Group Decision-Making in Ultimatum Bargaining: An Experimental Study*

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Abstract

Many rent-sharing decisions in a society are result from a bargaining process between groups of individuals (such as between the executive and the legislative branches of government, between legislative factions, between corporate management and shareholders, etc.). The purpose of this work is to conduct a laboratory study of the effect of different voting procedures on group decision-making in the context of ultimatum bargaining. An earlier study (Bornstein and Yaniv, [2]) has suggested that when the bargaining game is played by unstructured groups of agents, rather than by individuals, the division of the payoff is substantially affected in favor of the ultimatum-proposers. Our theoretical arguments suggest that one explanation for this could be implicit voting rules within groups. We propose to explicitly structure the group decision-making as voting and study the impact of different voting rules on the bargaining outcome.

Keywords: Bargaining games, group decision making and experimental design.

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1 Introduction

Many rent-sharing decisions in a society are result from a bargaining process between groups of individuals, such as the bargaining between the executive and the legislative branches of government, between legislative factions, between corporate management and shareholders, etc. In contrast, most experimental results on bargaining involve one-on-one play between individuals.

We explore the consequences of group-on-group action in the context of ultimatum bargaining. In this game, one side proposes how to partition a total available payoff between herself and another side, who, in turn can choose to accept or reject the proposal. In case of acceptance the proposal is implemented, while in case of the rejection neither side receives anything. As is well-known, the subgame-perfect equilibrium outcome is for the ultimatum-proposer to receive (almost) the entire surplus. In contrast, in laboratory implementation of the game ultimatum-responders consistently obtain a significant, though smaller, share.

The basic motivation is to see the extent to which the well-studied theoretical properties and empirical regularities on bargaining established in the earlier literature can be affected by introducing group decision-making, and to compare the impact of different rules of aggregating individual preferences into group decisions. If such impact is non-negligible, it has implications for bargaining between groups using different explicit voting rules to agree on intragroup decisions. This also may shed light on implicit preference aggregation mechanisms used in groups that do not have explicit rules.

The issue of intergroup interaction in games has received most attention from social psychologists. In a recent paper Wildschut *et al.* [23] provide a "meta-study" of a large body (some 130 studies) of experimental evidence on what is known in psychology as a *group discontinuity effect*: the general tendency of groups of agents to behave more aggressively than individuals in similar circumstances, be that due to social reinforcement of aggressive behavior, greater anonymity within the group, or emergence of fear of aggressive behavior by the opposing group. It is only recently that the issue has been taken on by economists, who have often redefined, occasionally somewhat simplistically, the discontinuity hypothesis as the hypothesis of "greater rationality" of groups. This hypothesis has so far received mixed support. To mention but a few of these studies Bornstein and Yaniv [2] claim to observe more aggressive proposer behavior in group ultimatum games, while Bornstein *et al.* [3] see earlier group exit in the centipede game, both pointing towards the backward induction outcomes of these games. Similarly, Cox [7] observes that in an investment game group decisions seem to correspond to action of the most aggressive member and, thus, most closely "game-theoretic" in terms of monetary payoffs. Kocher and Schmidt [13] observe more aggressive group behavior to prevail in a gift-exchange experiment even when group members are not allowed any face-to-face interaction but rather achieve decision via a computer communication protocol.[1] On the other hand, in a context of the dictator game Cason and Mui [6] observe that more generous (other-regarding) agents dominate group decisions. The issue thus remains unsettled, and Camerer [5] includes further study of the manner in which groups act in games as one of the ten top open research questions in behavioral economics.

One difficulty involved in studies of intergroup interaction is that the intragroup decision-making may be difficult to observe or categorize, unless it is explicitly imposed. Of course, the imposition of the preference aggregation rule may have direct impact on the way the game is played. Thus, Wildschut *et al.* [23] conclude that when a group has to reach a single decision (in many experiments by consensus) agents tend to behave more in accordance with the discontinuity hypothesis than when the group decision is a sum of decentralized individual decisions. A further question is to which extent intragroup decision rules matter. Here, it seems, the evidence so far is extremely limited. While the decision rule obviously affects the group decision, it is another matter if this is understood and internalized by the opposing group. In a few studies which asked that question previously, as in Messick *et al.* [16], and in a very recent study by Bosman *et al.* [4], the answer seems to be negative: members of a group tend to view the opposing group as unitary and ignore its decision process. On the whole, the issue remains underexplored, and our study seems to challenge some of the earlier conclusions.

The one-on-one ultimatum bargaining game has been repeatedly played in laboratory settings, beginning with Guth *et al.* [10], and a number of robust regularities has emerged, as summarized in Roth [21] and Camerer [5]. In particular, it has been repeatedly observed that, at least in industrialized societies, the proposers of the ultimatum tend to offer the responders a sizeable chunk of the payoff (often in excess of 40%), while the "too low" offers get consistently rejected by the responder side.[2] While at variance with the subgame-perfect equilibrium prediction for

[1] It should be noted that the communication protocol in this study is rather complicated, perhaps designed to simulate face-to-face interaction; its game-theoretic analysis would be challenging, and the authors do not attempt it.

[2] An intriguing exception is reported by Henrich [11], who presents results showing that in a pre-industrial society

a game with purely monetary payoffs, it could be explained by an uncontrolled non-monetary payoff component, such as utility of fairness or of punishing "insulting" offers. This is indeed the conclusion Ochs and Roth [17] draw from a series of sequential bargaining experiments. In fact, for a number of such experiments, Prasnikar and Roth [18] suggest that ultimatum-proposers may be trying to maximize monetary payoff subject to the empirical rejection behavior of ultimatum-responders, which, in turn, might be generated by unobserved (and uncontrolled) payoffs (possibly due to some sort of *interdependent preferences*).

Kennan and Wilson [14] suggested that "[e]ven the basic single-offer ultimatum game becomes a game of private information in which the optimal offer depends on beliefs about how much the responder is willing to forgo to punish unfair behavior". In other words, laboratory bargaining games should be modeled as incomplete information games, which in the ultimatum game context may be done by explicitly modeling rejection thresholds as responder *types.* This has been formalized by, among others, Levine [15], who incorporated altruism and/or spitefulness into individual preferences; the equity-reciprocity-competition model of Bolton and Ockenfels [1], who allow the agents to care about their relative position in the society; and the fairness model of Fehr and Schmidt [8]. In these models, the agents may only be aware of the preference distribution in the population, but not of the actual types in front of them. In the context of the ultimatum game, this generates an incomplete information game with ultimatum-proposers facing a belief about the rejection probability of any given ultimatum. In this paper we provide a simple model in the spirit of Bolton and Ockenfels [1] and Fehr and Schmidt [8], narrowly targeted to provide comparative empirical predictions for our experiment. We deliberately remain agnostic about features of the model that cannot be tested in our setting. It is thus consistent with a variety of extant incomplete information models.

As mentioned above, until quite recently all laboratory ultimatum bargaining games have been implemented in a one-on-one setting. A 1998 study (Bornstein and Yaniv [2]) has suggested that when the ultimatum game is played by unstructured groups of agents, rather than by individuals, the division of the payoff is substantially affected in favor of the ultimatum-proposers (though, on should note that their sample is quite small, one round with a total of 20 one-on-one and 20 group-on-group; in fact, they observe only two rejections). In their language, this result can be

of Machiguenga Indians in Peru the bargaining outcomes are significantly closer to giving everything to the ultimatum proposer. This has given rise to a fascinating worldwide "anthropological" research project, as reported in Camerer [5].

explained by thinking of groups as "more rational" agents than individuals, if rationality is viewed as playing closer to the subgame-perfect outcome of the ultimatum game with pure monetary payoffs. Note, however, that if the payoffs of ultimatum-responders have non-monetary components, the equilibrium prediction of the monetary-payoff game is, in fact, "incorrect"; for this explanation to work, members of groups somehow persuade each other to ignore the non-monetary payoffs. In a concluding remark, Bornstein and Yaniv [2] suggest that an alternative explanation could be that ultimatum proposers take into account an implicit decision-making process of the responder group (such as, perhaps, majority voting). This conjecture cannot be tested without either a control for or an explicit model of such a process.

A couple of papers have attempted to deal with the issue of intragroup decision-making. Robert and Carnevale [20] claim to observe in a group-on-group ultimatum game that proposer groups tend to follow the preferences of its "most competitive" member (they elicit the individual preferences from observations of one-one-one play by the same agents). The result is a substantially more aggressive proposer group behavior, as in Bornstein and Yaniv [2]. Unfortunately, their responder groups are actually fictitious, and the proposers don't explicitly observe rejections; it is thus impossible to figure out if they are best-responding to anything on the responder side.

A more explicit laboratory implementation of intragroup decision-making has been attempted by Messick *et al.* [16], who compare group-on-group bargaining under two explicit decision-making procedures in the responder group: in one treatment the responders must unanimously agree to accept the offer, while in the other the unanimity is required for rejection. Strikingly, they do not observe any difference in proposer behavior, even though the best response in the former treatment would imply much less aggressive ultimatums than in the latter (since they did not do a benchmark one-on-one treatment, we can't compare their group-on-group results with the one-on-one case). However, there seems to be an important peculiarity in their experimental design, which complicates interpretation of their results. The problem is in their technique for eliciting the responders' strategies. In standard ultimatum bargaining, the experimenter observes only acceptance or rejection of the actual offer, but not the entire strategy, which should specify what the agent would have done if he were to get a different offer. Messick *et al.* [16] attempt to overcome this by requiring the responders to report their entire strategies before they see the offer (in fact, in at least some of their treatments, they explicitly tell this to the proposers). Unfortunately, this forces the responders to commit, thereby destroying the sequential nature of the game. Thus, in their game subgame-perfection provides no refinement of the Nash equilibrium, and, as is well-known, there is a continuum of Nash equilibria in this game, with pretty much any division of the surplus being a possible equilibrium outcome.

While the previously mentioned studies only look at a single-shot bargaining interaction between inexperienced subjects, Grosskopf [9] has studied how behavior changes as agents learn from their experience. In a comparison between one-on-one and one-on-group ultimatum bargaining (with the group decision rule similar to one of the treatments in Messick *et al.*'s [16]: unanimity required for rejection) she concludes that though the agents might not be able to figure out the difference immediately, with learning a clear difference emerges between the play against groups versus play against individuals. In particular, she observes that when playing against groups proposers eventually learn to be more aggressive.

The rest of this paper is organized as follows. In section 2, we develop an explicit model of ultimatum bargaining under incomplete information and derive testable predictions. In section 3, we discuss experimental design. In section 4, we present laboratory results. Section 5 concludes.

2 The Model

We start by providing a simple incomplete information model of ultimatum bargaining, specified to the extent we shall be able to implement it in the lab. As noted above, our model most closely resembles those of Bolton and Ockenfels [1] and Fehr and Schmidt [8].

For simplicity, we shall assume that the proposers care only for their monetary payoff, while the responders may have other motivations. While relaxable, this assumption has some support in earlier experimental results, such as Prasnikar and Roth [18], as discussed in Roth [21]. This assumption is also supported by the experiments with varying information about payoffs conducted by Kagel *et al.* [12], in which proposers behave more aggressively, if they know that responders don't know the payoff size and so can't figure out if they are treated "unfairly" or "insultingly" by the proposers. This suggests that when unfairness works on one's favor, many people do no dislike it too much, as long as they can't be observed as unfair or punished for it. In other words, assuming that one cares about inequity only when it works against him or her, seems not to contradict the data too much. In the same vein, Fehr and Schmidt [8] cite psychological literature to support the assumption in their model that people dislike unfairness that works in their favor more than they dislike the same when it works against them. Since in ultimatum games the proposers typically get at least half the total payoff, we shall, for now, go further and just suppress the fairness component of their utility. Incorporating some sort of non-monetary preference in proposers' utility does not present a serious difficulty, since it would only affect quantitative, but not qualitative predictions as to the comparative behavior of agents in different treatments of our experiment.

Therefore, we assume that each (weakly) risk-averse proposer has a strictly increasing and concave Bernoulli utility function of money $u_p(x_p)$, where x_p is how much money she gets.[3]

The responder also likes money, but she also gets utility from being treated fairly. In case she is facing a bad offer, she will prefer to reject, since that would result in a fairer distribution, or since it will punish the "insolent" proposer. In general, we shall remain agnostic on the true nature of the possible rejection (our experiment is not designed to elicit this information). One possible assumption here is that the difference between the payoffs of the proposer and the responder enters his utility, which is thus $u_r(x_r, x_r - x_p, D)$, where x_r is her monetary wealth and $D = accept/reject$ is her action. Allowing the utility to depend on acceptance or rejection makes it possible to model explicitly preference for "punishing" the proposer of a distastefully low amount (this could be easily suppressed in the first approximation). Note, of course, that to the extent that there are only two agents involved in actual play, the pair $(x_r, x_r - x_p)$ describes the entire monetary payoff distribution between them (in this setting our approach is equivalent, both to the Bolton and Ockenfels [1] assumption that the agents care about their share of total prize and the Fehr and Schmidt [8] assumption that they care about absolute differences). We assume the function u_r to be increasing in both arguments.

The total payoff size available for sharing between a proposer and a responder is $\pi > 0$. The proposer has to choose a number $x \in [0, \pi]$ that she will offer to the responder, with the balance of $\pi - x$ being left to herself. The responder will accept the offer whenever

$$u_r(x, 2x - \pi, A) \geq u(0, 0, D)$$

and reject otherwise.[4]

[3] We are aware of the questions raised about the appropriateness of assuming risk-aversion for experimental-sized stakes, or, more specifically, the apparent inconsistency between the small-stake and large-stake estimates of risk-aversion (see Rabin[19]). Since our results, in fact, do not depend on the presence or absence of risk-aversion we choose to allow the possibility of it.

[4] For simplicity we assume acceptance in case of indifference; since it is going to be a zero-probability event in the incomplete information version of the game, this assumption is innocuous.

If the proposer knows preferences of the responder, the subgame-perfect equilibrium is obvious. The proposer should choose $x^* \in [0, \pi]$ that solves.

$$u_r(x^*, 2x^* - \pi, A) = u(0, 0, R)$$

and the responder should only accept offers as high as, or higher than this x^*. In particular, if u_r is independent of the third variable (the agent only cares about the income distribution, and does not get utility from punishment) $x^* \in \left[0, \frac{\pi}{2}\right)$. Indeed, offers above half the prize size are almost never rejected.

Of course, the key problem here is that the proposer can't *ex ante* observe (and experimenter can't exactly control) the responders preferences. The only thing subject to observation and experimental control is the monetary payoff x. Therefore, the only thing that the proposer may know is that each responder τ will reject offers below a certain cut-off value x_τ and that this x_τ is drawn from some probability distribution with the support $[0, \pi]$ with the distribution function $F(x)$.[5] Clearly, $F(x)$ can be interpreted as the acceptance probability of offer x.

We shall denote the probability of rejection $P(x) = 1 - F(x)$. Suppose that $P(\pi) = 0$ (if you give everything to the responder she always accepts) and $P(0) = 1$ (offers of nothing are always rejected), both of which (especially the former) are very robust empirical regularities observed in ultimatum game experiments. These assumptions clearly imply impossibility of corner solutions to the proposer's maximization problem. The proposer's expected payoff from the ultimatum x is

$$\Pi(x) = u_p(\pi - x)(1 - P(x))$$

Assuming differentiability of u_p and P (both, essentially, not falsifiable empirically), clearly $u_p' \geq 0$ and $P' \leq 0$. The first order necessary condition for expected utility maximization in the interior is

$$u_p'(\pi - x)(1 - P(x)) = -u_p(\pi - x)P'(x)$$

Furthermore, a necessary condition for maximization is $P(x) < 1$ (since $P(x) = 1$ would guarantee a zero payoff). The first order conditions are easily seen to be sufficient if $P(x)$ is convex at x.

[5] As noted above, the absence of any utility from punishment would imply that for all recipients $x_\tau \in \left[0, \frac{\pi}{2}\right)$. In fact, this seems to be confirmed empirically, since large offers almost never get rejected. On the other hand, large offers (above half of the total prize), though rare, do occur, which can't be explained as a best response to a probability distribution of the rejection cut-offs with the support $x_\tau \in \left[0, \frac{\pi}{2}\right]$. One explanation for this could be that some proposers may have a model of recipients in mind, which allows for punishment utility and, hence, lower cut-offs.

Since we do not observe $P(x)$ directly, in principle, there is a possibility of multiple local maxima, though multiplicity of global maxima is clearly non-generic in the space of utility functions and rejection probabilities.

2.1 Group bargaining

The group bargaining framework has to be designed as closely as possible to the one-on-one treatment in order to minimize any unmodelled difference in behavior. For this reason, in the model that follows, as in our experimental design to be discussed later we preserve the symmetry between the sides, assuming the same group size of proposers and responders and equipartition of the monetary payoff within each side. This avoids either payoff scale differences or public good/ efficiency aspects which would be inevitable if the symmetry were to be broken.

Suppose therefore that instead of a one-on-one game the game is between groups of three proposers and three responders for a prize 3π. The proposers' share of the prize will be divided equally between the proposers and the responders' share between the responders, so that the monetary payoffs to agents are unchanged. An ultimatum x shall mean that each proposer gets $\pi - x$, and each receiver gets x. Under these conditions the pair $(x, \pi - x)$ continues to completely describe the distribution of the monetary payoffs in case of acceptance. We shall first analyze the model under the assumption that the responders' utilities do not depend on their acceptance/ rejection vote, but only on the distribution of monetary payoffs.

Assume that one of the members of the proposer group is chosen to decide which ultimatum to give. In what follows we explore consequences of four intragroup decision rules among the responders: dictatorship (a single responder makes the decision to accept or reject) ; majority decision to accept/ reject; unanimity needed to overturn acceptance; unanimity needed to overturn rejection. If we assume that there is no utility of rejection per se (u_r does not depend on acceptance/ rejection), the dictatorship can be easily seen to be equivalent to the one-to-one game.

In general, the (non-dictatorial) voting games played by the responders will have multiple equilibria, since, for instance, if I believe that my partners in a group both always vote to accept and the decision rule is majority, I am indifferent between voting to accept and to reject. Note, however, that such equilibria involve playing weakly dominated strategies. In fact, for a voter facing an ultimatum x doing anything other than voting sincerely is weakly dominated by sincere voting (this is an election between just two alternatives). Therefore, we shall only consider sincere voting equilibria.

The above discussion provides an additional reason to give up on eliciting the entire strategies of responders (as attempted by Messick *et al.* [16] and discussed in the introduction): even just the cut-off acceptance/ rejection strategies are relatively complex objects and if voting over them would be allowed, empirically disentangling the multiple equilibria could be hard. On the other hand, at their action node the responders face a simple binary decision: accept or reject the offer in front of them. Unfortunately, the action of proposers is more complicated: they have to choose a number in the $[0, \pi]$ interval. At least initially, we want to avoid voting complications. Therefore, we shall let each proposer make his ultimatum ignorant of the rest, and then randomly choose one of the ultimatums to be presented to the responders, making it optimal for each proposer to act as if he were a dictator on their side of the game.

The following table summarizes the rejection probability under each of the four intragroup decision rules on the ultimatum responder side, where $P(x)$ is as in the previous section:

Group Decision Rule	Default	Probability of Rejection
Individual Response	-	$P(x)$
Majority Rule	-	$P(x)^3 + 3P(x)^2(1 - P(x))$
Unanimity Rule	Accept	$P(x)^3$
Unanimity Rule	Reject	$1 - (1 - P(x))^3$

This implies, that the *proposer's* expected utility for the ultimatum x are as follows:

Group Decision Rule	Default	Expected Utility: $\Pi(x)$
Individual Response	-	$u_p(\pi - x)(1 - P(x))$
Majority Rule	-	$u_p(\pi - x)(1 - P(x))^2(1 + 2P(x))$
Unanimity Rule	Accept	$u_p(\pi - x)(1 - P(x)^3)$
Unanimity Rule	Reject	$u_p(\pi - x)(1 - P(x))^3$

Hence, the first order necessary conditions for expected utility maximization, somewhat simplified by dividing both sides by equal positive factors, are as follows:

Group Decision Rule	Default	FOC Expected Utility Maximization
Individual Response	-	$u_p^{'}(\pi - x)(1 - P(x)) = -u_p(\pi - x)P^{'}(x)$
Majority Rule	-	$u_p^{'}(\pi - x)(1 - P(x))(1 + 2P(x)) = -6u_p(\pi - x)P^{'}(x)P(x)$
Unanimity Rule	Accept	$u_p^{'}(\pi - x)(1 - P(x)^3) = -3u_p(\pi - x)P^{'}(x)P^2(x)$
Unanimity Rule	Reject	$u_p^{'}(\pi - x)(1 - P(x)) = -3u_p(\pi - x)P^{'}(x)$

Once again, adding convexity of $P(x)$ and ensuring that $P(x) < 1$ makes the first order conditions sufficient. Unfortunately, without a further assumption on P, multiple local maxima are possible. Though global maximum, generically (in either P or u), would be unique, multiplicity of local maxima might allow the global maximum to "jump" depending on the voting rule, which might create problems with identifying the impact of the rules. Unfortunately, P is not directly observable either by the experimenters or the subjects. The following assumption, which is satisfied by most "symmetric" models of rejection probability (such as linear, logit or probit) would avoid this problem.

Assumption A: $P(x)$ is (weakly) convex whenever $P(x) \leq \frac{1}{2}$.

We can now state the following proposition

Proposition 1 *Assuming the proposers believe that no recipient gets utility from punishment, if assumption A holds, the optimal offer by any risk-averse individual in each treatment will be ranked as follows (where the subscript UA stands for Unanimity with acceptance default, UR - unanimity with rejection default, M - majority rule and I - for the one-on-one case):*

$$x_{UA} < x_I < x_M < x_{UR} \quad \text{if } P(x) > \frac{1}{4}$$

$$x_{UA} < x_M < x_I < x_{UR} \quad \text{if } P(x) < \frac{1}{4}$$

Proof. *The proof is done by comparing first order conditions. Assumptions on P we impose in the one-to-one case ($P(0) = 1; P(\pi) = 0$) ensure that the solution is interior. Furthermore, assumption A ensures that there is at most one local maximum for each voting rule such that $P(x) \leq \frac{1}{2}$. But for all voting rules other than unanimity with acceptance default this must be the global maximum, since the proposer can always ensure the payoff equal to $\frac{\pi}{2}$ by offering to share the prize equally (in the absence of utility from rejection this will always be accepted).*

Consider now the optimal offer for the one-on-one case. Then

$$u_p'(\pi - x_I)(1 - P(x_I)) = -u_p(\pi - x_I) P'(x_I)$$

(the condition for the one-on-one case). Then

$$u_p'(\pi - x_I)\left(1 - P^3(x_I)\right) > -3u_p(\pi - x_I) P'(x_I) P^2(x_I)$$

for every $P < 1$. Since offering a proposal that would spur rejection with probability one cannot be optimal for the proposer, clearly the inequality holds at the optimal x_I. The right hand side is decreasing in x,the left is increasing in x, hence to restore equality x has to be decreased for the optimum in the unanimity (with acceptance default) case to be achieved. Of course, unanimity with acceptance default is the only voting rule for which the true global maximum might involve $P(x) > \frac{1}{2}$, but that implies even more aggressive behavior by the proposers, so that the conclusion that $x_{UA} < x_I$ is maintained.

Similarly

$$u_p'(\pi - x_I)(1 - P(x_I)) < -3u_p(\pi - x_I) P'(x_I)$$

and x has to be increased to get to the optimum in the unanimity (rejection default) case (in this case there is no problem with non-uniqueness of the maximum).

We thus have that $x_{UA} < x_I < x_{UR}$. It can be similarly shown that $x_{UA} < x_M < x_{UR}$. Finally, to establish the position of x_M vis a vis *x_I observe that*

$$\begin{aligned} u_p'(\pi - x_I)(1 - P(x_I))(1 + 2P(x_I)) &> -6u_p(\pi - x_I) P'(x_I) P(x_I), \text{ if } P(x) < \frac{1}{4} \\ &\text{and} \\ u_p'(\pi - x_I)(1 - P(x_I))(1 + 2P(x_I)) &< -6u_p(\pi - x_I) P'(x_I) P(x_I), \text{ if } P(x) > \frac{1}{4} \end{aligned}$$

To see the necessary direction of change of x divide both sides of the previous inequality condition by $P(x) > 0$ to get

$$\frac{u_p'(\pi - x_I)}{P(x_I)}(1 - P(x_I))(1 + 2P(x_I)) < (>) - 6u_p(\pi - x_I) P'(x_I)$$

with the left-hand side increasing and the right hand side decreasing in x. ■

It should be stressed that empirical predictions summarized by the Proposition 1 admit a broad array of the shapes of u and P. Furthermore, the assumptions of (weak) risk-aversion and (weak) convexity of P in the relevant part of the domain are not necessary and could be further relaxed.

Predictions of the play against the unanimity groups are very straightforward; less so with the case of the majority rule. In general, the equilibrium rejection probability, of course, depends on the proposers' degree of risk-aversion and the shape of the rejection probability $P(x)$, both of which are hard to control in an experiment. In previous studies [21] empirical rejection probabilities have usually been below $\frac{1}{4}$ (except occasionally, as in Israel - Roth [21] - where it has been closer to

$\frac{1}{3}$). Our *ex ante* expectation, therefore, is that playing against the majority rule group will *on average* result in more aggressive behavior than the one-on-one treatment. However, the initially more "aggressive" (less risk-averse) proposers are predicted to moderate in this case (though they would stay more aggressive than the more risk-averse types)!

3 Experimental Design

3.1 Structure of the Ultimatum Bargaining

The experimental design used directly measures the relative performance of the ultimatum bargaining game when two groups of players have to bargain over an amount of money: A group of (3) players, the proposers, proposes a division of a fixed amount of money, and a second group of (3) players, the responders, accepts or rejects it. After observing the proposal, responders must decide whether to accept or reject the proposal following a pre-determined voting rule. If responders reject, no group receives any pay, and if responders accept, each group receives the amount specified in the proposal.

Each voting rule specifies a treatment for our group-on-group ultimatum bargaining. We consider the following three voting rules:

Unanimity with Rejection Default: An offer is considered accepted when every member of the responder group votes to accept it. Otherwise it is considered rejected.

Unanimity with Acceptance Default: An offer is considered rejected when every member of the responder group votes to accept it. Otherwise it is considered accepted.

Majority Rule: An offer is considered accepted when at least two members of the responder group votes to accept it. Otherwise it is considered rejected.

As a control treatment, we use a standard one-on-one ultimatum bargaining where an agent, the proposer, proposes a division of a fixed amount of money, and a second agent, the responder, accepts or rejects it. If responder rejects, no individual receives any pay, and if responder accepts, each individual receives the amount specified in the proposal. This control treatment tests, first, whether individual behavior is affected by group size and, second, whether the comparative statics predictions of the offer size hold.[6]

[6] An alternative control treatment could be following: two groups of players have to bargain over an amount of money, but one agent (a "dictator") is chosen within each group to decide for the entire group .

Table 1: Experimental Design

Experimental Treatments of the Ultimatum Bargaining	Group Size	# of Subjects per Session
Standard One-on-One	1	24 and 30
Majority Rule	3	24 and 30
Unanimity with Rejection Default	3	30 and 30
Unanimity with Acceptance Default	3	30 and 30

Table 1 briefly summarizes the experimental treatments, the group size, and the number of subjects per session.

3.2 Design Parameters

This section describes the basic parameters and the general procedure of the experiment.

Participants and Venue. Subjects were drawn from a wide cross–section of students at Instituto Tecnológico Autónomo de México (ITAM) in Mexico City. Each subject participated in only one session. The experiment was run at ITAM using computers.

Experimental Sessions. In order to familiarize subjects with the procedures, two practice periods were conducted before the 10 real (played for money) periods.

Agent Types. For each of the group-on-group treatments, each participant was designated as a member of a type A group (i.e., proposers) or a member of a type B group (i.e., responders). For the one-on-one treatment, each participant was designated either as a type A agent (i.e., proposer) or as a type B agent (i.e., responder) before the beginning of the practice periods. All designations were determined randomly by the computer at the beginning of the experimental session, and remained constant during the entire session.

Matching Procedure and Group Size. For each of the group-on-group treatments, membership composition of each group was changed in a random fashion, so that each participant formed part of a new group (of the same type) at the beginning of each period. Each group consisted of exactly three participants. For the one-on-one treatment, a type A agent was paired with a type B agent, and each pairing was randomized for each period. Furthermore, agents did not know who they were paired with in any given period.

Bargaining Procedure. Subjects were informed that they had to bargain over 100 points. For the group-on-group treatments, the task of each pair of groups was to divide 100 points in each period using the following rules: a) group A had to make a final offer of points to group B; b) to make a final offer, each group A member had to write and send an offer via computer, each offer being in the range from 0 to 100 points; c) one of these offers was chosen randomly by the computer as group A final offer to group B; d) upon receiving the final offer, group B members had to decide whether to accept or reject the offer according to the voting rule announced for this session. No communication (except as explicitly discussed in this and next paragraph) was allowed among participants. For the one-on-one treatment, a very similar procedure was followed: a type A agent had to make and send an offer to an agent B, and after receiving the offer, agent B had to on his own decide whether to accept or reject it.

Information Feedback. For the group-on-group treatments, group A members observed simultaneously all the offers made by each group member, and the final offer sent to group B. Group B members observed the final offer, but not the other offers made by group A members. At the end of each round, members of both groups were informed whether the final offer was accepted or rejected, the number of individual acceptance and rejection votes (between 0 and 3) in the responder group, and the number of points obtained by their group in that round. For the one-on-one treatment, each agent type received complete feedback about whether the offer was accepted or rejected and her own amount of points obtained for that round.[7]

Payoffs. The final payoff was determined by randomly selecting one round out of the 10 real periods. The pay for the chosen period was calculated as follows: Each group member got $2.6 Mexican pesos (about 23 US cents) for each point obtained by her own group, in addition to the basic amount of $20 pesos (roughly US$1.75) for participation. Thus, each pair of groups effectively bargained over $780 pesos (around US$68 in Spring 2004 when the experimental sessions where conducted). For the one-on-one treatment, each agents pair had to bargain over $260 pesos.

[7] One peculiarity of these treatments is the fact that the proposer group is observing the decision made by each member of the responder group. The purpose of revealing this information is the fact that it helps proposers to update their beliefs about the probability of individual and group rejection, and thus may induce some kind of learning behavior across periods.

Table 2: Summary of Experimental Results: One-on-One and Group Majority Rule

Offer	One-on-One		Majority Rule			
Range	% F Off.	% I Rej.	% A Off.	% F Off.	% I Rej.	% G Rej.
> 50	5.9	0.0	9.3	8.9	0.0	0.0
	(16)	(0)	(25)	(8)	(0)	(0)
= 50	5.6	0.0	10.0	12.2	6.1	0.0
	(15)	(0)	(27)	(11)	(2)	(0)
45 - 49	13.7	2.7	7.4	2.2	16.7	0.0
	37	(1)	(20)	(2)	(1)	(0)
40 - 44	25.2	1.5	8.1	6.7	16.7	16.7
	(68)	(1)	(22)	(6)	(3)	(1)
35 - 39	14.4	20.5	18.1	20.0	18.5	16.7
	(39)	(8)	(49)	(18)	(10)	(3)
30 - 34	11.5	6.5	16.7	14.4	20.5	15.4
	(31)	(2)	(45)	(13)	(8)	(2)
25 - 29	13.7	37.8	20.4	20.0	24.1	16.7
	(37)	(14)	(55)	(18)	(13)	(3)
< 25	10.0	81.5	10.0	15.6	61.9	64.3
	(27)	(22)	(27)	(14)	(26)	(9)
All Off.	100.0	17.8	100.0	100.0	23.3	20.0
	(270)	(48)	(270)	(90)	(63)	(18)
Statistics						
Avg.	37	27	35	33	27	25
Med.	40	25	34	31	25	25
Var.	93	52	190	122	97	87
# Excl.	2		2			

Note: The number in parentheses below each percentage represents the occurrence's absolute frequency.

Table 3: Summary of Experimental Results: Group Unanimity Rules

Offer	Unanimity with Rejection Default				Unanimity with Acceptance Default			
Range	% A Off.	% F Off.	% I Rej.	% G Rej.	% A Off.	% F Off.	% I Rej.	% G Rej.
> 50	14.0	10.0	0.0	0.0	8.0	6.0	5.6	0.0
	(42)	(10)	(0)	(0)	(24)	(6)	(1)	(0)
= 50	12.7	10.0	0.0	0.0	2.3	3.0	0.0	0.0
	(38)	(10)	(0)	(0)	(7)	(3)	(0)	(0)
45 - 49	33.7	32.0	5.2	15.6	11.0	17.0	5.9	0.0
	(101)	(32)	(5)	(5)	(33)	(17)	(3)	(0)
40 - 44	18.0	20.0	13.3	25.0	16.3	19.0	19.3	0.0
	(54)	(20)	(8)	(5)	(49)	(19)	(11)	(0)
35 - 39	9.7	12.0	22.2	50.0	27.3	20.0	35.0	5.0
	(29)	(12)	(8)	(6)	(82)	(20)	(21)	(1)
30 - 34	7.0	9.0	29.6	66.7	15.7	17.0	49.0	17.6
	(21)	(9)	(8)	(6)	(47)	(17)	(25)	(3)
25 - 29	2.3	3.0	66.7	100.0	8.0	5.0	33.3	0.0
	(7)	(3)	(6)	(3)	(24)	(5)	(5)	(0)
< 25	2.7	4.0	91.7	100.0	11.3	13.0	59.0	23.1
	(8)	(4)	(11)	(4)	(34)	(13)	(23)	(3)
All Off.	100.0	100.0	15.3	29.0	100.0	100.0	29.7	7.0
	(300)	(100)	(46)	(29)	(300)	(100)	(89)	(7)
Statistics								
Avg.	44	43	29	33	36	37	30	26
Med.	47	45	30	35	36	38	33	33
Var.	113	121	178	139	125	143	118	110
# Excl.	0				0			

Note: The number in parentheses below each percentage represents the occurrence absolute frequency.

4 Experimental Results

This section compares the experimental results from the four treatments of ultimatum bargaining discussed in the previous section. We concentrate on measuring how different voting rules affect individuals and group rejection rates and proposals.

Table 2 describes for the one-on-one treatment the distribution of individual proposals and rejections aggregated across all ten periods. The offer range indicates the amount of points a proposer offers a responder. Consider, for example, the offer range from 35 to 39. In the one-to one treatment the number of proposals within this range was 39 out of a total of 270; the proportion of the total number of offers was 14.4% (39/270). Likewise, the rejection number within this range was 8 out of 39 offers; so the resultant rejection rate was 20.5% (8/39).

In the same table we also have the data for majority rule group-on-group treatment. As in the one-on-one case, consider the offer range from 35 to 39. The total number of proposals within this range was 49 out of 270 offers; thus the total offers proportion was 18.1% (49/270). Since just 1 out of 3 proposals was actually sent to a responder group, the final proposals are simply a random selection of the individual ones. The number of final proposals within this range was 18 out of a total of 90 offers sent. Therefore, the final offers proportion was 20.0% (18/90). Since all 3 members of a responder group received the same offer, the individual rejection number within this range was 10 out of 54 (18×3), implying the individual rejection rate for this range of 18.5% (10/54). At group level, the rejection number within this range was 3 out of 18, resulting in a 16.7% (3/18) group rejection rate. Table 3 describes the same information for both unanimity treatments.

At the bottom of Tables 2 and 3 some summary statistics are shown for the offers made and offers rejected. For the one-on-one and majority rule, the statistics exclude some subjects offers. For the one-on-one, two subjects were excluded: one subject that offered 100 for 8 consecutive periods and then 45 twice and another subject that offered 1 for 6 consecutive periods and then 15, 50, 30, 20.[8] For the majority rule, two subjects offers were excluded: one subject that offered 5 times more than 90 then 50 and then 4 times less than 15, and one that offered 5 times more than 90, 3 times between 70 and 80, twice at 50 and then offered 1.[9] For both unanimity treatments, no

[8] The subjects excluded for the one-on-one treatment were subjects 63 and 74. We believe the former of these to be simply confused about the meaning of the offer (whether it was the offer or the fraction retained by him). The latter, probably, took some game theory class.

[9] The subjects excluded for the group-on-group majority rule were subjects 359 and 368. Subject 359 subject offers were picked as a group final offer in five periods. These offers were the following: 100, 100, 95, 50 and 5. Subject 368

subjects were excluded.[10]

4.1 Individual Rejection Behavior

Considering all final offers together, group rejection rate decreases from 29.0% (29/100) in unanimity with rejection default to 20.0% (18/90) and 7.0% (7/100) in majority rule and unanimity with acceptance default, respectively.[11] At individual level, rejection rate decreases from 29.7% (89/300) in unanimity with acceptance default to 23.3% (63/270) and 15.3% (46/300) in majority rule and unanimity with rejection default, respectively. For the one-on-one treatment, rejection rate is clearly the same, 17.8% (48/270). Therefore, we observe a rejection rates rank order reversion among different voting rules when we move from group level to individual level, preserving the position of the one-on-one treatment somewhere in the middle closer to majority rule. Of course, in itself this is fairly meaningless, since it could result from different offer distributions in different treatments.

First thing we check is whether group rejection rates differ across treatments conditional on the offer size. In particular, we expected that group rejection rate for unanimity with rejection default should be higher than for the one-on-one treatment, and these two higher than for the unanimity with acceptance default. Meanwhile, majority rule rejection rate should be almost indistinguishable from one-on-one rejection rate. Second thing we check is whether decisions within a group affect individual behavior. That is, whether there is a difference in behavior when an individual have to decide by herself compare to when she has to decide within a group, following a specific decision rule. We expected that individual rejection rates should not differ across different treatments. Thus, group decision can be considered as the sum of decentralized individual decisions.

offers were picked as a group final offer in four periods. These offers were the following: 90, 97, 95, and 1. As in the one-on-one case the subjects might have been confused about the meaning of the offer.

[10]For the one-on-one treatment, the average and variance of proposals were for the whole data set 38 and 236, respectively. The average and variance of rejected proposals were 23 and 118, respectively. For the group-on-group majority rule, the average and variance of total proposals were for the whole data set 37 and 297, respectively. The average and variance of final proposals were 37 and 394, respectively. The average and variance of rejected proposals at individual level were 25 and 131, respectively. And the average and variance of rejected proposals at group level were 23 and 129, respectively.

[11]In a previous analysis (Slonim and Roth, [22]), only offers less than 50% were considered since it was expected that anything above or equal to 50% would be accepted. In our analysis, however, we consider all offers since some (although very few) offers above 50% were actually rejected at the individual level.

Table 4: Individual Probability of Offer Rejection: Logit Estimation

Coefficients	First Period		All Periods			
	Model I	Model II	Model III	Model IV	Model V	Model VI
Intercept	3.804···	4.680···	4.750···	4.574···	5.631···	5.375···
Offer	-0.142···	-0.183···	-0.201···	-0.203···	-0.206···	-0.207···
URejection		0.928		0.793		0.698
		($p = 0.306$)		($p = 0.270$)		($p = 0.363$)
UAcceptance		1.151		0.990		1.019
		($p = 0.207$)		($p = 0.206$)		($p = 0.197$)
Majority		0.250		-0.147		-0.139
		($p = 0.741$)		($p = 0.808$)		($p = 0.826$)
Period					-0.131···	-0.129···
# of Obs.	112	112	1093	1093	1093	1093
Model		vs. Model I		vs. Model III	vs. Model III	vs. Model V
Comparison		$\chi^2_{(3)} = 2.480$		$\chi^2_{(3)} = 4.100$	$\chi^2_{(1)} = 11.430$···	$\chi^2_{(3)} = 3.670$
$\chi^2_{(\#var)}$		($p = 0.479$)		($p = 0.251$)		($p = 0.229$)

·: $p<0.05$, ··: $p<0.01$ and ···: $p<0.001$.

Table 5: Group Probability of Offer Rejection: Logit Estimation

	First Period		All Periods			
Coefficients	Model I	Model II	Model III	Model IV	Model V	Model VI
Intercept	3.304$^{\cdot}$	4.596$^{\cdot}$	3.935$^{\cdot\cdot\cdot}$	5.301$^{\cdot\cdot\cdot}$	4.862$^{\cdot\cdot\cdot}$	6.234$^{\cdot\cdot\cdot}$
Offer	-0.134$^{\cdot\cdot}$	-0.180$^{\cdot}$	-0.215$^{\cdot\cdot\cdot}$	-0.229$^{\cdot\cdot\cdot}$	-0.220$^{\cdot\cdot\cdot}$	-0.236$^{\cdot\cdot\cdot}$
URejection		1.754		2.171$^{\cdot\cdot}$		2.239$^{\cdot\cdot}$
		($p = 0.185$)				
UAcceptance		0.188		-2.931$^{\cdot\cdot}$		-2.911$^{\cdot\cdot}$
		($p = 0.894$)				
Majority		-0.914		-1.367		-1.447
		($p = 0.273$)		($p = 0.127$)		($p = 0.122$)
Period					-0.141	-0.1360
					($p = 0.072$)	($p = 0.074$)
# of Obs.	54	54	531	531	531	531
Model		vs. Model I		vs. Model III	vs. Model III	vs. Model IV
Comparison		$\chi^2_{(3)} = 3.210$		$\chi^2_{(3)} = 19.280^{\cdot\cdot\cdot}$	$\chi^2_{(1)} = 3.240^{\cdot\cdot\cdot}$	$\chi^2_{(1)} = 3.190^{\cdot\cdot\cdot}$
		($p = 0.360$)			($p = 0.072$)	($p = 0.074$)

$^{\cdot}$: $p<0.05$, $^{\cdot\cdot}$: $p<0.01$ and $^{\cdot\cdot\cdot}$: $p<0.001$.

4.1.1 Rejection Behavior: First Period

Group rejection rates for all first period offers were 33.3% (3/9), 30.0% (3/10), 20.0% (5/25) and 10.0% (1/10) in majority rule, unanimity with rejection default, one-on-one treatment, and unanimity with acceptance default, respectively. Significant differences in rejection rates were rejected for all treatment, but for the unanimity with acceptance default treatment vs. majority rule ($z = -1.65$, $p < 0.05$).[12] At individual level, rejection rates were 20.0% in unanimity with rejection default (6/30), one-on-one treatment (5/25), and unanimity with acceptance default (6/30), and 44.4% (12/27) in majority rule. A significant difference in individual rejection rate was found just for majority rule.[13]

Slonim and Roth [22] had pointed out at least two reasons that explain these ambiguous results: a) sample size and b) differences among offer distributions across treatments. Since we are looking at decisions made by groups, the number of responses shrinks from 3 at individual to 1 at group level.[14] On the other hand, since there are significant differences in offer distributions across treatments, there are offer ranges within which we do observe rejections for some treatments and do not observe rejections for other treatments.

Following Slonim and Roth [22], we consider two different models for estimating rejection probability using data set from the first period in order to control for "equivalent offers":

$$\Pr(Reject_i = 1) = F(\alpha + \beta_{offer} Offer_i) \tag{1}$$

$$\begin{aligned} \Pr(Reject_i &= 1) = F(\alpha + \beta_{offer} Offer_i \\ &+ \beta_{ur} URejection + \beta_{ua} UAcceptance + \beta_m Majority) \end{aligned} \tag{2}$$

where $Offer_i$ is the offer responder i receives from 0 to 100; $URejection$, $UAcceptance$ and $Majority$ are dummies for each of the voting rules; $F(z_i) = \frac{1}{1+e^{-z_i}}$ is the cumulative logistic distribution function; and $Reject_i = 1$ means that an offer was rejected. For these and further estimation analyses we exclude the offers made by the four subjects mentioned before for the one-on-one and group-on-group majority rule.

[12] For the one-on-one vs. unanimity with rejection default and the one-on-one vs. unanimity with acceptance default, the one-tailed proportion test results are: $z = -1.17$, $p = 0.120$ and $z = 1.29$, $p = 0.098$., respectively. For the one-on-one vs. majority rule a two-tailed proportion test result is: $z = -1.54$, $p = 0.124$.

[13] For the one-on-one vs. majority rule a two-tailed proportion test results is: $z = -2.53$, $p < 0.05$.

[14] It should be noted, that our sample size is not particulary small by the literature standards. Thus, Borstein and Yaniv [2] have only 20 one-on-one and 20 group-on-group observations (they only observe final group decisions). In all they observe only 2 rejections, making it difficult to make any conclusions about rejection probabilities.

Table 4 and 5 show the logit estimations for these two models at individual and group levels, respectively. Model II checks whether different voting rules affect individual rejection probability in addition to the offer size considered in Model I. We should expect the offer size coefficient be less than zero ($\beta_{offer} < 0$), meaning that while an offer is higher the probability of rejection should be lower. At individual level, we should expect all treatment coefficients be equal to zero ($\beta_{ur} = \beta_{ua} = \beta_m = 0$). At group level, we should expect that all three treatment coefficients differ in sign ($\beta_{ur} > 0$, $\beta_{ua} < 0$, $\beta_m = 0$), where a positive coefficient should indicate a higher probability of rejection for a given offer than a negative coefficient.

Model I shows similar results at both individual and group levels. The offer size coefficient (β_{offer}) is significant and correct in sign. For Model II, none of the treatment coefficients are significantly different from zero. In addition, the inclusion of these treatment variables does not contribute to the overall performance of the estimation. A χ^2 test result indicates that the null hypothesis of $\beta_{ur} = \beta_{ua} = \beta_m = 0$ cannot be rejected either at the individual level ($p = 0.479$) or at the group level ($p = 0.360$). This satisfies our expectations for individual analysis. That is, individual behavior do not seem to be affected by acting within a group. At group level, however, these results does not seem to give support to our initial expectations.[15]

Summing up our results, smaller offers results in a higher probability of rejection and we cannot reject the null that treatment coefficients have no effect on rejection rates at group level ($\beta_{ur} = \beta_{ua} = \beta_m = 0$). That is, different treatments do not affect group rejection probabilities.[16] Since, however, the individual and group conditional rejection probabilities cannot all be actually the same (section 2 above provides a formula relating them), it remains to conclude that we simply do not have enough observations in one period to make any statistical conclusions.

4.1.2 Rejection Behavior: All periods

We are now going to consider next the data set for all ten periods. Following Slonim and Roth [22], we consider four different models for estimating rejection probability using data set from all

[15] In addition, note that although not significantly different from zero, the sign of the unanimity with acceptance default coefficient (β_{ua}) at group level is opposite to what was expected.

[16] Results for the last period were even more ambiguous. The unanimity with rejection default coefficient showed significance for a $p < 0.01$ at individual level. On the other hand, the offer size coefficient was not significantly different from zero for a $p = 0.169$ at group level. Model II could not be implemented for the group analysis since the majority rule rejection rate did not show variation.

ten periods:

$$\Pr(Reject_i = 1) = F(\alpha + \beta_{offer} Offer_i) \tag{3}$$

$$\begin{aligned} \Pr(Reject_i &= 1) = F(\alpha + \beta_{offer} Offer_i \\ &+ \beta_{ur} URejection + \beta_{ua} UAcceptance + \beta_m Majority) \end{aligned} \tag{4}$$

$$\Pr(Reject_i = 1) = F(\alpha + \beta_{offer} Offer_i + \beta_{period} Period) \tag{5}$$

$$\begin{aligned} \Pr(Reject_i &= 1) = F(\alpha + \beta_{offer} Offer_i + \beta_{period} Period \\ &+ \beta_{ur} URejection + \beta_{ua} UAcceptance + \beta_m Majority) \end{aligned} \tag{6}$$

where $Period$ is the time period in which a decision was taken and all other variables preserve the same meaning as in previous section. Table 4 and 5 show the logit estimations for these four models at individual and group levels, respectively.[17] We did not have a definite expectations about the sign of coefficient period: β_{period}. A negative coefficient should indicate the responders willingness to reject less often as time pass.[18]

[17] This is actually random effect logit, to account for individual agent variability.

[18] We also evaluated other model specifications. These results are not shown for reasons explained below. The additional models evaluated were the following:

$$\begin{aligned} \Pr(Reject_i &= 1) = f(\alpha + \beta_{offer} Offer_i + \beta_{period} Period \\ &+ \beta_{ur} URejection + \beta_{ua} UAcceptance + \beta_m Majority \\ &+ Period * (\beta_{pur} URejection + \beta_{pua} UAcceptance + \beta_{pm} Majority)) \\ \Pr(Reject_i &= 1) = f(\alpha + \beta_{offer} Offer_i + \sum_{j=2}^{10} \alpha_j Period_j \\ &+ \beta_{ur} URejection + \beta_{ua} UAcceptance + \beta_m Majority \end{aligned}$$

The first specification takes into account the possibility of differences in rejection rates across periods within each treatments. We could not reject the null hypothesis that $\beta_{purd} = \beta_{puad} = \beta_{pmr} = 0$ for a $p < 0.5$, indicating that a restricted model does a better performance in explaining rejection probability.

The second specification introduces a dummy variable for every period, treating time as a discrete time variable. This specification also helps to check the validity of considering the period variable as a continuos variable. At the individual level, we reject the null hypothesis that all coefficients were different from zero for a $p < 0.05$. Therefore, discrete time contributes to explaining rejection rate variations across periods. However, this was not the case at group level. On the other hand, we could not reject at individual level the null hypothesis $44\beta_2 - \sum_{i=3}^{10} \beta_i = 0$ for a $p < 0.05$, indicating that the description of time influence using a continuos variable will be indistinguishable from using a discrete variable. We finally decided to treat time as a continuos variable for our analyses.

At group level, another model specification was considered:

$$\begin{aligned} \Pr(Reject_i &= 1) = f(\alpha + \beta_{offer} Offer_i + \beta_{period} Period \\ &+ \beta_{ur} URejection + \beta_{ua} UAcceptance + \beta_m Majority) \\ &+ \beta_{om} Offer_i * Majority) \end{aligned}$$

As is seen in Table 4, Model IV shows no significance for the treatment coefficients at individual level. A χ^2 test result indicates that the null hypothesis of $\beta_{ur} = \beta_{ua} = \beta_m = 0$ cannot be rejected for a $p = 0.251$, favoring the restricted Model III. While preserving the significance and sign for the offer size coefficient ($\beta_{offer} < 0$), Model V also shows significance for the time period coefficient. The time period coefficient's negative sign indicates that individual rejection rate decreases over time. Model VI preserves the significance and sign for both the offer size and the time period coefficients, but shows the no significance for the treatment coefficients. A χ^2 test result indicates that the null hypothesis of $\beta_{ur} = \beta_{ua} = \beta_m = 0$ cannot be rejected for a $p = 0.229$, favoring the restricted Model V. Figure 1 shows the expected group rejection probabilities based on the individual rejection response, $P(x)$, from Model V (Table 4).[19]

In Table 5, Model IV shows significance of the treatment coefficients at group level including the signs characterization. The positive sign of the unanimity with rejection default coefficient ($\beta_{ur} > 0$) indicates that rejection probability is higher when a responder group has to decide according to this voting rule. On the opposite side, the negative sign of the unanimity with acceptance default coefficient ($\beta_{ua} < 0$) indicates that rejection probability is lower when a responder group has to decide according to this voting rule. Finally, the majority rule coefficient (β_m) is not significantly different from zero. At this level of analysis, Model IV χ^2 test result indicates that the null hypothesis of $\beta_{urd} = \beta_{uad} = \beta_{mr} = 0$ can be rejected for a $p < 0.001$, favoring this model with respect to the restricted Model III. Finally, Models V and VI show no significance for time period ($p = 0.074$). Figure 2 shows the estimated group rejection probabilities from Model IV (Table 5) and the actual rejection rates for different offer intervals.

Summing up our results, the rejection probability estimations using the data set from all ten periods show how different voting rules affect individual and group responses in the ultimatum bargaining. On one hand, individuals tend to respond in the same way whether they are deciding within a group or alone. On the other hand, different voting rules affect group rejection probabilities as expected. Smaller offers result in higher rejection probability. Finally, time is important to explain changes on individual rejection probability over time. In particular, equivalent offers are less likely to be rejected over time. Figure 3 shows a comparison between the expected group

This specification takes into account for majority rule the possibility of higher rejection rates at lower offers and lower rejection rates for higher offers ($\beta_m > 0$ and $\beta_{om} < 0$). We could not reject the null hypothesis that $\beta_{om} = \beta_m = 0$ for a $p < 0.5$, indicating that a restricted model does a better performance in explaining rejection probability.

[19] The value for time period was 5.

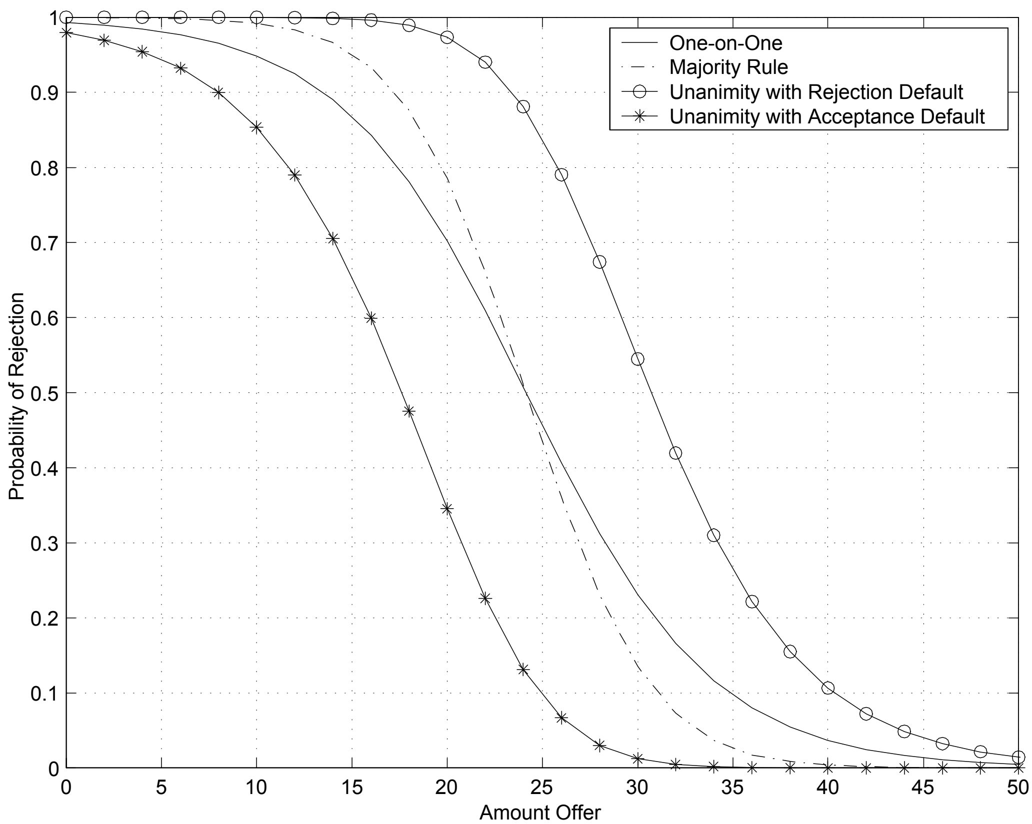

Figure 1: Expected Group Rejection Probabilities based on Individual Response Estimation from Model V (Table 4)

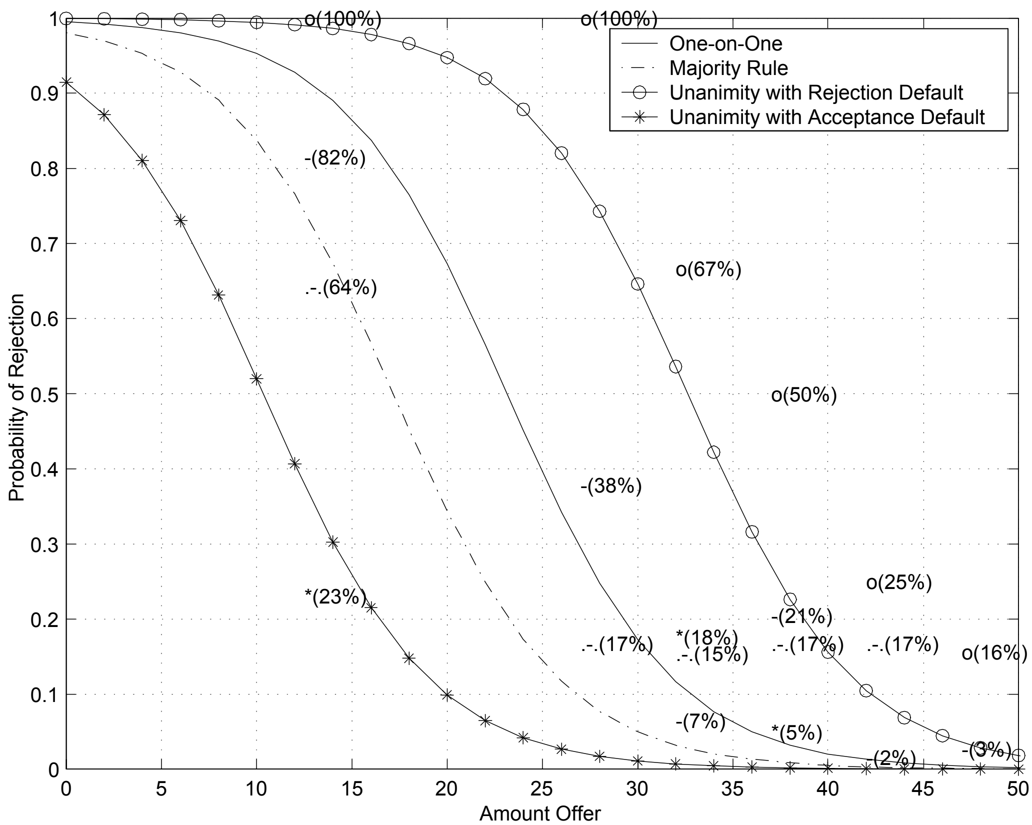

Figure 2: Estimated Group Rejection Probabilities from Model IV (Table 5) and the Actual Rejection Rates

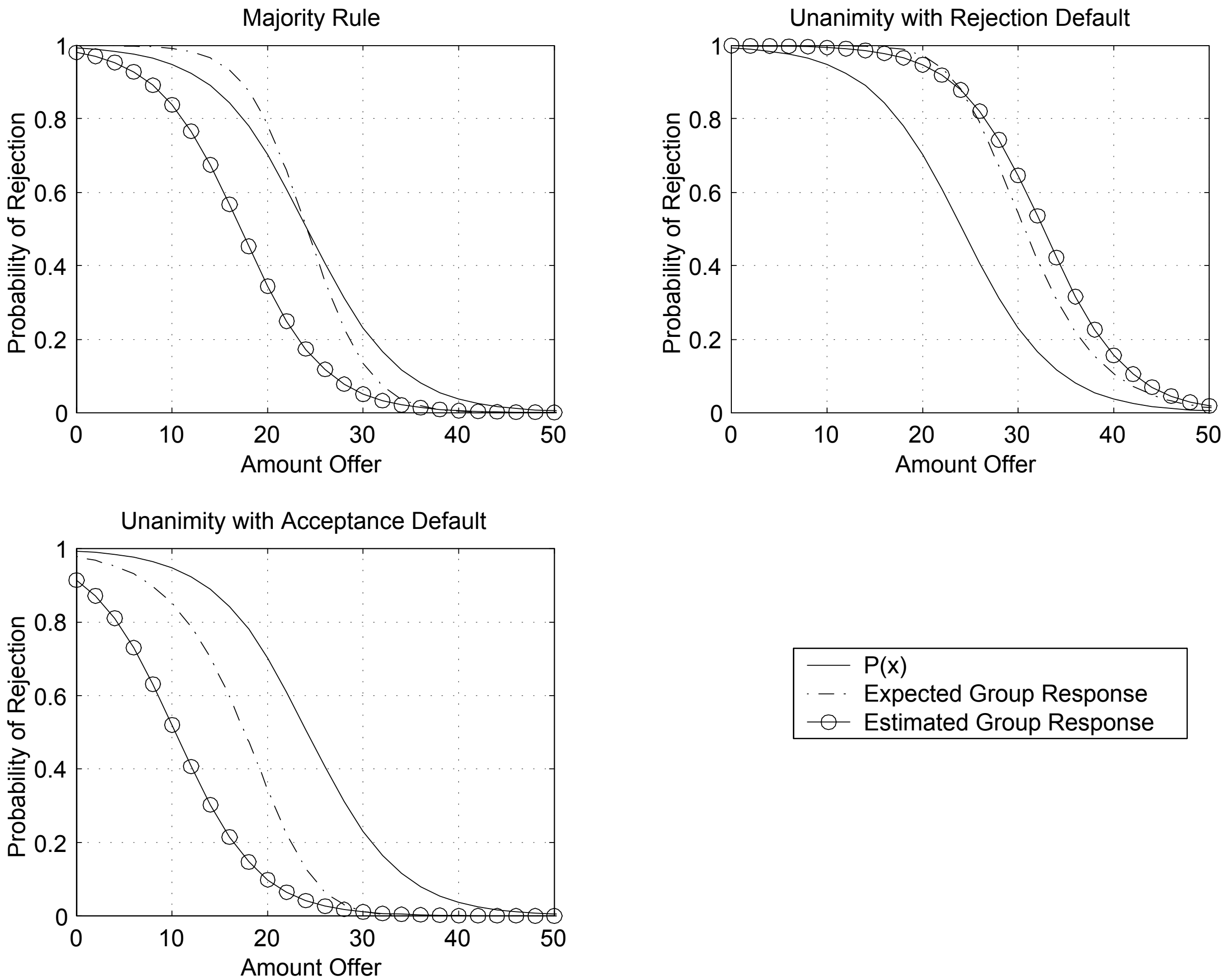

Figure 3: Expected Group Response vs. Estimated Group Response

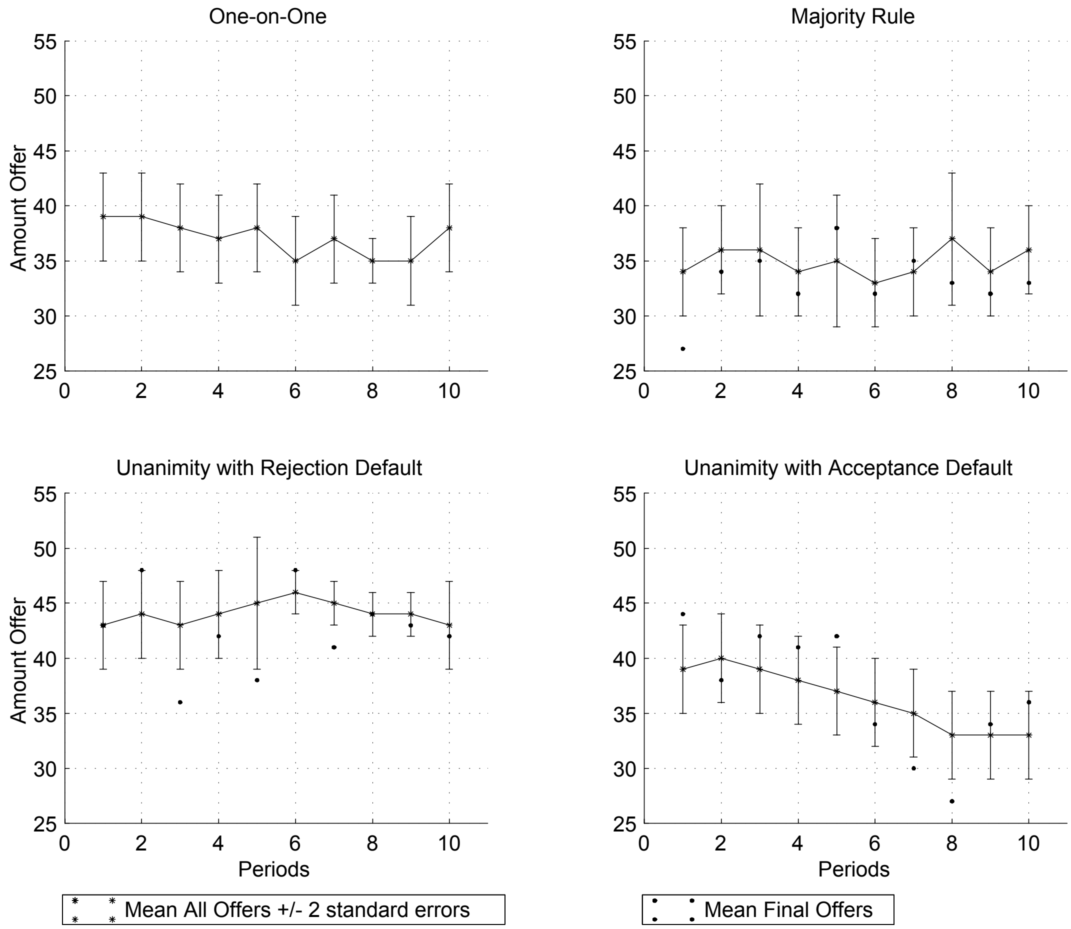

Figure 4: Amount Offers

response and the estimated group response for each treatment. We conclude that our comparative static predictions for the rejection probabilities seem to hold at least in qualitative terms.

4.2 Proposer Behavior

Given the differences in group rejection probabilities for different voting rules, we should expect changes in offers across treatments. Figure 3 shows, for each treatment, the final offer average and all offers average (+/- 2 standard errors) across all ten periods. We consider the following four main specification for estimating the offer size differences across all treatments for the all periods:

$$Offer_i = \alpha_0 \tag{7}$$

$$Offer_i = \alpha_0 + \beta_{period} Period \tag{8}$$

Table 6: Proposer Behavior

Coefficients	All Periods			
	Model VII	Model VIII	Model IX	Model X
Intercept	$38.3364^{\cdots}$	$40.0200^{\cdots}$	$38.7636^{\cdots}$	$38.8293^{\cdots}$
Period		$-0.3061^{\cdots}$	$-0.3061^{\cdots}$	$-0.3181^{\cdots}$
URejection			$7.0667^{\cdots}$	$5.3307^{\cdots}$
UAcceptance			-0.8100	2.3529
			$(p = 0.735)$	$(p = 0.372)$
Majority			-1.9800	-3.9813
			$(p = 0.429)$	$(p = 0.148)$
URejection*Period				0.3156
				$(p = 0.113)$
UAcceptance*Period				$-0.5751^{\cdots}$
Majority*Period				$0.3639^{\cdot\cdot}$
# of Obs.	1100	1100	1100	1100
Model		vs. Model VII	vs. Model VII	vs. Model VII
Comparison		$\chi^2_{(1)} = 18.54^{\cdots}$	$\chi^2_{(4)} = 36.98^{\cdots}$	$\chi^2_{(7)} = 67.42^{\cdots}$
			vs. Model VIII	vs. Model IX
			$\chi^2_{(3)} = 18.44^{\cdots}$	$\chi^2_{(3)} = 29.94^{\cdots}$

$^{\cdot}$: p<0.05, $^{\cdot\cdot}$: p<0.01 and $^{\cdots}$: p<0.001.

$$Offer_i = \alpha_0 + \alpha_{ur} URejection + \alpha_{ua} UAcceptance + \alpha_m Majority + \beta_{period} Period \quad (9)$$

$$\begin{aligned} Offer_i &= \alpha_0 + \alpha_{ur} URejection + \alpha_{ua} UAcceptance + \alpha_m Majority + \beta_{period} Period \quad (10) \\ &+ Period * (\beta_{pur} URejection + \beta_{pua} UAcceptance + \beta_{pm} Majority) \end{aligned}$$

where $Offer_i$ is the offer proposer i sent from 0 to 100; $Period$ is the period time in which an offer was made; and $URejection$, $UAcceptance$ and $Majority$ are dummies for each of the voting rules. We use for these estimations all the offers made. We again exclude the offers made by the same subjects mentioned before for the one-on-one and group-on-group majority rule. Table 6 shows the random effect estimations for these specifications.

Model VII is just the offers' average for the whole data. Model IX checks whether different voting rules affect individual proposals in addition to time period considered in Model VIII. We should expect the offer size coefficient for unanimity with rejection default be greater than zero ($\alpha_{ur} > 0$), meaning that compared to the one-on-one treatment proposers should be willing to offer more given the high rejection probability behind by this voting rule. For unanimity with acceptance default, we should expect a coefficient less than zero ($\alpha_{ua} < 0$), which means that compared to the one-on-one treatment proposers should be willing to offer less given the low probability of rejection. Compared to the one-on-one treatment, proposers in majority rule should be willing to offer less when $P(x) < \frac{1}{4}$ and more otherwise. Therefore, it is difficult to clearly specify in advanced the coefficient sign associated to this treatment. Model X allows the possibility of a different dynamic within each treatment.

Model VII shows that the time period coefficient (β_{period}) is significant for a $p < 0.001$. This means that proposers were willing to offer less overtime. Model IX shows first that the unanimity with rejection default coefficient is different from zero ($p < 0.001$), indicating that proposers tend to offer more than in the one-on-one treatment. On the other hand, the other two treatment coefficients are not significantly different from zero. The majority rule and unanimity with acceptance default coefficient are not significantly different from zero for a $p = 0.429$ and $p = 0.735$, respectively. However, a χ^2 test result indicates that the null hypothesis of $\beta_{ur} = \beta_{ua} = \beta_m = 0$ can be rejected for a $p < 0.001$. Model VIII and IX assume that the dynamic within each treatment is the same. Model X removes this restriction introducing a time period interaction for each treatment. Model X χ^2 test result indicates that the null hypothesis of $\beta_{pur} = \beta_{pua} = \beta_{pm} = 0$ can be rejected for a $p < 0.001$. Therefore, the introduction of this interaction of time period and treatments contribute to the explanation of the offers. In particular, Model IV shows that proposals tend to decrease over time faster in the group-on-group unanimity with acceptance default than in the one-on-one treatment. It also shows that proposal tend to increase over time faster in the group-on-group majority rule than in the one-on-one treatment.

Summing up our results, our estimations indicate that offers decrease over time; offers are higher for the unanimity with rejection default than for other treatments; offers are not significantly different for the other two voting rules compared to the control treatment; and while offers decrease over time in the unanimity with acceptance default, they increase in the majority rule.

5 Conclusions

In this paper we provide a comparison between four different treatments of ultimatum bargaining: the one-on-one bargaining and three different group-on-group games differentiated by the controlled decision rule used on the responder side to agree on acceptance or rejection. At present, the results of our experiments seem to support the following conclusions:

We cannot reject the hypothesis that individual responder behavior is the same in all four treatments. The willingness to reject low offers clearly suggests existence of a non-monetary component in individual payoffs. The absence of difference between the behavior inside and outside the group suggests that this behavior could be fully explained by assuming that agents care about the distribution of monetary payoffs among the bargainers (in particular, by their dislike of being treated unfairly). We do not get any evidence of either preference for expressing displeasure and or satisfaction through one's vote, nor of some common non-monetary value (such as would arise if agents cared about behaving according to some social norm): both of these would have clear predictions on the comparative statics of responder behavior across treatments.

We can reject hypothesis that the proposer behavior is the same in all four treatments. In particular, in the unanimity with rejection default proposers are clearly substantially more cautious than in other treatments, which indicates that they correctly respond to the increased difficulty of obtaining acceptance of their proposals. We, so far, cannot reject that proposers behave identically in the other three treatments. In particular, we fail to reproduce the Grosskopf [9] result that in the unanimity with acceptance default treatment proposers would be more aggressive. One reason for this may be that, though, as discussed above, the difference in responder behavior between the treatments is not statistically significant, the realization of the individual conditional rejection probability in this treatment happened to be somewhat high, possibly “training” the agents to behave somewhat more cautiously. This is supported by the fact that in Grosskopf’s [9], though similarly not significantly different from the one-on-one case, the realization of group rejection probability is low, possibly reinforcing her results.

It is suggested by the previous discussion that proposers may be best-responding to empirical rejection probabilities they face. Furthermore, there does seem to be evidence that agents learn the “correct” behavior over time. Further research is needed to establish exactly the nature of this learning process and how it responds to the empirical rejection.

A number of things remain to be done. Most obviously, more sessions will have to be run to collect the data, since our statistical inference does suffer from low numbers of observations (in each round we observe only 9 to 10 plays of each group treatment). Furthermore, it may be interesting to let the same subjects participate in different experimental treatments (in particular, this may help us test the majority rule predictions, since these depend on individual aggressiveness of the proposers). Finally, since the results clearly support importance of agents’ learning in ultimatum bargaining games, future research would have to address the relationship between our results and the literature on learning in games.

6 Appendix 1: Experimental Instructions

The following is the verbatim translation (from Spanish into English) of experimental instructions administered to subjects at ITAM (the Spanish original is available from the authors upon request).

6.1 Instructions Group-on-Group

This is an experiment about decision-making. The instructions are simple and if you follow them carefully and take good decisions, you can earn a CONSIDERABLE AMOUNT OF MONEY, which will be PAID YOU IN CASH at the end of the experiment

General Proceedings

In this experiment you will participate as a member of a GROUP A or a GROUP B. Your participation as a part of one of these two groups shall be determined at the beginning of the experiment and will be constant during the entire session. Each group shall consist solely of three (3) participants.

The experiment shall consist of 12 periods: two practice periods, and 10 periods played for money, one of which shall be randomly selected at the end of the experiment to determine your final pay. For this reason you should consider each period as if it were "the chosen period" for your pay.

At the beginning of each period, each TYPE A GROUP will interact with a TYPE B GROUP. The formation of pairs of GROUPS A and B will be done randomly. Likewise, the membership composition of each group will change in a random fashion, so that each participant will form a part of a new GROUP (of the same type) at the beginning of each period.

Specific Proceedings

In each period the task of each pair of groups is to try to divide 100 points using the following rules.

1) The members of GROUP A must make an offer of points to members of GROUP B.

1.1) To make the final offer from GROUP A to GROUP B each member of GROUP A must write and send an offer via the computer. Each offer must be in the range of 0 to 100 points.

1.2) After that, one of these offers made shall be chosen randomly by the computer as the final offer of GROUP A to GROUP B.

2) The final offer of GROUP A shall be sent to each member of GROUP B. After observing the offer sent, the members of GROUP B must decide if they accept of reject the offer according to the following rule:

The offer is considered accepted when every one of the members of the group votes to accept it. Otherwise it is considered rejected.[20]

2.1) If GROUP B rejects the offer, no GROUP receives any pay.

2.2) If GROUP B accepts the offer, the GROUP A receives the amount of 100 points minus the points offered to GROUP B. In its turn, GROUP B receives the amount of points which has been offered by GROUP A.

3) Once taken, the decision to accept or reject the offer of points is final, no counter-offer shall be possible, and the next period shall start with a new grouping of participants for each group type.

Payment Proceedings

Once the 10 periods played for money are over, one of them will be chosen randomly to determine the final pay. For this reason, you should consider each period as if it were final "chosen period" for your pay.

[20]This corresponds to Unanimity with rejection default; instructions for other treatments are as follows.

Unanimity with acceptance default:

"The offer is considered rejected when every one of the members of the group votes to accept it. Otherwise it is considered accepted".

Majority rule:

"The offer is considered accepted when at least two of the members of the group vote to accept it. Otherwise it is considered rejected."

The pay for the chosen period shall be calculated as follows: Each member of each group shall get $2.6 pesos for each point obtained by the group to which she\he belongs, in addition to the basic amount of $20 pesos for participation.

At the end of the session, each of the participants shall be called by the identification number assigned by the computer at the beginning of the experiment to receive his/her pay in a sealed envelope, thus ensuring the complete anonymity of his/her decisions and their results.

6.2 Instructions One-on-One

This is an experiment about decision-making. The instructions are simple and if you follow them carefully and take good decisions, you can earn a CONSIDERABLE AMOUNT OF MONEY, which will be PAID YOU IN CASH at the end of the experiment

General Proceedings

In this experiment you will participate as a TYPE A or TYPE B AGENT. Your participation as one of these agent types shall be determined at the beginning of the experiment and will be constant during the entire session

The experiment shall consist of 12 periods: two practice periods, and 10 periods played for money, one of which shall be randomly selected at the end of the experiment to determine your final pay. For this reason you should consider each period as if it were "the chosen period" for your pay.

At the beginning of each period, each TYPE A AGENT will interact with a TYPE B AGENT. The formation of pairs of TYPE A and TYPE B AGENTS will be done randomly.

Specific Proceedings

In each period the task of each pair of agents is to try to divide 100 points using the following rules.

1) Each TYPE A AGENT must make an offer of points to a TYPE B AGENT. For this each TYPE A AGENT must write and send an offer via the computer. Each offer must be in the range of 0 to 100 points.

2) After observing the offer sent by the TYPE A AGENT, the TYPE B AGENT must decide if she\he accepts or rejects it.

2.1) If the TYPE B AGENT rejects the offer, no AGENT receives any pay.

2.2) If TYPE B AGENT accepts the offer, the TYPE A AGENT receives the amount of 100 points minus the points offered to TYPE B AGENT. In its turn, TYPE B AGENT receives the amount of points which has been offered by TYPE A AGENT.

3) Once taken, the decision to accept or reject the offer of points is final, no counter-offer shall be possible, and the next period shall start with a new grouping of agent pairs.

- Payment Proceedings

Once the 10 periods played for money are over, one of them will be chosen randomly to determine the final pay. For this reason you should consider each period as if it were final "chosen period" for your pay.

The pay for the chosen period shall be calculated as follows: Each agent shall get $2.6 pesos for each point obtained, in addition to the basic amount of $20 pesos for participation.

At the end of the session, each of the participants shall be called by the identification number assigned by the computer at the beginning of the experiment to receive his/her pay in a sealed envelope, thus ensuring the complete anonymity of his/her decisions and their results.

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