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ABSTRACT

Fairness norms are crucial in understanding the emergence and enforcement of large-scale cooperation in human societies. The most widely applied framework in the study of human fairness is the Ultimatum Game (UG). In the UG, a proposer suggests how to split a sum of money with a responder. If the responder rejects the proposer's offer, both players get nothing. Rejection of unfair offers is considered to be a form of punishment implemented by fair-minded individuals, who are willing to sacrifice their own resources in order to impose the fairness norm. However, an alternative interpretation is equally plausible: punishers might actually be using rejections in a competitive, spiteful fashion as a means to increase their relative standing. This hypothesis is in line with recent evidence demonstrating that "prosocial" and "antisocial" punishers coexist in other experimental games. Using two large-scale experiments, we explore the nature of UG punishers by analyzing their behavior in a Dictator Game. In both studies, we confirm the coexistence of two entirely different sub-populations: prosocial punishers, who behave fairly as dictators, and spiteful (antisocial) punishers, who are totally unfair. Such a result is fundamental for research on the foundations of punishment behavior employing the UG. We discuss how focusing only on the fairness-oriented part of human behavior might give rise to misleading conclusions regarding the evolution of cooperation and the behavioral underpinnings of stable social systems.

Keywords: costly punishment; ultimatum game; cooperation; fairness; spite

INTRODUCTION

A wealth of interdisciplinary research has attested to the pivotal role of fairness norms in explaining cooperation amongst unrelated individuals (1-6). The Ultimatum Game (UG) (7) has been one of the most prolific set-ups for unraveling the nature of human fairness over the last years (3,5,8,9). In this game, one player (the proposer) proposes a way to split a sum of money with another player (the responder). If the responder accepts the offer, both players are paid accordingly; if she rejects the offer, neither player is paid. The rejection of positive, albeit low offers is considered to be an expression of costly punishment of unfair behavior able to enforce the social norm of fairness (2,3). Thus, the prevailing view is that individuals' (prosocial) preferences for fairness motivate the rejection of low offers in the UG. Such an argument has been used to support the strong reciprocity model of the evolution of human cooperation (4,10). However, recent evidence now challenges this interpretation (11).

Indeed, less prosocial motivations may be behind UG rejections. Rejections are equally compatible with competitive, spiteful motives (12-15). A spiteful responder who is concerned with her own relative standing prefers a zero-zero outcome over one that leaves her below the proposer. Thus, she will reject any offer below the equal split, just like an individual concerned with the fairness norm. This implies that the mere observation of UG behavior is insufficient to determine the motivation of rejections. A crucial factor that should not be overlooked points directly to the punisher (16,17): does she herself comply with the norm?

Recent research on cooperation games reveals that costly punishment is not only used by cooperators but also by non-cooperators who punish (other) non-cooperators (18), cooperators (19,20) or both (17). These punishment patterns, which cannot be reconciled with fairness motives, have been traced back to competitive, spiteful individuals aiming to increase their own relative payoff. Such findings are particularly important insofar as theoretical and empirical evidence demonstrates that the commons can be destroyed by the presence of "spiteful (unfair) punishers", which can ultimately turn a sanctioning institution into a detrimental force for public cooperation (19-21).

Here, we investigate experimentally to what extent fair and unfair punishers coexist in the UG. To disentangle "prosocial" and "antisocial" types of punishment, this paper combines the rejection behavior of subjects in the UG with their decisions as dictators in a Dictator Game (DG) (22). The DG is identical to the UG except that the second player is now passive, that is, she cannot reject the offer. As a result, generous offers by dictators are genuinely prosocial. A prosocial individual concerned about fairness will split the pie equally in the DG *and* reject unequal offers in the UG. A spite-driven, antisocial individual, however, will still reject unequal offers but transfer nothing in the DG (hence being totally unfair) in order to achieve the highest payoff differential. Note that pure selfishness also predicts a zero-transfer in the DG but never the rejection of any positive offers in the UG. Therefore, the rejection of unequal but positive offers combined with zero-transfers in the DG is an unequivocal symptom of competitive spite.

RESULTS

We report data from two large-scale experimental studies. Study 1 (n=754) is a survey-experiment employing a representative sample of a city's adult population which was carried out at the participants' households. The pie to be split was €20 in each game. For UG responses, the strategy method was used in which the responder states whether she accepts/rejects any possible offer beforehand. Study 2 (n=623) is a replication of Study 1 in the laboratory employing university students (freshmen) as subjects (see Materials and Methods).

Figure 1 breaks down the sample into three groups according to participants' decisions in the DG: "unfair" refers to participants who offer zero in the DG, "fair" refers to those who make an equal split, while those who make an offer in between the two are labeled "remaining". For each group, we display the percentage of responders who reject offers below the equal split in the UG. Study 1 [2] is captured by the left [right] panel.

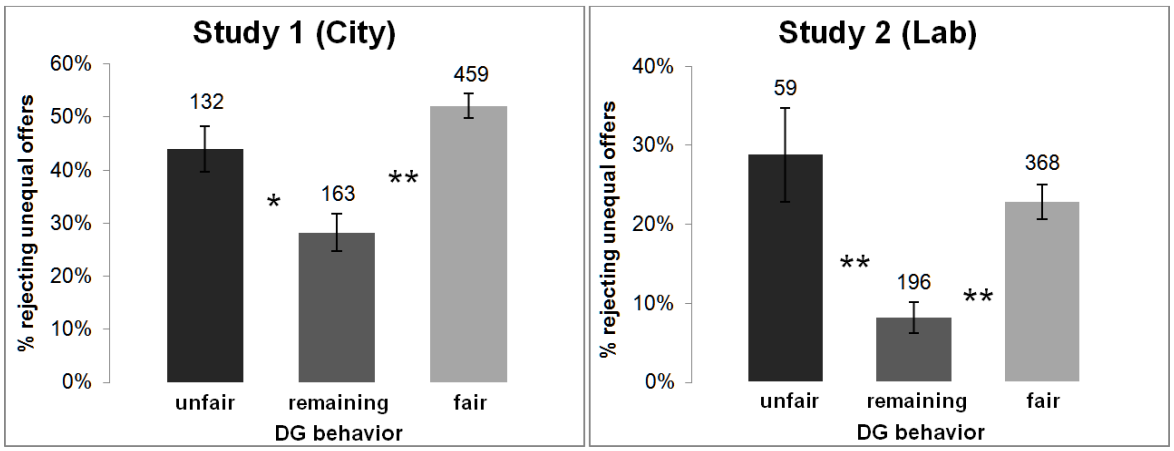

Figure 1. Willingness to reject unequal offers by DG groups. Left [right] panel for Study 1 [2]. The horizontal axis depicts behavior in the DG: unfair (offer 0%), remaining (offer between 0 and 50%), fair (offer 50%). The numbers on top of the bars denote the total number of observations in each group. The vertical axis represents the percentage of individuals (± SE) who reject offers below 50% in the UG, i.e. whose minimum acceptable offer is the equal split. * p=0.005, ** p=0.000.

We find that not only the "fair" but also the "unfair" dictators reject unequal offers significantly more often than the "remaining" group (Probit model controlling for order effects in decisions; fair vs. remaining: p=0.000 in Study 1 and 2; unfair vs. remaining: p=0.005 in Study 1, p=0.000 in Study 2). What is more, both groups are similarly likely to reject an unequal offer (p=0.123 in Study 1, p=0.356 in Study 2) (see SI).[*] Thus, fair and unfair punishers coexist in the UG. Notice, however, that in our samples fair dictators are more numerous than unfair ones (see the numbers on top of the bars in Figure 1). This implies that fairness-based punishment is more frequent, which, nevertheless, should not necessarily be the case in samples taken from other populations/societies (19).

DISCUSSION

Our results show that punishment decisions in the UG are indistinguishably "prosocial" and "antisocial". It is not one or the other, but both kinds of human behavior that shape the

[*] As analyzed in SI, we find a statistically significant U-shaped, non-linear relationship between the two variables (all p-values=0.000) when using the offers in the DG as a continuous variable (rather than comparing between the three DG groups). Interestingly, in (11) rejection behavior does not relate non-linearly (neither does linearly) to DG offers. This is possibly attributable to the fact that capturing such a non-linearity statistically requires a relatively large sample.

outcomes of the UG game. This has several important implications for the study of social behavior across a number of disciplines.

To start with research in social neuroscience: data from rejections in the UG have been extensively used to investigate the neurobiological basis of costly punishment. This research has implicated the brain areas responsible both for negative emotional processes (e.g., the anterior insula) and for executive control (e.g., the dorsolateral prefrontal cortex [DLPFC]) in rejection behavior. Yet there is much debate on the exact role of executive control. The seminal work of Sanfey et al. (5) found that when the activation of the DLPFC was stronger than that of the anterior insula, responders were more willing to accept unequal offers, while lower relative activation of the DLPFC correlated with higher rejection rates. Their interpretation was that executive control is implicated in overriding the emotional impulse to punish norm violations. However, Knoch et al. (8) found that disruption of the functioning of the DLPFC led subjects to be more willing to accept unequal, albeit positive offers. According to Knoch et al.'s viewpoint, the DLPFC facilitates subjects' normative, fairness-oriented behavior, and is thus involved in the executive control of selfish impulses. Though further studies have shed some light on these apparently contradictory observations (23-28), the debate is far from closed.

Our results indicate that there is a non-negligible fraction of rejections that are rooted not in normative, fairness-based judgments but instead in competitive, spiteful desires. It would in fact be hard to claim that a common neural mechanism underlies these extremely different natures of rejection behavior. We argue that one of the two might be overrepresented in some databases, which might have been due to the small sample sizes typically featured in brain studies. In addition, the proportion of prosocial and antisocial punishers may vary dramatically across societies (19). The argument that different sample compositions might be able to explain the above controversy (as suggested by Espín et al. (18)) remains unexplored so far. In order to unravel the neurobiological basis of costly punishment, researchers should carefully investigate not only which behavior gets punished but also *who is* the punishing individual. However, this cannot be addressed using the standard UG as the only information researchers obtain from responders is whether they accept or reject a given proposal (or a number of them).

Our findings also have important implications from the viewpoint of evolutionary biology and the social sciences. Costly punishment has been shown to be crucial in promoting cooperation (29,30). Nevertheless, in the presence of spiteful punishers, social efficiency becomes difficult to sustain since spiteful behavior often leads to escalating conflict rather than to lasting cooperation. When sanctions are not used as norm-enforcement devices but instead at the service of dominance- or conflict-seeking behavior, their effects over social stability can be perverse (19-21). If the punisher lacks the legitimacy to teach a moral lesson—because she does not comply with the social norm herself—the punished individual can view punishment as unjustified coercion. This might activate the mechanisms involved in competition with conspecifics instead of those involved in norm compliance, thus paving the way to inefficient, corrupt societies (31) rather than to efficient, cooperative ones. In fact, corruption among the responsible for the enforcement of rules is recognized as a major source for the failure of social institutions (32). Therefore, special care has to be taken when interpreting rejection behavior as a mechanism to enforce the norms implicated in the maintenance of stable social systems.

MATERIALS AND METHODS

The details of the survey-experiment have been reported elsewhere (33). In both studies, subjects made their decisions in the UG (both roles) and the DG in random order. Subjects' decisions as proposers in the UG are not being used here as a measure of fairness since generous offers might equally be motivated by strategic self-interest (avoidance of rejection) and by other-regarding concerns, thus making them difficult to interpret (34) (indeed, zero offers in the UG are extremely rare). In contrast, the interpretation of subjects' offers in the DG is straightforward because they are not influenced by strategic concerns. In the DG, subjects had to split a pie of €20 between themselves and another anonymous participant. Subjects decided which share of the €20 (in €2 increments) they wanted to transfer to the other subject.

For the role of responder in the UG we used the strategy method (35). That is, subjects had to state their willingness to accept or reject each of the following proposals (proposer's

payoff [€], responder's payoff [€]): (20, 0); (18, 2); (16, 4); (14, 6); (12, 8); (10, 10). After making their decisions, participants in each study were randomly matched and one of every ten was selected for real payment (see SI).

All participants in the experiments reported in the manuscript were informed about the content of the experiment prior to participating. Verbal informed consent was obtained from participants in the city experiment (Study 1) since literacy was not a requirement to participate (this was necessary to obtain a representative sample), and all the instructions were read aloud by the interviewers. Written informed consent was obtained from participants in the lab experiment (Study 2). Anonymity was always preserved (in agreement with Spanish Law 15/1999 on Personal Data Protection) by randomly assigning a numerical code to identify the participants in the system. No association was ever made between their real names/addresses and the results. As is standard in socio-economic experiments, no ethic concerns are involved other than preserving the anonymity of participants. This procedure was checked and approved by the Vice-dean of Research of the School of Economics of the University of Granada; the institution hosting the experiments.

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Supporting Information (SI) for

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S1. Experimental procedures

After completing a questionnaire (identical across studies) to collect socio-economic and psychological information, subjects made decisions in a Dictator Game, an Ultimatum Game (both roles) and a Trust Game (both roles).[†] Since every subject made all five experimental decisions, the order both between and within games was randomized across subjects, resulting in 24 different orders (the two decisions of the same game were always set aside). In each study, one out of ten subjects was randomly selected to be paid for one randomly chosen game and role. Matching and payment took place within the next two weeks and the average earnings among winners were €9.60 in Study 1 and €10.43 in Study 2. In both cases the max. payoff was €40.

Study 1 (City) took place from November 23rd to December 15th 2010 in Granada, Spain. A total of 835 individuals between 16 and 91 years old participated (average age 38.5±17.5 [SD], 53.9% female, 22% college students). The experiment was carried out in the subjects' houses and data were collected by 108 pairs of senior-year university students who had previously undergone a 10-hour training program on the methodology of field experiments. The sample was obtained via a stratified random method, which ensured its representativeness. Extended information on the sampling procedures and the resulting sample has been previously reported (S1) and is also available at https://sites.google.com/site/experimentalcity/home.

The experiment in Study 2 (Lab) took place during October 2011 in the Granada Lab of Experimental Economics EGEO at the University of Granada. In this study, all first-year

[†] An English translation of the questionnaire and the complete experimental instructions (Study 1) are available at https://sites.google.com/site/experimentalcity/home.

students at the School of Economics, were invited to participate in the experiment during their first week of problem-solving classes. Thus, participants in Study 2 were "pseudo-volunteers".[‡] a sample of 659 students participated (average age 19.1±2.3 [SD], 58.1% female) in a total of 27 sessions.

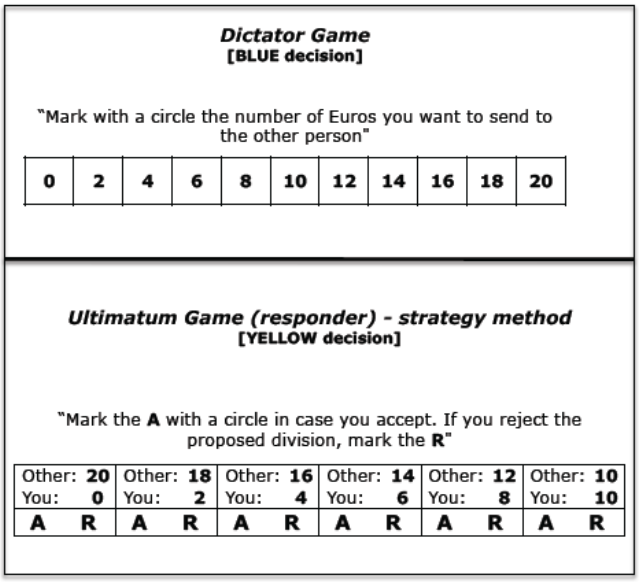
In the Dictator Game (DG), subjects had to split a pie of €20 between themselves and another anonymous participant (S3). Subjects decided which share of the €20 (in €2 increments) they wanted to transfer to the other subject. For the role of responder in the Ultimatum Game (UG), we used the strategy method (S4). That is, subjects had to state their willingness to accept or reject each of the following proposals (proposer's payoff [€], responder's payoff [€]): (20, 0); (18, 2); (16, 4); (14, 6); (12, 8); (10, 10).

With this method we obtained the minimum acceptable offer (MAO) of each subject. For the analyses in this paper, we only consider subjects with complete and reliable observations in both decisions. This involves excluding from the sample those subjects with missing values in any of the two decisions and those making inconsistent choices (i.e., those following non-monotonic patterns or making multiple switching between acceptance and rejection) as responders in the UG. Finally, we excluded subjects that transferred more than 50% of the pie in the DG (5.3% in Study 1 and 3.4% in Study 2) since our interest is in fairness-based versus spite-based behavior; transfers above the equal split, although obviously generous, cannot be easily linked to any fairness norm. The resulting sample sizes used in the analyses are n=754 in Study 1 and n=623 in Study 2.

An English translation of the experimental instructions for Study 1 (only minor adjustments were made for Study 2) can be found in section S3. In Study 1, the instructions were read aloud by the interviewer and subjects had to write their decisions on a decision sheet which was subsequently placed in a sealed envelope (see Figure S1 for an English translation of the decision sheet). For Study 2, the procedures were computerized using an online web-based system.

[‡] It has been found that pseudo-volunteer students are more generous than the typical student subjects who volunteer in laboratory economic experiments (S2). Indeed, we find that offers in the DG are above what is normally observed within student samples.

Figure S1. Decision sheet (Study 1)



Dictator Game
[BLUE decision]

"Mark with a circle the number of Euros you want to send to the other person"

0	2	4	6	8	10	12	14	16	18	20

Ultimatum Game (responder) - strategy method
[YELLOW decision]

"Mark the **A** with a circle in case you accept. If you reject the proposed division, mark the **R**"

Other: **20** You: **0**		Other: **18** You: **2**		Other: **16** You: **4**		Other: **14** You: **6**		Other: **12** You: **8**		Other: **10** You: **10**	
A	**R**	**A**	**R**	**A**	**R**	**A**	**R**	**A**	**R**	**A**	**R**

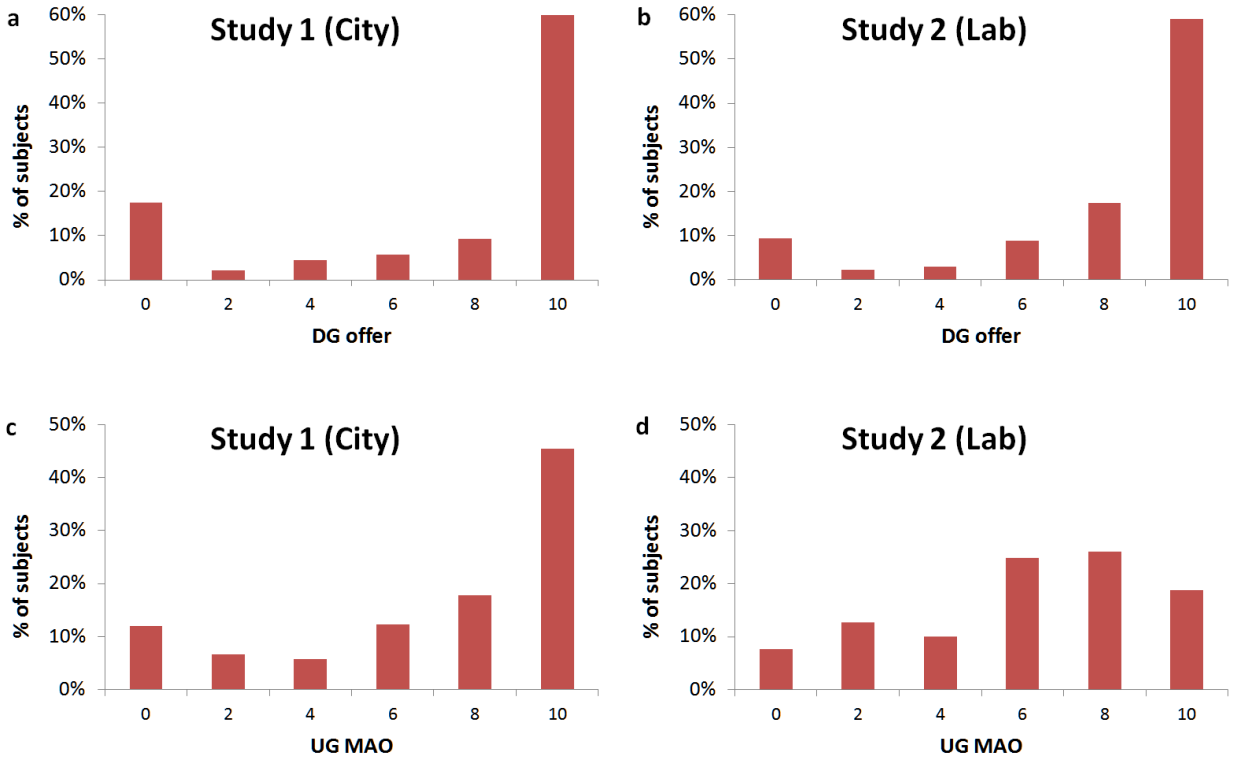
S2. Supporting analyses

The average (±SD) DG offer and UG MAO were, respectively, €7.40±3.87 and €7.07±3.53 in Study 1, and €7.99±3.18 and €6.10±3.04 in Study 2. This behavior is consistent with previous findings (S5, S6). Figure S2 presents the histograms of DG (panels a and b) and MAO (panels c and d) decisions for the final sample of both studies. It can be observed that the distributions of choices in the DG were similar in the two studies although €0 transfers were more frequent in Study 1, while €8 (40% of the pie) transfers were more frequent in Study 2.

On the other hand, the distribution of MAOs is clearly different between the studies, particularly in terms of the subjects' willingness to reject unequal offers, which constitutes the focus of the paper: while 45.49% of subjects in Study 1 set their MAO to €10 (i.e., rejecting any offer below the equal split), the percentage sharply decreases to 18.78% in Study 2. Students in Study 2 appear to be "less strict" responders, setting their MAOs to €6 or €8 more frequently than subjects in Study 1. We do not think, however, that these differences discredit our basic results. Rather the opposite: as we discuss later, despite

using two samples with different rejection behavior, the *relationship* between the subjects' willingness to reject unequal offers in the UG and their behavior in the DG follows an almost identical pattern in the two studies.

Figure S2. Distribution of subjects' choices in the games



Nevertheless, in terms of rejecting very low offers, the differences between Study 1 and Study 2 are less striking. Offers of €4 or less were rejected by 75.6% and 69.7% of subjects, respectively. This is also congruent with previous literature as rejection rates up to 80% have been observed for offers below 25% of the stake (S5).

In Tables S1 (Study 1) and S2 (Study 2) we present the estimations of the models used to support the results of the paper. In all regressions, the dependent variable is the likelihood of rejecting an unequal offer in the UG, that is, whether the subject set her MAO to €10. We present Probit estimates for the comparison between "unfair" (DG transfer=0) and "remaining" (0<transfer<10) dictators, between "fair" (transfer=10) and "remaining"

dictators, and between "unfair" and "fair" dictators. The coefficients together with their standard errors and *p*-values are displayed for each comparison.

Table S1. Impact of DG behavior on the likelihood of rejecting unequal offers (Study 1)

	(1)	(2)	(3)	(4)
unfair – remaining	0.446*	0.424*	0.481*	0.457*
	(0.157)	(0.151)	(0.163)	(0.156)
p-value	0.005	0.005	0.003	0.003
fair – remaining	0.647**	0.628**	0.631**	0.610**
	(0.124)	(0.120)	(0.129)	(0.124)
p-value	0.000	0.000	0.000	0.000
unfair – fair	-0.201	-0.204	-0.150	-0.153
	(0.131)	(0.124)	(0.136)	(0.129)
p-value	0.123	0.100	0.271	0.234
order effects	YES	NO	YES	NO
pseudo R^2	0.0565	0.0275	0.0705	0.0399
log likelihood	-490.208	-505.274	-470.687	-486.208
LR (chi^2)	58.71**	28.58**	71.44**	40.39**
Controls	no	no	yes	yes
observations	754	754	735	735

Notes: Probit estimates. Standard errors in brackets. *, ** indicate significance at the 0.01 and 0.001 levels, respectively. In columns (3) and (4), controls are: age, gender, household income, educational level, and cognitive abilities. The sample is reduced (19 observations) due to missing values in control variables.

In column (1) of both tables we show regressions controlling for the order in which decisions were made. These are the results reported in the main text. Column (2) presents estimates for regressions without controlling for order effects. In columns (3) and (4) we repeat the same regressions adding a set of controls consisting of basic socio-demographic variables (age, gender, educational level, and household income) and a proxy for cognitive abilities (number of correct responses to a series of simple mathematical questions). The samples are slightly reduced for the regressions displayed in columns (3) and (4) due to

missing values in control variables. As can be observed, the results are robust to all of these specifications in both studies. The likelihood of "fair" and "unfair" dictators rejecting unequal offers in the UG is not significantly different, while both groups are significantly more likely to reject unequal offers than the "remaining" dictators. We also checked the effect of clustering standard errors by interviewer in Study 1, as in (S1). *P*-values slightly increase in all cases but none of the significant comparisons exceeds p=0.013. Two-tailed Fisher's exact tests also yield nearly identical results (departures from the *p*-values shown in column (1): unfair vs. remaining, p=0.007; unfair vs. fair, p=0.114 in Study 1; unfair vs. fair p=0.324 in Study 2).

Table S2. Impact of DG behavior on the likelihood of rejecting unequal offers (Study 2)

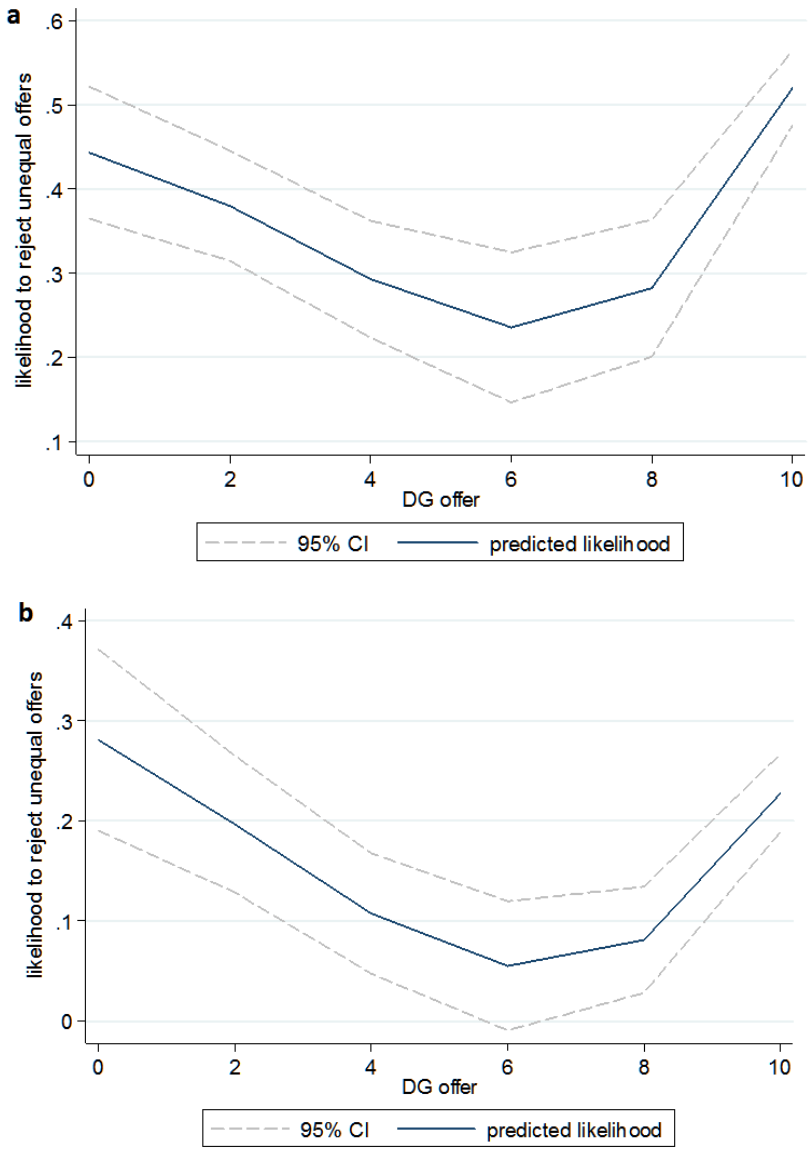
	(1)	(2)	(3)	(4)
unfair – remaining	0.834**	0.835**	0.769*	0.788**
	(0.227)	(0.216)	(0.233)	(0.221)
p-value	0.000	0.000	0.001	0.000
fair – remaining	0.653**	0.650**	0.609**	0.612**
	(0.155)	(0.148)	(0.157)	(0.150)
p-value	0.000	0.000	0.000	0.000
unfair – fair	0.181	0.186	0.160	0.176
	(0.196)	(0.187)	(0.202)	(0.192)
p-value	0.356	0.321	0.428	0.360
order effects	YES	NO	YES	NO
pseudo R^2	0.0784	0.0412	0.0865	0.0473
log likelihood	-277.328	-288.522	-270.708	-282.314
LR (chi^2)	47.19*	24.80**	51.24*	28.03**
Controls	no	no	yes	yes
observations	623	623	615	615

Notes: Probit estimates. Standard errors in brackets. *, ** indicate significance at the 0.01 and 0.001 levels, respectively. In columns (3) and (4), controls are: age, gender, household income, and cognitive abilities (educational level is constant in this study). The sample is reduced (8 observations) due to missing values in control variables.

Among the control variables included in the regressions of columns (3) and (4), only the coefficients of the subject's age and educational level are statistically significant. In both studies, older subjects are more likely to reject unequal offers. For columns (3) and (4), respectively, the coefficient of age reports a *p*-value of 0.038 and 0.039 in Study 1 and of 0.052 and 0.059 in Study 2. The coefficients of educational level are negative and the *p*-values are 0.074 and 0.044, respectively, in Study 1 (in Study 2, educational level was constant across subjects as all were university students). These effects, although only marginally significant in some cases, can partially explain the higher proportion of subjects setting their MAO to €10 in Study 1: subjects were on average older and less educated in that sample.

In Figure S3 we plot the likelihood of subjects rejecting an unequal offer in the UG as a function of their transfers in the DG using a fractional polynomial model. The predictions of the model for Study 1 are displayed in panel a, and those for Study 2 in panel b. We observe that the above results are not due to the aggregation of subjects offering an amount between €0 and €10 within the group of "remaining" dictators. Specifically, Figure S3 shows that, in both studies, dictators offering €6 are the least likely to reject an unequal offer and that the likelihood increases as we move either to the left ("unfair" dictators) or to the right ("fair" dictators). A quadratic regression analysis (not reported) also reveals a significant U-shaped relationship (in all cases, both the linear and the quadratic term report p=0.000). As mentioned earlier, the fact that subjects in Study 2 are less likely to set their MAO to €10 does not imply any change in terms of the relationship between such behavior and subjects' offers in the DG. This supports the existence of both spite- and fairness-driven punishers in the UG, even across very different samples.

Figure S3. Rejection of unequal splits as a function of DG offers. (a) Study 1, (b) Study 2



S3. Game instructions (Study 1)

In this part, you are going to make decisions with real money. This money comes from a national research project to be used specifically for this purpose. The money you will earn depends on 5 decisions that you are going to make later. Your decisions are totally independent of each other. You have to make the decisions that you prefer in each situation, without taking into account your decisions on the other situations. You are going to be paid for only one decision.

We will make a draw in which 1 out of 10 people will earn the real amount of money corresponding to the decision s/he has taken. Moreover, the decision that really "pays" among the 5 will be drawn randomly. For this reason, think carefully about your decisions because if you are drawn, what you have declared will be taken into account for your payment. In case you are drawn, we will make your payment within a few days.

The money you earn might also depend on the decisions of another person. Let us explain: for the 5 decisions you are going to be paired with another person. For each decision, your pair will be different and randomly selected. This person is another interviewee but none of you can identify the other, only that it is a person also living in Granada – we do not even know who s/he is. Anonymity is totally guaranteed. This is why not even we are going to know the decisions you make in this part. For this reason, I am going to give you a sheet to write down your answers. After you write down your answers, please place them in an envelope without letting us look at them. When I ask you, do not say your decisions out loud, just fill in the answer sheet.

Dictator Game:

For this decision, we give you 20€ in order for you to divide it between you and the other person. From this amount you can send the share you want to the other person, that is, you can send nothing, everything, or just a part. Obviously, the part that you do not send is for you to keep. How much money do you send to the other person? In the **BLUE** table you have to mark with a circle the number of euros you want to SEND to the other person. You can only choose even numbers: (0, 2, 4,…, 20).

Ultimatum Game (responder):

In this part, we give you 20€ in order for you to divide it between you and the other person. One of you is going to propose how to divide it, while the other can either accept or reject the proposed division. If s/he rejects it, none of the two will earn anything. For example: the one who decides the division sends 4€ to the other, keeping 16€ for him/herself and the other accepts it. Hence, the one who divides earns 16€ and the other, who accepts the division, earns 4€. In contrast, if s/he does not accept the proposed division none of the two will earn anything. Understood? Decisions:

If you are the one who receives the money sent by the other person, you can accept or reject the division. If you accept the proposed division, you have to mark the **A** in the **YELLOW** table with a circle. If you reject the proposed division, mark the **R** but do not say out loud that you rejected it. If s/he sends you:

- 0€ and keeps 20€, you accept or reject the proposed division (A or R in the first cell of the YELLOW table). Remember that a rejection means that nobody earns anything.
- …
- 10€ and keeps 10€ (A or R in the last cell of the YELLOW table)

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