Asymmetric Social Distance Effects in the Ultimatum Game

Orestis Vravosinos[1] and Kyriakos Konstantinou[2*]

[1] *Universitat Pompeu Fabra, Spain; orestis.vravosinos@upf.edu*
[2] *London School of Economics, UK*

ABSTRACT

We argue that in the ultimatum game the effects of altruistic behavior and reciprocity vary more in the spectrum of positively compared to negatively-valenced relationships. Thus, we suggest that social distance effects are asymmetric. Our experimental results support this hypothesis; in the region of positively-valenced relationships, the proposers increase the percentage they offer as relationship quality increases more drastically compared to when the relationship is negatively-valenced, in which case they appear more invariant to relationship effects. Also, by eliciting a minimum share which the responder is willing to accept out of the total sum, we provide clearer results on the social distance and stakes effects on the latter's behavior. We find a negative effect of relationship quality on the minimum acceptable share. This contradicts a strand of the literature which suggests that closer-"in-group" individuals may be punished more severely, so that cooperation in a group is maintained.

Keywords: ultimatum game; social distance; other-regarding behavior; relationship; negative valence; asymmetry; stakes

JEL Codes: C70, C91, D63, D91

1 Introduction

Based on Gintis (2014) and Kreps (1990) we first describe the ultimatum game. Two players are given a sum of money and are asked to distribute it between the two of them with player 1 (the proposer, who will be referred to as "she") making a distribution proposal and player 2 (the responder, who will be referred to as "he") responding to the offer. If he accepts it, the distribution takes place as proposed by player 1; if he declines, none of the players receives any money. No negotiation or actions of player 2 affecting player's 1 proposal are allowed.

Under the assumptions of rationality, players' "materialistic selfishness" (strictly increasing preferences over own monetary reward and invariant preferences over the opponent's payoff), perfect and complete information, and perfect divisibility of the total sum of money, there is a unique subgame perfect equilibrium where player 1 offers no money to player 2 and the latter accepts the offer.[1] However, player 1 may not know player's 2 type (incomplete information).[2] More importantly, Güth (1995) underlines that the assumption of perfect rationality is unrealistic and can only be thought of as an "as if"-explanation. People often rely on what they consider fair or justified and player 2 punishes if player 1 asks for "too much" often sacrificing significant amounts of money (Güth *et al.*, 1982; Güth and Tietz, 1990).

In this context, studies have examined how the impact of the sense of fairness on players' actions may vary, while other factors change. It has been argued that increased stakes (larger sum of money distributed) can reduce sensitivity to fairness of player 2 making it more likely that he accepts lower shares of the total sum, thus, giving player 1 the op-

[1] The perfect divisibility assumption is inessential in the sense that even if the division can only be made in increments, the equilibria of the game—contrary to experimental evidence—still feature a vast imbalance in the shares the two players receive. Namely, apart from the stated equilibrium there would be one more equilibrium in which player 2 rejects the proposal where he receives nothing and accepts any proposal where he receives a positive amount and player 1 offers one increment of the total sum (*e.g.,* 99 cents go to player 1 and 1 cent to player 2 out of a total of €1).

[2] For example, Forsythe *et al.* (1994) suggest that the ultimatum game can be treated as one, where there are multiple types of players concerned with fairness to varying degrees. Apart from "fair" players, Slembeck (1999) also documents a large percentage of "tough" players in his experiments.

portunity to offer a lower share (*e.g.,* Kim *et al.*, 2013; Bechler *et al.*, 2015). Social distance has also been found to affect fairness considerations (*e.g.,* Hoffman *et al.*, 1996a; Slonim and Roth, 1998; Cameron, 1999; Munier and Zaharia, 2002; Andersen *et al.*, 2011; Bechler *et al.*, 2015).

In the existing literature, social distance commonly varies only from players being close relatives or friends to complete strangers, even though negatively-valenced relationships can be important from an economic point of view. For example, literature has stressed their relevance in organizations and the workplace (Labianca and Brass, 2006; Morrison and Nolan, 2007; Laurence *et al.*, 2018; Venkataramani *et al.*, 2013; Parthasarathy and Forlani, 2016), networks (Easley and Kleinberg, 2010), business-to-business relationships (Doney and Cannon, 1997) and consumers' engagement in market-related behavior (Heinonen, 2018).

Our study aims to fill this gap by introducing negatively-valenced relationships between the players and testing for asymmetries in their behavior, when the relationship is negatively compared to positively-valenced. Our survey-based experimental results suggest that in the region of positively-valenced relationships the proposers increase the percentage they offer as relationship quality increases more drastically compared to when the relationship is negatively-valenced, in which case they appear more invariant to relationship effects.

In our experiment, subjects state the strategy that they would follow under a hypothetical situation where they play the game. This way we elicit a minimum acceptable proportion from player 2 and provide clearer results on social distance and stakes effects in the latter's behavior. We find a negative effect of relationship quality on the minimum percentage acceptable by player 2. This contradicts a strand of the literature (*e.g.,* see Fehr and Gächter, 2002; Shinada *et al.*, 2004) which suggests that cooperation in groups is maintained through punishment of noncooperators, which could entail that selfish behavior of player 1 is more likely to face punishment when the relationship of the players is closer.

The rest of the paper is organized as follows: after this short introduction, section 2 reviews the literature on stakes and social distance effects and section 3 describes the experimental design and presents the hypotheses tested along with the statistical methods employed to test them. Finally, section 4 presents and discusses the results and the last section concludes.

2 Literature Review

In this section, we first review the literature on social distance and stakes effects.[3] Next, we provide concepts that can help explain such effects on players' behavior.

2.1 Social Distance Effects

One stream of studies on social distance effects focuses on the degree of anonymity. In their dictator game experiments, Hoffman *et al.* (1996b) vary the distance-degree of anonymity between the dictator and the experimenter—and, presumably, the degree of reciprocity in their relationship—to find that when a higher degree of anonymity is ensured, players tend to offer less. Charness and Gneezy (2008) report higher portions allocated by dictators, when the latter know the family name of their counterparts. However, in the ultimatum game they trace no such effect explaining that strategic considerations seem to prevail over generosity or charity impulses. In Bolton and Zwick's (1995) ultimatum game experiments, experimenter-subject anonymity can explain part of the deviation from the game-theoretic equilibrium, as 46% of the games under anonymity is in equilibrium opposed to 30% when there is no anonymity.[4] In Eckel and Grossman (1996), dictators offer more when their counterpart is an established charity versus an anonymous subject.

Another stream of the literature examines social distance effects as a result of relationship closeness. In the studies of Jones and Rachlin (2006) and Rachlin and Jones (2008a), Rachlin and Jones (2008b), and Rachlin and Jones (2010), where social distance varies from 1 (dearest friend) to 100 (mere acquaintance), the lower the social distance between the participants, the larger the amounts of money they are willing to forsake in order for the other player to receive money. In

[3] For a broader review of the literature on the ultimatum game, see van Damme *et al.* (2014), Güth and Kocher (2014), Camerer (2003), Bearden (2001), Camerer and Thaler (1995), Güth (1995) and Güth and Tietz (1990).

[4] However, they find the punishment hypothesis to explain deviations even better.

Kim *et al.* (2013) player 2 replies to an offer by a hypothetical proposer imagining that he played the ultimatum game (i) for themselves, (ii) on behalf of their best friend, (iii) on behalf of a stranger. When the recipient is represented in a more distant manner, subjects accept unfair offers more easily due to a more "objective" perspective induced by increased psychological distance. Bechler *et al.* (2015) vary social distance between the players (*i.e.,* relative, non-relative, "abstract" recipient/no specific person in mind) to find that the proportion offered decreases as social distance increases.

2.2 Stakes Effects

Bechler *et al.* (2015) also research stakes effects to conclude that the proportion of the amount the proposers offer decreases as the size of the total sum distributed increases. Research on these effects is no new to the ultimatum game literature. Tompkinson and Bethwaite (1995) find that individuals are less concerned with fairness (*i.e.,* relative payoffs), when the total sum is larger. Andersen *et al.* (2011) conclude that when stakes are high, player 1 offers lower proportions, while player 2 almost fully converges to full acceptance of low offers, even in the absence of learning (subjects played the game only once). Further studies have documented similar results, although proposers are often found reluctant to decrease the shares they offer as stakes increase (Slonim and Roth, 1998; Cameron, 1999; Munier and Zaharia, 2002; Carpenter *et al.*, 2005).

2.3 Causes of social distance and stakes effects

Alternate concepts can be employed to explain players' behavior in regard to fairness, social distance and stakes effects: (i) pure preference towards fairness (other-regarding behavior) (Hoffman *et al.*, 1994; Hoffman *et al.*, 1996b; Forsythe *et al.*, 1994; Bolton and Zwick, 1995; Bohnet and Frey, 1999; Nagel, 2001; Rulliére, 2001), (ii) altruism towards deserving counterparts, identifiability and empathy (Eckel and Grossman, 1996; Bohnet and Frey, 1999; Burnham, 2003; Charness and Gneezy, 2008),[5] (iii) reciprocity (Hoffman *et al.*, 1996b; Bohnet and

[5]See Schelling (1968) and Jenni and Loewenstein (1997) for an analysis of these concepts.

Frey, 1999; Hoffman *et al.*, 2008; Dhaene and Bouckaert, 2010; Nicklisch and Wolff, 2012; Neo *et al.*, 2013), (iv) strategic considerations—possibly regarding repercussions in future interactions between the players (Hoffman *et al.*, 1994; Forsythe *et al.*, 1994; Bolton and Zwick, 1995; Zamir, 2001; Nagel, 2001; Rulliére, 2001; Charness and Gneezy, 2008),[6] (v) social concern for reputation (Piazza and Bering, 2008; Vignolo, 2010; Avrahami *et al.*, 2013; Gomaa *et al.*, 2014) and (vi) trust (Dunn and Schweitzer, 2005; Hergueux and Jacquemet, 2015).

Burnham and Johnson (2005) describe an "evolutionary legacy hypothesis" suggesting that cooperative behavior can be attributed to the value cooperation used to have in ancestral environments. They argue that the brain design inducing this tendency towards cooperation was selected over millions of years and has thus persisted until today, even though society has rapidly transformed in recent times; as a result, human cooperative mechanisms are not in equilibrium with the current environment. Johnson *et al.* (2003) stress the importance of punishment from external institutions in enhancing cooperation. They argue that even in pre-industrial times, when the enforcing institutions of modern states were absent, religion promoted cooperation through taboos, codes of conduct and the "threat" of divine punishment for those breaking these codes of conduct.

3 Methodology and Hypotheses tested

The invariance of player 1 to stake shifts is a caveat that researchers have been faced with when trying to examine player's 2 responses to low offers (rarely made by proposers). Andersen *et al.* (2011) have described this as a "challenging issue for the literature". Another limitation in studies has been the range of stakes that can be offered.[7] To overcome these limitations, we ask subjects to state how they would act under a hypothetical situation where they would play the game. This allows us to "offer" arbitrarily large stakes and ask player 2 to

[6]Repeated games have also been widely discussed in the literature. See for example Slembeck (1999), Königstein (2000), Anderhub *et al.* (2004) and Avrahami *et al.* (2013).

[7]Scientists have often chosen to conduct their experiments in low income regions in order to be able to provide relatively strong financial incentives.

cite the minimum amount he would accept out of the total sum instead of having him respond to a specific offer. Similar procedures have been employed before (Tompkinson and Bethwaite, 1995; Jones and Rachlin, 2006; Rachlin and Jones, 2008a; Rachlin and Jones, 2008b; Rachlin and Jones, 2010; Novakova and Flegr, 2013; Bechler *et al.*, 2015). Thus, although a limitation is posed by the hypothetical nature of the responses, this aspect of the experimental design also features important advantages. At the same time, we have taken measures to mitigate concerns regarding this limitation (see for example footnote 8).

3.1 Experimental Design

The sample consists of 94 people, most of whom were second-year undergraduate students of accounting and finance at the University of Macedonia. Randomly selected students of this second-year class were orally and personally invited to participate after the lectures at the university. Participation in the experiment was voluntary and no one of those invited refused to participate. A concern can be raised from the voluntary nature of subjects' participation. As the number of rounds played by each subject depended on the time constraint of the subject and in the absence of monetary incentives, the more altruistic ones may have been likely to devote more time for the experiments. We address this concern by running some robustness tests described below in subsection 3.3.

At the same time, Camerer and Hogarth (1999) suggest that increased incentives do not substantively affect subjects' average behavior in bargaining games, but they can matter as long as other-regarding behavior and generosity are seen as socially desirable. The fact that no individual of those invited refused to participate can alleviate concerns of a self-selected sample bias caused by the absence of a show-up fee. We conducted the experiments face-to-face with each subject separately.[8] The instructions to the subjects are presented in detail in the Appendix; at this point, we briefly describe the procedure.

[8] A concern in the literature in this type of games is that lack of subject-experimenter anonymity could lead to very generous offers due to a potential "experimenter effect" (*e.g.,* see Hoffman *et al.*, 1994). However, the results are mixed. For example, Barmettler *et al.* (2012) find that the presence of experimenter-subject anonymity in the dictator game and the ultimatum game only slightly lowers the

First, the game was explained to the subject and the subject was randomly assigned the role of the proposer or that of the responder.[9] Then, the subject was asked to bring to mind a person and evaluate their relationship (R) in a scale from -10 (worst possible) to $+10$ (best possible),[10] imagine playing the game with that person and state what strategy they would follow in the game.[11] That is, in the case the subject had been assigned the role of player 1, she was asked to state what allocation (A_1, A_2) of the total sum she would propose, where A_i the amount going to player i. When their role was that of player 2, the subject was asked to state the minimum A_2 ($\min A_2$) for which he would accept the allocation (A_1, A_2) as a proposal by the person he had brought to mind. The question was repeated for each value of the total sum (*i.e.,* $TS =$ €10, 100, $1,000$, $10,000$, $100,000$, $1,000,000$).[12]

Then, the subject was asked to bring another person (opponent)

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offers made by dictators and proposers with the effect being statistically insignificant.

At the same time, the face-to-face approach helps balance the limitations posed by the hypothetical nature of the experiment, as it can ensure a higher quality of responses and better comprehension of the game by the subjects compared to other experimental designs, where the experiment is conducted in written form or through a computer (*e.g.,* as in Tompkinson and Bethwaite, 1995; Jones and Rachlin, 2006; Rachlin and Jones, 2008a; Rachlin and Jones, 2008b; Rachlin and Jones, 2010; Novakova and Flegr, 2013; Bechler *et al.*, 2015). For example, face-to-face survey respondents have been shown to be less prone to satisficing and respond more properly compared to web or telephone survey respondents thanks to nonverbal communication allowed in face-to-face surveys (*e.g.,* see Krosnick, 1991; Holbrook *et al.*, 2003; Heerwegh and Loosveldt, 2008). In the conduct of the experiment there were cases where the game and the procedure were explained to the subject a second time, while in a non "face-to-face" design, the subjects could have proceeded to answer without a firm understanding of what their responses mean.

[9] A balance between the number of players 1 and 2 was maintained.

[10] In our context, a "good", positively-valenced relationship means that the subject gets along with the person they have brought to mind. The relationship is not necessarily related to the frequency of interaction between them. This is especially relevant for negatively-valenced relationships, where the subject and the person they have brought to mind may eschew interaction. The relationship still denotes the "attitude" towards one another (*e.g.,* a sense of mutual dislike, a feeling of discomfort when interacting or being in the same environment).

[11] They could also be asked to answer assuming they played the game with an abstract opponent, a complete stranger (R=0).

[12] (A_1 and A_2) had to be non-negative integers. When $TS >$ €10, they had to be multiples of $TS/100$.

to mind and the whole procedure was repeated (1-6 times in total).[13] Table 1 presents the number of subjects for whom the procedure was performed $1, 2, \ldots, 6$ times. One could fear that those who are assigned the role of the proposer are more likely to think of positive relationships compared to negative ones. However, the subjects were guided with respect to what person (*i.e.*, of what relationship quality) they would bring to mind, so that there is a sufficient spread for both player 1 and player 2 responses.[14] Table 2 shows the number of opponents against whom the subjects cited their strategy by relationship quality, which confirms that the role assigned is not positively correlated with relationship quality.[15] The mean relationship quality is 2.72 and 3.22 for player 1 and player 2, respectively.

Each session lasted approximately 10 minutes (depending on the number of times the procedure was repeated) and subjects responded verbally. None of the respondents was asked to answer both as player 1 and 2. The sample of 94 subjects multiplied by 6 (for $TS =$ €10 $, \ldots, 1,000,000$) and by approximately 3.2 (the average number of opponents each respondent cited their strategy against) generated $1,806$ observations (936 for player 1 and 870 for player 2).[16]

Table 1: Number of subjects asked for $1, 2, \ldots, 6$ different opponents

# of opponents	1	2	3	4	5	6	Total
# of player 1 subjects	1	12	17	12	4	2	48
# of player 2 subjects	3	4	29	4	5	1	46

Note: for example, 29 of the 46 player 2 subjects were asked for 3 different opponents.

[13] The procedure was repeated for a (random) number of times/opponents (1 to 6) based on the amount of time the subject was available. Ideally, every subject would participate for the same number of opponents, but this would greatly limit the sample size.

[14] To ensure an adequate spread of relationship ratings, we often explicitly asked subjects to bring a person they had a (very) good/bad relationship with. However, subjects were sometimes unable to think of a person for whom R was too low below zero. Thus, although a sufficient spread is ensured, there are more cases where $R > 0$.

[15] A simple χ^2-test for independence using the grouping of Table 2 returns a p-value of 17.8% suggesting no systematic differences.

[16] The data are available upon request.

Table 2: Number of opponents by relationship quality

Relationship class	$[-10,-9]$	$[-8,-7]$	$[-6,-5]$	$[-4,-3]$	$[-2,-1]$	0	$[1,2]$	$[3,4]$	$[5,6]$	$[7,8]$	$[9,10]$
# of opponents for player 1	15	4	6	4	5	24	7	8	13	20	50
# of opponents for player 2	10	7	11	4	3	28	4	4	10	33	31

Note: for example, in total, player 2 subjects replied for 11 opponents of relationship quality -5 or -6.

3.2 Hypotheses

Let $PO = A_2/TS$ denote the percentage of TS that player 1 stated she would offer to player 2 and $MPA = \min A_2/TS$ the minimum percentage of TS player 2 would accept as an offer by the person he had brought to mind. Table 3 presents the means of PO and MPA for each value of TS. Figures 1 and 2 present the means and outline the distributions of PO and MPA by relationship class and for each value of TS. First, we test the following four hypotheses:

Hypothesis 1. *As TS increases, PO decreases.*

Hypothesis 2. *As TS increases, MPA decreases.*

Hypothesis 3. *As R increases (social distance decreases), PO increases.*

Hypothesis 4. *As R increases (social distance decreases), MPA decreases.*

Table 3: Mean PO and MPA by total sum and relationship quality sign

TS (in €) $/R$ sign	10	10^2	10^3	10^4	10^5	10^6	$R>0$	$R=0$	$R<0$
Mean PO (%)	36.99	37.41	32.51	30.49	27.81	15.25	34.89	30.37	23.70
Median PO (%)	40	40	30	30	30	20	40	30	20
Mean MPA (%)	37.72	35.79	32.40	28.26	24.35	22.57	27.11	30.14	37.41
Median MPA (%)	50	40	40	30	20	15	25	35	50

Notes: these descriptive statistics are only meant to outline the general behavior of the participants; not to be used for inference, as the mean and median by TS value depend on the specific distribution of R in the sample and vice-versa and those by R sign on the distribution of R itself within the subsample.

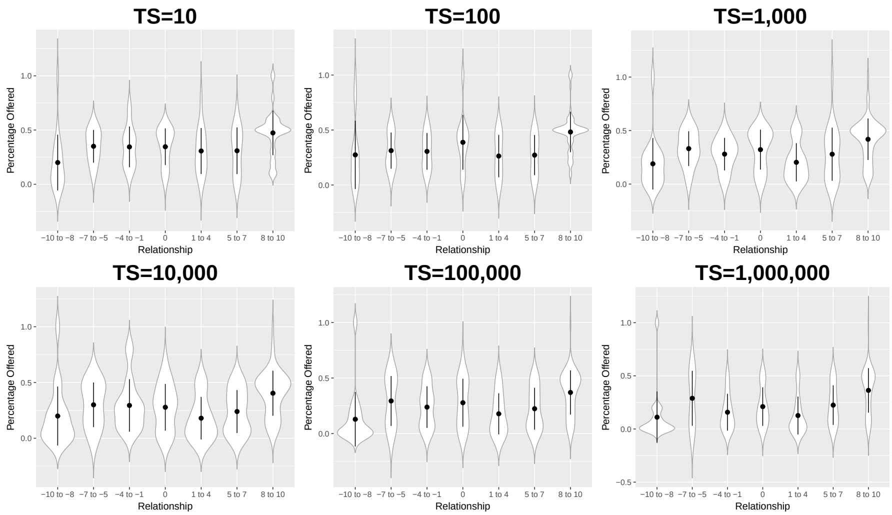

Figure 1: Violin plots for player 1 mean PO by relationship class for each TS value
Note: the black solid lines are standard deviation bars.

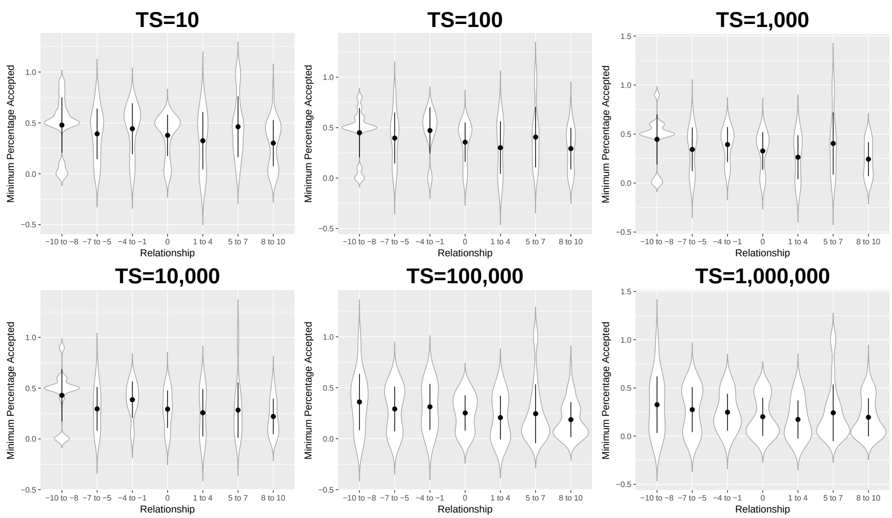

Figure 2: Violin plots for player 2 mean MPA by relationship class violin plots for each TS value
Note: the black solid lines are standard deviation bars.

Although relationship closeness "steadily" increases from $R = -10$ to $R = 10$, the same may not hold for relationship-social distance effects. Altruistic and empathetic behavior of the proposer towards the responder may not vary (increase) as significantly in the region of negative relationships compared to the region of positive relationships; disliking a person "less" can be expected to have a less pronounced (positive) effect on altruistic behavior than having a closer positively-valenced relationship—compared to a less close positively-valenced one. Similarly, social distance effects stemming from reciprocity may be weaker in the region of negative relationships. Such an asymmetry may be amplified by strategic considerations for future interactions, given that "negatively-related" individuals probably eschew interaction with each other "however much" negative their relationship is, while the frequency of future interactions can more significantly increase with the closeness of a positively-valenced relationship.

Thus, we expect social distance–relationship effects to be asymmetric for negative compared to positive relationships; that is, stronger in the latter case.[17] This asymmetry is mainly expected for player 1, as the parameters of social distance discussed above mostly influence their behavior. However, we also test for asymmetric relationship effects in the behavior of player 2. We test the following hypotheses:

Hypothesis 5. *When $R > 0$, $\partial PO/\partial R$ is higher compared to when $R < 0$.*

Hypothesis 6. *When $R > 0$, $\partial MPA/\partial R$ is lower (higher in absolute value) compared to when $R < 0$.*

3.3 Statistical Methods

As our dependent variables PO and MPA assume values in the unit interval $[0, 1]$, we employ beta regression developed by Ferrari and Cribari-Neto (2004) to test our hypotheses.[18] Since the two vari-

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[17] Although, to the best of our knowledge, there is no literature of such asymmetries in the ultimatum game or any other similar context, there have been a few studies examining asymmetric effects of negatively compared to positively-valenced relationships. For example, Labianca and Brass (2006) have argued that negative relationships can explain workplace outcomes better than positive relationships.

[18] This nature of the dependent variables inherently incorporates greater variability and captures the spectrum of the subjects' behavior more completely than a

ables assume the extremes 0 and 1 and the standard beta distribution assumes values only in the open interval $(0, 1)$, we use Smithson and Verkuilen's (2006) transformation $(y \cdot (n-1) + 0.5)/n$, where $y = PO, MPA$ and n the sample size.[19] The common logarithm of the total sum is used in the regressions. This log-transformation essentially produces an ordinal variable. The independent variables are described in Table 4. Apart from estimating separate coefficients for $R > 0$ and $R < 0$ (using the variables R^+ and R^-) and testing for equality of the coefficients (Wald test), we also use the square of R to test for asymmetries under non-linearity.[20] For player 1 (where the asymmetry is most expected as argued above) a positive and statistically significant coefficient of R^2 will suggest a "convex" relationship between R and PO; that is $\partial PO/\partial R$ will increase with R and thus will be higher for $R > 0$ compared to $R < 0$ supporting hypothesis 5.[21]

Beta regression allows us to perform tests for the asymmetric effects of hypotheses 5 and 6, which would not be possible under other statistical frameworks.[22] Also, it naturally incorporates features such as heteroskedasticity and skewness, which are inherent in proportion data and especially in the players' behavior. We estimate the models using the **betareg** package in R developed by Zeileis *et al.* (2016).[23] A Cauchy link function is used, as it maximizes the log-likelihood of the

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dependent dummy variable for whether player 2 accepted the offer or not. See for example Andersen *et al.* (2011), where a binary response model is employed.

[19] An alternative methodology could be the zero-one-inflated beta regression suggested by Ospina and Ferrari (2012), where the response variable follows a mixed continuous–discrete distribution with probability mass at zero and one. However, this would rather complicate than facilitate the examination of asymmetric effects, as in this model additional equations (coefficients) are estimated for the probability masses at zero and one apart from the equation for the continuous part of the distribution.

[20] We test equality of the coefficients using the *linearHypothesis* function of the **car** package in R; see Fox and Weisberg (2011).

[21] The term "convex" is loosely used and refers to the mean equation, as PO is a nonlinear function of R even for model (1) as shown in Figure 3 to follow. In other words, a positive coefficient of R^2 will suggest that $\partial PO/\partial R$ increases with R more than it would with a zero coefficient of R^2.

[22] For example, rank correlation tests, such as Jonckheere's 1954 employed in Hoffman *et al.* (1996b), or any bivariate method would not serve our purpose.

[23] For a review of the implementation of beta regression in R see Cribari-Neto and Zeileis (2010).

Table 4: Independent variables used in the analysis

Name	Description	Domain
R	Relationship quality between the subject and the opponent they brought to mind	$\{-10, -9, \ldots, 10\}$
R^+	$= \begin{cases} R & \text{if } R > 0 \\ 0 & \text{if } R \leqslant 0 \end{cases}$	$\{0, 1, \ldots, 10\}$
R^-	$= \begin{cases} 0 & \text{if } R \geqslant 0 \\ R & \text{if } R < 0 \end{cases}$	$\{-10, -9, \ldots, 0\}$
R^2	Square of R (not to be confused with the R-squared of the regressions)	$\{1, 4, 9, \ldots, 100\}$
$\log TS$	Common logarithm of the total sum	$\{1, 2, \ldots, 6\}$

models in most cases (see Table 7 in the Appendix).[24] The robustness of the results is tested using the variable dispersion beta regression model employed by Smithson and Verkuilen (2006) and formally introduced by Simas *et al.* (2010). This model allows for non-linearities and variable dispersion, as the precision parameter is not assumed to be constant in the whole sample, but instead is modeled similarly to the mean parameter. In our case, we allow dispersion to depend on R and $\log(TS)$.

To check for misspecification, we use the RESET-inspired diagnostic test employed by Cribari-Neto and Lima (2007).[25] We include the squared linear predictor as an auxiliary regressor in the mean equation and check its significance through a likelihood-ratio test. Significant results would indicate misspecification.

We also test the robustness of our results in subsamples created based on the number of repetitions of the experiment by the subject. The first subsample includes the subjects that hypothetically played against up to three people and the second those that reported strategies for four to six opponents, who could be argued as the more al-

[24] In all player 1 models the Cauchy link yields the highest log-likelihoods often with considerable difference from the rest. In player 2 models the log-log link yields the highest ones, but only with minimal differences from the Cauchy.

[25] See also Pereira and Cribari-Neto (2014) for misspecification testing in inflated beta regressions.

truistic ones. These robustness tests have relatively decreased power, as the number of observations for negatively-valenced relationships is decreased after splitting the sample; the second subsample includes a limited number of subjects, as can be seen in Table 1 (16 subjects in the case of player 1 and 10 for player 2).[26]

Last, a limitation is posed by the fact that each subject has given multiple responses given that standard beta regression does not account for dependencies in the dependent variable. Thus, we check the robustness of our results in a Generalized Additive Models for Location Scale and Shape (GAMLSS) framework estimating the models including random subject effects in the intercept, R and $\log(TS)$ coefficients.[27] GAMLSS were introduced by Rigby and Stasinopoulos (2005), who have also developed the **gamlss** package in R which we use to estimate these models.

4 Results & Discussion

Tables 5 and 6 present the estimated models for player 1 and 2 respectively.[28] The first four hypotheses are supported by models (1) in standard and variable dispersion beta regressions for both players. In player 1 models the $\log(TS)$ coefficients are all negative and statistically significant at the 1% level. Similarly, for player 2 they are negative and significant at the 1% level (in variable dispersion models even more so). R coefficients in models (1) for player 1 are positive and statistically significant at the 1% level, while for player 2 negative and significant at the 1% or 5% level depending on model specification. While this result for the effect of social distance on player 2's behavior is in accordance with those by Jones and Rachlin (2006), Rachlin

[26]The split cannot be more balanced as can be seen in Table 1.

[27]If it were not for the multiple responses, gathering a sample as large would not be possible. Alternate beta regression methods that try to accommodate within-subject correlation have recently been proposed; see, for example, the mixed effects models developed by Zimprich (2010), Verkuilen and Smithson (2012), Figueroa-Zúñiga *et al.* (2013), Wang and Luo (2015) and Bonat *et al.* (2015). Most of these five methods are Bayesian and in our case the selection of prior distributions would be "too arbitrary".

[28]The precision parameter equations of the variable dispersion models are available upon request. In these equations, R coefficients are significant in player 1 models, while $\log(TS)$ coefficients in player 2 models.

and Jones (2008a), Rachlin and Jones (2008b), and Rachlin and Jones (2010) and Halpern (1992) and Halpern (1994), it contradicts a strand in the literature which suggests that cooperation in groups is maintained through punishment of group members that do not cooperate (*e.g.,* see Fehr and Gächter, 2002; Shinada *et al.*, 2004). This could mean that selfish behavior of player 1 is more likely to face punishment from player 2, when their relationship is closer—and, thus, they are more likely to mutually belong in a group.[29]

Hypothesis 5 is also supported, as the Wald test for equality of the R^+ and R^- coefficients in models (2) is rejected at the 1% level. Models (3) show that PO is a convex function of R; $\partial PO/\partial R$ is positive and increasing in R and, thus, is higher for $R > 0$ (see Table 5).[30]

On the other hand, as expected, hypothesis 6 is not as strongly supported. Although in models (2) the R^+ coefficients are higher (in absolute value) than those for R^-, the Wald test for equality cannot be rejected. In models (3) the signs of the R^2 coefficients suggest that MPA is a concave function of R as anticipated, but the coefficients are not statistically significant (see Table 6).

Figures 3 and 4 present the expected PO and MPA, respectively, as functions of R based on separate standard beta regressions for each value of TS.[31] In Figure 3 we can observe that the asymmetric relationship effects ignored in model (1) are captured in models (2) and (3), especially for higher values of TS. For some values of TS the

[29] One could argue that in the region of negatively-valenced relationships, relationship quality and the probability of mutually belonging in a group could be negatively correlated, since in order for a really bad relationship to develop, individuals may need to belong (possibly not by choice) in the same group (*e.g.,* as coworkers). However, there is still evidence supporting this negative relationship between R and MPA when the latter is tested solely in the spectrum of positively-valenced relationships, where the positive relation between R and reciprocal behavior can hardly be questioned. The corresponding coefficient of R^+ in model (2) in Table 6 is negative and statistically significant at the 10% level in the standard beta regression and its p-value is close to 10% in the variable dispersion model.

[30] $\partial PO/\partial R = 0$ for $R \approx -9.5$.

[31] The models are as the ones described in Tables 5 and 6, but with no coefficient for $\log(TS)$, as the latter remains constant in each separate model. Results of these models are available upon request. Standard beta regressions are selected, as variable dispersion models for player 1 seem to suffer from misspecification based on the LR test (see Table 5), while for player 2 p-values for misspecification are lower in variable dispersion models as well.

Table 5: Player 1 models; dependent variable: PO (transformed)

	Standard beta regressions			Variable dispersion models		
	(1)	(2)	(3)	(1)	(2)	(3)
R	0.067***		0.057***	0.055***		0.037***
	(0.007)		(0.007)	(0.007)		(0.007)
R^+		0.085***			0.085***	
		(0.011)			(0.011)	
R^-		0.032*			−0.006	
		(0.017)			(0.017)	
R^2			0.003***			0.005***
			(0.001)			(0.001)
log(TS)	−0.126***	−0.125***	−0.126***	−0.125***	−0.125***	−0.126***
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
Constant	−0.482***	−0.618***	−0.628***	−0.404***	−0.634***	−0.622***
	(0.083)	(0.103)	(0.094)	(0.085)	(0.104)	(0.095)
$R^+ = R^-$ p-value		**0.0310**			**0.0001**	
Observations	936	936	936	936	936	936
R-squared	0.060	0.057	0.056	0.059	0.048	0.045
Log Likelihood	338.021	340.415	343.183	354.749	361.934	367.724
SIC	-648.6749	-646.6213	-652.1579	-668.4474	-675.9771	-687.5567
LR misspecification test χ^2 p-value	0.3315	0.5431	0.3897	0.0215	0.03171	0.01259

Notes: ***, **, * stand for significance at the 1%, 5% and 10% levels respectively. p-values lower than 0.0001 are reported as 0.0001. Coefficient standard errors in parentheses. "$R^+ = R^-$ p-value" refers to the χ^2 p-value of the Wald test for equality of the two coefficients: $H_0 : \beta_{R^+} = \beta_{R^-}$ against $H_1 : \beta_{R^+} \neq \beta_{R^-}$. SIC is the Schwarz information criterion. The last line gives the result of the RESET-inspired diagnostic test employed by Cribari-Neto and Lima (2007), where the squared linear predictor is included in an auxiliary regression in the mean equation. Significance of its coefficient would indicate misspecification.

Table 6: Player 2 models; dependent variable: MPA (transformed)

	Standard beta regressions			Variable dispersion models		
	(1)	(2)	(3)	(1)	(2)	(3)
R	-0.017^{***}		-0.014^{**}	-0.015^{**}		-0.013^{*}
	(0.006)		(0.006)	(0.007)		(0.007)
R^+		-0.019^{*}			-0.018	
		(0.011)			(0.012)	
R^-		-0.013			-0.012	
		(0.014)			(0.014)	
R^2			-0.001			-0.001
			(0.001)			(0.001)
$\log(TS)$	-0.084^{***}	-0.084^{***}	-0.084^{***}	-0.110^{***}	-0.110^{***}	-0.110^{***}
	(0.023)	(0.023)	(0.023)	(0.026)	(0.026)	(0.026)
Constant	-0.393^{***}	-0.374^{***}	-0.333^{***}	-0.317^{***}	-0.301^{***}	-0.259^{**}
	(0.086)	(0.105)	(0.097)	(0.092)	(0.110)	(0.103)
$R^+ = R^-$ p-value		0.7561			0.7868	
Observations	870	870	870	870	870	870
R-squared	0.003	0.003	0.001	0.003	0.003	0.001
Log Likelihood	359.569	359.622	360.430	362.331	362.371	363.119
SIC	-692.0647	-685.4009	-687.0179	-684.0513	-677.3619	-678.8592
LR misspecification test χ^2 p-value	0.4228	0.4263	0.3071	0.2354	0.238	0.1941

Notes: ***, **, * stand for significance at the 1%, 5% and 10% levels respectively. p-values lower than 0.0001 are reported as 0.0001. Coefficient standard errors in parentheses. "$R^+ = R^-$ p-value" refers to the χ^2 p-value of the Wald test for equality of the two coefficients: $H_0 : \beta_{R^+} = \beta_{R^-}$ against $H_1 : \beta_{R^+} \neq \beta_{R^-}$. SIC is the Schwarz information criterion. The last line gives the result of the RESET-inspired diagnostic test employed by Cribari-Neto and Lima (2007), where the squared linear predictor is included in an auxiliary regression in the mean equation. Significance of its coefficient would indicate misspecification.

graphs of the latter two models are even almost flat in the negative region and become significantly steeper in the positive one. No strong asymmetries are observed for player 2 in Figure 4.

Tables 9 and 10 in the Appendix present the models estimated in two subsamples for each player: the first one includes the subjects that answered for playing against up to three opponents and the second those that reported strategies against four to six opponents. In general, the results are robust within subsamples. Hypotheses 1, 2 and 3 are supported in both subsamples, while hypothesis 4 is supported in the first subsample and not rejected in the second at the 5% level. Strong evidence in favor of hypothesis 5 is found in the second subsample (at the 1% level), but not in the first. Last, there is also some evidence in favor of hypothesis 6 in the first subsample (at the 5% level). However, we should note that the tests in the models estimated in two subsamples have decreased power, as the second subsamples include a limited number of subjects—and especially of observations for negatively-valenced relationships.

Last, our results remain greatly robust under the GAMLSS framework where we take into account the repeated measurements nature of the data. Table 8 in the Appendix presents the results that are analogous to those in the left parts of Tables 5 and 6.

5 Concluding Remarks

In this paper we argue that social distance effects in the ultimatum game are asymmetric, since the effects of altruistic behavior and reciprocity can be weaker in the spectrum of negatively-valenced relationships compared to the region of positively-valenced relationships between the players. Such an asymmetry can be reinforced by strategic considerations for future interactions. We experimentally test this hypothesis of asymmetries in social distance effects in the ultimatum game.

In our experimental design, social distance is allowed to vary based on the quality of the players' relationship from −10 to +10—with −10 being the worst possible (*e.g.*, an "enemy") and +10 the best possible (*e.g.*, a close relative or dear friend). Using a survey based experiment where subjects state the strategy they would follow under a hypotheti-

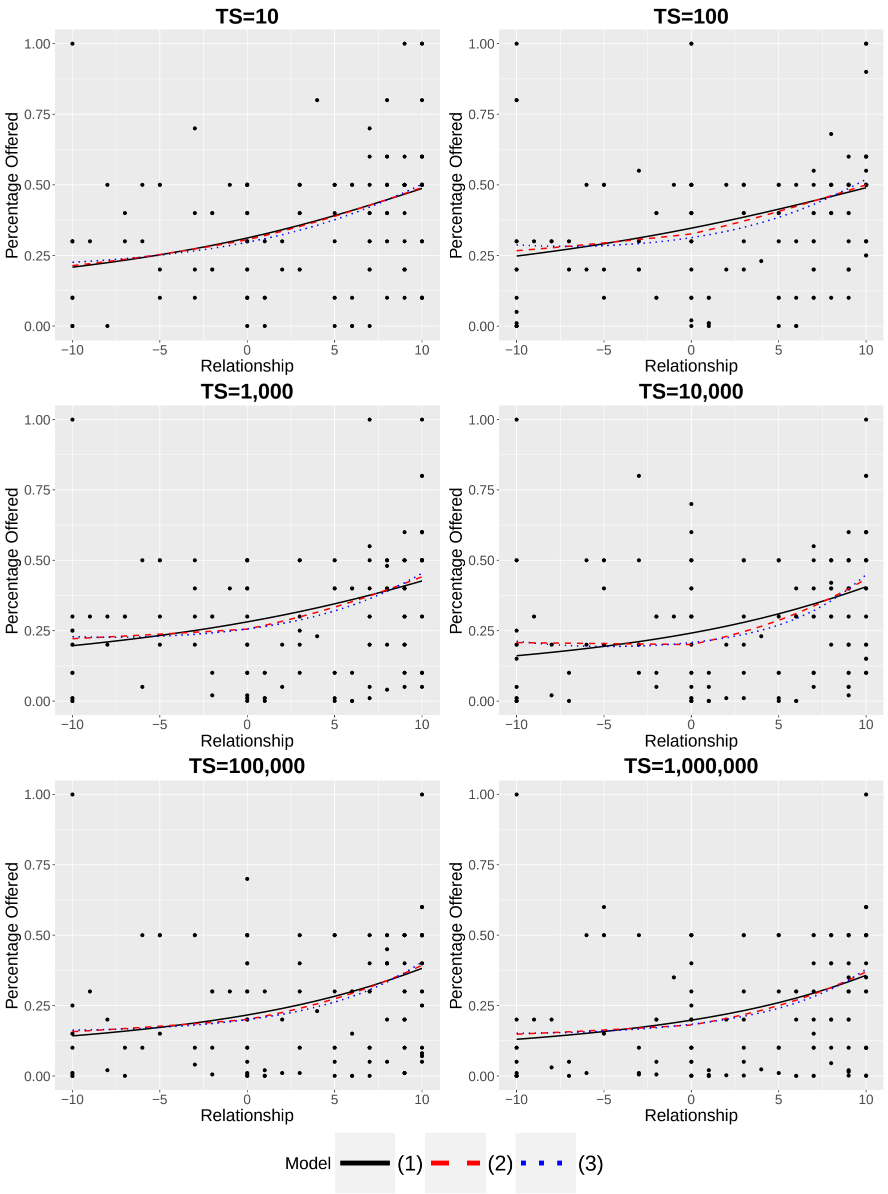

Figure 3: Player 1 expected PO conditional on R for each TS value
Notes: the black solid line, the red dashed line and the blue dotted line give the expected PO under model 1, 2, 3 specifications, respectively; see Table 5 for the models' specification. The expected values for PO in the graphs come from separate beta regressions for each value of TS, so that TS is not included as an exploratory variable in the regressions. Dots are observed PO's.

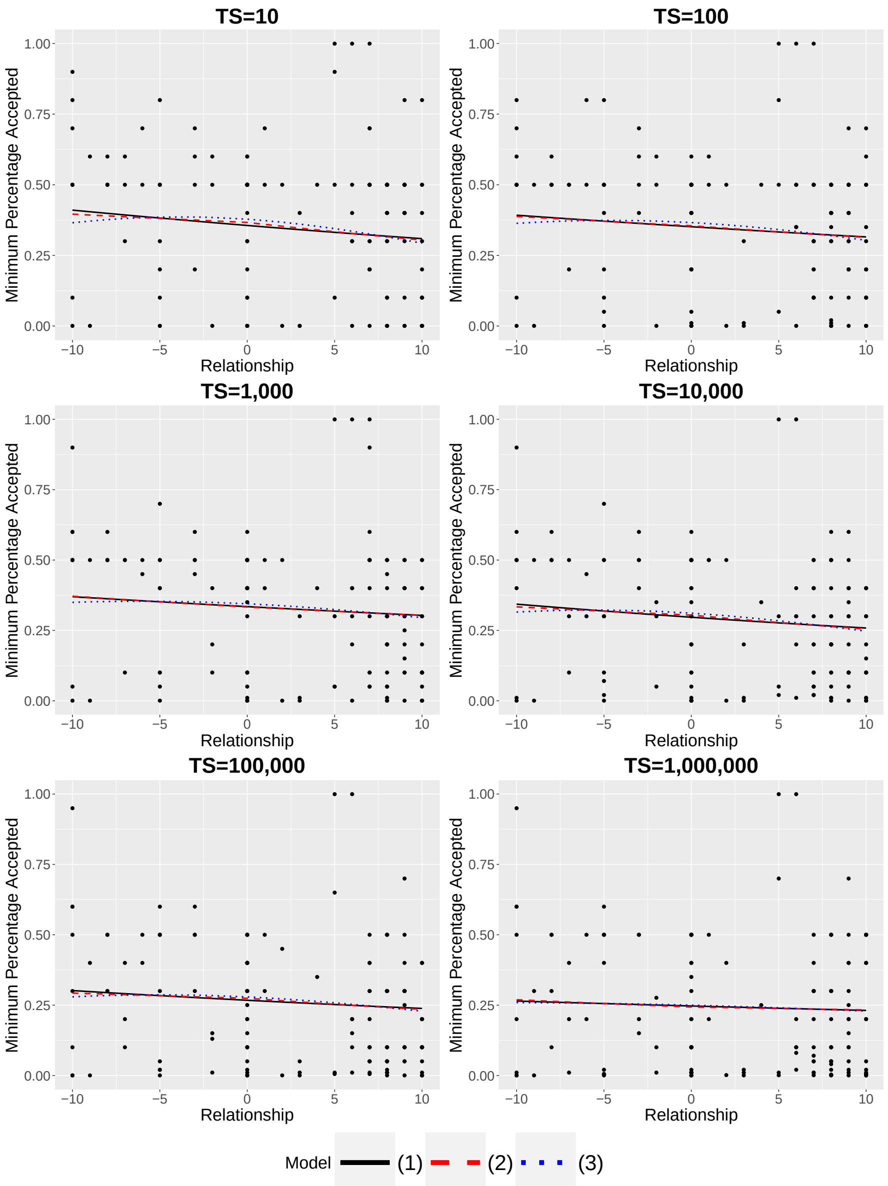

Figure 4: Player 2 expected MPA conditional on R for each TS value
Notes: the black solid line, the red dashed line and the blue dotted line give the expected MPA under model 1, 2, 3 specification, respectively; see Table 6 for the models' specification. The expected values for MPA in the graphs come from separate beta regressions for each value of TS, so that TS is not included as an exploratory variable in the regressions. Dots are observed MPA's.

cal situation where they play the game, we can "offer" arbitrarily large stakes. At the same time, we elicit a minimum acceptable proportion from player 2 and in this way offer clearer results on social distance and stakes effects in the latter's behavior. In past studies, proposers have often been found reluctant to decrease the shares they offer, as stakes increase (Slonim and Roth, 1998; Cameron, 1999; Munier and Zaharia, 2002; Carpenter *et al.*, 2005), which has created hindrances to the examination of player 2's behavior (Andersen *et al.*, 2011).

Our experimental results support the following four hypotheses: as the total sum distributed in the game increases, both (i) the percentage offered by player 1 and (ii) the minimum percentage player 2 is willing to accept decrease; the better the relationship between the players (the lower the social distance), (iii) the higher the percentage offered and (iv) the lower the minimum percentage accepted. Similar results have been documented before for player 2 (*e.g.,* Jones and Rachlin, 2006; Rachlin and Jones, 2008a; Rachlin and Jones, 2008b; Rachlin and Jones, 2010; Bechler *et al.*, 2015). However, the negative effect of relationship quality (positive of social distance) on the minimum percentage accepted by player 2 contradicts a strand of the literature (*e.g.,* see Fehr and Gächter, 2002; Shinada *et al.*, 2004), based on which cooperation in groups is maintained through punishment of noncooperators. The latter could mean that selfish behavior of player 1 is more likely to face punishment from player 2 when their relationship is closer, which is not in accordance with our results.

Turning to asymmetric relationship effects, we find that in the region of positively-valenced relationships (relationship evaluation from subject higher than zero), as relationship quality increases, player 1 increases the percentage she offers more drastically than she does in the region of negatively-valenced relationships. That is, in the negative region player 1 is more invariant to relationship-social distance effects. The size and signs of the coefficients estimated are in agreement with this higher sensitivity to relationship effects in the positive region for player 2 as well, but the results are not statistically significant in this case. This was partly expected, as the parameters that we argue to cause the asymmetries (*i.e.,* altruistic behavior, reciprocity and strategic considerations) are relevant mostly in regard to player 1's behavior.

Future research could expand on theoretical considerations underlying the asymmetric effects captured in our study. The asymmetries can also be examined in experiments where two subjects play the game with real financial rewards. Last, in our results, the degree of asymmetry in social distance effects on player 1's behavior seems to vary as the total sum changes. Thus, further research is warranted on the interaction between social distance and stakes effects.

A Appendix

A.1 Instructions to subjects

First, the person was randomly assigned either the role of the proposer or that of the recipient; a balance between the number of proposers and recipients was maintained. The following instructions were given orally and the researchers were responsible for reporting down the answers to an answer sheet. The instructions in each case were the following:

A.1.1 Instructions to subjects in the role of player 1

You are taking part in an experiment. You can take part multiple times; that is from 1 to 6 times. The first conduct of the experiment lasts about 4–5 minutes and each repetition after the first one lasts approximately 2 minutes. How many times are you available to participate?

Thank you. Now, suppose you are playing the ultimatum game having the role of the proposer; the other player is the responder. In this game, you are given an amount of money and you are asked to offer a portion of this amount to the responder. Then, if the responder accepts the offer, the distribution takes place as proposed, whereas if they reject it, none of you receives money. Zero is an allowable value for your offer. Neither of the players is allowed to attempt any negotiation or take any action trying to affect the other player's decision. Both players know the rules of the game. Are there any questions?

Now, I would like you to bring to mind a person that you have a (very) good (/bad) relationship with.[32] Now, grade your relationship in a scale from −10 to +10 using integers only with −10 being the "worst

[32]First was the case of a (very) good relationship. The exact procedure depended on the amount of time the subject was available to participate and their ability to bring to mind individuals they have a negatively-valenced relationship with.

possible" and +10 the "best possible". If you played the game with this person and you were given €10, what would be the amount which you would offer them? Your answer should be an integer number. If the total amount given to you was €100? (and so on till a million €; for $TS >$ €10, the subjects was asked to give answers that were multiples of $TS/100$) Are you sure about the answers that you gave?

(The procedure described in the paragraph above was repeated with the subject bringing another person to mind—except if they were asked to answer supposing they played against a stranger—and the same set of questions repeated.)

Thank you for your participation.

A.1.2 Instructions to subjects in the role of player 2

You are taking part in an experiment. You can take part multiple times; that is from 1 to 6 times. The first conduct of the experiment lasts about 4–5 minutes and each repetition after the first one lasts approximately 2 minutes. How many times are you available to participate?

Thank you. Now, suppose you are playing the ultimatum game having the role of the responder; the other player is the proposer. In this game, the proposer is given an amount of money and is asked to offer a portion of this amount to you, the responder. Then, if you accept the offer, the distribution takes place as proposed by the other player, whereas if you reject it, none of you receives money. The proposer is allowed to offer zero. Neither of the players is allowed to attempt any negotiation or take any action trying to affect the other player's decision. Both players know the rules of the game. Are there any questions?

Now, I would like you to bring to mind a person that you have a (very) good (/bad) relationship with.[33] Now, grade your relationship in a scale from −10 to +10 using integers only with −10 being the "worst possible" and +10 the "best possible". If you played the game with this person and they were given €10 and were asked to propose a distribution, what would be the minimum amount which you would accept out of the total sum as a proposal from the other player? That

[33] See footnote 32.

is, supposing the money was real, if you were given a lower amount you would decline and neither of you would receive any money, right?[34] If the total amount given to you was €100? (and so on till a million €; for $TS >$ €10, the subject was asked to give answers that were multiples of $TS/100$) Are you sure about the answers that you gave?

(The procedure described in the paragraph above was repeated with the subject bringing another person to mind—except if they were asked to answer supposing they played against a stranger—and the same set of questions repeated.)

Thank you for your participation.

A.2 Link function selection and robustness tests

Here we report the log-likelihood for each link function tested for use in the models. Also, we present the models by estimated subsamples based on the number of repetitions of the experiment by the subject. The first subsample includes the subjects that answered for playing against up to three people and the second those that reported strategies for four to six opponents. Last, we check the robustness of our results in a Generalized Additive Models for Location Scale and Shape (GAMLSS) framework estimating the models including random subject effects in the intercept, R and $\log(TS)$ coefficients.

[34] This ascertainment was made when the minimum amount cited was not zero.

Table 7: Log-Likelihood by link function used

Standard beta regression						
Model		logit	probit	clog-log	Cauchy	log-log
Player 1	(1)	336.157	335.742	336.933	**338.02**	334.475
	(2)	339.51	339.271	340.102	**340.41**	338.313
	(3)	341.759	341.42	342.514	**343.18**	340.194
Player 2	(1)	359.741	359.762	359.701	359.569	**359.81**
	(2)	359.786	359.805	359.748	359.622	**359.85**
	(3)	360.66	360.687	360.603	360.43	**360.75**
Variable dispersion models						
Model		logit	probit	clog-log	Cauchy	log-log
Player 1	(1)	352.001	351.524	352.913	**354.75**	350.208
	(2)	359.677	359.284	360.594	**361.93**	358.013
	(3)	364.664	364.128	365.88	**367.72**	362.427
Player 2	(1)	362.673	362.715	362.593	362.331	**362.81**
	(2)	362.706	362.747	362.627	362.371	**362.84**
	(3)	363.505	363.551	363.412	363.119	**363.65**

Note: clog-log stands for complementary log-log.

Table 8: Player 1 and 2 models with random subject effects in intercept, R and $\log(TS)$; dependent variable: PO and MPA (transformed)

	Player 1 models			Player 2 models		
	(1)	(2)	(3)	(1)	(2)	(3)
R	0.106***		0.072***	−0.019***		−0.008
	(0.004)		(0.005)	(0.007)		(0.005)
R^+		0.134***			−0.022**	
		(0.008)			(0.009)	
R^-		0.032***			−0.013	
		(0.011)			(0.012)	
R^2			0.007***			−0.003***
			(0.001)			(0.001)
$\log(TS)$	−0.161***	−0.161***	−0.161***	−0.125***	−0.125***	−0.126***
	(0.016)	(0.016)	(0.016)	(0.018)	(0.018)	(0.018)
Constant	−0.653***	−0.892***	−0.897***	−0.410***	−0.388***	−0.310***
	(0.064)	(0.078)	(0.071)	(0.085)	(0.085)	(0.079)
Clarke (2007) test, H_0: model (1) preferred over (2) p-value		**0.0001**			**0.0001**	
Observations	936	936	936	870	870	870
R-squared	0.679	0.686	0.692	0.611	0.611	0.614
Log Likelihood	793.759	804.9	813.591	759.819	759.97	762.982
SIC	-873.428	-882.689	-897.496	-845.289	-839.257	-847.239

Notes: ***, **, * stand for significance at the 1%, 5% and 10% levels respectively. p-values lower than 0.0001 are reported as 0.0001. A logit link function is used. SIC is the Schwarz information criterion. Coefficient standard errors in parentheses. Cox and Snell (1989) R-squared values are reported. To check for statistically significant difference between the coefficients of R^+ and R^- we use the Clarke (2007) test with null hypothesis that model (1) is preferred over model (2).

Table 9: Player 1 variable dispersion models by number of repetitions of experiment; dependent variable: PO (transformed)

	Up to three repetitions		Four to six repetitions		
	(2)	(3)	(1)	(2)	(3)
R		0.068***	0.082***		0.039***
		(0.014)	(0.014)		(0.011)
R^+	0.040***			0.180***	
	(0.012)			(0.022)	
R^-	0.104***			−0.103***	
	(0.031)			(0.027)	
R^2		−0.002			0.013***
		(0.002)			(0.002)
$\log(TS)$	−0.143***	−0.142***	−0.110***	−0.110***	−0.114***
	(0.028)	(0.028)	(0.034)	(0.033)	(0.033)
Constant	−0.227*	−0.277**	−0.777***	−1.575***	−1.356***
	(0.119)	(0.112)	(0.157)	(0.215)	(0.181)
$R^+ = R^-$ p-value	0.0735			**0.0001**	
Observations	456	456	480	480	480
R-squared	0.133	0.135	0.054	0.038	0.041
Log Likelihood	226.913	226.305	361.640	381.084	388.602
LR misspecification test χ^2 p-value	0.0001	0.011	0.0008	0.0001	0.0008

Notes: ***, **, * stand for significance at the 1%, 5% and 10% levels respectively. p-values lower than 0.0001 are reported as 0.0001. Coefficient standard errors in parentheses. "$R^+ = R^-$ p-value" refers to the χ^2 p-value of the Wald test for equality of the two coefficients: $H_0 : \beta_{R^+} = \beta_{R^-}$ against $H_1 : \beta_{R^+} \neq \beta_{R^-}$. SIC is the Schwarz information criterion. Transformation of PO has been done in each of the two subsamples separately (*i.e.,* using the subsample's size). The last line gives the result of the RESET-inspired diagnostic test employed by Cribari-Neto and Lima (2007), where the squared linear predictor is included in an auxiliary regression in the mean equation. Significance of its coefficient would indicate misspecification. The first model of up to three repetitions does not converge (the **betareg** package uses the quasi-Newton BFGS algorithm with analytical first derivatives to maximize the log-likelihood function).

Table 10: Player 2 variable dispersion models by number of repetitions of experiment; dependent variable: MPA (transformed)

	Up to three repetitions		Four to six repetitions		
	(2)	(3)	(1)	(2)	(3)
R		-0.033^{***}	0.017		0.006
		(0.009)	(0.018)		(0.017)
R^+	-0.066^{***}			0.054^{*}	
	(0.016)			(0.030)	
R^-	-0.001			-0.052	
	(0.016)			(0.038)	
R^2		-0.005^{***}			0.003
		(0.001)			(0.003)
$\log(TS)$	-0.099^{***}	-0.100^{***}	-0.111^{*}	-0.110^{*}	-0.110^{*}
	(0.031)	(0.031)	(0.059)	(0.059)	(0.059)
Constant	-0.209	-0.183	-0.699^{***}	-0.993^{***}	-0.810^{***}
	(0.127)	(0.121)	(0.230)	(0.299)	(0.260)
$R^+ = R^-$ p-value	**0.0126**			0.0753	
Observations	588	588	282	282	282
R-squared	0.009	0.017	0.002	0.012	0.003
Log Likelihood	274.070	277.925	358.450	360.292	359.059
LR misspecification test χ^2 p-value	0.3055	0.2667	0.1911	0.0305	0.02

Notes: ***, **, * stand for significance at the 1%, 5% and 10% levels respectively. p-values lower than 0.0001 are reported as 0.0001. Coefficient standard errors in parentheses. "$R^+ = R^-$ p-value" refers to the χ^2 p-value of the Wald test for equality of the two coefficients: $H_0 : \beta_{R^+} = \beta_{R^-}$ against $H_1 : \beta_{R^+} \neq \beta_{R^-}$. SIC is the Schwarz information criterion. Transformation of MPA has been done in each of the two subsamples separately (*i.e.*, using the subsample's size). The last line gives the result of the RESET-inspired diagnostic test employed by Cribari-Neto and Lima (2007), where the squared linear predictor is included in an auxiliary regression in the mean equation. Significance of its coefficient would indicate misspecification. The first model of up to three repetitions does not converge (the **betareg** package uses the quasi-Newton BFGS algorithm with analytical first derivatives to maximize the log-likelihood function).

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