LETTERS
https://doi.org/10.1038/s41562-018-0338-z

nature human behaviour

Spoils division rules shape aggression between natural groups

Gönül Doğan[1,6], Luke Glowacki[2,3,6]* and Hannes Rusch[4,5,6]*

Violent intergroup conflicts cause widespread harm; yet, throughout human history, destructive hostilities occur time and time again[1,2]. Benefits that are obtainable by victorious parties include territorial expansion, deterrence and ascendency in between-group resource competition[3–6]. Many of these are non-excludable goods that are available to all group members, whereas participation entails substantial individual risks and costs. Thus, a collective action problem emerges, raising the question why individuals participate in such campaigns at all[7–9]. Distinguishing offensive and defensive intergroup aggression provides a partial answer: defensive aggression is adaptive under many circumstances[10–14]. However, participation in offensive aggression, such as raids or wars of conquest, still requires an explanation. Here, we focus on one condition that is hypothesized to facilitate the emergence of offensive intergroup aggression: asymmetric division of a conflict's spoils may motivate those profiting from such inequality to initiate between-group aggression, even if doing so jeopardizes their group's welfare[15–17]. We test this hypothesis by manipulating how benefits among victors are shared in a contest experiment among three Ethiopian societies whose relations are either peaceful or violent. Under equal sharing, between-group hostility increased contest contributions. By contrast, unequal sharing prompted offensive contribution strategies in privileged participants, whereas disadvantaged participants resorted to defensive strategies, both irrespective of group relations.

Studies of warfare in many traditional societies show that fitness-relevant spoils seized from outgroups, such as appropriated livestock or access to captured females, are often not shared equally[8,16,18–20]. For example, sharing often depends on social rank within the victorious group and is thus heterogeneous[8,16,19]. In livestock raids among East-African pastoralists, for instance, elders and prominent individuals frequently receive greater shares, independent of their efforts in a given raid[21].

Sharing rules that assign larger shares to certain individuals independent of these individuals' efforts toward group success have only very recently been incorporated in evolutionary models of intergroup conflict[7,15,17]. These games theoretically analyse evolutionary dynamics in populations in which individuals' fitness depends on the behavioural strategies they use in intergroup conflicts. In these games, individuals can exert costly efforts that increase their group's probability of victory against competing outgroups. The benefits obtained in case of victory are assumed to be shared within the winning group, whereas costs are borne individually, modelling the collective action problem addressed above[7,15].

Recent analyses of models incorporating effort-independent sharing rules that assign higher shares of the benefits to certain privileged individuals show that such sharing rules can prompt these privileged group members to fuel intergroup hostilities, whereas disadvantaged group members face incentives to reduce their efforts or even free-ride if they cannot be coerced to participate[8,22]. Thus, paradoxically, inequality in prospective gains from conflict can theoretically both reduce overall conflict participation rates and motivate privileged individuals to be more conflict seeking than their group members. Accordingly, heterogeneous benefits from conflict may be a decisive factor in the emergence of real-world intergroup conflict.

In this study, we experimentally test whether introducing effort-independent inequality to the division of victors' benefits prompts higher (or lower) aggression in privileged (or disadvantaged) group members. We do so by utilizing a unique sample of three small-scale societies with pre-existing relationships that either involve lethal intergroup violence or peaceful trade relationships, allowing us to compare the effects of two factors that may contribute to offensive intergroup aggression: heterogeneity in individual incentives and pre-existing intergroup hostility.

Intergroup violence increases within-group cooperation[23,24], and strong negative attitudes against outgroups have been found to promote individually costly behaviour that benefits the ingroup while harming the outgroup[25,26]. Furthermore, between-group competition can reduce individuals' within-group equity concerns and increase their willingness to sacrifice personal gains to promote their group's success[9,27]. Thus, if we find that heterogeneous incentives differentially affect individuals' participation in conflicts even when group relations involve real-world hostility, this is strong evidence that such incentives have a crucial role in the emergence of intergroup conflicts.

Our experiment used a two-by-two between-subjects design utilizing a Tullock contest game[28], modified for our field context (see Methods). We crossed two manipulations: (1) neutral versus hostile natural group relations, by matching groups composed of subjects from societies with either peaceful relationships or relationships with intergroup conflict, and (2) equal versus unequal sharing of the contest spoils obtained by victorious groups, by either assigning all members of the winning group an equal share or assigning one member of the winning group a larger share than his group mates. The experiment had two stages. In stage one, participants made a single unconditional contribution decision. In stage two, we elicited conditional contest contribution strategies that allowed us to classify participants' contribution choices as either offensive or defensive (see below).

[1]Chair of Corporate Development and Business Ethics, University of Cologne, Köln, Germany. [2]Institute for Advanced Study in Toulouse, Toulouse, France. [3]Department of Anthropology, Pennsylvania State University, University Park, PA, USA. [4]Public Economics Group, School of Business and Economics, Philipps-University Marburg, Marburg, Germany. [5]Peter Löscher Chair of Business Ethics, TUM School of Management, TU München, Munich, Germany. [6]These authors contributed equally: Gönül Doğan, Luke Glowacki and Hannes Rusch. *e-mail: glowacki@fas.harvard.edu; hannes.rusch@tum.de

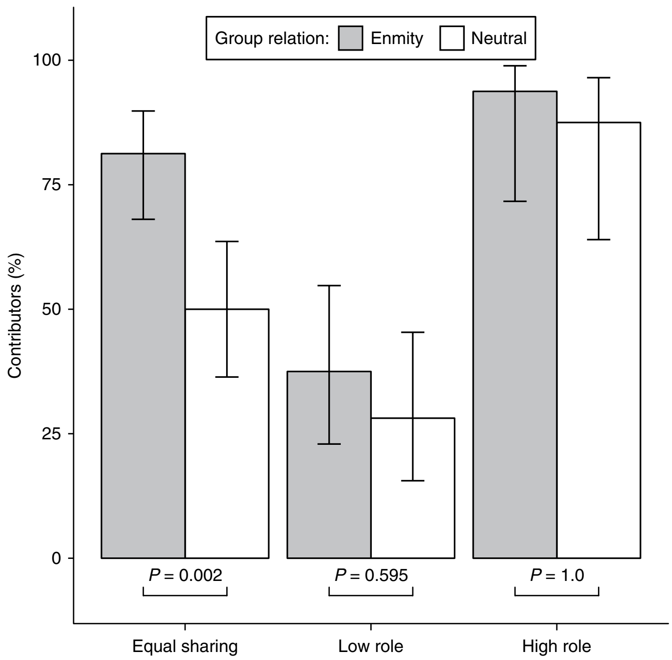

Fig. 1 | Unconditional contribution decisions in stage one. The percentage of participants who contributed to their group's pot per experimental condition and spoils share (total $N=192$; per experimental condition: $N=96$, 64 and 32 for equal, low and high roles, respectively) is shown; error bars indicate 95% Wilson's confidence intervals for single proportions; significance indicators show P values of FETs between group relation conditions within share roles.

We recruited $N=192$ adult males from three societies residing in the South Omo Valley of Ethiopia: Nyangatom ($N=96$), Daasanach ($N=48$) and Highland Ethiopians ($N=48$). The Nyangatom and the Daasanach have a history of mutual raiding and small-scale warfare that continues to the present day, whereas Highlanders have peaceful trade relationships with both groups[29] (for background information, see Methods). Contests between the Daasanach and the Nyangatom represent our 'enmity' condition. In our 'neutral' condition, Highlanders were matched against the Daasanach or the Nyangatom.

Contest games were played between two randomly matched groups of three players randomly selected from the same society. Participants made binary decisions. For each stage, each participant was endowed with 10 chips (worth 20 Ethiopian Birr (ETB), approximately half a day's wage) and had to choose between either keeping all 10 chips for himself or keeping 4 and contributing 6 to his group's pot. Contributions to the pot were unredeemable and served no other purpose than increasing one's own group's winning probability in case a contest realized. This happened if at least two members of one of the two groups contributed to their group's pot. This threshold makes it salient that initiating a contest requires collective effort and allows us to distinguish offensive from defensive strategy choice (see below). In case of no contest, each player earned the chips he had retained. The winning group was determined probabilistically using $P(\text{group } x \text{ wins}) = X/(X+Y)$, where X and Y represent the total contributions by groups x and y, respectively. The winning group appropriated all the chips that the losing group's members had kept for themselves. These 'spoils' were distributed among winners according to the respective condition's sharing rule. In the 'equal' condition, every member of a winning group received one-third of the spoils. In the 'unequal' condition, one player received two-thirds ('high' share role), whereas the others each received one-sixth ('low' share role). Roles were assigned randomly prior to decision making.

The contest earnings of a member of the winning group were the chips he retained plus his share of the spoils. Members of the losing group earned nothing from the contest. The unique pure-strategy Nash equilibrium of this one-shot game, irrespective of the sharing condition, is universal non-contribution (see Supplementary Information).

In the first decision stage, participants made a single contribution choice with no information about their opponent group's behaviour. The second decision stage was explained in detail only after participants had completed the first stage. In stage two, participants made four conditional contribution decisions, one for each possible size of the opponent group's pot (0, 6, 12 and 18, for 0–3 outgroup members contributing, respectively). Stage two decisions are informative of individuals' 'escalation thresholds', that is, the size of the opponents' pot at which a participant decided to switch from keeping to contributing. Participants who switch from keeping to contributing when faced with the opponent group's pot sizes of 12 or 18 (that is, escalation thresholds of ≥ 12) are selecting a defensive strategy, as a contest was initiated by the opponent group in these cases. Conversely, if participants decide to contribute when facing an opponent's pot size of ≤ 6, they are adopting an offensive strategy, as they show a willingness to aggress an opponent group that does not represent a threat.

The sharing rule and cultural identity (Nyangatom, Daasanach or Highlander) of the members of both matched groups were public information. Decisions were made anonymously and in private. Participants did not receive feedback or information about the decisions made by others. In the unequal condition, prior to decisions, participants received information about their own share role (high or low). Participants were informed that one of the decision stages

Table 1 | Strategy choice in stage two

	Equal		Low		High	
Strategy	**Enmity**	**Neutral**	**Enmity**	**Neutral**	**Enmity**	**Neutral**
Never contribute[a]	4 (8%)	5 (10%)	4 (13%)	5 (16%)	0 (0%)	0 (0%)
Contribution if and only if outgroup's pot = 18	1 (2%)	5 (10%)	2 (6%)	5 (16%)	0 (0%)	0 (0%)
Contribution if and only if outgroup's pot ≥ 12	26 (54%)	19 (40%)	9 (28%)	9 (28%)	1 (6%)	1 (6%)
Contribution if and only if outgroup's pot ≥ 6	5 (10%)	6 (13%)	11 (34%)	6 (19%)	4 (25%)	3 (19%)
Always contribute	6 (13%)	6 (13%)	3 (9%)	4 (13%)	8 (50%)	8 (50%)
Mixed[b]	6 (13%)	7 (15%)	3 (9%)	3 (9%)	3 (19%)	4 (25%)

The numbers and percentages (in parentheses) of participants who chose a particular strategy per experimental condition and share role are shown. [a]For Fig. 2 and statistical analyses reported in the main text, 'never contribute' was coded as a threshold of 24. [b]Twenty-six subjects who switched at least once from contributing to not contributing with increasing outgroup pot size are categorized as 'mixed' and excluded from further analyses. Our results for stage two are robust to including those 26 subjects' choices categorized as 'mixed' and alternative ways of coding the threshold of the strategy 'never contribute' (see Supplementary Information).

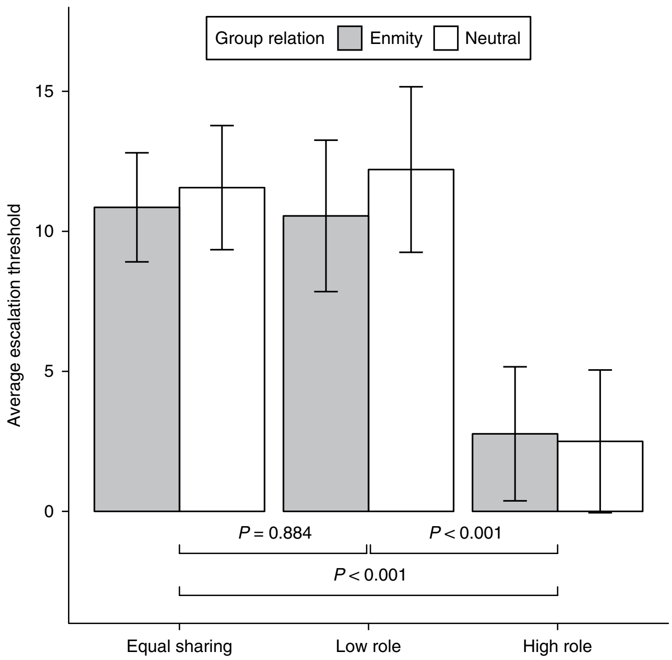

Fig. 2 | Conditional strategy choice in stage two. The average escalation thresholds, that is, the average minimum outgroup pot sizes at which participants' strategies switch from keeping to contributing, per experimental condition and share role are shown; error bars indicate 95% confidence intervals; significance indicators show *P* values of WRSTs between share roles within group relation conditions. $N = 166$; 'mixed' strategies are excluded, see Table 1.

would be randomly selected for payout and were paid after decisions by all participants had been collected. Average earnings from the contest game were 18.6 ETB in addition to a show-up fee of 20 ETB.

Figure 1 shows the results of the first decision stage. Pitted against an enemy (neutral) group, 81.25% (neutral: 50%) of participants contributed to their group's pot when spoils were shared equally (Fisher's exact test (FET): $P = 0.002$, odds ratio $= 4.26$ (95% confidence interval: 1.59–12.30)), indicating that group relation had a strong effect on these participants' choices. By contrast, 37.5% (neutral: 28.13%) of low-role participants and 93.75% (neutral: 87.50%) of high-role participants contributed in stage one (FET: $P = 0.595$ and $P = 1.0$, respectively). Thus, although pre-existing group relationships strongly affected unconditional contribution decisions when spoils were equally shared, we found no such effect under unequal sharing. Here, participants mostly separated into contributors in the high role and non-contributors in the low role, with no significant differences between enmity and neutral for either role. (See Supplementary Information for a full analysis.)

Table 1 and Fig. 2 show the results of the second decision stage. High-role participants were significantly more likely to choose offensive strategies than participants in the low and equal roles ($P < 0.002$, $r > 0.50$, for pairwise comparisons of escalation thresholds between these share roles, two-tailed Wilcoxon rank sum test (WRST)). Low-role and equal-role participants' escalation thresholds were statistically indistinguishable ($P > 0.20$, for all pairwise WRSTs). Within all share roles, escalation thresholds were not significantly different between enmity and neutral ($P > 0.36$, for all pairwise WRSTs), suggesting that participants contributed more in the equal-enmity condition of stage one because they expected higher contributions by their opponents. (See Supplementary Information for further analyses.)

Our results from stage two underscore the motivational relevance of ingroup defence: irrespective of group relations, most participants in the equal and low roles adopted defensive contest strategies, confirming recent laboratory findings based on student samples[10–12]. Beyond this, our experimental results demonstrate a strong causal effect of inequality in spoils sharing, supporting the hypothesis that such heterogeneity has dual consequences. First, the inequality imposed in our unequal conditions prompted increased efforts by individuals who expected to receive higher shares in case of victory and led them to choose considerably more offensive strategies. Second, it also decreased efforts by disadvantaged group members, leading them to choose contribution to the ingroup's effort only in case their personal earnings were threatened.

Taken together, our results provide a nuanced picture of how between-group conflict can emerge. Our study shows that both pre-existing group relations as well as individual incentives matter. Specifically, we find that the effect of hostile group relationships is moderated by how the spoils from conflict are to be divided. Accordingly, heterogeneity in anticipated benefits can undermine collective offensive efforts if it is not countered by redistributional or punitive norms and institutions[8,11]. However, the expectation of receiving high spoils shares can also prompt substantially greater efforts by privileged group members, regardless of their group's pre-existing relationship to the outgroup.

Hence, although unequal returns from conflict may subvert group success when victory requires widespread participation, they may simultaneously amplify the participation of privileged individuals. Such increased efforts by privileged group members can be important for initiating larger collective actions whose success depends on leading by example or reaching a threshold of participants that is sufficiently small[7,11,30,31]. Simultaneously, heterogeneous incentives may also prompt a small number of profiteers to attack outgroups without approval by their ingroup. In many cases, this may suffice to initiate the spirals of aggression and retaliative counter-aggression that are frequently observed in real-world intergroup conflict[20,32].

Methods

Experimental design. Tullock contest games are a canonical paradigm for studying interindividual and intergroup conflicts, both theoretically[7,17,28,33–35] and experimentally[36–38]. For our study, we designed and implemented a new contest game that was suitable for our lab-in-the-field context. Our game needed to satisfy four criteria. One, it needed to be simple enough to be understandable for participants without any formal education. To this end, we only elicited binary choices and limited payoffs to integers ≤ 20. Two, the game needed to be complex enough to allow us to manipulate the sharing rule. Thus, groups consisted of three players and contest 'spoils' were integers divisible by three. Three, offensive and defensive strategy choice needed to be distinguishable. Thus, we introduced the threshold of at least two group members' contributions being required for a contest to realize and elicited conditional contribution strategies in stage two. Four, the game needed to have universal non-contribution as its unique pure-strategy Nash equilibrium. This ensures that positive contest contributions cannot be explained by purely selfish payoff maximization.

Like most economic experiments, our paradigm used monetary incentives to model selected aspects of real-world strategic interaction[39–41]. In accordance with our primary research question, we focused on manipulating the rules for the distribution of benefits from intergroup conflict. Inevitably, real-life costs of raiding, such as time, energy and risk of injury or death, could only be approximated through lost earnings. Still, our design allows for an experimental test of the isolated causal effects of different sharing rules, group relations and their interaction on individually costly contributions toward the own group's success in conflicts with natural outgroups.

Ethnographic background. The Nyangatom are primarily nomadic pastoralists inhabiting southwest Ethiopia in Nyangatom woreda[42,43] (the Ethiopian administrative unit; also see Supplementary Fig. 1). Since 2006, an increasing number of Ethiopian Highlanders have migrated to the area seeking employment owing to development projects and increasing urbanization constituting a minority of the population. The Daasanach reside in Daasanach woreda, which borders Nyangatom woreda, and the two groups have a long history of violent conflict with each other that includes small-scale raids, ambushes and occasional battles continuing to the present day[29,44]. In fact, the Nyangatom refer to the Daasanach with the term *emoit*, meaning enemy. There is little contact between the Daasanach and the Nyangatom beyond occasional trading relationships in border areas. Although both the Daasanach and the Nyangatom occasionally incorporate outgroups, they each have distinct cultural identities. We chose Ethiopian Highlanders as a neutral outgroup because they are not indigenous to the Omo Valley and are one of the few groups with almost entirely amicable relationships with both the Nyangatom and the Daasanach. However, although the Nyangatom and the Daasanach constitute recognized cultural groups, Ethiopian Highlanders can in principle come from any of multiple cultural groups in the highlands of Ethiopia. In Nyangatom woreda, the vast majority of Highlanders identify as *Wolayta*.

Raiding parties usually form when several men reach a decision to go on a raid[21]. In these raids, all participants take a moderate amount of risk, but the material gains from raiding, which are primarily livestock, are divided by both the amount of investment and with privileged individuals receiving larger shares independent of their investment, usually owing to being older or having higher status. Intriguingly, defectors sometimes also receive a share of the spoils, even if they abandoned the raid before its conclusion[21]. Perhaps because real-world division of spoils is in part independent of investment, raids tend to be led by high status and older individuals who anticipate receiving larger shares[31].

Experimental procedures. Because only young-to-middle-aged men participate in raids, we recruited only male participants <40 years of age to approximate real-world raiding party composition (Nyangatom: $N=96$, Highland: $N=48$ and Daasanach: $N=48$). Nyangatom and Highland participants were recruited by word-of-mouth and snowball sampling from in and around Kangaten, whereas Daasanach participants were recruited from the town of Omorate. Because the study was conducted in a rural area (Nyangatom and Daasanach woreda), participants were embedded in a cultural context where intergroup raiding occurs. They are familiar with the social dynamics of raiding and would likely have had the opportunity to participate themselves.

For each session, 12 participants from the same cultural group (Nyangatom, Daasanach or Highlander) were assembled in a private area. These participants all participated in the same experimental condition, that is, they played against the same (neutral or hostile) outgroup with the same sharing rule (equal or unequal). Verbal informed consent was obtained from all participants and the Committee on the Use of Human Subjects at Harvard University approved this research. The study was administered with the use of a translator who was informed of the study purpose and procedure. Once all participants were gathered together, they were introduced to the experimental design, read the instructions as part of this group and given the chance to ask questions. The randomization device used in the Tullock contest was demonstrated to the group through the use of coloured plastic tokens and a transparent box to facilitate comprehension. Participants were informed that their group would consist of themselves plus two other randomly assigned members from their cultural group who would remain anonymous. They were also told the cultural identity and size of the opponent group. They were asked not to talk among themselves while the study was being conducted. Subjects individually participated in the experimental phase of the study conducted by one of the authors (L.G.), while a field assistant remained with the waiting study participants to minimize discussion about the task. L.G. explained the instructions again and asked comprehension questions that needed to be answered correctly before decision stage one began. Prior to decisions, participants were informed that another decision stage would follow after stage one and that one of the stages would be randomly chosen for payout. However, no details about stage two were given at this point. Participants in the unequal condition were then randomly assigned to either the high-share or low-share role and told their assignment. Then, participants made their stage-one decisions. When subjects had completed stage one, stage two was explained and subjects made their decisions. Participants were then debriefed and requested not to share their decisions with others. All participants received a show-up fee of 20 ETB paid at the completion of the experimental session, equivalent to half a day's wage. Payouts earned from the contest game were made at the conclusion of data collection based on the decisions made by all participants.

Reporting Summary. Further information on experimental design is available in the Nature Research Reporting Summary linked to this article.

Code availability. The source file for statistical analyses is publicly available as Supplementary Data here: https://doi.org/10.17605/osf.io/fu5r9.

Data availability. Experimental data are publicly available as Supplementary Data here: https://doi.org/10.17605/osf.io/fu5r9.

Received: 26 October 2017; Accepted: 16 March 2018;
Published online: 16 April 2018

References

1. Allen, M. W., Bettinger, R. L., Codding, B. F., Jones, T. L. & Schwitalla, A. W. Resource scarcity drives lethal aggression among prehistoric hunter-gatherers in central California. *Proc. Natl Acad. Sci. USA* **113**, 12120–12125 (2016).
2. Pinker, S. *The Better Angels of our Nature. Why Violence has Declined* (Viking, New York, NY, 2011).
3. Gat, A. *War in Human Civilization* (Oxford Univ. Press, Oxford, 2008).
4. Glowacki, L., Wilson, M. & Wrangham, R. The evolutionary anthropology of war. *J. Econ. Behav. Organ.* http://dx.doi.org/10.1016/j.jebo.2017.09.014 (2017).
5. Wilson, M. L. in *War, Peace, and Human Nature* (ed. Fry, D. P.) 361–388 (Oxford Univ. Press, Oxford, 2013).
6. Wrangham, R. W. & Glowacki, L. Intergroup aggression in chimpanzees and war in nomadic hunter-gatherers. *Hum. Nat.* **23**, 5–29 (2012).
7. Gavrilets, S. Collective action problem in heterogeneous groups. *Phil. Trans. R. Soc. B* **370**, 20150016 (2015).
8. Mathew, S. & Boyd, R. Punishment sustains large-scale cooperation in prestate warfare. *Proc. Natl Acad. Sci. USA* **108**, 11375–11380 (2011).
9. Rusch, H. The evolutionary interplay of intergroup conflict and altruism in humans: a review of parochial altruism theory and prospects for its extension. *Proc. R. Soc. B* **281**, 20141539 (2014).
10. Böhm, R., Rusch, H. & Gürerk, Ö. What makes people go to war? Defensive intentions motivate retaliatory and preemptive intergroup aggression. *Evol. Hum. Behav.* **37**, 29–34 (2016).
11. de Dreu, C. K. W. et al. In-group defense, out-group aggression, and coordination failures in intergroup conflict. *Proc. Natl Acad. Sci. USA* **113**, 10524–10529 (2016).
12. Halevy, N. Preemptive strikes: fear, hope, and defensive aggression. *J. Pers. Soc. Psychol.* **112**, 224–237 (2017).
13. Rusch, H. Asymmetries in altruistic behavior during violent intergroup conflict. *Evol. Psychol.* **11**, 973–993 (2013).
14. Rusch, H. The two sides of warfare. An extended model of altruistic behavior in ancestral human intergroup conflict. *Hum. Nat.* **25**, 359–377 (2014).
15. Gavrilets, S. & Fortunato, L. A solution to the collective action problem in between-group conflict with within-group inequality. *Nat. Commun.* **5**, 3526 (2014).
16. Glowacki, L. & Wrangham, R. W. The role of rewards in motivating participation in simple warfare. *Hum. Nat.* **24**, 444–460 (2013).
17. Rusch, H. & Gavrilets, S. The logic of animal intergroup conflict: a review. *J. Econ. Behav. Organ.* https://dx.doi.org/10.1016/j.jebo.2017.05.004 (2017).
18. Almagor, U. Raiders and elders. A confrontation of generations among the Dassanetch. *Senri Ethnol. Stud.* **3**, 119–145 (1979).
19. Glowacki, L. & Wrangham, R. Warfare and reproductive success in a tribal population. *Proc. Natl Acad. Sci. USA* **112**, 348–353 (2015).
20. Walker, R. S. & Bailey, D. H. Body counts in lowland South American violence. *Evol. Hum. Behav.* **34**, 29–34 (2013).
21. Glowacki, L. *Incentives for War in Small-Scale Societies*. PhD thesis, Harvard Univ. (2015).
22. Sääksvuori, L., Mappes, T. & Puurtinen, M. Costly punishment prevails in intergroup conflict. *Proc. R. Soc. B* **278**, 3428–3436 (2011).
23. Bauer, M. et al. Can war foster cooperation? *J. Econ. Perspect.* **30**, 249–274 (2016).
24. Schaub, M. Threat and parochialism in intergroup relations: lab-in-the-field evidence from rural Georgia. *Proc. R. Soc. B* **284**, 20171560 (2017).
25. Weisel, O. & Böhm, R. "Ingroup love" and "outgroup hate" in intergroup conflict between natural groups. *J. Exp. Soc. Psychol.* **60**, 110–120 (2015).
26 Böhm, R., Rusch, H. & Baron, J. The psychology of intergroup conflict: a review of theories and measures. *J. Econ. Behav. Organ.* https://doi.org/10.1016/j.jebo.2018.01.020 (2018).
27. Chen, Y. & Li, S. X. Group identity and social preferences. *Am. Econ. Rev.* **99**, 431–457 (2009).
28. Konrad, K. A. *Strategy and Dynamics in Contests* (Oxford Univ. Press, Oxford, 2009).
29. Glowacki, L. et al. Formation of raiding parties for intergroup violence is mediated by social network structure. *Proc. Natl Acad. Sci. USA* **113**, 12114–12119 (2016).
30. Centola, D. M. Homophily, networks, and critical mass. Solving the start-up problem in large group collective action. *Ration. Soc.* **25**, 3–40 (2013).
31. Glowacki, L. & von Rueden, C. Leadership solves collective action problems in small-scale societies. *Phil. Trans. R. Soc. B* **370**, 20150010 (2015).
32. Boehm, C. *Blood Revenge. The Anthropology of Feuding in Montenegro and Other Tribal Societies* (Penn Press, Philadelphia, PA, 1984).
33. Chowdhury, S. M. & Sheremeta, R. M. A generalized Tullock contest. *Public Choice* **147**, 413–420 (2011).
34. Kimbrough, E. O., Laughren, K. & Sheremeta, R. War and conflict in economics: theories, applications, and recent trends. *J. Econ. Behav. Organ.* https://dx.doi.org/10.1016/j.jebo.2017.07.026 (2017).
35. Ryvkin, D. Tullock contests of weakly heterogeneous players. *Public Choice* **132**, 49–64 (2007).
36. Dechenaux, E., Kovenock, D. & Sheremeta, R. M. A survey of experimental research on contests, all-pay auctions and tournaments. *Exp. Econ.* **18**, 609–669 (2015).
37. Sheremeta, R. M. Overbidding and heterogeneous behavior in contest experiments. *J. Econ. Surv.* **27**, 491–514 (2013).
38. Sheremeta, R. M. Behavior in group contests. A review of experimental research. *J. Econ. Surv.* https://doi.org/10.1111/joes.12208 (2017).

39. Falk, A. & Heckman, J. J. Lab experiments are a major source of knowledge in the social sciences. *Science* **326**, 535–538 (2009).
40. Kessler, J. B. & Vesterlund, L. in *Handbook of Experimental Economic Methodology* (eds Fréchette, G. R. & Schotter, A.) 391–406 (Oxford Univ. Press, Oxford, 2015).
41. Wiessner, P. Experimental games and games of life among the Ju/'hoan Bushmen. *Curr. Anthropol.* **50**, 133–138 (2009).
42. Glowacki, L. & Molleman, L. Subsistence styles shape human social learning strategies. *Nat. Hum. Behav.* **1**, 0098 (2017).
43. Yntiso, G. in *Creating and Crossing Boundaries in Ethiopia* (ed. Epple, S.) 49–71 (LIT, Zürich, 2014).
44. Tornay, S. Armed conflicts in the lower Omo Valley, 1970–1976. An analysis from within Nyangatom society. *Senri Ethnol. Stud.* **3**, 97–117 (1979).

Acknowledgements

We thank M. Albert, R. Böhm, T. Friehe, M. Greiff, M. Hoffman, R. Ligtvoet, F. Morath, K. M. Zimmermann and the audiences at MPI Bonn, NCBEE 2016 Oslo, ESA 2016 Bergen, GfeW 2016 Giessen and MACIE Marburg for helpful comments and suggestions. G.D. gratefully acknowledges financial support by the Dr. Jürgen Meyer Foundation. H.R. gratefully acknowledges financial support by VU Amsterdam. L.G. gratefully acknowledges support from the Eric M. Mindich Research Fund for the Foundations of Human Behavior, the Mind Brain and Behavior Interfaculty Initiative at Harvard University and the ANR Labex IAST. This work was assisted through participation of L.G. and H.R. in the 'Evolution & Warfare' Investigative Workshop at NIMBIOS, sponsored by the National Science Foundation through the NSF Award no. DBI-1300426, with additional support from the University of Tennessee, Knoxville, Tennessee, USA. The funders had no role in study design, data collection and analysis, decision to publish or preparation of the manuscript.

Author contributions

All authors contributed equally to this work and are listed alphabetically.

Competing interests

The authors declare no competing interests.

Additional information

Supplementary information is available for this paper at https://doi.org/10.1038/s41562-018-0338-z.

Reprints and permissions information is available at www.nature.com/reprints.

Correspondence and requests for materials should be addressed to L.G. or H.R.

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

nature research

Corresponding author(s): Luke Glowacki & Hannes Rusch

Life Sciences Reporting Summary

Nature Research wishes to improve the reproducibility of the work that we publish. This form is intended for publication with all accepted life science papers and provides structure for consistency and transparency in reporting. Every life science submission will use this form; some list items might not apply to an individual manuscript, but all fields must be completed for clarity.

For further information on the points included in this form, see Reporting Life Sciences Research. For further information on Nature Research policies, including our data availability policy, see Authors & Referees and the Editorial Policy Checklist.

Please do not complete any field with "not applicable" or n/a. Refer to the help text for what text to use if an item is not relevant to your study.
For final submission: please carefully check your responses for accuracy; you will not be able to make changes later.

Experimental design

1. Sample size

Describe how sample size was determined.

Sample sizes were determined as a compromise between logistical feasibility (this is a lab-in-the-field experiment) and statistical considerations. A power analyses indicate that our design has a power of $\beta \geq 0.8$ at $\alpha = 0.05$ for differences in proportions ≥ 0.3 for our main stage 1 result and for effect sizes $r \geq 0.4$ for stage 2 results.

2. Data exclusions

Describe any data exclusions.

No data were excluded.

3. Replication

Describe the measures taken to verify the reproducibility of the experimental findings.

This study reports the results of a single experiment. Experimental procedures and materials are publicly available for the purpose of reproduction.

4. Randomization

Describe how samples/organisms/participants were allocated into experimental groups.

Recruitment/randomization for this study was carried out in a walk-into-the-lab fashion. Whoever volunteered to participate on a given day was allocated to the experimental condition that was run on that day.

5. Blinding

Describe whether the investigators were blinded to group allocation during data collection and/or analysis.

Full blinding was not possible, because one researcher (LG) had to explain the experiment's instructions to participants with the help of a translator and to collect their decisions, which they communicated verbally. The researchers analysing the data (GD & HR) were blind to participants' identities.

Note: all in vivo studies must report how sample size was determined and whether blinding and randomization were used.

6. Statistical parameters

For all figures and tables that use statistical methods, confirm that the following items are present in relevant figure legends (or in the Methods section if additional space is needed).

n/a	Confirmed	
☐	☒	The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement (animals, litters, cultures, etc.)
☐	☒	A description of how samples were collected, noting whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☒	☐	A statement indicating how many times each experiment was replicated
☐	☒	The statistical test(s) used and whether they are one- or two-sided *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☒	☐	A description of any assumptions or corrections, such as an adjustment for multiple comparisons
☐	☒	Test values indicating whether an effect is present *Provide confidence intervals or give results of significance tests (e.g. P values) as exact values whenever appropriate and with effect sizes noted.*
☐	☒	A clear description of statistics including central tendency (e.g. median, mean) and variation (e.g. standard deviation, interquartile range)
☐	☒	Clearly defined error bars in all relevant figure captions (with explicit mention of central tendency and variation)

See the web collection on statistics for biologists for further resources and guidance.

Software

Policy information about availability of computer code

7. Software

Describe the software used to analyze the data in this study.	R (version 3.2.3)

For manuscripts utilizing custom algorithms or software that are central to the paper but not yet described in the published literature, software must be made available to editors and reviewers upon request. We strongly encourage code deposition in a community repository (e.g. GitHub). *Nature Methods* guidance for providing algorithms and software for publication provides further information on this topic.

Materials and reagents

Policy information about availability of materials

8. Materials availability

Indicate whether there are restrictions on availability of unique materials or if these materials are only available for distribution by a third party.	All data collected, experimental instructions and scripts used for statistical analyses are publicly available here: https://doi.org/10.17605/osf.io/fu5r9

9. Antibodies

Describe the antibodies used and how they were validated for use in the system under study (i.e. assay and species).	Not applicable

10. Eukaryotic cell lines

a. State the source of each eukaryotic cell line used.	Not applicable
b. Describe the method of cell line authentication used.	Not applicable
c. Report whether the cell lines were tested for mycoplasma contamination.	Not applicable
d. If any of the cell lines used are listed in the database of commonly misidentified cell lines maintained by ICLAC, provide a scientific rationale for their use.	Not applicable

Animals and human research participants

Policy information about studies involving animals; when reporting animal research, follow the ARRIVE guidelines

11. Description of research animals

Provide all relevant details on animals and/or animal-derived materials used in the study.	Not applicable

Policy information about studies involving human research participants

12. Description of human research participants

Describe the covariate-relevant population characteristics of the human research participants.	N=192 healthy adult male participants recruited from three different locations in Ethiopia for voluntary participation in a decision study (see Methods for details).