1} = x_{i,t} - x_{i,t}l_{i,t}$, where $l_{i,t} \sim \mathcal{N}(0.3, 0.1)$.

Need-based and greed-based requests and transfers occurred during the transfer phase. Each agent with $x_{i,t} < x_{min}$ makes a need-based request, $r_{i,t} = x_{min} - x_{i,t}$, of another random member of its group, j . In addition, with fixed probability p_G , each agent with $x_{i,t} > x_{min}$ makes a request, $r_{i,t}$, of a random member of its group. For such “greedy” requests, $r_{i,t}$ is a random draw from the empirical distribution of requests in the standard condition. In the “standard” (Aktipis et al.) condition, $p_G = 0$; in “greedy” conditions, $0 < p_G \leq 1$.

Transfers occurred as follows. If $x_{j,t} > x_{min}$, the agent transfers $\min(r_{i,t}, x_{j,t} - x_{min})$ to the requester with fixed probability $1 - p_S$; otherwise it transfers nothing. In the standard condition (from Aktipis et al.), $p_S = 0$; in “stingy” conditions, $p_S > 0$. Notice that if both partners are below the minimum viability threshold at the same time, they can send requests to each other but neither will transfer (because both are unable).

¹ Although this is an approximation that we make to conveniently estimate a medium-long timeframe, this generational equivalence is based on an assumption that household control of cattle is taken on around junior elderhood (about 30 years old) until death, where a typical lifespan is around 80 years.

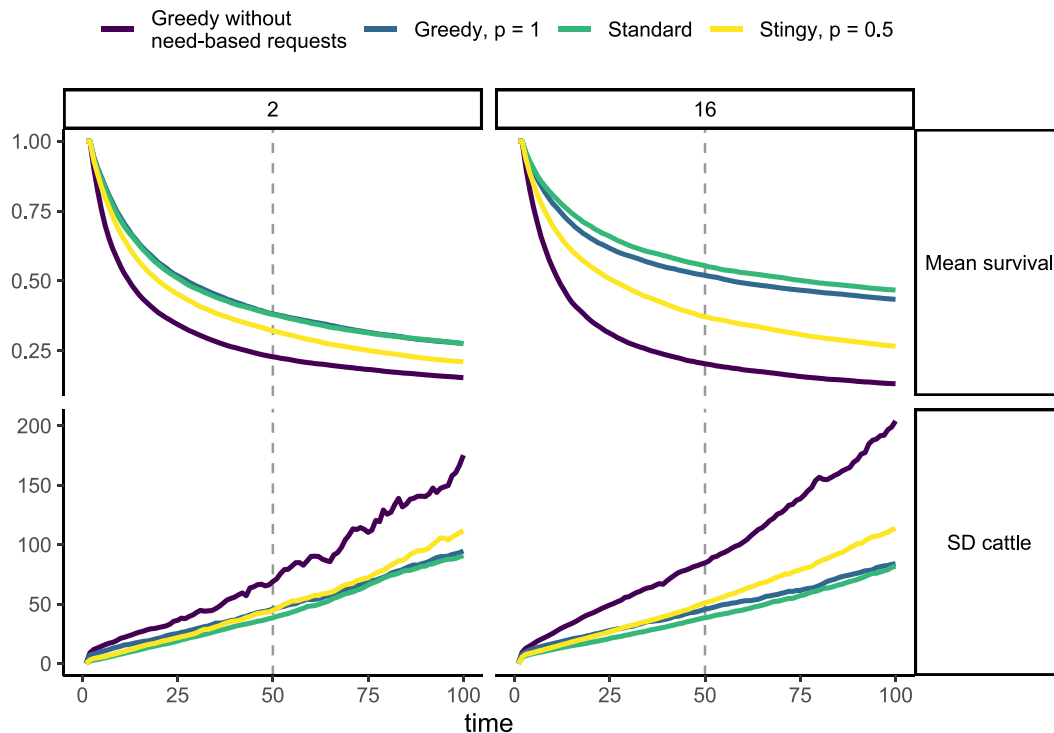


Fig. 1. Mean survival (top) and standard deviation in herd sizes (bottom) over time. Left: group size = 2. Right: group size = 16. Colors represent models. Standard: The Aktipis et al. (2011) ABM. Greedy: non-survival requests made in addition to need-based requests. Greedy without need-based requests: only greedy [non-survival based] requests are made (no need-based requests). Stingy: Need-based requests are refused with a probability of 0.5. The dashed line at $t = 50$ shows where we calculated the survival advantage (or disadvantage) of partnerships.

In the viability check phase, agents go extinct if $x_{i,t-1} < x_{min}$ and $x_{i,t} < x_{min}$, i.e., if it is below the threshold for two consecutive time steps. Once an agent is removed from the simulation, any agents partnered with it are no longer able to make requests from, or interact with, that agent. Note that like cooperative agents, stingy agents can still make need-based requests and refuse to share upon request when they are in need themselves. For simulations involving $N > 2$ agents, each request was made of one random agent in the same group, regardless of that agent's need or other requests directed at that agent. If a request was refused, no further request was made. An agent might receive multiple requests, and could transfer cattle for each request.

Our outcome of interest was [herd] survival, defined as the fraction of the population of agents still viable at a given time step, which we averaged over 100,000 simulation runs for each parameter set. A *parameter set* refers to a specific combination of partnership size (N) and the probability of defection per time step (p_G and p_S). Specifically, the parameter sets for each type of defection and partnership size were combinations across partnership sizes $N \in \{2, 3, \dots, 16\}$, greedy defection probability $p_G \in \{0, 0.1, 0.2, \dots, 1\}$, and stingy defection probability $p_S \in \{0, 0.1, 0.2, \dots, 1\}$. After running 100,000 simulations for each parameter set, we measured the long-term survival at $t = 50$ time steps. (Note that this is not strictly consistent with Aktipis et al. (2016), who averaged survival outcomes over 10,000 simulations. We increased this number to ensure reproducibility, though the difference from 10,000 runs was negligible.)

All data and simulation code can be found at <https://github.com/alightner/needBasedSharing-study>.

2.2. Results: assessing boundary conditions in need-based sharing

In the ABM, we first compared the survival among mutually cooperative pairs ($p_S = 0$ and $p_G = 0$), purely greedy pairs ($p_G = 1$ and $p_S = 0$), and purely stingy pairs ($p_G = 0$ and $p_S = 1$). The mutually cooperative pairs clearly outperformed the stingy pairs (i.e., where no sharing

occurs), replicating a key result of Aktipis et al. (Fig. 1). The substantial disadvantage incurred by stingy defectors is a straightforward consequence of the interdependence of need-based sharing partnerships: If defectors fail to share with their cooperative partners, then they will gain a short-term benefit while risking the loss of their partners. This loss is a steep cost to defectors because they will require aid in the future (which is no longer available if they have lost their partner—hence, they are dependent on them; see Kelley & Thibaut, 1978; Roberts, 2005; Tomasello et al., 2012; Aktipis et al., 2018). This steep cost vastly outweighs the short-term benefit of defection, meaning that in the long run, it genuinely pays better to cooperate when there is a looming threat of partner loss (Delton, Krasnow, Cosmides, & Tooby, 2011). In contrast to purely stingy defectors, purely greedy defectors suffered little-to-no survival costs in the long term, and had similar survival outcomes when compared to the standard condition (see also Fig. S1 in the Supplementary Materials). The reason is that the $p_G = 1$ condition, in which need-based transfers still occur, is about as effective at reducing variance as the $p_S = 0$ and $p_G = 0$ condition. A condition with only greedy requests, on the other hand, had higher variance and lower survival than any other condition (Fig. 1).

We then re-ran this simulation across different partnership sizes (N) and p_G and p_S values. When we increased N for mutually cooperative partnerships ($p_S = 0$ and $p_G = 0$), we saw higher survival outcomes. Further, and similar to the $N = 2$ results in Fig. 1, we saw that increasingly frequent greedy requests ($p_G \rightarrow 1$ while $p_S = 0$) had little-to-no impact on survival outcomes relative to the mutually cooperative outcomes. Hence, holding p_S to zero, increasing N substantially increased survival among all $p_G \in [0, 1]$. See Fig. 2. In contrast, increasing p_S from 0 to 1 reliably and substantially decreased survival across N values. Further, although survival when $p_S = 0$ increased as N increased, above moderate levels of stinginess, as partnership size increased from $N = 2$ to $N = 16$, survival outcomes were quicker to asymptote to $\sim 25\%$ of agents surviving to $t = 50$. In other words, stingy defection becomes increasingly costly at a larger N , because the difference in survival

between $p_S = 0$ and $p_S = 1$ is positively associated with N . See Fig. 2.

Taken together, these ABM results identify a critical caveat about need-based sharing: An interdependent need-based sharing institution like osotua is generally robust to greedy defection as long as there are still need-based requests whenever agents' survival is at risk, but stingy defection always undermines its long-term sustainability. Further, because need-based sharing improves survival in increasingly large partnerships (even when greedy defectors are present), the relative importance of generosity, compared to detecting and preventing greedy requests, should be higher among larger need-based sharing partnerships. Put differently, stinginess becomes more costly as need-based sharing institutions scale to larger, more interconnected groups.

With a paradigmatic need-based sharing institution such as osotua, we can only resolve the typical size of a partnership and the extent to which Maasai tolerate non-survival requests with empirical data. To what extent will osotua partners respond to survival need-based vs. non-survival requests with generosity? Are osotua partnerships restricted to dyads, or are they community-based, where we would expect greedy defection to be more likely to be tolerated?

3. The experimental vignette: testing the effect of need in Maasai osotua

In our empirical study, we conducted an experimental vignette with Kisongo Maasai pastoralists in Monduli Juu highlands of northern Tanzania ($N = 218$, 41.3% female). We asked how each participant would respond to a request for assistance from a person with whom they had osotua. Prior to the vignette, each participant was given a structured survey that included measures of household food insecurity and social network data. The vignette and survey were administered by ADL and translated to Maa by a Maasai translator, or conducted entirely in Maa by one of two Maasai research assistants. The untranslated text of the experimental vignettes from the field survey are included in the [Supplementary Materials](#). All participants were paid 10,000 TZS (about \$4.35) for their participation, and all protocols and survey materials were approved by Washington State University IRB and Tanzanian Commission for Science and Technology (COSTECH) prior to data collection.

The experimental vignette described a hypothetical Maasai person with whom the participant had osotua, who has requested cattle to help him during a difficult time. The participant in this scenario was told that s/he had twenty cows at the time.² Participants were randomly assigned to a condition in which this request was either based on *survival need* (what models would call a genuine need-based request), because it involved resource scarcity after a drought, or *non-survival need* (a greedy request), because it involved someone accumulating cattle to pay bridewealth for a second wife ($N = 116$ in the drought condition, $N = 102$ in the bridewealth condition).³ We refer to this manipulated variable as the presence/absence of *need*, where “need” refers to a condition that would cause relatively low chances of continued survival. See the [Supplementary Materials](#) for the translated text of the vignettes used in this study.

² A fixed number of cattle was included in the vignette to keep the allocation numbers comparable between participants. Twenty cattle was specifically chosen because this was deemed a realistic number based on observation data collected by ADL during fieldwork. Herds in this region are often disaggregated across households, families, and friends, and frequent trading, selling, and buying means that herd sizes are relatively fluid from year to year. Basically, the hypothetical scenario outlined to participants was designed to be as realistic as possible to as many participants as possible.

³ We specifically used *bridewealth for a second wife* in the non-survival need condition because although key informants stated that a first wife was important for having a family with children, more than one wife, while acceptable, is far less common.

Consistent with the rules of a Dictator game, in which participants are given a resource allocation and must decide how much of it to share, participants were asked how many of their cows they would share with the person in the vignette requesting help. This number of cows shared, between 0 and 20, was the outcome measure of interest, which we refer to as *shared*. The structured survey included household food insecurity scores (Blumberg, Bialostosky, Hamilton, & Briefel, 1999), which we refer to as *insecure*. Because the rules of need-based sharing include a caveat where individuals must share if they are able to, our confirmatory models controlled for food insecurity scores, a proxy for reduced sharing ability. Hence, the linear regression model used in our confirmatory analysis was

$$\text{shared} = \alpha + \beta_1 \times \text{need} + \beta_2 \times \text{insecure}$$

where we predicted that $\beta_1 > 0, p < 0.05$. We used social network data for exploratory analyses. Social network data consisted of egocentric networks, created after asking participants to list the people with whom they had the most osotua. As we will discuss further below, we collected social network data by asking participants with whom they had the most osotua, which allowed us to count the number of people mentioned per participant. Participants frequently volunteered more information about osotua during this part of the survey, and we collected these statements for additional context.

Preregistration materials can be found at <https://osf.io/ndfxc>, and the anonymized experimental and structured survey data can be found at <https://github.com/alightner/needBasedSharing-study>.

3.1. Results of the experiment

We found that survival need increased the amount shared ($\beta = 0.42$, $p = 0.044$, $SE = 0.21$), controlling for household food insecurity (Blumberg et al., 1999), a proxy for reduced sharing ability ($\beta = 0.014$, $p = 0.96$, $SE = 0.3$). Simplifying our model by not controlling for food insecurity – which deviates from our preregistered analysis plan – did not alter the positive causal effect of survival need on amount shared ($\beta = 0.42$, $p = 0.043$, $SE = 0.21$).

Nevertheless, most participants were willing to share small numbers of cattle even when survival need was absent. Despite amounts shared being slightly higher for need-based requests, both conditions elicited similar levels of generosity (drought: mean = 2.8, median = 3, $sd = 1.3$; bridewealth: mean = 2.4, median = 2, $sd = 1.7$; Mann–Whitney $U = 7507$, $p = 1.8 \times 10^{-4}$), and out of the 218 participants in this experiment, only 1 participant refused to share anything. See Fig. 3.

In our exploratory analysis, we assessed the scale of osotua partnerships using qualitative and observational data, interview data from key informants, and social network data from each participant. Qualitative and observational data suggested that osotua is a large-scale, community-level institution: when participants were asked with whom they had osotua, a common response was “everyone.” This was not surprising after our initial key informant interviews, where people referred to osotua as a perspective, a personality characteristic akin to generosity and kindness, and/or “comfort.” According to some informants, examples of “comfort” included helpful acts during times of distress, such as offering a Maasai stranger food and shelter when s/he is far from home, or helping a warrior calm his nerves before his circumcision ceremony. As a first pass, these ethnographic data suggest that osotua is indeed a broad institution (i.e., many connected to many) for Kisongo Maasai.

The participants' views of osotua as a community-level phenomenon made collecting social network data about osotua partnerships challenging. We addressed this challenge by asking participants, “with whom do you have the most osotua?” Consistent with our initial observations, many individuals had many relatively close osotua partners,

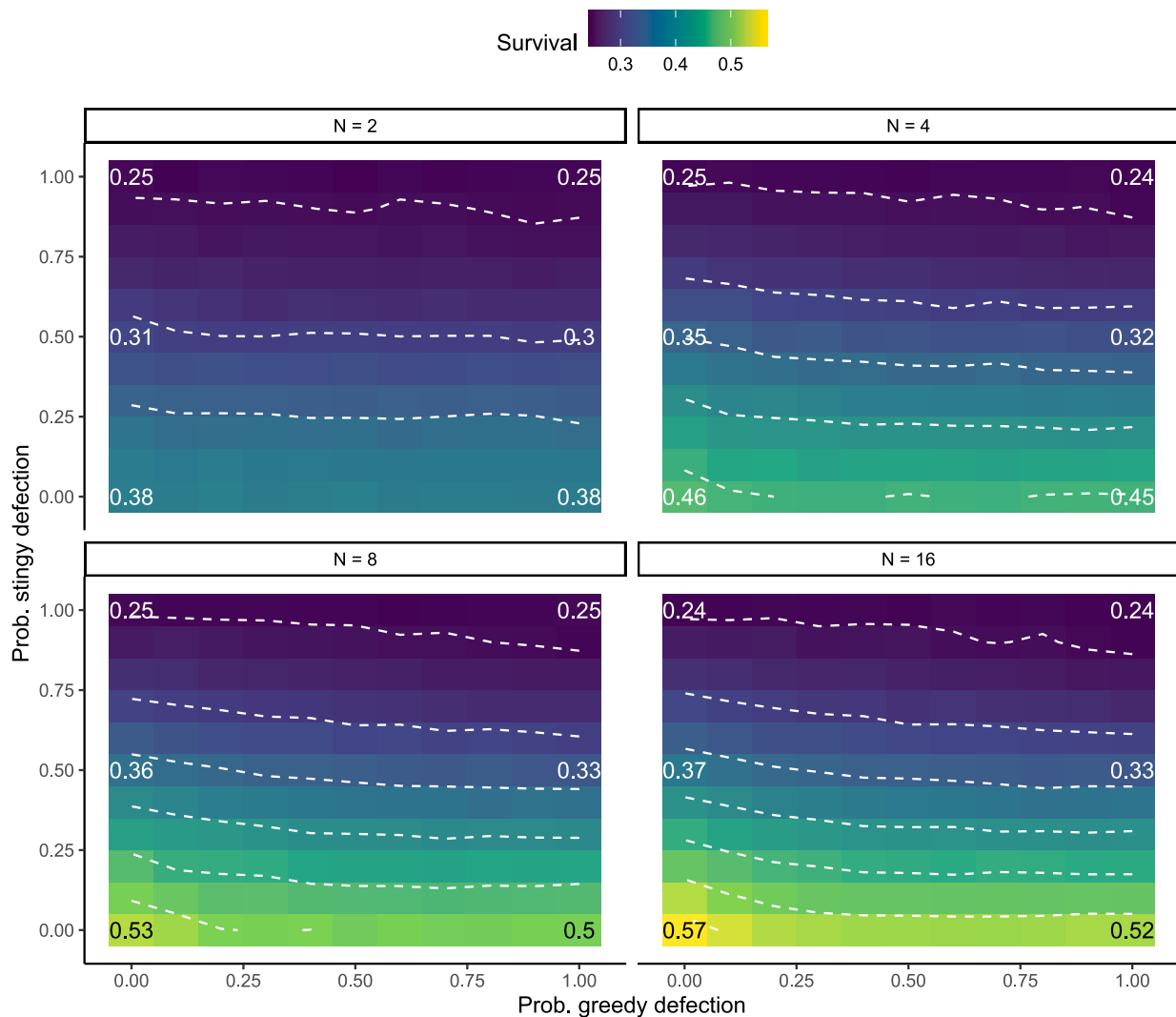


Fig. 2. Average survival outcomes after 50 time steps (color) across 100,000 simulation runs for each configuration of partnership sizes (N , shown here by facets), probability of stingy defection (y-axis), and probability of greedy defection (x-axis).

even after restricting their responses to their closest and most salient partners (Fig. 4).⁴

Our main results showed a positive effect of need on sharing, and as we and others have showed, need-based sharing in osotua *can* reduce individual livelihood risks. To evaluate whether or not this might actually be the case, we analyzed the impact of having more vs. fewer close osotua partners on household food insecurity, finding that – consistent with risk pooling accounts of need-based sharing – food insecurity was negatively associated with the number of close osotua ties ($\beta = -0.075$, $p = 0.0012$, $SE = 0.023$; see Fig. 5).

4. Discussion

In this study we investigated Maasai osotua, a paradigmatic example of a decentralized need-based sharing institution that reduces individuals' risk, improving long-term survival prospects (Aktipis et al., 2016; Campenni, Cronk, & Aktipis, 2021; Cronk & Aktipis, 2021). A

⁴ Many of the names given during the social network data collection phase had included mentions that were not included in our sample. These represent the boundaries of our social network, and this is a primary reason why we focus here on the number of ties per participant rather than a complete sociocentric network.

challenge for need-based sharing institutions, which many other cooperative institutions also face, is that societies must somehow motivate individuals to cooperate while reducing temptations to defect. Need-based sharing has two potential sources of defection — refusing to help someone when they ask for help (the stingy strategy) and asking for help when risks to survival are not present (the greedy strategy) — and existing models have not considered each separately. Yet, a vulnerability of need-based sharing is the potential ambiguity between genuinely need-based vs. greedy requests: Individuals might justify their claims about “genuine need” in ways that do not conform to its standard uses in formal and evolutionary models, which tend to narrowly focus on risks to continued survival.

We extended the agent-based model (ABM) of Aktipis et al. (2011), a dyadic model without defection, to both expand the size of need-based partnerships (e.g., Hao, Armbruster, Cronk, & Athena Aktipis, 2015; Kayser & Armbruster, 2016; Campenni et al., 2021) and to include two types of defection: greedy defection and stingy defection. Distinguishing greedy from stingy defection suggests that sharing, and not just sharing conditional on need, may underlie the long-term survival benefits that need-based sharing institutions offer: need-based sharing is resilient against greedy defection as long as need-based requests still occur with high probability, but is not resilient against stingy defection (Fig. 1). Further, increasing the size of need-based sharing partnerships also increases the benefits of risk pooling, and as they increase in size, these

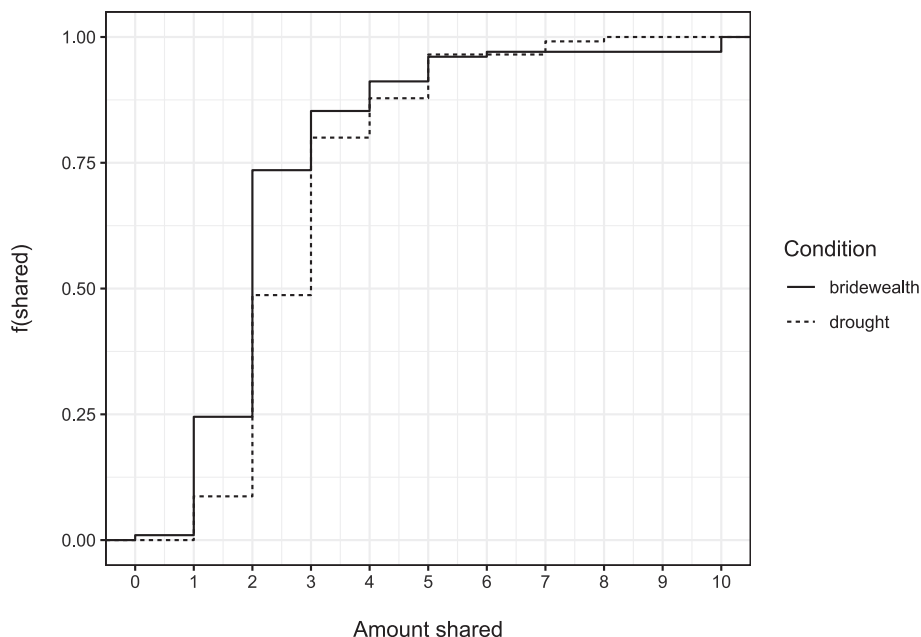


Fig. 3. Empirical cumulative distribution of the reported amounts of cattle that participants were willing to share, by experimental condition. Amounts were out of an initial resource holding of twenty head of cattle.

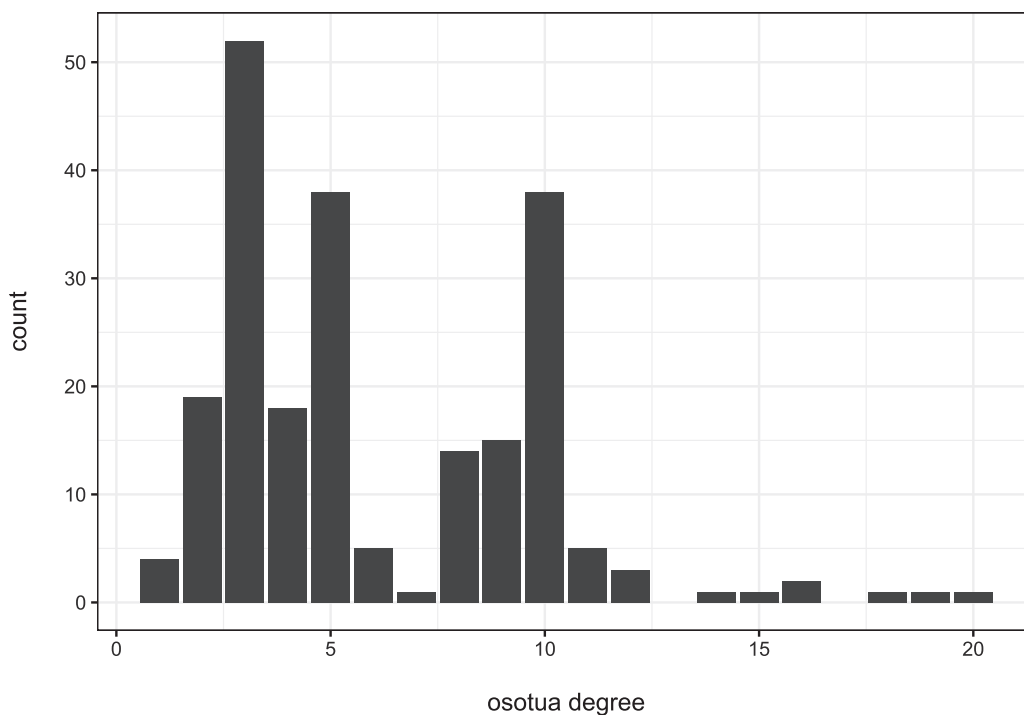


Fig. 4. Counts of the number of mentioned names that each participant gave when asked with whom he or she had the most osotua.

partnerships remain resilient to greedy defection. On the other hand, stingy defection is increasingly costly as partnership sizes increase (Fig. 2). We therefore identify a subtlety in the boundary conditions of need-based sharing institutions: Assuming interdependence, greediness is easily tolerated but stinginess is not – and stinginess becomes increasingly costly as partnerships increase in size.

We can consider the behavioral implications of this asymmetry between greedy vs. stingy behavior using error management theory (Haselton et al., 2009; McKay & Efferson, 2010) and the multiplicative growth of assets – both in terms of cattle herds and networks of

cooperators (Dyson-Hudson & Dyson-Hudson, 1980; Lesorogol, 2009; Bollig, 2010; Price & Jones, 2020). Consider the decision task for need-based sharing partners in an institution like osotua. Each agent takes on a scenario-specific role at each time step: a potential recipient who can send a signal for aid, and a potential donor who receives that signal. At each time step, the recipient sends a potentially ambiguous signal, which was either generated by a state of need or a state of “greed.” Under such ambiguity, the expected cost of stinginess toward needy requests ($p_S > 0$ and $p_G = 0$ in the ABM) always outweighs the expected cost of sharing with greedy requests ($p_G > 0$ and $p_S = 0$ in the ABM; see

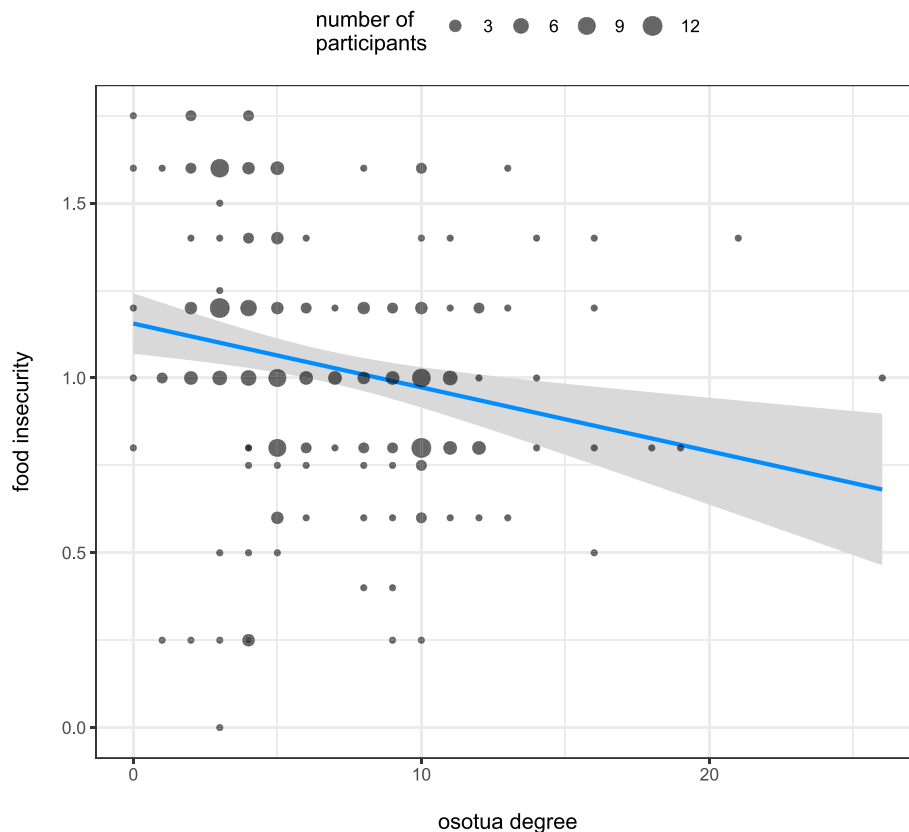


Fig. 5. Linear regression model of household food insecurity scores as a function of number of osotua partners, based on a social network of close osotua partnerships. Larger points indicate a greater number of participants with a given osotua degree and level of food insecurity.

Fig. 2), because the cost of rejecting a genuine request is high.

To understand why stingy rejections can be so mutually costly in the long run, first consider the substantial, often irreversible cost to an individual's herd when a genuine request is rejected. Because of the multiplicative nature of herd growth, rare shocks amplify variation and send each individual's resource level toward zero over time (Peters & Gell-Mann, 2016; Price & Jones, 2020). Hitting zero is irreversible, and need-based sharing reduces the risk of doing so. Second, each individual has to stay alive to help others in future instances of need, i.e., partners are strongly interdependent (Kelley & Thibaut, 1978; Roberts, 2005; Balliet, Tybur, & Van Lange, 2017; Aktipis et al., 2018). Future research could investigate the similarities and differences between the resource dynamics in need-based sharing (with or without non-survival requests) and group-level pooling strategies, the latter being an effective social mechanism for reducing variance around annual growth rates (and potential losses) (Price & Jones, 2020; Peters & Adamou, 2022).

Results from our empirical field study among Tanzanian Kisongo Maasai pastoralists were consistent with these insights about the asymmetrical costs of greed vs. stinginess. Supporting a need-based sharing account of osotua, we found that participants were willing to share more cattle when an osotua request was based on survival need (feeding one's family after a drought) rather than non-survival need (obtaining bridewealth for a second wife). We also found that individuals who were more involved in osotua partnerships had lower household food insecurity scores (Figs. 3 and 5). Importantly, participants also frequently complied with non-survival need-based, or "greedy," requests. Our interview data also suggested that osotua is an important and broad, community-level institution, and generosity in osotua was frequently described as something that was deeply important and should be applied to other Maasai people across many facets of life. Informants gave examples of how and when osotua can occur beyond formal cattle sharing partnerships – like about how it can even include

behaviors such as hospitality toward a traveling stranger. During social network data collection, even when we restricted participants' responses to the most salient and important osotua ties, participants reported widespread community involvement in osotua: many participants have many close ties (Fig. 4).

4.1. Toward a more unified model of generosity and interdependence

Taken together, our models and experimental vignette findings suggest a broad, testable framework that expands on the work of Aktipis, Cronk, and others, while also engaging the broader literature on the role of need in cooperative resource sharing. Although our results support the claim that osotua is a need-based sharing institution that beneficially pools risk (Aktipis et al., 2016, 2018; Aktipis et al., 2011; Campenni, Cronk, & Aktipis, 2021), the asymmetry between costs of greed vs. stinginess shows that sharing is generally favored, even when greedy requests might be prevalent. In future research we would expect that in institutions with need-based sharing and interdependence, people err on the side of honoring, rather than refusing, a potentially frivolous request. We would expect this tendency to increase as partnerships increase in scale, where need-based sharing among many densely connected individuals is less tolerant of stinginess (as we observed in our field study with Tanzanian Maasai pastoralists, and also in our ABM, Fig. 2), compared to rigid, dyadic partnerships (e.g., in a sparse and/or controlled social network) (Aktipis, 2004; Baumard, André, & Sperber, 2013; Pisor & Gurven, 2018). We would also expect this tendency to increase as interdependence increases (Balliet et al., 2017; Gerpott, Balliet, Columbus, Molho, & de Vries, 2018) and environments become harsher and more volatile, with the caveat that when shocks become very frequent, survival is so low that stinginess does not make things much worse. Conversely, when environments are more stable, there is less benefit from risk-pooling, and cooperation might shift towards other

strategies to generate benefits, such as divisions of labor or reciprocal exchanges.

Our results reframe ongoing conversations about the nature of human sociality, specifically with respect to how “need” works on the ground, how *osotua* works, and how need-based sharing is or is not distinct from other forms of cooperation, such as delayed reciprocity. First, in general, formal evolutionary models of cooperation that involve “need” tend to characterize it in terms of continued survival prospects. As we show, in the context of these models, some culturally acceptable ways of justifying need are formally equivalent to the greedy strategy – even in Maasai *osotua*, a paradigmatic example of an interdependent, decentralized need-based sharing institution. Future research could apply a similar approach to other evolutionary theories by investigating the extent to which theoretical constructs in our formal models actually map onto folk constructs “on the ground” in a given cultural context (e.g., Stibbard-Hawkes, Smith, & Apicella, 2022).

Second, a compelling avenue for future research would be to investigate how need-based sharing and other forms of cooperation are related. Our findings resemble key characteristics of delayed reciprocity, for example, where future returns are somehow expected, but strict book-keeping is not (Wiessner, 2002). Indeed, during fieldwork, multiple informants told ADL a common Kisongo Maasai saying about *osotua*: *engiteng osotua elo eshukunyiye* (translated from Maa: “whatever cow I give in *osotua* will someday come back” – if not from one *osotua* partner, from another). Maasai attitudes toward *osotua* were also similar to those described in other ethnographic cases of risk management through food sharing, where people strongly value *participation* in need-based sharing rather than benefiting from their participation in the short term, possibly because the long-term benefit of participation outweighs any short-term cost to parting with a material resource (Gurven et al., 2000). Examples of this include sharing concepts such as *tomora maráy* among the Ik (Townsend et al., 2020) and *debe tonar* among the Meriam (Bliege Bird, Bird, Smith, & Kushnick, 2002).

Higher vs. lower levels of interdependence might account for how, cross-culturally, different societies deem non-need-based requests as unacceptable vs. acceptable. Community-level need-based sharing practices that we observed in this study seemed to bear key similarities to the demand sharing practices, for example, which have been documented among some forager groups (Jones, 1984; Blurton Jones, 1987; Peterson, 1993). In such cases, requests are frequent and not necessarily based on need, but an expectation of generosity compels people to share small amounts. In the *osotua* case, this results in generalized reciprocity (Rankin & Taborsky, 2009) – widespread sharing among people with whom one has *osotua*, based on having experienced sharing before, not strict account-keeping.

Nevertheless, strict account-keeping (*esile*) does coexist alongside *osotua* in certain social contexts. The Maasai have many different types of resource exchange friendships, and the norms of each type can be associated with the types of resources being shared (Perlov, 1987). ADL observed some of these types of friendships that go beyond *osotua* (e.g., *patureshi*, a term for crafted bead sharing friends that was often used among women), but we lack systematic field data on *esile* and these other types of resource exchange rules. It is possible, though, that complying with the rules of these other types of cooperative friendships (e.g., following *esile* rules by paying back a lender) follows a similar logic to the one we demonstrated here with need-based sharing: while *esile* involves strict reciprocity and *osotua* transferring from “haves” to “have nots,” over time and with a shadow of the future, cooperation is often favored in both cases because, in the long run, defectors miss out on future gains for cooperating (Nowak & Sigmund, 1992; Skyrms, 2004; Delton et al., 2011).

In future work, a more general theory of sharing as risk reduction could unify need-based sharing principles and (what could be argued to be) these other apparently separate modes of cooperation (e.g., Winterhalder, 1986, 1996; Bird & Bird, 1997; Iyer, 2016). Need-based requests can be a central feature of reciprocity, for example (Wilkinson,

1984), where long-term payoffs are a critical part of individuals’ relevant costs and benefits (Delton et al., 2011). Also, institutions that combine need-based requests with frequent greedy requests can resemble demand sharing (Peterson, 1993). It is worth repeating, though, that across these different forms of cooperation, risk reduction requires that the “haves” share with the “have nots” (e.g., in the context of our ABM, agents make requests when in survival need, and have minimal levels of stinginess when asked to give). As long as need-based requests, generosity, and a willingness to share are firmly in place, agents participating in sharing can continue benefiting from long-term risk pooling benefits. It is possible that more stable conditions (e.g., higher wealth, less environmental harshness) would reduce the importance of need-based requests, leading high levels of greedy defection to transform pure need-based sharing into a more general model of cooperation (i.e., individuals simply trade favors that positively impact fitness). This was not the case in our model, however; need-based requests were critical for risk reduction across individuals’ levels of greed (Figs. 1 and 2).

Third, our findings suggest that for Kisongo Maasai, *osotua* is less akin to a formal partnership and more akin to a broad, community-level need-based sharing ethos in which non-survival requests are acceptable. It is nevertheless conceivable that need-based sharing in other cultural contexts is less forgiving of non-survival requests. Cronk (2007), for example, found that among the Mukogodo Maasai—who live in Kenya, geographically quite distant from the Kisongo Maasai in northern Tanzania—non-need-based requests among *osotua* partners were “unthinkable” (p. 353).

We see a few possible reasons for this difference in attitudes toward non-need-based requests among Mukogodo Maasai vs. Kisongo Maasai. One possibility is based on the theoretical framework that we have laid out here: for Mukogodo Maasai, *osotua* might reflect a history of demand sharing as former foragers (rather than account-keeping; see also Iyer, 2016), possibly with a social structure with far less redundancy among sharing network ties than those observed among Kisongo Maasai. Another possible reason is that, despite their acquisition of livestock in the past century or so, Mukogodo Maasai are exceptionally poor and vulnerable to disasters compared to many other Maasai groups (Cronk, 2002; Carrier, 2011). Hence, Cronk’s observation that non-need-based requests are “unthinkable” might be a reflection of Mukogodo Maasai poverty, where need-based requests are taken far more seriously given the context of extreme scarcity. A final reason might be that attitudes toward *osotua* have changed with other cultural changes among Kisongo Maasai. Among other Maasai groups, many younger people have started using the word *osotua* more informally than older people (Cronk, personal communication), and Kisongo Maasai at and around the field site have become more tied to cash markets, formal education systems, and Christian churches (Hodgson, 2005; Lightner & Hagen, 2021; Myers, 2022).

4.2. Limitations

Our study has a few limitations. The ABM, for simplicity, assumes that increasingly large partnerships are completely connected communities. Network structure can play an influential role in need-based sharing (Hao et al., 2015; Kayser & Armbruster, 2016; Campenni et al., 2021), but we currently lack the empirical data to create a clear and detailed picture of how *osotua* networks are structured at the society level. Additionally, our ABM does not determine if the strategies we investigate can evolve over the course of multiple generations (for a stability analysis of an analytical model of sharing under stochastic, multiplicative growth, see Fant et al., 2022). Because the ABM is focused on the impact of *osotua* on risk of cattle losses over time, it also does not consider the many individual-level strategies that herders can also employ in combination with *osotua* to reduce their risk of cattle losses (Mace, 1993; Butt, 2010; Naess & Bårdsen, 2013).

Our field evidence that individuals with more close *osotua* partners

had lower household food insecurity was not a preregistered hypothesis, but a post hoc exploratory finding, and therefore has a higher risk of being spurious. Additionally, whereas we interpret the result as more support from osotua translating to lower-risk livelihoods, it might instead suggest that fewer resources translates to lower partner value, leading to fewer osotua partners. However, this interpretation would conflict with the observation that osotua partnerships often originate in childhood, and can even be passed down to one's children (Spencer, 1965; Cronk, 2007) (although wealth is also transmitted between generations among many pastoralist groups, so more direct research would be needed to address this; see Borgerhoff Mulder et al., 2010).

Further, we did not systematically investigate how people subjectively approved or disapproved of the requests in the experimental vignette. We thus inferred participants' approval based on their sharing behavior, although our key informants suggested that the bridewealth requests were neither taboo nor inappropriate. We also did not test the extent to which people prioritized sharing unconditionally, without expectation of future help, or how important people thought it was to be generous rather than stingy in the osotua interaction we described in the vignette. Our key informant interviews and observational evidence did suggest that generosity was extremely important, but because costly stinginess was so central to our theoretical results, future research should directly test our inferences that rules against greedy defection should be less stringent than rules against stingy defection.

5. Conclusion

Evolutionary theories of cooperation suggest that need-based sharing is a critical part of human cultures everywhere (Hruschka, 2010; Cronk et al., 2019). These theories suggest that need-based sharing practices follow two simple rules: help others when asked, and only ask for help when genuine need arises. Formally, genuine need is typically defined in terms of long-term survival risks, but cross-culturally and colloquially, its criteria might vary. In an experimental vignette, we investigated how and why Tanzanian Kisongo Maasai pastoralists respond to requests in osotua, a paradigmatic example of need-based sharing, that were either based on survival need (needing subsistence after a drought) or non-survival need (needing bridewealth to acquire a second wife). We found that requests based on survival need were weakly associated with more cattle sharing than requests based on non-survival need. Sharing was widespread across both conditions, however, and participants were almost always willing to share small amounts. In an ABM, we showed why this might be the case: interdependent need-based sharing partnerships can easily tolerate greediness, but they do not tolerate stinginess – especially in large, interconnected partnerships like osotua among the Kisongo Maasai. In need-based sharing, stinginess is far worse than greed.

Declaration of Competing Interest

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.

Acknowledgements

We especially thank the Maasai people who participated in this study. We also thank Musa Kamaika, Kotoke Ngilepoi, Cynthia Heckelsmiller, and an anonymous Maasai research assistant for invaluable aid during the field study. We acknowledge funding from a National Science Foundation Doctoral Dissertation Improvement Grant (award number 1918523) and from the Evolution of Science and Religion as Meaning-Making Systems project of the Issachar Fund and Templeton Religion Trust. ADL acknowledges funding from the Aarhus University Research Foundation. We thank Lee Cronk, Aaron Lukaszewski, one anonymous reviewer, and members of the Aarhus University Religion,

Cognition, and Culture group for comments and suggestions that greatly improved our manuscript.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.evolhumbehav.2023.02.010>.

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