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Economic Action and Reference Points: An Experimental Analysis

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Chapter 1

Introduction

This thesis involves the exploration of human motivations and its consequences in certain economic situations. While the debate on what motivations drive human behavior has its origin probably in the own origin of economics and, furthermore is also a topic of psychology and sociology, the object of this study is to analyze certain proposals that have recently appeared in economics. The methodology employed in this thesis will be mainly economic theory and economic experiments. I analyze di®erent situations, both theoretically and experimentally, in which the focus of the analysis is how subjects perceive certain kinds of information involved in the economic situation and how the perception of this information is used in the decision process. This rather general statement can be made speci¯c by adding that in the type of decisions I will study issues of fairness, reciprocity and other-regarding tendencies will be prominent.

I take into account the approach of Sen (1997) in considering the choice process as including preferences over comprehensive outcomes and not just culmination outcomes.

This distinction means that this study pays special attention to how an outcome is reached to understand the behavior of individuals leading to that outcome. The process leading to a possible outcome of the game involves information that may help agents to interpret the situation. This information may be relevant if one is considering the possibility that agents use reciprocity or fairness considerations.

As a convention in this thesis, the term "reciprocity" will refer to the willingness to reward perceived good intentions and to punish perceived bad intentions, based on observed actions. The term "fairness" will be used here in the sense of Rabin (1993) as the willingness to reward good and to punish bad intentions in simultaneous games, where agents use beliefs.

In the notion of fairness introduced by Rabin (1993), an outcome called the "reference point", used to evaluate the intentions of the other players, plays a key role. The notion of reference point will be central in the following chapters, in particular Chapter 2, Chapter 3 and Chapter 4 that study in detail the influence of reference points, though not in the strict sense of Rabin. With respect to the approach proposed by Sen (1997) this means that these chapters are devoted to the study of menu dependence, or the role that the menu of alternatives plays in the decision process.

This thesis employs the experimental methodology intensively to analyze the type of questions just described. The use of experimental methods in three chapters of this thesis is justified by the kind of question analyzed. Field data do not contain enough detail to obtain information on how certain decisions are taken, but the type of questions I study require this kind of information. The control that can be achieved with experiments allows us to obtain the appropriate type of data.

The experiments presented here share a few common properties that are standard in this research. These properties are common elements in the literature -see for example, Hey (1991), Davis and Holt (1993), Friedman and Sunder (1994), or Kagel and Roth (1995) for details of the methods and procedures generally used. First, participants in experiments are paid according to the decisions they make in the session in which they participate. Second, no deception is introduced in any part of the experiments. Third, all subjects were recruited from the Universitat Autònoma de Barcelona through billboards. Fourth, the whole series of experiments were run by hand, that is, with no computer interaction. The first three characteristics I just mentioned try to ensure that subjects have enough incentives to revel their true preferences, that the subjects are confident that the environment presented is as we present it to them (moreover, this allows a kind of public good across experiments, by setting a reputation of truthtelling in economics experiments) and that subjects do not feel any professor-student pressure from the experimenter to make certain decisions. The use of run-by-hand experiments can be justified by the rather simple games used, in which not much computation is required to find out the payoffs of the agents. Certain experiments are better conducted by computer to allow a reasonable amount of time in running the sessions, but certainly this is not case for the experiments presented in this thesis. A computerized extension of the work presented in Chapter 5 is planned.

Another common characteristic of the experiments presented here is the relatively simple structure of the decisions that subjects are asked to make. Since the subjects used in the sessions presented here had no previous experience with experiments, and most of them were not students from economics or business administration, special care was given to ensure comprehension of the decisions tasks and the environment presented to them. The instructions for Chapter 3 and Chapter 5 are included in the respective appendix of these chapters.[1]

In Chapter 2, (On Rabin's Concept of Fairness and the Private Provision of Public Goods) I consider the implications of the Rabin (1993) theory of fairness for the private provision of public goods through the Voluntary Contribution Mechanism where agents have continuous strategies. This model involves a modelization of a concept of fairness based on experimental results. The notion of fairness introduced implies the willingness to reward good intentions and to punish bad intentions. Evaluation of the intentions from other players need beliefs on what others will do and beliefs on what other players belief that the reaction to their actions will be. These beliefs on other players' actions are evaluated in terms of a reference point. Rabin (1993) set this reference point as the midpoint between those outcomes that are Pareto Efficient. Another way to put this is that every agent beliefs that she deserves half of the amount she can share with the other player, given Pareto Efficiency. I allow for a general reference point in this model to incorporate different subjective notions of fairness. For example allowing an individual who beliefs that she deserves everything. This model is used for the problem of the private provision of public goods because this area contains a vast amount of experimental results and because these results have been debated with respect to what notion of individual behavior can account for it. The standard setting involves several players that have the opportunity to make private contributions to one public good out of a private good. The characteristics of the situation

[1]The instructions for Chapter 4 are not included since they are the same as the ones in Chapter 3 but for the specific games used.

are that the dominant strategy for each player is contributing nothing to the public good, while e±ciency would require full contribution of the private resources to the public good production.[2]

Two main results are analyzed in detail, the so called splitting, or the observed behavior by which subjects contribute between 40% to 60% of their private resources to the public good (particularly in initial periods or in one-shot games) and what is known as the MPCR e®ect[3]. As the main results of this chapter, we observe that the model introduced by Rabin (1993) is able to explain splitting in the linear model as well as in a non-linear model with two players as a compromise between the private interest and the psychological part of the utility function, but does not rule out other equilibria not consistent with experimental data. The model fails to predict correctly the e®ect of the MPCR on contributions, one of the most accepted pieces of evidence in the ¯eld. These results question the suitability of using this model, even in the environments which are closer to its requirements, say simultaneous games of two players.

In Chapter 3 (Reference Points and Negative Reciprocity in Simple Sequential Games, joint work with Jordi Brandts) we investigate experimentally whether preferences over an outcome depend on what other possible outcomes of the situation under consideration are, i.e. whether choices are "menu dependent". In simple sequential games we analyze whether reactions to a certain benchmark outcome are in°uenced by changes in the payo®s of another outcome, not attainable at that time, the reference point. The change to sequential games with respect to Chapter 2 is originated by the fact that since Rabin's model of

[2]See Ledyard (1995) for a complete description of the environment, which can also be found in detail in Chapter 2.

[3]This concept was introduced and analyzed in experiments ¯rst by Isaac, Walker and Thomas (1984).

fairness could not account for the most accepted results in the most favorable environment, a di®erent approach could generate data to identify whether the notion of intentions detection and the use of it was reasonable. As a ¯rst step, a sequential game in which the control over perceptions was relatively high is a direct instrument to analyze whether agents perceive certain intentions and whether this a®ects their behavior. Our data provide evidence that is favorable to the notion of menu dependence. Alterations of the reference point can lead to quantitatively signi¯cant changes in behavior at the benchmark outcome. The behavior we observe can be interpreted in terms of negative reciprocity. That is, the reference points we use in the di®erent games a®ect subjects' reciprocity considerations toward the same alternative proposed by other players, suggesting that subjects may attribute a di®erent intention to the same proposal depending on the reference point available.

In Chapter 4 (Distributional Concerns and Reference Points) I analyze whether the degree of negative reciprocity in players' actions is a®ected by certain payo® changes at a reference point in two-person games similar to the ones analyzed in chapter 3. These changes correspond to variations in the relative payo® of one player at the reference point, in the absolute payo® and in both players' payo®s. These variations were not analyzed in the previous chapter and try to disentangle which speci¯c information contained in the reference point generates the kind of behavior observed in Chapter 3. Relative payo® considerations were analyzed by Bolton (1991) and proposed as a key element to understanding bargaining behavior in experiments. E±ciency considerations, on the other hand, were at the center of the debate around the di®erent results obtained in ultimatum games and best-shot games[4]. In this series of experiments I do observe high levels of negative reciprocity for the di®erent

[4] GÄuth and Tietz (1991)

games but none of the manipulations introduced a®ects signi¯cantly the level of negative reciprocity across games. This negative result may be the consequence of the conservative approach adopted in the design. The small measure of the payo® manipulations introduced in this chapter (in comparison to the manipulations introduced in the previous chapter) are a possible cause of the lack of impact on the subjects' behavior.

The research presented in Chapter 5 (The Sequential Prisoner's Dilemma: Reciprocity and Group Size E®ects) studies the e®ect of social information, instead of outcome information, as a reference point. This possible e®ect is called, in the spirit of Sen's terminology, number dependence. The hypothesis is that reciprocity considerations could emerge and be modi¯ed by a social process of sequential interaction among a number of agents. To study this hypothesis, I analyze a di®erent environment in which positive reciprocity may play a role. Sequential prisoners' dilemma games may be interpreted as formalizations of many everyday situations that involve a trade-o® between the private and the collective interest. Sequentiality in the interaction between people is a feature that seems more appropriate as a representation of the type of situations one wants to study than the perhaps more standard case of simultaneous decisions. The prisoner's dilemma game is a simple, structured instrument to approach these problems and additionally allows us to study fundamental behavioral questions. We study in detail what predictions one could obtain for this situation from two types of models of individual behavior: inequality aversion concerns [Bolton and Ockenfels (2000)] and altruism [Ledyard (1995)]. We run experimental sessions of the two-person and the three-person sequential prisoner's dilemma game and we observe that neither a model of inequality aversion concerns, nor the altruism model proposed fully accommodate the data. Our data, however, is consistent with general reciprocity considerations by individuals in each game. Moreover, comparing the two games, we do observe a pattern that could be interpreted as a group size e®ect in the sense that more cooperative actions seem to increase the perceived obligation to reciprocate with cooperation. If this direction could be con¯rmed statistically by replication, it would point to the in°uence of social interaction as a reference point in decisions.

Chapter 2

On Rabin's Concept of Fairness and the Private Provision of Public Goods

2.1 Introduction

This paper is aimed at connecting theoretical with experimental research. Recently, several models have incorporated evidence from experimental data to get more accurate descriptions of behavior. These papers present specific modelizations of reciprocity. A seminal paper in this direction is Rabin (1993), which incorporates a concept of fairness as an argument in the utility function of individuals. This paper is one of the most influential in the literature and key to understanding the posterior directions.

Here we will take a close look at Rabin's model of fairness and analyze it in the context of the Voluntary Contribution Mechanism (VCM). This will allow us to be precise in what refers to the model of fairness and its applicability.

In an experimental linear VCM each individual in a group is asked to make an allocation of her resources between a private account and a public account, with the characteristic that investing in the private account is individually rational but the efficient outcome implies investing everything in the public account. This decision is made, typically, privately and without any information about the decision of the other members in the group. Among others, Marwell and Ames (1980), Isaac and Walker (1988a, 1988b and 1991) Isaac, Walker and Thomas (1984) and Isaac, Walker and Williams (1994) are experiments that report results in this kind of setting. One common result is that people contribute more to the public account than expected. Based on the payoff function as a representation of the true utility function and standard notions of rationality and information, standard analysis predicts that agents should not allocate any resources to the public account. Ledyard (1995) considers that a standard experimental result is what he refers to as "splitting", contributing to the public account an amount of resources between 40% and 60%. This apparent failure of the standard model can be explained by alternative theories. In the literature there are two main kind of theories, those that consider that partial contributions are due to the use of one-shot experiments, thus ruling out learning, and those theories that provide alternative models of behavior to explain splitting. Among the latter we could include altruism, reciprocity or fairness.

Ledyard (1995) refers to fairness, in a general sense, as a factor that remains to be studied further. Theories presented by him as firsts attempts to deal with this issue are based on the concepts of group identification and status. Agents consider themselves with the right to be as well off as the others are. Unfortunately, these theories do not explain the behavior observed in experiments. The fundamental problem is that they can not explain why individuals split their endowments between the private and the public account.

Rabin (1993) models a specific concern for fairness by individuals that interact in economic processes. The formal approach is close to that of psychological games introduced by Geanakoplos, Pearce and Stacchetti (1989), in which agents incorporate in their utility function beliefs on what others will do, beliefs on the beliefs of others, and so on. In this way it is possible to study games with a different perspective, introducing psychological phenomena. Rabin (1993) uses this approach to introduce a formalization on how agents apply fairness considerations, relying on the idea that fairness considerations are based on evaluations of the other agents' intentions. To evaluate intentions, agents must have some beliefs on what others will do and what others believe. A main assumption is that agents have a subjective notion of what they should obtain from participating in an economic activity. This notion, plus the expectations on the others' actions and the evaluation of the others' intentions may generate a behavior that deviates from the standard assumptions. Depending on the outcome that agents think they will get and the perceived intentions of the other players, they react behaving kindly or unkindly to others, even in cases where this implies to sacrifice their own material well-being. Rabin specifies that these psychological components will play an important role as the material costs associated to certain decisions are not large. These specifications are justified based on experimental studies like those of Kahneman, Knetsh and Thaler (1986a, 1986b).

Rabin analyzes two player normal form games with finite strategy spaces. We will apply Rabin's model of fairness to the specific problem of the private provision of public goods through a VCM. This problem may be interpreted as a generalization of the prisoner's dilemma because the strategic interaction is the same.

What we present in this paper is a generalization of Rabin's theory to a specific area of research for which we have extensive experimental data. This will allow us to test whether this theory is consistent with several features of the empirical evidence. We introduce one variation into Rabin's model that will allow us to accommodate more patterns of behavior. Rabin considers that agents have a "reference point", an outcome that they consider fair. This outcome consists of sharing equally along the Pareto Frontier. We go beyond this and consider that agents may have other ideas of what is fair for them. Agents may believe that they deserve more than half the pie, because of a self-centered perspective or maybe because they claim some property rights. Whatever the reason, we do not rule out a fifty-fifty split, we just include other possibilities that may allow us to interpret observed behavior.

In this paper we will analyze whether this generalization of Rabin's model of fairness is able to explain why splitting occurs. Additionally, we will study the relation between the contributions to the public account and the Marginal Per Capita Return (MPCR), which measures the ratio of the benefit in increased returns from the group account to the opportunity cost in foregone returns from the individual exchange. This relation is important because it is a stylized fact in the literature that the MPCR is positively related to the level of contributions to the public account. Experimental papers that study this relations are, among others, Isaac, Walker and Thomas (1984), Isaac and Walker (1988a) and Isaac, Walker and Williams (1994).

We also discuss the e®ects of heterogeneities in endowments and in the MPCR between individuals. We conjecture that if individuals care about the fairness of the outcome and the intentions of the other player, di®erent endowments or di®erent returns from the technologies of the economy may lead to di®erent considerations of what every agent should contribute and, therefore, to disagreement and less cooperation. The experimental evidence about this conjecture is not clear. An experimental study on the e®ect of heterogeneities in MPCR is Fisher, Isaac, Schatzberg and Walker (1995). These authors ¯nd no clear e®ect of this kind of heterogeneity in the sense just described but they identify di®erent patterns of behavior for individuals that face di®erent MPCR. Brandts and Schram (1996), with a di®erent design, also fail to ¯nd evidence in favor of the e®ects in contribution levels across individuals due to heterogeneities in MPCR.

Finally, we apply our analysis to the case of a non-linear VCM. In this kind of environment the dominant strategy is to contribute some amount of resources to the public account, instead of contributing nothing to the public account. This case is interesting because it has been suggested that observed contributions in experiments may be the result of errors by agents. That is, every error in a decision may be incorrectly interpreted as an intentional contribution to the public good, see Ledyard (1995) and Andreoni (1995). This interpretation has been tested experimentally by Keser (1996), introducing a design with an interior dominant strategy while keeping as the e±cient outcome the full contribution of resources to the public account. She ¯nds that agents contribute to the public account more resources than the dominant strategy prediction. We analyze whether the fairness equilibrium concept is consistent with this evidence.

2.2 Fairness and the Private Provision of Public Goods

We present the problem of a public good that can be provided through the voluntary contributions of two agents. Our objective in this section is to show that there exists an equilibrium where both players split their initial endowments between the private and the public account using the framework proposed by Rabin (1993).

We consider two individuals that have the possibility to simultaneously allocate their endowments between a public account or a private account.

The public good account yields to each individual the return:

$$y = \frac{a}{2} \sum_{i=1} x_i = \frac{a}{2} \sum_{i=1} (z_i - t_i) \tag{2.1}$$

The quantity allocated to the private account is t_i, z_i is the agent's endowment, $x_i \in [0; z_i] = S_i$ is the quantity allocated to the public account and a is the return that the group receives from each unit invested in the public good. The private account yields to agent i the return $p_i \cdot t_i$, with $p_i > 0$. The monetary payoff to agent i can be summarized with the function:

$$\pi_i(x_i; x_j) = p_i(z_i - x_i) + \frac{a}{2}(x_i + x_j). \tag{2.2}$$

We are interested in the case in which the parameters are such that the unique dominant strategy for each player will be to contribute nothing to the public account. This is the same as requiring:

$$MPCR_i = \frac{\frac{a}{2}}{p_i} < 1; i = 1; 2. \quad \text{(Assumption 1)}$$

This means that the investment in the private account yields a higher return than the one that could be obtained by investing in the public account. If this is the case, every purely self-interested player will invest everything in the private account, whatever the action of the other player.

As a second feature we desire the game to have as efficient outcome both players contributing everything to the public good, that is, $(x_1; x_2) = (z_1; z_2)$. In this case, the amount of public good produced is $Y = a \cdot (z_1 + z_2)$. To find the efficient outcome of the game, we solve the following standard problem:

$$\max_{x_1; x_2} p_1 (z_1 - x_1) + p_2 (z_2 - x_2) + a (x_1 + x_2)$$

$$s.t. : x_1 \in [0; z_1]; x_2 \in [0; z_2]$$

The solution to this problem is $x_1 = z_1; x_2 = z_2$ if $a > p_1$ and $a > p_2$. This defines our second assumption.

$$a > p_i; i = 1; 2. \quad \text{(Assumption 2)}$$

Observe that what we require is that what agents can obtain collectively will be higher when they fully invest their resources in the public account.

The analysis provided identifies utility with payoff. Now we will enrich this setting by assuming that agents may have a utility function that incorporates other issues, apart from the material payoff. This utility function will incorporate fairness components and the specific modelization was introduced by Rabin (1993). Hence, the utility function for agent $i = 1; 2$ is given by:

$$U_i(x_i; \tilde{x}_j; \tilde{\tilde{x}}_i) = X \cdot \pi_i(x_i; \tilde{x}_j) + \tilde{f}_j(\tilde{x}_j; \tilde{\tilde{x}}_i)[1 + f_i(x_i; \tilde{x}_j)]: \tag{2.3}$$

Agent's i strategy is denoted by x_i; $\tilde{x}_j$ is the strategy that player i believes that player j will play and $\tilde{\tilde{x}}_i$ is the strategy that agent i believes that agent j believes will be her strategy. The material payoff that agent i expects from choosing strategy x_i and believing that j will play $\tilde{x}_j$ is $\pi_i(x_i; \tilde{x}_j)$. The parameter $X > 0$ is the scale of the game. Notice that X does not alter the strategic interaction, the scale affects equally the private account and the public account.

The functions $f_i(x_i; \tilde{x}_j)$ and $\tilde{f}_j(\tilde{x}_j; \tilde{\tilde{x}}_i)$ are the kindness functions for agent i. The function $f_i(x_i; \tilde{x}_j)$ reflects how kind agent i is being to agent j by playing x_i if she expects agent j playing $\tilde{x}_j$: On the other hand, $\tilde{f}_j(\tilde{x}_j; \tilde{\tilde{x}}_i)$ expresses agent i's beliefs about how kind agent j is treating her if she expects agent j playing $\tilde{x}_j$ and believing that she will play $\tilde{\tilde{x}}_i$. Rabin (1993) proposes a particular form for these functions, specifically are defined as:

$$f_i(x_i; \tilde{x}_j) = \frac{\pi_j(\tilde{x}_j; x_i) - \pi_j^e(\tilde{x}_j)}{\pi_j^h(\tilde{x}_j) - \pi_j^{min}(\tilde{x}_j)} \tag{2.4}$$

$$\tilde{f}_j(\tilde{x}_j; \tilde{\tilde{x}}_i) = \frac{\pi_i(\tilde{\tilde{x}}_i; \tilde{x}_j) - \pi_i^e(\tilde{\tilde{x}}_i)}{\pi_i^h(\tilde{\tilde{x}}_i) - \pi_i^{min}(\tilde{\tilde{x}}_i)} \tag{2.5}$$

Notice that these kindness functions express that agent i thinks that she is treating j kindly ($f_i(x_i; \tilde{x}_j) > 0$) if she is playing a strategy such that j obtains a higher payoff than a reference point payoff, $\pi_j^e(\tilde{x}_j)$ (defined later), and this kindness is normalized with the explicit intention to get bounded functions. The fact that these kindness functions are bounded captures the fact that psychological considerations will have less importance in the utility function as the material payoff part of the utility function increases. To construct the specific kindness functions we need to give a specific form to the reference point payoff mentioned above. In order to do so, consider first the set of payoffs that both agents can get if agent i plays x_i and she believes that j will play $\tilde{x}_j$:

$$\Pi(\tilde{x}_j) = (X \cdot \pi_i(x_i; \tilde{x}_j); X \cdot \pi_j(x_i; \tilde{x}_j)); x_i \in [0; z_i]: \qquad (2.6)$$

From this set we select the following payoffs that agent i believes she is giving to j. The maximum payoff attainable by j is $\pi_j^h(\tilde{x}_j) = X\left[p_j(z_j - \tilde{x}_j) + \frac{a}{2}(z_i + \tilde{x}_j)\right]$; that is, when agent i contributes everything to the public account. The minimum payoff j can get is obtained when agent i contributes nothing to the public account, in this case the payoff to j is $\pi_j^{min}(\tilde{x}_j) = X\left[p_j(z_j - \tilde{x}_j) + \frac{a}{2}\tilde{x}_j\right]$: To obtain the equitable payoff, $\pi_j^e(\tilde{x}_j)$; we need to look first for the lowest payoff to agent j among the Pareto efficient points in the set $\Pi(\tilde{x}_j)$: Observe that in our environment $PE(\Pi(\tilde{x}_j)) = \Pi(\tilde{x}_j)$ because any increase (decrease) in i's contribution lowers (raises) her own payoff and increases (decreases) j's payoff. Consequently, $\pi_j^l(\tilde{x}_j) = \pi_j^{min}(\tilde{x}_j)$: Now we define the equitable payoff as a convex combination of the lowest payoff and the highest payoff, that is, each agent believes that she should obtain a share α of $PE(\Pi(\tilde{x}_j))$; consequently the other agent, j, should obtain $(1-\alpha)$: Hence $\pi_j^e(\tilde{x}_j) = X\left[p_j(z_j - \tilde{x}_j) + \frac{a}{2}((1-\alpha)z_i + \tilde{x}_j)\right]; \alpha \in [0; 1]$: That is, agent i believes that in order to give the equitable payoff to agent j, she should contribute to the public account the amount $(1 - \alpha) z_i$. Notice that $\pi_i^e(\tilde{b}_i)$, on the other hand, will be $\pi_i^e(\tilde{b}_i) = X p_i(z_i - \tilde{b}_i) + X \frac{a}{2}(\tilde{b}_i + \alpha z_j), \alpha \in [0, 1]$. Rabin (1993) defines the equitable payoff as the midpoint between the lowest payoff and the highest payoff, both defined in the text. We prefer to extend the concept to a more general consideration of what an individual believes that is fair for him to obtain as a reference point. In this case, $\pi_j^e(\tilde{c}_j) = (1 - \alpha)\pi_j^h(\tilde{c}_j) + \alpha \pi_j^l(\tilde{c}_j)$. The kindness functions for agent i turns out to be:

$$f_i(x_i; \tilde{c}_j) = \frac{x_i}{z_i} - (1 - \alpha) \in [-(1 - \alpha); \alpha] \tag{2.7}$$

$$\tilde{f}_j(\tilde{c}_j; \tilde{b}_i) = \frac{\tilde{c}_j}{z_j} - \alpha \in [-\alpha; 1 - \alpha] \tag{2.8}$$

The functions for agent j are symmetric. Hence, agent i thinks that she is being nice to j when she is contributing to the public account a share of her resources that exceeds what she believes that agent j deserves, $1 - \alpha$. On the other hand, she believes that agent j is being kind to her when j is contributing a share greater than the share that i believes that she deserves, α. Notice that a high α implies that, for the same level of contribution, agent i thinks that is being nicer to agent j. For the same reason, a high α implies that agent i will perceive the contributions of agent j as less generous. That is, a high α means being very demanding to the other agent and highly satisfied of one's own behavior. The implications of this extension of Rabin's equitable payoff in equilibrium behavior will be discussed further.

The utility function of agent i, therefore, can be now fully specified according to these derivations.

$$U_i(x_i; b_j; c_i) = X \cdot \pi_i(x_i; b_j) + \left(\frac{b_j}{z_j} - \alpha\right)\left[1 + \frac{x_i}{z_i} - (1 - \alpha)\right] \tag{2.9}$$

The equilibrium analysis will follow the definition of fairness equilibrium by Rabin (1993). This equilibrium will be the result of both players maximizing her utility function and imposing rational expectations in the beliefs about the other agent and higher order beliefs. Formally we state:

Definition 1 (Rabin 1993): The pair of strategies $(x_1^*; x_2^*) \in (S_1; S_2)$ is a fairness equilibrium if, for i=1,2, $j \neq i$;

i) $x_i^* \in \arg\max_{x_i \in S_i} U_i(x_i; b_j; c_i)$

ii) $c_i = b_j = x_i^*$

Without loss of generality, we suppose that $\left(p_i - \frac{a}{2}\right) z_i \geq \left(p_j - \frac{a}{2}\right) z_j$ (or equivalently, $(1 - MPCR_i)\, p_i z_i \geq (1 - MPCR_j)\, p_j z_j$), that is, the net gain from investing the whole resources in the private account is greater or equal for agent i than for j. This will be useful to organize the results.The following proposition describes the equilibria of this model that will be characterized by the relevant parameters.

Proposition 2 i) If $X(1 - MPCR_i)\, p_i z_i < 1 - \alpha$, there exist three types of equilibria. a) An equilibrium where both players contribute their whole endowment to the public account, $x_i^* = z_i$ and $x_j^* = z_j$: b) An equilibrium with both agents contributing a positive amount $x_i^* = \left[X\left(p_j - \frac{a}{2}\right) z_j + \alpha\right] z_i$; $i = 1; 2$; $j \neq i$. c) An equilibrium with both agents contributing nothing to the public account.

ii) If $X(1 - MPCR_i)\, p_i z_i = 1 - \alpha$; there exist two types of equilibria. a) Equilibria with $x_j^* = z_j$ and $x_i \in \left[\left(\sum p_j - \frac{a}{2}\right) z_j + \alpha z_i ; z_i\right]$: b) An equilibrium with both agents contributing nothing to the public account.

iii) If $\sum (1 - MPCR_i) p_i z_i > 1 - \alpha$; the unique equilibrium is the one where both agents contribute nothing to the public account.

Proof: See the Appendix ■

The interpretation of these results follows from standard analysis including the characteristics of the utility function that we consider. An agent will be willing to contribute one more unit to the public account if the marginal benefits of doing so compensate the losses. That is,

$$\sum \frac{a}{2} + \left(\frac{\tilde{x}_j}{z_j} - \alpha\right) \frac{1}{z_i} > \sum p_i \tag{2.10}$$

The left hand side of this inequality expresses the marginal gain to agent i from contributing one unit if he expects that agent j will contribute $\tilde{x}_j$: Notice that the sources of these marginal benefits are, on one hand, the return from the public account and, on the other hand, the consideration by agent i of what j is doing for her. This consideration will be positive if agent j contributes a share of her endowment in excess of the reference point that i considers she deserves for herself. Moreover this consideration will be mitigated by the endowment of agent i. That is, a relatively high endowment to agent i will mean that j will have to contribute more to the public account in order to push i to contribute. This is also true when observing the right hand side of this inequality. Agent j will have to compensate a higher private return of agent i by contributing more.

The previous inequality may be manipulated in order to understand how equilibrium behavior is derived.

$$\left(\frac{x_e}{z_j} - \alpha\right) > X(1 - MPCR_i)\, p_i z_i \qquad (2.11)$$

The maximum level of kindness that i can expect from j is $1 - \alpha$. Hence, when this level exceeds the monetary costs of contributing, cooperation is possible. If we had an equality, as in case ii) in Proposition 2, then the psychological gains from cooperation compensate the monetary costs just if i expects full cooperation from j. Finally, if the maximum psychological payoff is smaller than the cost of cooperation, no equilibrium with positive contributions survives. Therefore, when the right hand side of Equation (2.11) increases, we change to cases where less cooperation is possible or a case where no cooperation is the unique equilibrium.

A feature that may be disturbing is the presence of the full free riding outcome in every case. In fact, its robustness is due to the nature of the fairness concept. Consider one equilibrium with zero contributions to the public account. If one player is contributing nothing to the public account, the other agent interprets that she is being treated unkindly. If this player changes her strategy, this change will both reduce her material payoff as well as her psychological payoff, letting the other agent hurt him without reacting to it. Observe that this is true for any scale of the game because the material and the psychological interest go in the same direction.

On the other hand, optimal provision of the public good turns out to be also a fairness equilibrium when the monetary parameters are sufficiently small. If both players know that they are playing this equilibrium, a unilateral deviation would lead the deviator to increase her material payo® while reducing her psychological payo®. Observe that the other player is giving her the maximum psychological bene¯t, hence a reduction in the contribution implies to give the other player a smaller psychological bene¯t reducing at the same time her own payo® because an agent prefers being nice when the other player is being nice to her.

Finally, intermediate contributions by both agents is also an equilibrium for small values of the material parameters. A deviation from any agent of this equilibrium towards a higher contribution to the public account leads to a decrease in the material bene¯ts that does not compensate her for the higher psychological utility of being nicer to the other agent. Reducing her contribution neither compensates the psychological loss with the higher material bene¯ts. Observe that, as the scale of the payo®, the return from the private account or the endowment increase and the MPCR decreases, this equilibrium exists with higher levels of contribution to compensate the material losses of contributing to the public account. This observation is important because it contradicts one of the most common observations in experimental games. Hence, we provide a formal statement in the following proposition.

Proposition 3 Given the conditions in which the equilibrium with intermediate contributions exists, X (1 ¡ $MPCR_i$) $p_i z_i$ < 1 ¡ ®; these intermediate contributions increase in the scale of the payo®s, X; the endowments, the return from the private account of the other agent, the reference point ® and decrease with increases in the return from the public account.

Proof: See the Appendix. ■

This proposition states a result that is contradictory with evidence found in the experimental literature. Recall that the MPCR is an increasing function of a, the return from the public account. It is a stylized fact in the literature that as the MPCR increases, the individual contributions to the public account increase. The reason to obtain this result in the model is that a higher MPCR induces one agent to require less contribution from the other agent in order to contribute herself, since a higher MPCR increases the monetary benefits from contributing to the public account and, consequently, less cooperation to satisfy the psychological needs is required. As a result, in equilibrium both agents contribute less to the public account if their MPCR increase.

2.3 Fairness and Experiments

In order to discuss other empirical evidence in the experimental literature and the capacity of Rabin's model to predict them, we will consider different simple cases with respect to the parameters.

The first simplification would be to consider two identical individuals. In this case observe that the most interesting result is that the model predicts, for small values of X, p, z the possibility of splitting. In fact, this result is repeatedly observed in experiments with simultaneous moves, on the other hand, the model does not predict correctly the MPCR effect as shown in several experiments, as those of Isaac and Walker (1988) and Isaac, Walker and Williams (1994).

Consider now the case where agents differ just in endowments, we can consider $z_i > z_j$: This kind of heterogeneity has not been exhaustively analyzed experimentally.

However, it is mentioned as one factor that experimentalists expect that will hurt cooperation. Proposition 2 and 3 apply here making the relevant simplifications. Observe that in this case, when the equilibrium with intermediate contributions occur, agent i contributes more than agent j, but this agent contributes more relatively to her endowment. The reason being that agent j has to make more effort to compensate agent i for her contribution. There are more differences with respect to a homogeneous case. The agent with higher endowment requires some level of cooperation from agent j in order to compensate her for the material loss when she contributes to the public account. This level of cooperation may not be affordable for j given her own endowment. As a consequence, when cooperation is possible at intermediate levels, agent j contributes relatively more. The conclusion of the model, hence, is that heterogeneities in endowments would affect individual behavior.

A different possibility for contrasting the model with experimental data is to consider the case where agents are identical except with respect to the MPCR. Ledyard (1995) suggests it as one factor that may hurt cooperation, however some results fail to find support for this suggestion[1]. Consider the case where both agents are homogeneous but $p_i > p_j$; i.e. agent i has a lower MPCR. Notice that the statements in Proposition 2 still hold with the opportune changes in the parameters and that agent i's parameters are the relevant ones to obtain cooperation. This occurs because for cooperation to appear, agent j has to be able to compensate the opportunity cost for agent i of contributing, higher for agent i that receives a higher return from the private account. Observe also that, whenever intermediate contributions do exist, agent j contributes more agent i does. This is consistent with results

[1] Brandts ans Schram (1996) have tested it with no relevant differences in individual contributions with respect to an homogeneous group. Fisher, Isaac Schatzberg and Walker (1995) neither find evidence suggesting a decrease in contributions due to heterogeneities in MPCR.

found by Fisher, Isaac, Schatzberg and Walker (1995). This consistency of the model with individual behavior is weakened by another experimental result in the same paper. Fisher, Isaac, Schatzberg and Walker (1995) compare the levels of contribution to the public account of individuals in a group composed of individuals of the same type (types defined by their MPCR). They find that there exist differences in behavior and this would mean that, at an individual level, agents behave differently depending on the MPCR of the other agents in the group. The model presented here also shares this characteristic. Consider a homogeneous group with private return equal to p_i (we will call this a "low MPCR" group) and the condition that allows intermediate contribution, $X(1 - MPCR_i)p_i z < 1 - \alpha$. The level of contribution of each agent is:

$$x_i^* = x_j^* = \left[X\left(p_i - \frac{a}{2}\right)z + \alpha\right]z \text{ (Homogeneous group, low MPCR)} \qquad (2.12)$$

Consider now the case where both agents differ in their MPCR and consider the level of contribution that the agent with low MPCR (agent i) makes in the equilibrium with intermediate contributions. This level of contribution corresponds to:

$$x_i^* = \left[X\left(p_j - \frac{a}{2}\right)z + \alpha\right]z \text{ (Heterogeneous group, agent with low MPCR)} \qquad (2.13)$$

Since $p_i > p_j$, the agent with low MPCR behaves differently depending on whether the other agent shares the same MPCR or not. The experiment mentioned shows that, when participating in mixed groups (where groups just differ by their MPCR) the low MPCR agents contribute to a higher degree than do their equivalents in homogeneous groups with low MPCR: We have shown that, however, the model by Rabin predicts the opposite. The agent with low MPCR in a heterogeneous group contributes less than an agent in a homogeneous group of low MPCR agents. This is so in the model because low MPCR agents have less incentives to contribute to the public account and, consequently, when cooperation appears, the high MPCR individual makes a higher e®ort (by contributing more) to get cooperation.

At an aggregate level, Rabin's model ¯ts another piece of evidence observed in Fisher, Isaac, Schatzberg and Walker (1995). These authors observe that, at an aggregate level, there are no di®erences in the total provision of the public good due to the presence of heterogeneities. We can apply their method to check whether Rabin's model maintains this characteristic. They test whether the provision of the public good in a heterogeneous group would be some average of the contributions of two groups, one composed of low MPCR agent and the other composed of high MPCR agents. In the model, we do observe that we reach the same conclusion: aggregate behavior is not a®ected by heterogeneities[2]. Notice, ¯nally, that the MPCR e®ect in this case would follow the general proposition, although no empirical evidence of this e®ect in the presence of heterogeneities exists.

2.4 A slightly di®erent environment

We will introduce in this section an environment where the payo® from the private account for each individual it is not anymore a linear function. The reason to introduce

[2] The method consists of summing up the contributions in a heterogeneous group (that di®ers just in MPCR) and considering the intermediate contributions in two homogeneous groups, one of them with $MPCR_i$ and the other with $MPCR_j$. Summing these contributions and ¯nding the average, one can observe that the di®erence with the aggregate contribution in the heterogeneous group is zero.

this change is that it has been argued that, if the dominant strategy is in the corner (as it happens in the linear VCM), then it might be that contributions to the public account are due to errors of the players that, by the structure of the game, are interpreted as intentional cooperative behavior. This interpretation, if correct, would mean that the experiments with the linear VCM do not justify modelizations incorporating fairness. Keser (1996) tested this hypothesis constructing an example that generates as a dominant strategy an interior solution and where efficiency requires contributing the whole endowment to the public account. In this setting, the experiment shows that subjects contribute more than the dominant strategy. Hence, the interpretation of contributions due to errors is questioned. However, it remains to explain why subjects contribute. Fairness considerations may be part of the explanation to it and, therefore, Rabin's model could accommodate this evidence.

The environment designed by Keser (1996) is a simultaneous one-shot game played by two identical agents that have to decide how to allocate their resources between a private and a public account. Considering the notation introduced before, the material payoffs are defined as follows:

$$\pi_i(x_i; x_j) = A(z - x_i) - (z - x_i)^2 + B(x_i + x_j); i = 1; 2; j \neq i: \qquad (2.14)$$

The parameters have to satisfy two conditions. First, the dominant strategy for each individual maximizing her own material payoff has to be an interior solution where each agent contributes to the public account less than half her endowment[3]. The conditions

[3]Keser (1996) sets the parameters in this way to avoid the middle contribution point because it is a prominent outcome. However, with her model, if one observes overcontributions it might be because people tend to go to the prominent outcome. The solution to this possible problem with her data would be to generate a dominant strategy equilibrium to contribute already more than half their endowment. After this change, if we observed overcontribution, the explanation of subjects tending to make a decision that goes to

that we need to impose on the parameters to get this characteristic and that the efficient outcome will be full contribution, plus a condition to ensure that the MPCR is positive are:

$$\frac{z}{2} > z - \frac{A - B}{2} = z - D > 0 > z - \frac{A}{2} > z - B. \qquad \text{(Assumption 3)}$$

The dominant strategy for agent $i = 1, 2$ is contributing to the public account the amount $z - D$. The kindness functions are constructed as in the linear model noting that the set of Pareto Efficient payoffs is $PE(\Pi(\tilde{x}_j)) = \{(\pi_i(x_i, \tilde{x}_j), \pi_j(x_i, \tilde{x}_j))$ s.t. $x_i \in [z - D, z]\}$. Hence, the kindness functions for agent $i = 1, 2$ are in this case:

$$f_i(x_i, \tilde{x}_j) = \frac{x_i - (z - \alpha D)}{z}$$

$$\tilde{f}_j(\tilde{x}_j, \hat{x}_i) = \frac{\tilde{x}_j - (z - (1 - \alpha) D)}{z} \qquad (2.15)$$

These kindness functions share the same characteristics that those in the linear model, they are continuous and bounded. Observe that the kindness of agent i to agent j is an increasing function of her contribution to the public account and that this kindness will take higher values for higher values of α. The fairness consideration for i of what j is doing is also an increasing function of the contribution that i expects from j and a decreasing function of α. The utility function for agent $i = 1, 2$ is:

$$U_i(x_i, \tilde{x}_j, \hat{x}_i) = X \cdot \Pi_i(x_i, \tilde{x}_j) + \frac{\tilde{x}_j - (z - (1 - \alpha) D)}{z}\left[1 + \frac{x_i - (z - \alpha D)}{z}\right] \qquad (2.16)$$

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the prominent outcome is ruled out.

The equilibrium in this case will be described in the following proposition and uses Definition 1 stated before.

Proposition 4 i) If $X \le \frac{1-\alpha}{2z^2}$ there exist three types of equilibrium: a) An equilibrium where both agents contribute nothing to the public account, $x_i^* = x_j^* = 0$. b) An equilibrium where both agents contribute their whole endowment to the public account, $x_i^* = x_j^* = z$. c) An equilibrium with intermediate contributions. In this equilibrium with splitting, the quantities allocated to the public account are larger than at the Dominant Strategy Equilibrium.

$$x_i^* = x_j^* = z - D - \frac{\alpha D}{2Xz^2 - 1}$$

ii) If $\frac{1-\alpha}{2z^2} < X \le \frac{z-(1-\alpha)D}{2z^2(z-D)}$ there exists one equilibrium where agents contribute nothing to the public account, $x_i^* = x_j^* = 0$.

iii) If $\frac{z-(1-\alpha)D}{2z^2(z-D)} < X$ there exists a unique interior equilibrium. In this equilibrium, the quantities allocated to the public account are:

$$x_i^* = x_j^* = z - D - \frac{\alpha D}{2Xz^2 - 1} < z - D$$

Notice that $\lim_{X \to \infty} x_i^* = z - D$.

Proof: See the Appendix. ■

This proposition shows that, for sufficiently small payoffs, there exist multiplicity of equilibria. Observe that in the first situation, there is an equilibrium with no contribution to the public account. In this equilibrium both agents hurt themselves as well as they do hurt the other agent. No one wants to deviate because, by doing so, the deviator would increase her monetary payoff, but she would reduce simultaneously her psychological payoff. Given the scale of the game in situation i), this would result in a total decrease in her utility function. In the full contribution equilibrium any deviator would increase again her monetary payo® but reducing her psychological payo®. For this scale of the game there exists also an intermediate contributions equilibrium. In this equilibrium the quantities allocated to the public account are larger than in the DSE, in line with results found in Keser. Observe also that, as the scale of the payo®s increases this equilibrium would need more contributions to the public account, until it converged to the full contributions outcome. The change to the second situation of the proposition leads to ruling out also the full contribution equilibrium. Given the scale of the game and supposing that ® > :5; the unique equilibrium that incorporates psychological factors, negative ones, is the no contribution equilibrium. In the last case of the proposition (case iii), this equilibrium is no longer possible because the psychological factor, recall the boundedness of the kindness functions, is even less important, leading to the convergence to the DSE. As it could be expected, as the scale of the payo®s tends to in¯nity, the unique equilibrium will approach the DSE equilibrium because the psychological part of the utility function will play a residual role and, hence, the material part of the utility function will determine the equilibrium.

The model predicts an intermediate contribution equilibrium with overcontributions, as Keser found. This result, hence is consistent with experimental data, but it should be stressed that the model presents multiplicity of equilibria for this case. Moreover, as the scale of the game is higher, the results do not justify overcontributions but on the contrary, predict smaller contributions.

2.5 Conclusions

In this paper we present an analysis of the private provision of public goods through voluntary contributions. We use a model of fairness presented by Rabin (1993) that incorporates psychological issues into the utility function in order to accommodate some evidences of the experimental literature. This model is intensively cited in the literature but has not been analyzed in detail to check its consistency with the main stylized facts in the literature. Here we provide an generalization of the model that allows us to show that, in the standard VCM, intermediate cooperation levels are possible, consistently with results repeteadly found in the experimental literature, when the material stakes of the game are su±ciently small. This consistency happens whether the players are identical or di®er in endowments, MPCR or both. This result is satisfactory, but there are more pieces of evidence in the literature that are also important, in particular, what is known as the MPCR e®ect. The model presented does not predict the positive correlation between MPCR and contributions to the public good. In fact, the model would predict a negative correlation. This negative result is independent of analyzing the model with homogeneous or heterogeneous individuals.

If we just consider heterogeneities in MPCR, we have found consistency of the model with the available experimental evidence on the absence of aggregate e®ects of this kind of heterogeneity. However, the e®ects on individual behavior of this kind of heterogeneity are not consistent with the experimental paper of Fisher, Isaac, Schatzberg and Walker (1995).

When we introduce the model to a setting where the dominant strategy is interior, the model is partially consistent with the available evidence of overcontribution. The model predicts one case where this kind of equilibrium occurs, but in all other cases this equilibirum dissapears. Moreover, as the scale of the game increases, we should observe a result exactly in the opposite direction, that is, less contribution than the dominant strategy equilibrium.

The model of Rabin (1993), as a consequence of this analysis, is partially consistent with experimental data for the type of situations described here. Moreover, testing directly the model may be not possible since we can not observe directly beliefs and intentions.

2.6 Appendix

2.6.1 Proof of Proposition 2:

In order to prove this result we have to solve the maximization problem for each individual. By introducing the equilibrium conditions defined in Definition 1 we obtain the results of the proposition.

Observe that the utility function attributed to each individual is a linear function in the decision variable. Hence, the conditions are given by the slope of this function. The conditions for agent i (those for agent j are symmetric) are:

a) If $X\left(-p_i+\frac{a}{2}\right)+\left(\frac{œ_j}{z_j}-\alpha\right)\frac{1}{z_i}>0$ then $x_i^{*}=z_i$: This condition defines the best-reply of agent i to a given belief on agent j. In particular, from the previous inequality, $œ_j>\left[X\left(p_i-\frac{a}{2}\right)z_i+\alpha\right]z_j$: Moreover, we know that $0\leq œ_j\leq z_j$: From here we obtain the condition that appears in case i) in the proposition:

$$X\left(p_i-\frac{a}{2}\right)z_i<1-\alpha \text{ or } X\left(1-MPCR_i\right)p_iz_i<1-\alpha: \qquad (1A)$$

b) If $X\left(-p_i+\frac{a}{2}\right)+\left(\frac{\tilde{x}_j}{z_j}-\alpha\right)<0$, then $x_i^*=0$. This defines the following condition, $0 \le \tilde{x}_j < \left[X\left(p_i-\frac{a}{2}\right)z_i+\alpha\right]z_j$. Observe that the right hand side is strictly positive, hence this inequality is always possible.

c) If $X\left(-p_i+\frac{a}{2}\right)+\left(\frac{\tilde{x}_j}{z_j}-\alpha\right)=0$; then $x_i \in [0;z_i]$. Since $0 \le \tilde{x}_j \le z_j$, these two conditions imply $0 \le \tilde{x}_j = \left[X\left(p_i-\frac{a}{2}\right)z_i+\alpha\right]z_j \le z$. From here, $X\left(p_i-\frac{a}{2}\right)z_i \le 1-\alpha$.

The conditions for agent j are symmetric to these ones. From here we set the following condition: $\left(p_i-\frac{a}{2}\right)z_i \ge \left(p_j-\frac{a}{2}\right)z_j$. This condition allows us to organize the best-reply correspondances in cases. To get the equilibria it just remains to consider that, in equilibrium, beliefs must coincide with actions. The previous conditions then describe the best-reply of agent i to possible actions of agent j.

2.6.2 Proof of Proposition 3:

Recall the equilibrium contributions, in the case where intermediate contributions exist, are:

$$x_i^*(X;a;p_j;z_j;z_i;\alpha)=\left[X\left(p_j-\frac{a}{2}\right)z_j+\alpha\right]z_i;\ i=1;2:\ j\neq i. \qquad (2A)$$

Consequently, the partial derivatives with respect to the different arguments are:

$$\frac{\partial x_i^*(X;a;p_j;z_j;z_i;\alpha)}{\partial X} = (1 - MPCR_j)\, p_j z_j z_i > 0$$

$$\frac{\partial x_i^*(X;a;p_j;z_j;z_i;\alpha)}{\partial z_i} = X(1 - MPCR_j)\, p_j z_j + \alpha > 0$$

$$\frac{\partial x_i^*(X;a;p_j;z_j;z_i;\alpha)}{\partial z_j} = X(1 - MPCR_j)\, p_j z_i > 0$$

$$\frac{\partial x_i^*(X;a;p_j;z_j;z_i;\alpha)}{\partial \alpha} = z_i > 0$$

$$\frac{\partial x_i^*(X;a;p_j;z_j;z_i;\alpha)}{\partial p_j} = X z_j z_i > 0$$

$$\frac{\partial x_i^*(X;a;p_j;z_j;z_i;\alpha)}{\partial a} = -\frac{1}{2} X z_j z_i < 0$$

2.6.3 Proof of Proposition 4:

In this case both agents are identical, so we solve the maximization problem for agent i. By using the Kuhn-Tucker theorem we find the best-responses for each agent given the expectations on the behavior of the other agent. Notice that the utility function is concave in its argument. The Kuhn-Tucker program is:

$$\max_{x_i} \; X \cdot \Pi_i(x_i; \tilde{x}_j) + \frac{\tilde{x}_j - (z - (1-\alpha)D)}{z}\left[1 + \frac{x_i - (z - \alpha D)}{z}\right]$$
$$+ \lambda x_i + \mu (z - x_i)$$

Conditions:

i) $X(-A + 2(z - x_i) + B) + \frac{\tilde{x}_j - (z - (1-\alpha)D)}{z^2} + \lambda - \mu = 0.$

ii) $\lambda \geq 0; \mu \geq 0.$

iii) $x_i \geq 0; (z - x_i) \geq 0.$

iv) $\lambda x_i = 0; \mu (z - x_i) = 0.$

From here we derive the best-responses of agent i to given beliefs on j's behavior situations:

a) $x_i^* = 0$ if $\tilde{x}_j < z - (1-\alpha)D - 2Xz^2(z - D).$

Since $0 \leq \tilde{x}_j \leq z$; this is possible when $X < \frac{z-(1-\alpha)D}{2z^2(z-D)}$

b) $x_i^* = z$ if $\tilde{x}_j > z - (1-\alpha)D + 2Xz^2 D.$

Since $0 \leq \tilde{x}_j \leq z$; this is possible when $X < \frac{1-\alpha}{2z^2}$

c) $x_i^* = (z - D) + \frac{\tilde{x}_j - (z-(1-\alpha)D)}{2Xz^2}$

if $\max\left\{0; z - (1-\alpha)D - 2Xz^2(z - D)\right\} \leq \tilde{x}_j$ and

$\tilde{x}_j \leq \min\left\{z - (1-\alpha)D + 2Xz^2 D; z\right\}.$

Notice that $\max\left\{0; z - (1-\alpha)D - 2Xz^2(z - D)\right\} = z - (1-\alpha)D - 2Xz^2(z - D)$ when $X \leq \frac{z-(1-\alpha)D}{2z^2(z-D)}.$

Moreover, $\min\left\{z - (1-\alpha)D + 2Xz^2D; z\right\} = z - (1-\alpha)D + 2Xz^2D$ when $X \leq \frac{1-\alpha}{2z^2}.$

From here, we obtain the best-response correspondances for each agent to the belief on the action of the other agent. In equilibrium beliefs must coincide with actions, hence we obtain the effective best-responses organized by cases depending on the scale of the game, X.

For the intermediate contributions equilibrium, when it exists, calculations show that the equilibrium contributions are given by:

$$x_i^* = x_j^* = z - D - \frac{\alpha D}{2Xz^2 - 1} \tag{3A}$$

Chapter 3

Reference Points and Negative Reciprocity in Simple Sequential Games

3.1 Introduction

Experimental research on motivation in games has made progress. The accumulation of results from experiments with a variety of games has made it clear that, in many situations, subjects' behavior is not exclusively guided by the drive to obtain the highest possible individual monetary payo®. However, the precise motivational forces behind observed behavior are not yet clear. The next task before us is a systematic experimental investigation of these forces. This new research phase will probably evolve in parallel to the formulation of new data-based theoretical models of motivation. The use of experiments allows this interrelated development of data and models.

We believe that people's concern about the distribution of payoffs is a natural ingredient of any explanation of the facts. What different distributional explanations have in common is a conception of individuals' behavior in terms of their own payoff and of some features of the distribution of payoffs among the individuals involved in the situation. To understand motivation in these terms, one just needs to take into account realized outcomes, and not be concerned with any elements of the process by which outcomes are reached.

Distributional concerns may, however, only allow for a very partial explanation of behavior. A crucial question is whether individuals' behavior is also affected by their perceptions of others' intentions. Now, how are intentions judged? For intentions to be a distinct motivational factor, the basis on which individuals attribute them to others must be some kind of non-outcome information, i.e. information that does not pertain to the distribution of payoffs that has resulted from individuals' choices, so that choices are not based solely on comparisons between the resulting individual outcomes. This non-outcome information could, a priori, be of many different types. Experimental analysis can be directed to identifying which of these types of information actually matter.

Concern for intentions is at the basis of what we will refer to as reciprocity: positive reciprocity involves rewarding perceived good intentions, while negative reciprocity leads to punishing perceived bad intentions. One important difference between various existing theoretical models of motivation is whether they allow for the influence of intentions and reciprocity. Recent distributional models by Bolton and Ockenfels (2000) and Fehr and Schmidt (1999) do not integrate intentions, whereas it is at the heart of Rabin (1993).

Models of the first type involve rather direct extensions of the simple individualistic notion of own-payoff maximization, while models that do incorporate the effects of intentions need to take one more step away from the standard economic view. We believe that presently there is not yet enough evidence to judge what type of models will be needed to accommodate the emerging body of data. More specifically, additional experiments are needed to explore the role of intentions.

This paper presents some new experimental data that are favorable to the relevance of intentions and reciprocity in simple sequential games. Section 2 places our experiment in the context of previous work in the area. Section 3 presents the specifics of our design and the experimental procedures. In section 4 we discuss the results and in section 5 we present our conclusions.

3.2 Previous experiments on reciprocity and the act of choice

Interest in the issue of whether behavior depends only on outcomes or whether it is also influenced by the choice process is not limited to experimental economists. Sen (1997) has analyzed this from a more general theoretical perspective. He states that: "A person's preferences over comprehensive outcomes (including the choice process) have to be distinguished from the conditional preferences over culmination outcomes given the act of choice"[1]. He then proceeds to say that the responsibility associated with choice can influence people's rankings over narrowly-defined outcomes, and singles out two of the ways in which responsibility may matter. His classification provides a good organizing tool for

[1] The italics stem from the original.

previous experiments on intentions and reciprocity, and for the design used in this paper.

The first manner in which, following Sen, the choice process may matter is through "chooser dependence": a person's evaluation of an outcome may depend on the identity or some characteristics of the chooser, i.e. the decision maker that led to that outcome. "Menu dependence" is the second channel through which the act of choice may affect decisions: preferences over an outcome may depend on what other possible, but unreached, outcomes of the situation involved were. It is, of course, also conceivable that chooser-dependence and menu-dependence interact with each other, i.e. the effects of varying the menu may be different for choosers of different types.

All the experiments that have investigated the issue of intentions are based on rather simple sequential games, involving first and second movers. The behavior that is analyzed to detect the influence of intentions is the second mover's reaction to the first mover's action. The crux of the problem is whether variations in the circumstances under which the first mover makes his choice affect the second mover's reaction to it.

Blount (1995) and Charness (1997) focus on a certain kind of "chooser" dependence by comparing reactions to actions taken by humans with reactions to random actions. In this case, the basis for possible differences in reactions to favorable or unfavorable actions is the attribution of different responsibilities to the two types of chooser. Human players can be judged to be responsible for making fully conscious decisions, whereas random players are obviously unconscious.

Blount studies second mover behavior in ultimatum games comparing reactions to offers by self-interested human first movers with those to offers by random first movers.

The procedure involves asking second movers for minimum acceptable o®ers. She ¯nds that, even controlling for ¯rst mover behavior, minimum acceptable o®ers for human ¯rst movers were higher than in the random condition. This behavior of second movers can be interpreted as the rejection of some o®ers due only to the fact that they were consciously made, i.e. as a punishment for consciously making low o®ers.[2]

Charness analyzes the same kind of chooser dependence in a bilateral gift-exchange. In this kind of game a ¯rst mover chooses one among many gift levels. The second mover then decides on the degree to which he returns the gift.[3] He ¯nds that the slope representing second movers' reactions to preceding gifts by humans is steeper than the one corresponding to random players.[4] The higher rate at which human gifts are returned, as compared with those resulting from the random mechanism, is attributed to the reward of good intentions.

Bolton, Brandts and Ockenfels (1998) study menu dependence. They investigate it in the context of simple sequential two-person dilemma games, comparing players' decisions in two di®erent types of choice situations.[5] In the ¯rst situation, a player individually

[2] The experiments reported in Blount (1995) did not actually involve self-interested human or random ¯rst movers. All subjects were in the second mover position and they were asked what they would do in response to an ultimatum game proposal made by either a self-interested human, a human third party, or a draw from a given random distribution. There were no actual ¯rst-mover choices and subjects were paid a °at fee for their participation, instead of being paid for their decisions, as they were told they would be.

[3] A gift-exchange game is strategically similar to a sequential public goods game. However, in the design used in Charness (1997) the asymmetry between the payo®s of the two players gives the game a di®erent °avor.

[4] Kagel, Kim and Moser (1996) analyze chooser dependence of a somewhat di®erent sort. In standard ultimatum games they compare second movers' reactions to o®ers by two types of human ¯rst movers, with di®erent information. In their experiments players bargained over chips and the two relevant treatments consisted in the following variation of the information regarding their chip payo®s: in one of the treatments both players knew both chip payo®s, while in another one the second player knew both chip payo®s, but the ¯rst player knew only his own payo®. As in Blount and Charness one type of ¯rst mover is fully informed about the consequences of his actions for both players; the other type of human ¯rst mover does not know what the economic consequences of his actions are for the other player. These di®erences in the chooser's circumstances may induce di®erent judgements of intentions in the second mover. The results of Kagel, Kim and Moser are, however, inconclusive since the treatment e®ect varies with changes in the chip conversion rate.

[5] We use the term dilemma games to refer to a wide class of games that includes the standard prisoner's dilemma, public goods games and common pool resource games, among others. The games actually used

chooses among different distributions of payoffs between himself and another player in a dictator-type context in which the player can increase the other player's as well as the total payoff at a cost to himself. In the second situation, players choose among the same set of options, given that another player has selected that set of options among two possible sets. In this context, menu dependence would imply that the presence of the second set of options affects the choice among the first set of options. The reason why menu dependence might matter is because the second player may attribute a good or a bad intention to the first player on the basis of his prior choices. More specifically, if the choice set that the second player has already discarded is inferior for the second player than the one actually chosen, he may react more favorably to the first player's choice than when he just has to choose among the options of the first choice set in the dictator-type situation. If that happened, it would indicate that the attribution of intentions matters and that it leads to positive reciprocity. The evidence obtained by Bolton, Brandts and Ockenfels, however, is not consistent with menu dependence and, hence, with the notion that intentions affect behavior. Their results show that players' decisions within a choice set are not affected by variations in another choice set.[6]

The body of previous experimental results can be summarized by saying that there is some evidence that non-outcome information matters. However, all this evidence pertains to chooser dependence, rather than menu dependence. In this paper we search for the influence of menu dependence in the context of simple sequential games related to the ultimatum game. The simplicity of the games we use allows for a very transparent

were 2x6 matrix games with a dilemma structure.

[6]Bolton, Brandts and Ockenfels (1998) actually study both positive and negative reciprocity. Their evidence is inconsistent with the reward of good intentions, while they find some weak (statistically insignificant) indication of subjects punishing bad intentions.

exploration of the presence and the nature of this menu dependence.

3.3 Experimental design and procedures

Our starting point is the game shown in figure 3.1. This is the game Bolton and Zwick (1995) call the cardinal ultimatum game and Gale, Binmore and Samuelson (1995) call the ultimatum mini-game. A consequence of the simplified structure of this game is that player 1 is extremely restricted in his strategy space with respect to the classical ultimatum game: he can only propose two different divisions of the pie. This simplification has two important consequences. First, as mentioned by Abbink, Bolton, Sadrieh and Tang (1996), the structure of the ultimatum mini-game allows for a clear separation of outcomes of different types. Second, as is explained below, the control over players' perceptions and expectations is increased.

The standard ultimatum game has a unique subgame perfect equilibrium (hereafter, SPE). A central feature of the SPE outcome is the strong inequality of the payoffs of the two players. The outcome (R,l2) with associated payoffs (320,80), shown in figure 3.1, is supposed to capture this inequality in the framework of the ultimatum mini-game. The reason for not choosing the most extreme split-up of 400 units, (400,0), is basically procedural: a somewhat less unequal distribution of payoffs makes it possible to pay player 2 subjects some compensation for their time.

In the ultimatum game in its standard form there are (infinitely) many alternative outcomes to the SPE outcome. It is not clear which of these are actually envisioned as alternatives by player 2 when he receives a specific offer. However, the equal split is often

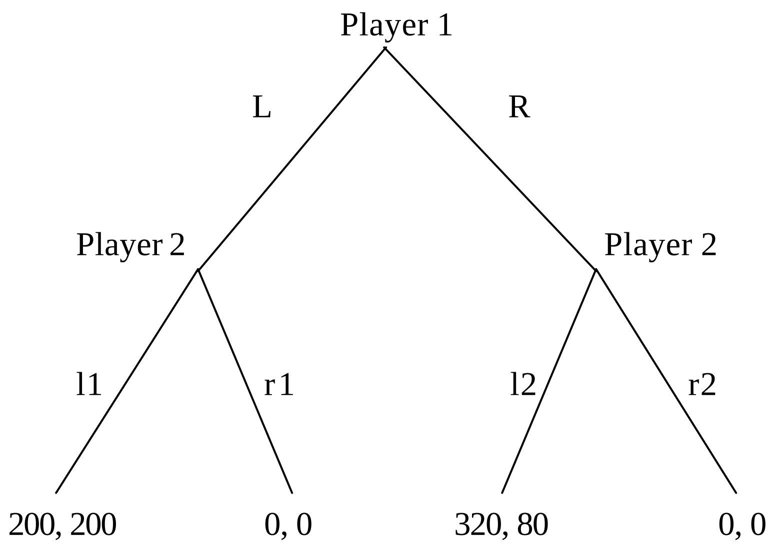


Figure 3.1: The Ultimatum mini-game. Key: (payo® to player 1, payo® to player 2).

considered to be the most "focal" alternative to the SPE outcome. The ultimatum mini-game was precisely constructed to guarantee that players only consider the equal split as alternative to the unequal SPE outcome. This approach can now be taken one step further.

In the experiments reported on in this paper we modi¯ed the above game by varying the payo®s corresponding to the (L, l1) outcome, without altering any of the other payo®s. We will call this outcome the "reference point" of the game. We will look at behavior in variations of the ultimatum mini-game which only di®er in their reference point.

The purpose of the experimental design we use in this paper is to analyze how player 2's reaction to player 1 having chosen R is a®ected by modi¯cations in the features of the reference point. Our ¯rst objective is to detect whether there is any e®ect at all. If so, then that will be direct evidence of the presence of menu dependence, since the reaction to having to choose between l2 and r2 (after R) will have been a®ected by other possible outcomes of the game. We wish, however, to go one step further and to delineate more concretely in which direction menu dependence guides behavior in our games.[7]

The reference points that we consider in this paper were selected according to two criteria. First, the sum of the payo®s at the reference point will always be 400, as with the SPE outcome. Second, given the restriction of keeping the pie constant, we begin at the ultimatum mini-game and look at variations along two rather natural dimensions. Figure 3.2 shows the ¯ve reference points that we consider and organizes them along the two dimensions we selected. The ultimatum mini-game can be seen as our starting point. The ¯rst dimension of variation refers to whether the payo® to player 2 at the reference point is more or less than at the ¯fty-¯fty split. The second variation corresponds to payo®s being more or less equal at the reference point than at the benchmark outcome, (320,80). As shown below, this selection of reference points yields a rather complete picture of behavior in this type of games.

The reference points for game 2 and game 4 represent symmetric deviations from the ¯fty-¯fty split. Those for games 1 and 5 are also symmetric deviations and result in payo®s more unequal than the (320,80) outcome.[8]

What are conceivable patterns of responses by player 2 to player 1¶s choice of R, across games 1 to 5? One possibility is, of course, that player 2 only cares about his own payo® and, possibly, the distribution of payo®s at the outcome (320, 80). In this case, reactions to R will be independent of the reference point. Another possibility, however,

[7] Camerer and Thaler (1995) refer brie°y to this kind of analysis.
[8] Note that in Game 1 the SPE outcome does not correspond to the outcome (320,80) but to (350,50).

Equality of reference point with respect to the benchmark (320, 80) / Distribution of payoffs at the reference point with respect to equal split	More equality than at the benchmark (320, 80)	Less equality than at the benchmark (320, 80)
Higher payoff to player 1	(300, 100) **GAME 2**	(350, 50) **GAME 1**
Equal Split	(200, 200) **GAME 3**	
Higher payoff to player 2	(100, 300) **GAME 4**	(50, 350) **GAME 5**

Figure 3.2: The games and their associated reference point payo®s.

is that choices are menu dependent and that reference points matter. For example, it is possible that player 2 reacts more negatively to player 1 choosing R the higher the payo® that the reference point assigns to player 2. Reference points may also matter in other ways, as will be discussed in the results section.

Both games 4 and 5 can be seen as approximations, in this simple setting, to the best-shot game analyzed by Harrison and Hirshleifer (1989) and Prasnikar and Roth (1992). In the best-shot game there are two Nash equilibrium outcomes which both yield very unequal payo®s to the two players involved. The payo® combinations at the two equilibria are actually mirror images of each other: at one of the equilibria player 1 gets a relatively large amount and player 2 a rather small amount, while at the other equilibrium it is exactly the other way around. However, only the first of these corresponds to an SPE. Results from experiments with the best-shot game show strong adherence to the SPE outcome.

There are two important differences between games 4 and 5, on one hand, and the best-shot game, on the other hand. Games 4 and 5 lack the complexity of the best-shot game and the payoffs at the two Nash equilibrium outcomes are not exactly mirror images of each other.[9] Results from our games will allow us to shed some additional light on the determinants of behavior in the best-shot game.

We present results from ten sessions, two for each of the games presented in the precedent pages. All sessions were run at the Universitat Autònoma de Barcelona. Students were recruited using billboards posted in social sciences buildings of the university, giving the incentive to earn some money. Each session involved the participation of sixteen subjects (except session 2A, where only 14 subjects appeared on time). Average earnings were 2000 pesetas (about $13) The experiment involved a total of 158 students. Subjects earned a fixed amount for participation plus the points earned in each period, which were converted, from the amounts shown in games 1 to 5, directly into pesetas.

The sessions were conducted by three experimenters. At the beginning of each session subjects were given written copies of the instructions and one of the experimenters read them aloud. After the instructions had been read and questions publicly answered,

[9] The best-shot game involves two players. Player 1 states a quantity q1, after which player 2, informed of q1, states a quantity q2. An amount of public good equal to the maximum of the two quantities results, and each player i receives the payoff corresponding to that quantity of public good minus his own quantity, qi, times a given factor. The payoff consequences of their actions are presented to subjects in terms of schedules of redemption values and expenditure values for different quantity levels up to 21. We believe that it is fair to say that the games we use in this paper are in a general sense simpler than the best-shot game just described.

subjects were randomly assigned to one of two groups in di®erent rooms. In one group subjects had the role of player 1 (the proposers) while in the other group they had the role of player 2 (the deciders). Each subject's role was constant during the whole session, which involved eight periods against di®erent opponents using a no-contagion matching scheme (seven periods in session 2A). All this was common information. Once the subjects had been separated into two groups they were randomly distributed across the rooms by the experimenters in such a way that they could not see each other's decisions. The session began with the proposers' choices in the ¯rst period. After all proposers had made their decisions, the monitors collected their decisions individually and transmitted the decision of the proposers to the corresponding deciders' information sheet. Then, all deciders made their decisions, which were communicated to the corresponding proposers. Following this, players privately computed their payo®s for the periods. Subsequent periods were conducted in the same way. At the end of a session, each player had played eight (seven in session 2A) one shot games with di®erent players of the other type. The appendix contains a copy of the instructions for game 1.

3.4 Results: presentation and interpretation

We will center our analysis on how changes in the reference point in°uence the behavior of those experimental subjects that we assigned to be deciders.[10] A summary of our treatments and data is presented in Table 3.1.

Due to two features of our design we expected behavior of each player 2 to be

[10] Other papers, as Bolton and Zwick (1995) and Forsythe, Horowitz, Savin and Sefton (1994), study proposers' motivations.

	Ref. Point	N	Prop. (320,80)	Prop. reject.
Game 1	(350, 50)	128	0.41 (53)	0.0535 (3)
Game 2	(300, 100)	113	0.42 (48)	0.1217 (7)
Game 3	(200, 200)	128	0.46 (60)	0.17 (13)
Game 4	(100, 300)	128	0.55 (70)	0.13 (35)
Game 5	(50, 350)	128	0.80 (103)	0.1626 (20)

Table 3.1: Main descriptive results.

independent across periods and, hence, to obtain results from a set of one-shot games. The non-contagion matching scheme we used makes repeated game e®ects impossible, since there is no direct or indirect way in which a decider could a®ect the decisions of those proposers with which he will be matched in subsequent periods. Through the simplicity of the games employed we expected to eliminate the deciders' adaptation over time that often results from learning in more complex environments.

Figure 3.3 presents data that support the claim that behavior is independent over time. It shows the numbers of the (320,80) proposals and the number of these proposals' rejections, for each session and each round. We do not observe any strong tendencies. In particular, rejection rates do not change in a clear way over time and do not appear to be related to a particular time-pattern of the (320,80) proposals.

Figure 3.4 presents information about rejection behavior; it shows the number of rejections of the (320,80) proposal by individual ordered from higher to lower together with the associated number of (320,80) proposals received; for each game we separately show the results from the two corresponding sessions.[11] The ¯gure reveals that there are some

[11] For instance, the data for game 2 in ¯gure 3.4 show that in session 2A, the player that rejected the highest number of (320, 80) proposals (denoted by player 1 in this case) made 7 rejections. Another player, player 2, rejected 6 proposals, another one 4 etc. The graph also shows that player 1 received 8 (320, 80) proposals, player 2 also received 8, player 3 received 6, etc.

differences in the distribution of rejections; games 2 and 3 appear to exhibit the largest discrepancy in decider behavior. Averaging over individual rejection rates for the different treatments we find values of .0333, .1444, .2183, .3492 and .1641 for games 1 through 5. Note that the ordering of these averages is in line with those shown in table 3.1.[12]

The information shown in figures 3.3 and 3.4 is the basis for our statistical tests. Several statistical comparisons of the results from the different games support the presence of menu dependence in our data. The information presented in figure 3.3 justifies treating each individual as a statistically independent observation. Using as data individual rejection rates for the five games a Kruskal-Wallis one-way analysis of variance by ranks rejects the hypothesis of no difference across games at the 5% level ($p<.01$ after correcting for ties). This result only tells us that at least one of the groups is different from all the other ones. To determine which pairs of groups are different we can use the multiple-comparison test described in Siegel and Castellan (1988). Imposing a significance level of 5% we can only reject the null hypothesis of equality for the pair formed by games 1 and 4. The Mann-Whitney or Wilcoxon rank-sum test yields complementary evidence about differences between games 1 and 4; it rejects the hypothesis of no difference across the two games ($p<.01$ after correcting for ties).

Another way of directly comparing the two treatments is based on the classification of each individual observation into one of two groups depending on the number of times that individual rejected in a session; this information can be gauged from figure 4.[13] We use

[12] Although our focus is on behavior after player 1 choosing R, the reader may also be interested in behavior after L. Average individual rejection rates after player 1 choosing L were .1927, .0365, 0, .125, .0555 for games 1 through 5.

[13] For instance, in game 4 there were five individuals who never rejected (four in session 2A and 1 in session 2B); all the others rejected at least once.

two di®erent ways of allocating subjects into two groups. The ¯rst one consists in assigning individuals with zero rejections, those who behave according to the usual assumption in economics, into one group and individuals with any other number of rejections into the other. With these data one can now perform tests of di®erences of proportions. Using the Fischer exact test we can reject a one-tail null hypothesis of equality at p=.001. This test can be redone based on a di®erent grouping of individuals: one group formed by individuals with none or one rejection and another group with all the others. A one-tail test allows a rejection of equality of behavior at p=.008.

We can also use the Â^2 test to test for di®erences between games 1 and 4. On the basis of the two di®erent groupings of individual observations mentioned in the previous paragraph we reach the same conclusion with p=.01 in both cases.[14]

All previous studies on chooser and menu dependence, as well as the present one only elicit and examine subjects' choices and not their thought processes. To directly connect either type of dependence with the notion that humans react to others' intentions, one would need independent information about motivation and the attribution of intentions. One possible way of collecting this information is through asking subjects directly about their interpretation of other's behavior under di®erent conditions. In the absence of this kind of information we present an explanation of behavior that is consistent with the overall picture that emerges from the data of our ¯ve games. We interpret the observed type of

[14] An alternative way of using Â^2 tests is to test for equality of the ¯ve samples. For the ¯rst partition of individual rejection frequencies mentioned above (individuals with zero rejections in one group all others in the other group), a test with four degrees of freedom rejects the null hypothesis that the ¯ve sample frequencies come from the same population (p<0.05). However, the decomposition procedure described in Siegel and Castellan (1988) which aimed at identifying the source of the discrepancy between k samples does not make it possible to separate one treatment from all the others. Also, lack of data does not make it possible to perform the test for di®erences in the ¯ve samples with the second way of partitioning individual behavior.

dependence in terms of a psychological mechanism by which people attribute intentions to others, rewarding good ones and punishing bad ones.

Our explanation uses the overall rejection rates shown in table 3.1. When the reference point has payo®s (350,50) the rejection rate is rather low; a possible interpretation of this fact is that the responder can not feel badly treated at the outcome (320,80). If the reference point is changed to (300,100) the rejection rate goes up. A rationale for this change is that now the responder would be better o® than at what is now the SPE outcome. However, as revealed by the Kruskal-Wallis test, the di®erence is not statistically signi¯cant. A simple explanation for the lack of a statistically signi¯cant e®ect is that the di®erence between the two reference points is rather small. This is also true when we move to the ultimatum mini-game. By contrast, the change to reference point payo®s (100,300) leads to a substantial increase in the rejection rate, which now is signi¯cantly di®erent than for reference point payo®s (350, 50).

Up to this point the rejection rate has varied directly with increases in the absolute and relative payo® of the responder at the reference point. However, when moving to reference point payo®s (50,350) the rejection rate goes down again. This last fact is consistent with the interpretation that the responder does not only consider his absolute and relative payo® at the reference point, but also takes into account the proposer¶s situation: responders do not punish the proposer heavily for not making an o®er that gives a larger share to the responder and is more unequal than the SPE payo® combination.[15]

[15]The interpretation we present may go against some readers' intuitions. For instance, the lack of di®erence in rejection rates between Games 1 and 3 may come as a surprise. It can be argued that in Game 1 the proposer is particularly unfair if he chooses the (320,80) outcome, because both options give the proposer already an advantage and he could be "fair" at a low cost to himself by proposing the (300,100) distribution. This very natural conjecture is, however, not con¯rmed by our data.

It is not hard to show that, in our data, the e®ects caused by changes in the reference point also have some quantitative importance. The ratio between the statistically di®erent rejection rates for games 1 and 4 is about 6 to 1. Given that the rejection rate at a reference point with payo®s (400,0) can reasonably be assumed to be no greater than the one for (350,50), the factor 6 can actually be considered to be a lower bound on the maximum variation of rejection rates that can be caused, in the kind of games with study, by changes in reference points. Our interpretation is that this six-fold multiplication of rejection rates is a negative reaction to having been made an o®er of (320,80) when a certain other o®er was available; it can, therefore, be seen as a punishment of bad intentions, what previously we have referred to as negative reciprocity.

Our results also shed some indirect light on the debate about behavior in the best-shot game. Prasnikar and Roth (1992) interpret the fact that, in contrast to the ultimatum game, behavior in the best-shot game is very close to the SPE prediction as evidence that subjects are guided by strategic considerations. GÄth and Tietz (1990), however, argue that the best-shot game has the feature that "fairness considerations" do not interfere with the acceptance of the SPE outcome. In our terminology, the best-shot game has a reference point which induces few rejections of the SPE outcome. Therefore, behavior in the best-shot game cannot be taken as evidence that "fairness considerations" do not matter in this type of games.

Our data is consistent with the idea of GÄth and Tietz that, in a sequential game with various equilibria, the characteristics of the reference point a®ect the acceptance of the SPE outcome. This is shown by comparing results from a series of games which di®er in their reference point, but which are all the same from the cognitive point of view. In our opinion, this is a much more direct line of exploring this issue than by working with games of very di®erent character, like the Bertrand competition game studied by Prasnikar and Roth.[16]

3.5 Conclusions

In this paper we present the ¯rst experimental evidence of the presence of menu dependence. In the context of sequential mini-games, the proportion of rejections of a speci¯c o®er depends on the payo® distribution at an alternative outcome of the game, which we call the reference point. We also provide some indications of how reference points matter. In three of our ¯ve treatments we observe that the proportion of rejections to a given o®er increases with the absolute payo® (and relative payo®, given the character of the payo®s in our games) to the decider. In the remaining treatment we ¯nd evidence that responders do more than just compare their payo® at the reference point to their payo® at the benchmark outcome. Responders seem to feel that they can not expect the proposer to choose an outcome which more than reverses the distribution of payo®s of the unequal benchmark outcome. As in other experimental work in the area, we ¯nd evidence of punishing behavior. However, the features of our experimental design allow us to obtain a more complete picture of the motivational factors that prompt this kind of behavior; the degree of punishment may be a®ected by reference points.

[16] We do no have data from a game with a reference point with payo®s (80, 320). Therefore, our data can not directly support or reject the idea that rejections in the best-shot game are lower than in a game with a very egalitarian reference point. Actually, Games 2 and 4 which are close to the best shot game exhibit very di®erent behavior.

Taken together, the accumulated experimental evidence can be considered to be quite favorable to the relevance of intentions and reciprocity in a number of simple games. The problem is, however, still very open. We see at least two lines for further research. First, a more complete analysis of the e®ects of reference points is needed. For instance, it remains to be seen what behavior will be like if reference points are more or less e±cient than the benchmark outcome. Second, it would be interesting to analyze how important the phenomenon of reciprocity is in richer environments, which are closer to natural economic situations. It would be particularly relevant to investigate whether the attribution of intentions can have any in°uence in market contexts.

Thus, there is now evidence that both menu and chooser dependence can be sources of reciprocity. Our impression is that menu dependence is a rather pervasive force. That is, counterfactuals may matter in many economic situations. This is, of course, just a conjecture which will need to be con¯rmed in future research.

3.6 Appendix: Written Instructions for Game 1

INTRODUCTION:

You will be taking part in a experimental study on decision making. The instructions are simple and if you read them carefully, you may earn a signi¯cant amount of money. We will now give you a show-up fee of 500 pesetas. All the money you obtain in the experiment is for you and this money will be paid to you at the end of the experiment.

We will start by reading the instructions and, following this, you will have the opportunity to ask questions about the procedures described in theses instructions.

TYPES OF PLAYERS:

In this experiment there will be two types of players: player 1 and player 2. At the end of the reading of these instructions, each participant will take one of the cards you can see in this box. Each card has a letter written on it. All the participants who draw a letter A will remain in this room. All the participants who draw a B will go to a adjacent room where they will be assigned to di®erent seats. Each participant will be of the same type during the whole experiment.

ROUNDS:

The experiment will consist of 8 rounds. In each round there will be 8 pairs of participants, each of these pairs containing a player 1 and a player 2. For each round, each player 1 will be paired with a di®erent player 2 and vice versa. In this way no participant will be paired with the same partner twice.

DECISIONS:

In each round and for each pair, player 1 will make a decision and player 2 will make a decision. First, player 1 will choose between two alternative options: Left or Right. Next, player 2 will be informed of the decision of player 1 in his/her pair. Then, player 2 will choose between two alternative options: Left or Right. Finally, player 1 will be informed of the decision of the player 2 in his/her pair, and players will know their payments for the round. Following rounds will develop in the same way until round 8.

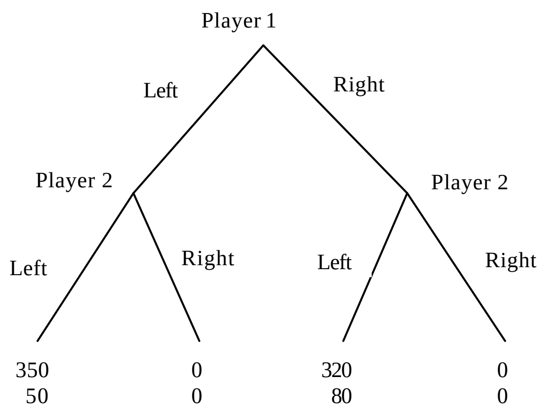
For each combination of decisions in a pair there is a payment to player 1 and a payment to player 2 as you can observe in the following table:

The decisions can be described by the following ¯gure where, in the bottom part,

Player 1 chooses	Player 2 chooses	Player 1 gets	Player 2 gets
Left	Left	350	50
Left	Right	0	0
Right	Left	320	80
Right	Right	0	0

Table 3.2: Decisions/Payo®s for the instructions to Game 1

you can observe the corresponding payments to player 1 and player 2 (payment to player 1 above and payment to player 2 below):



Game representation for the instructions (Game 1)

RECORD OF RESULTS:

Now observe your sample record sheet, given to you together with the instructions. Once the types of players will have been drawn and the experiment will be about to start, we will give you the record sheet on which you will actually record your decisions.

Your identi¯cation number will appear at the top of the sheet. Below your assigned type of player, 1 or 2, will appear. Recall that all type 1 players will remain in this room and all type 2 players will be in an adjacent room.

Below you will see a table of payments.

At the bottom of the page, the ¯rst column shows the round number. The second column will show the identi¯cation number of the participant that will be paired with you in each round. Observe that in each round, you will be paired with a di®erent partner. In the next two columns decisions will be registered. Once you will have been informed of the decision of your partner in a round, you will register your payment in pesetas in the last column.

PAYMENT:

At the end of the eight rounds you will compute the sum corresponding to your earnings for the 8 rounds of the experiment. You will add to it the 500 pesetas that you have already received for your participation and you will ¯ll out the receipt that we have given you. Following this, you will wait silently until one of the organizers will pay you privately.

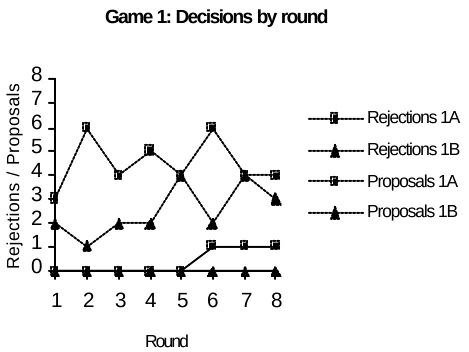
QUESTIONS:

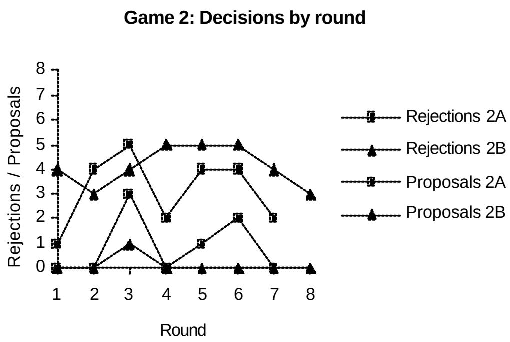
The experiment is going to start. Do you have any question about the procedures described in the instructions?

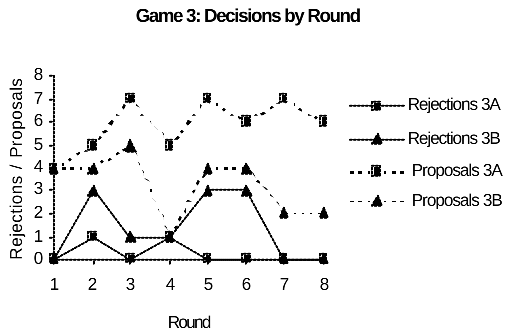
FINAL OBSERVATION:

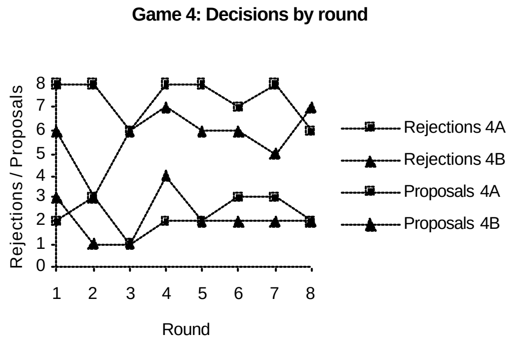
In the experiment you are not allowed to talk or communicate with other participants. Please, do not ask public questions during the experiment. If you have any question once the experiment has started, raise your hand and one of the organizers will come to answer it to you.

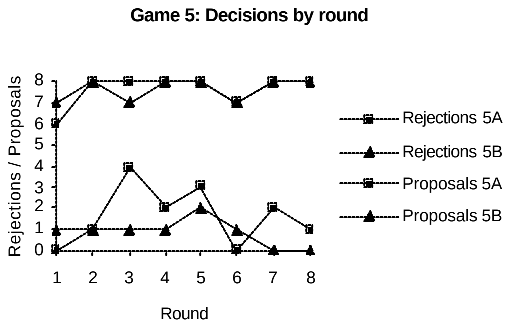
Now, please take one of the cards and follow the instructions of the organizers of this experiment.







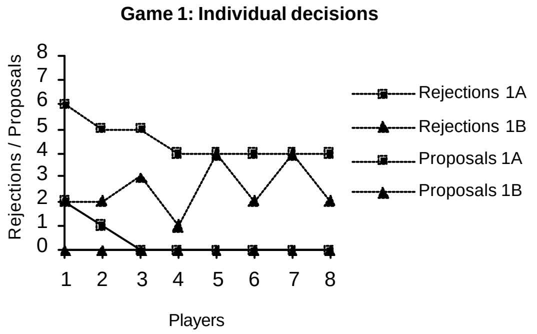


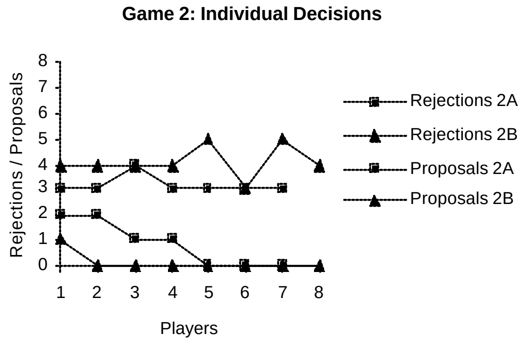


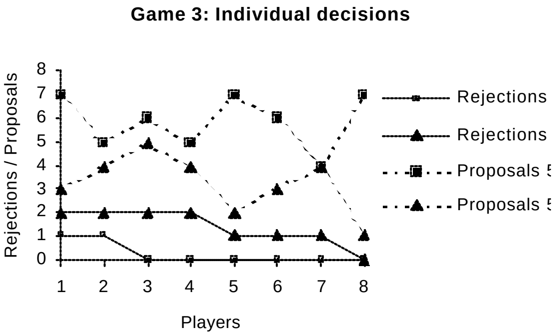
Number of rejections and number of (320,80) offers received by round.

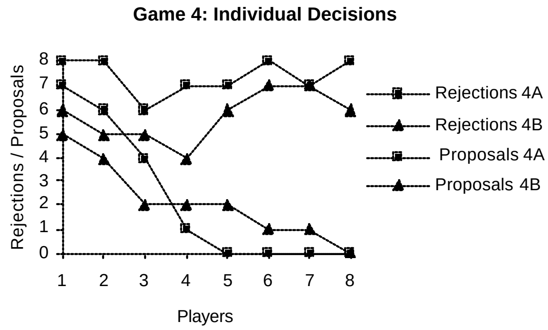
Game 1: Reference Point payoff: (350, 50)
Game 2: Reference Point payoff: (300, 100).
Game 3: Reference Point payoff: (200, 200).
Game 4: Reference Point payoff: (100, 300).
Game 5: Reference Point payoff: (50, 350).

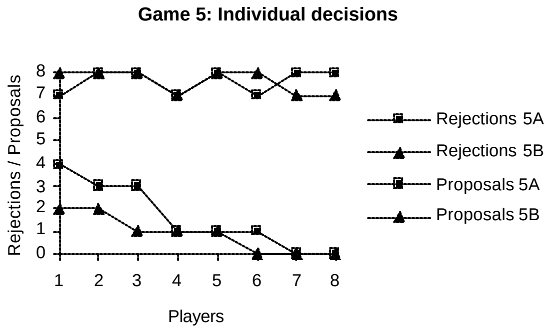
Figure 3.3: Decisions by round.











Individual decisions in each treatment and each session ordered from higher number of rejections to the (320,80) offers to lower number of rejections to these offers. Number of rejections is presented with the associated number of (320,80) offers each player received.
Game 1: Reference Point payoff: (350, 50)
Game 2: Reference Point payoff: (300, 100).
Game 3: Reference Point payoff: (200, 200).
Game 4: Reference Point payoff: (100, 300).
Game 5: Reference Point payoff: (50, 350).

Figure 3.4: Individual decisions

Chapter 4

Distributional Concerns and Reference Points

4.1 Introduction

Research on decision making in economic problems is increasing both from a theoretical point of view and from an experimental point of view. The dialogue between theory and experiments is generating a better understanding of decision processes in several contexts. This paper contributes to this dialogue from the experimental point of view, but the theoretical foundations will be discussed. We study simple extensive-form, two-person games in which negative reciprocity plays a key role. The term reciprocity will refer to the willingness to reward perceived good intentions and to punish perceived bad intentions, based on observed actions. Hence, a player's choice of an action that reduces the payo® of the other player (with respect to payo®s associated to other available actions) in response to a situation considered as unfair will be considered as motivated by negative reciprocity. In this paper we consider situations in which negative reciprocity results in lower payoffs for the punishing player also. We analyze whether the degree of negative reciprocity in players' actions is affected by payoff changes at a reference point. A reference point is an outcome of the game that may give information to a player on the fairness or desirability of other outcomes.

In the games proposed here we study how manipulations in a Nash Equilibrium outcome of an Ultimatum Mini-game, the reference point, affect negative reciprocity at the Subgame Perfect Equilibrium outcome, hence the frequency with which the theoretical predictions are observed. This influence may also be considered as menu dependence [Sen (1997)]. The manipulations involve varying the relative payoff or the absolute payoff of the second player and the joint payoff at the reference point across games.

This analysis is placed in the context of ultimatum games. Brandts and Solà (2000) analyzed simple sequential two-person games that simplify the structure of the ultimatum game to increase control over players' perceptions of reciprocity considerations. They show that different reference points lead to significantly different rejection rates of the SPE proposal. That is, a certain factor influencing punishment and a partial explanation of its effect was found. Here we carry out a systematic analysis of the way in which reference points may matter. The experimental data presented here are not designed to test subgame perfection but to make a constructive analysis of factors that concern decision processes. In particular, this chapter studies the interaction between reference points and absolute payoffs, relative payoffs and efficiency considerations. These concepts allow us to study how agents interpret the intentionality of another agents' action in terms of the reference point, represented here as a lost opportunity. The experiment presented here analyzes whether reference points outcomes are used as instruments that help deciders to choose an action. The interaction analyzed contributes to understand failures of the SPE prediction and provides data that may help the developing of behavioral theories.

This chapter is organized as follows. Section 4.2 discusses the concept of choice dependence and discusses the related literature. Section 4.3 introduces the hypotheses and designs used. Section 4.4 presents and discusses results and section 4.5 concludes.

4.2 Distributional concerns and intentionality

The ultimatum game has generated a fruitful discussion of theories of behavior because of its robust experimental results which di®er from the theoretical results.[1] Di®erent theories have proposed explanations for the evidence presented.

Distributional theories such as those of Bolton and Ockenfels (2000) and Fehr and Schmidt (1999) have been proposed to explain results for a variety of games within a uni¯ed theory. While distributional motivations explain some results, new experimental evidence seems to con¯rm that additional factors play a role in observed behavior, in particular the role of intentionality detection. This is clearly observed in the behavior of the second mover in ultimatum games where the choice process has been analyzed in detail. We proceed to present recent studies to describe the problem and to place this paper in the research associated to it.

[1]See Kagel and Roth (1995) for a complete overview of experimental results.

Sen (1997) analyzes the importance of the choice process in decision making focusing on two aspects: chooser dependence and menu dependence. These concepts refer to the idea that, in order to understand certain choices by individuals, it is necessary to consider that the structure of the sequential decision problem may a®ect choices independently of monetary payo®s.

Chooser dependence refers to the fact that a speci¯c opponent is involved in the process. The importance of chooser dependence has been established for ultimatum games and gift exchange games by Kagel, Kim and Moser (1996), Blount (1995), and Charness (1997). These studies show, in di®erent contexts, that agents react di®erently to the same action depending on the type of agent that they face. Kagel, Kim and Moser (1996) deal with agents, the proposers of ultimatum games, who have di®erent information about the consequences of their actions. These informational di®erences are taken into account by the responders and reactions to identical o®ers di®er according to such di®erences, showing that responders consider the intentionality of an action (given by the knowledge of its consequences) as relevant information. Blount (1995) analyzes reactions of responders to proposals in ultimatum games when the proposers are an interested partner, a computer or an uninterested partner. This line of research focuses on the attribution of intentionality to player 1 when he plays his SPE strategy. This attribution is possible if player 1 knows the consequences that his/her action has on player 2 or is an interested partner. Charness (1997) found that in gift exchange games simulating labor markets, workers react di®erently to the same contracts generated by di®erent types of contractors.

Menu dependence refers to the fact that preferences over outcomes are dependent on the menu or the choice set in which this alternative is placed. This line of research, which is directly connected to models of reciprocity and fairness, has not been intensively analyzed using experimental methods. In sequential two-person games, Beard and Beil (1994) present a study where menu dependence is not observed for the second mover but the possibility of it a®ects ¯rst mover behavior. The relevance of menu dependence has been analyzed in di®erent sequential two-person games by Brandts and Solà (2000), showing that the menu with which a choice is presented, even if the outcomes involved in the choice are not changed, a®ects the reaction to these outcomes. They present a situation that entails a negotiation between two players similar to an ultimatum game. The SPE equilibrium of the game implies a highly unequal distribution of resources, but the ¯rst mover had the opportunity to present a di®erent o®er, which is a Nash Equilibrium outcome. Their results show that variations in the Nash Equilibrium outcome (a reference point) a®ect the frequency with which the second mover plays his/her SPE strategy. Not playing their SPE strategy is a negative reciprocal action in response to an o®er considered unfair.

This research is closely related to models that incorporate fairness in subjects' behavior. Fairness was introduced in a seminal paper by Rabin (1993) following the analysis of psychological games provided by Geanakoplos, Pearce and Stachetti (1989). Rabin (1993) uses the framework of psychological games and presents a model in which agents value the monetary payo® as well as a psychological payo®. The psychological payo® incorporates the fairness component, since agents may be willing to react kindly to those who act kindly to them or unkindly to those acting unkindly to them, even in situations where this implies to give up monetary payo®s. Intentions play an important role in this model since fairness is based on the beliefs about the reasons of others' expected actions. These reasons are measured in terms of the possible actions available to the other players. While Rabin's model is presented for simultaneous games, Dufwenberg and Kirchsteiger (1998) develop a similar model for sequential games and more than two players. They use the concept of sequential reciprocity. Kindness or spitefulness towards each player is the result of actions of others that a®ect one's own payo®. The direction of the present paper is close to Dufwenberg and Kirchsteiger (1998) by using a design to test how negative reciprocity in sequential games is a®ected by introducing speci¯c payo® variations in the reference point. These variations try to connect distributional theories with the role of reference points.

4.3 Experimental Design and Hypotheses

In order to clarify our main research hypotheses consider the following extensive form game in Figure 4.1.

Notice that the outcome (320,80) is the unique Subgame Perfect Equilibrium outcome of the game. The outcome (200,200) corresponds to the other Nash equilibrium outcome of the game. The focus of this paper is on whether certain variations of the payo®s in the Nash Equilibrium may play a role as a reference point in that they may a®ect the frequency with which player 2 plays his part of the Subgame Perfect Equilibrium strategy pro¯le [even if it is o® the equilibrium path]. We will use Game 1 as our baseline to analyze the in°uence that a reference point may have on observed behavior.

Observe that if player 2 is not playing his part of the SPE when this subgame is reached, player 2 renounces to a positive payo® to punish player 1. This behavior will be in-

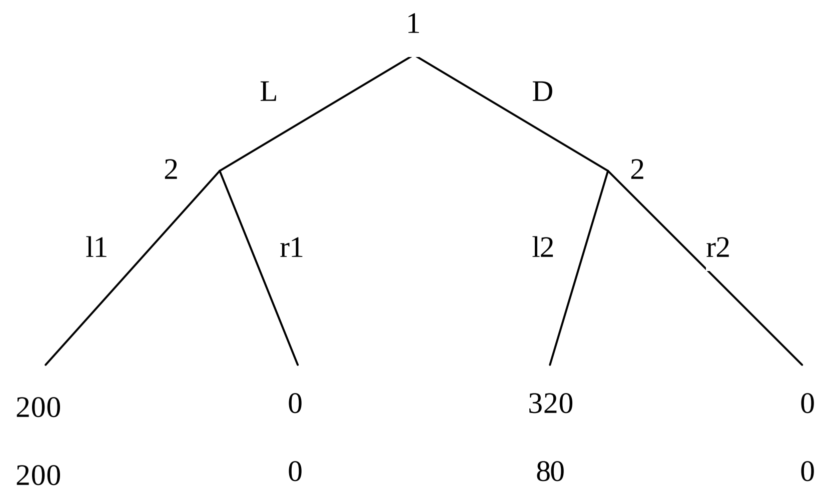


Figure 4.1: Game 1. The Ultimatum mini-game.

terpreted as negative reciprocity. Negative reciprocity may be in°uenced by several factors. Bolton (1991) and Bolton et al (1996) suggest the magnitude of player 2s relative payo®, meaning the ratio between his payo® and the payo® of the other player at the SPE, as the main factor. Lower player 2's relative payo®s would result in higher negative reciprocity. The model of fairness by Rabin (1993) and the model of sequential reciprocity by Dufwenberg and Kirchsteiger (1998) suggest other in°uences. Depending on the opportunities that were available to player 1 (the reference point), di®erent intentions can be attributed to a given action. A "bad intention" may trigger negative reciprocity.

Brandts and Sola (2000) present experimental evidence that, varying the payo®s of the reference point will a®ect the frequency with which player 2 plays his SPE strategy. Their experimental results show that increasing player 2's payo® at the reference point (while reducing simultaneously the payo® to player 1, to keep the sum of payo®s -joint payo®- at the reference point constant) increases signi¯cantly the frequency of negative reciprocity. That is, player 2 plays with lower frequency his part of the SPE. This result holds for four out of ¯ve treatments.[2] When the payo® to player 2 at the reference point was the highest, the frequency of play by this player of the SPE increased again. For this case it also happened that the payo® to player 2 at the reference point was even larger than the payo® of player 1 at the SPE (and therefore, the payo® of player 1 at the reference point was smaller than the payo® of player 2 at the SPE). This means that the two outcomes with positive payo®s in this game were highly unequal and the SPE favored player 1 while the reference point favored player 2. Thus, player 2 considered possibly that the SPE o®er was no longer such an unfair action, given the other option available to player 1.

These results con¯rm the importance that the reference point may have in some situations. In order to explain these failures of the SPE equilibrium prediction and the possible motivation that guides the individuals' actions in these situations, this paper addresses how the payo® characteristics of the reference point may a®ect negative reciprocity by focusing on three aspects: relative payo®, absolute payo® and joint payo® considerations. By relative payo® we mean the ratio between player 2's payo® and player 1's payo® at the reference point. Absolute payo® means player 2's payo® at the reference point and joint payo® will be the sum of both players' payo®s at the reference point. Observe that introducing any change in player 2's relative payo® at the reference point in Game 1 without changing her (absolute) payo® (and vice versa), means that player 1's payo® will also be changed. This will imply that the sum of payo®s at the reference point will be di®erent to the sum of payo®s at the SPE. These simultaneous e®ects will be separated in one case directly but

[2]The manipulations at the reference point in Brandts and Sola (1998) generated ¯ve treatments. Payo®s at the reference point for the di®erent games were (350,50), (300,100), (200, 200), (100,300) and (50,350). The ultimatum mini-game was initially not in that investigation, but was the key to this one.

we well need an auxiliary game in the other case to disentangle (absolute) payo® and joint payo® considerations.

To illustrate how relative payo®s may be manipulated to analyze its importance at the reference point, consider Game 2 in Figure 4.2.

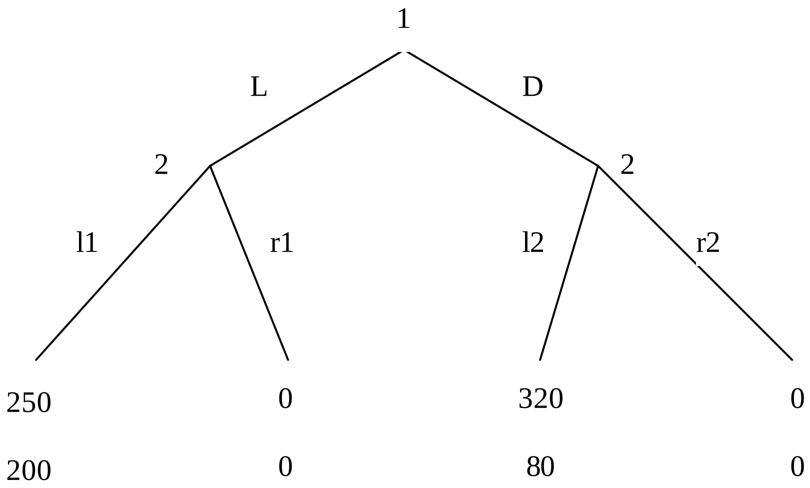


Figure 4.2: Game 2. Variation in relative payo® at the reference point.

Observe that Game 2 has the same SPE prediction as Game 1. Also, the payo® to player 2 at the reference point -that in this case is (250,200)- is the same as in Game 1. Note that the payo® of player 1 at the reference point is the only di®erence with respect to Game 1. This change allows isolating what may be the two causes of possible di®erences between Game 1 and Game 2 in the frequencies with which player 2 plays his/her SPE.

First, the relative payo® of player 2 at the reference point in Game 2 is worse than in Game 1 (the relative payo® at the ref. point is 1 in Game 1 and 200/250 in Game 2). If player 2 considers what could have obtained at the reference point in terms of relative payo®s, he is better o® at the SPE in Game 2 than at the SPE in Game 1. Therefore, we might expect higher negative reciprocity in Game 1, where player 2 could have obtained a higher relative payo® at the reference point. This conjecture based on relative payo® considerations will be stated as Hypothesis 1 below.

Hypothesis 1 (H1): If player 2's negative reciprocity is increased by relative payo® increases at the reference point, we should observe a higher frequency of SPE play by player 2 in Game 2 than in Game 1.

The second source of possible di®erences between Game 1 and Game 2 is the joint payo® (sum of players' payo®s) at the reference point, higher in Game 2 than in Game 1 (and higher than the joint payo® attainable at the SPE). Suppose that player 2 is concerned about joint payo® considerations at the reference point when he/she has to decide at the SPE node of the game. If this is true, the outcome at the SPE in Game 2 is worse for player 2 than the outcome at the SPE in Game 1. The reason being that a higher joint payo® could be reached at the reference point in Game 2. If negative reciprocity is positively a®ected by joint payo® considerations at the reference point, this should be re°ected in a lower frequency for player 2's of SPE play in Game 2 (or higher negative reciprocity). This argument is stated as Hypothesis 2.

Hypothesis 2 (H2): If negative reciprocity is increased by joint payo® increases at the reference point with respect to the SPE outcome, we should observe a higher frequency of SPE play by player 2 in Game 1 than in Game 2.

To discuss our next hypotheses we need to introduce Games 3 and 4, in Figures 4.3(a) and 4.3(b) respectively.

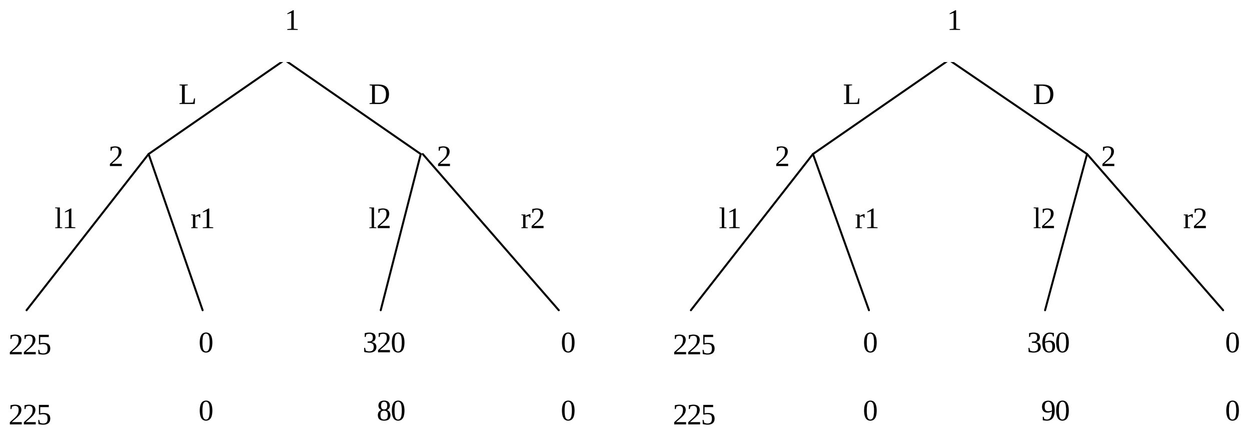


Figure 4.3: Game 3: Absolute payo® manipulation and Game 4: Ultimatum mini-game re-scale.

We now consider Games 1 and 3. Both games have the same SPE outcome as well as the same relative payo® to player 2 at the reference point (200/200 in Game 1 and 225/225 in Game 3). The di®erence between Game 1 and Game 3 is on the players' (absolute) payo®s at the reference point. This di®erence has two implications on player 2: his/her absolute payo® at the reference point and the joint payo® at the reference point are higher in Game 3. Observe that if higher absolute payo® to player 2 or higher joint payo® at the reference point both increase negative reciprocity at the SPE node, then higher punishment should be observed in Game 3 with respect to Game 1. The impossibility to separate both causes by comparing Game 1 and Game 3 is the reason to introduce Game 4.

Game 4, in Figure 4.3(b), is a version of Game 1 at a slightly higher scale . With respect to Game 3, Game 4 maintains constant the payo®s at the reference point. Moreover the relative payo® to player 2 at the SPE outcome is the same in Game 3 and Game 4. The di®erence between both games is the increase in absolute payo®s to player 1 and player 2 at the SPE outcome in Game 4, changing from (320,80) in Game 3 to (360,90) in Game 4. The reason of introducing Game 4 is that by doing this manipulation, Game 4 has constant joint payo® across the two nodes of the game and the same outcome at the reference point as Game 3. This characteristic allows us to separate the in°uence of absolute payo® at the reference point and joint payo® di®erences between the reference point and the SPE. Now absolute payo® considerations have been removed in Game 4 with respect to Game 3. We proceed to make explicit what hypotheses can be studied through the experimental analysis of these games.

The (absolute) payo® that player 2 receives at the reference point is higher in Game 3 than in Game 1 but is equal in Game 3 and Game 4. If player 2 considers the absolute payo® that he could have obtained at the reference point, he is worse at the SPE in Game 3 than at the SPE in Game 1 and he is (almost) in the same situation between Game 3 and Game 4. Therefore, we should expect higher negative reciprocity in Game 3 with respect to Game 1 and no di®erence in negative reciprocity between Game 3 and Game 4.

Hypothesis 3 (H3): If negative reciprocity is increased by absolute payo® increases at the reference point, we should observe a higher frequency of SPE play by player 2 in Game 1 than in Game 3 and no di®erence in frequencies between Game 3 and Game 4.

On the other hand, joint payo® considerations may play a role in Game 3, when compared to Game 1 and Game 4, because the joint payo® attainable at the reference point is higher than the joint payo® attainable at the SPE in Game 3. Therefore, if joint payo®

increases at the reference point with respect to the SPE increase negative reciprocity of player 2, then this factor should play a role when we compare Game 1 and Game 3 and when comparing Game 3 and Game 4.

Hypothesis 4 (H4): If negative reciprocity is increased by joint payoff increases at the reference point with respect to the SPE, we should observe a higher frequency of SPE by player 2 in Game 1 than in Game 3 and also a higher frequency in Game 4 than in Game 3.

4.4 Experimental procedures

Our experiments involved eight sessions run in March 1998 at the Universitat Autònoma de Barcelona. Two sessions were run for each of the four games we presented. Students of the Universitat Autònoma de Barcelona were recruited using billboards posted around the social sciences schools. In total, 128 students of social sciences (non-economics majors) participated in the experiment. Each session involved sixteen participants.

Each session started by distributing the instructions to the participants and paying a fixed amount for participation of 500 PTAs ($3.50). The experimenter proceeded to read the instructions aloud and to answer questions publicly. After that, participants were assigned randomly to be either player 1 or player 2. Type 1 players and type 2 players were allocated in different rooms to increase privacy and anonymity in decisions. When this process was completed, participants played eight bargaining rounds of the same game (either Game 1, Game 2, Game 3 or Game 4) against different, anonymous, opponents, as in a no-contagion scheme. After each round players only knew his/her own payoff and

	Ref. Point Payo®s	SPE payo®s	Obs.	SPE play	Ind. rej. (mean)
Game 1	(200, 200)	(320, 80)	128	0.46	0.21
Game 2	(250, 200)	(320, 80)	128	0.14	0.4
Game 3	(225, 225)	(320, 80)	128	0.23	0.359
Game 4	(225, 225)	(360, 90)	128	0.2	0.354

Table 4.1: Main descriptive results.

the opponent's payo®. Using this procedure, no player has information about what his/her opponent in the present round did in previous rounds. All these facts were common information to all players from the beginning. This procedure is used to obtain a series of independent one-shot games for each treatment and each session. When the series of rounds ¯nished, payments were distributed privately and the session ¯nished. Each session lasted about 45 minutes. Average earnings were about 2500 PTAs ($17).

4.5 Results

Since the design is explicitly made to study the implications of manipulating reference points on punishment levels, we focus on the rates at which players 2s play their part of the SPE strategy pro¯le across treatments.

We pool the data for all sessions of a given treatment. The aggregate results obtained in this experiment can be summarized in Table 4.1, which presents the four treatments, the sessions involved in them and the proportion of the games that ended at the Subgame Perfect Equilibrium. The last column shows the mean of the individual rejection rates for each game.

Before turning into the analysis of rejection rates, notice the observed frequencies of SPE play. These frequencies show that ¯rst movers do not rely on the payo® maximization of the second mover, or act fairly. This result is consistent with other papers and is analyzed in detail for another kind of two-person sequential games in Beard and Beil (1994). Results in Brandts and Sola (1998) also present important deviations from SPE.

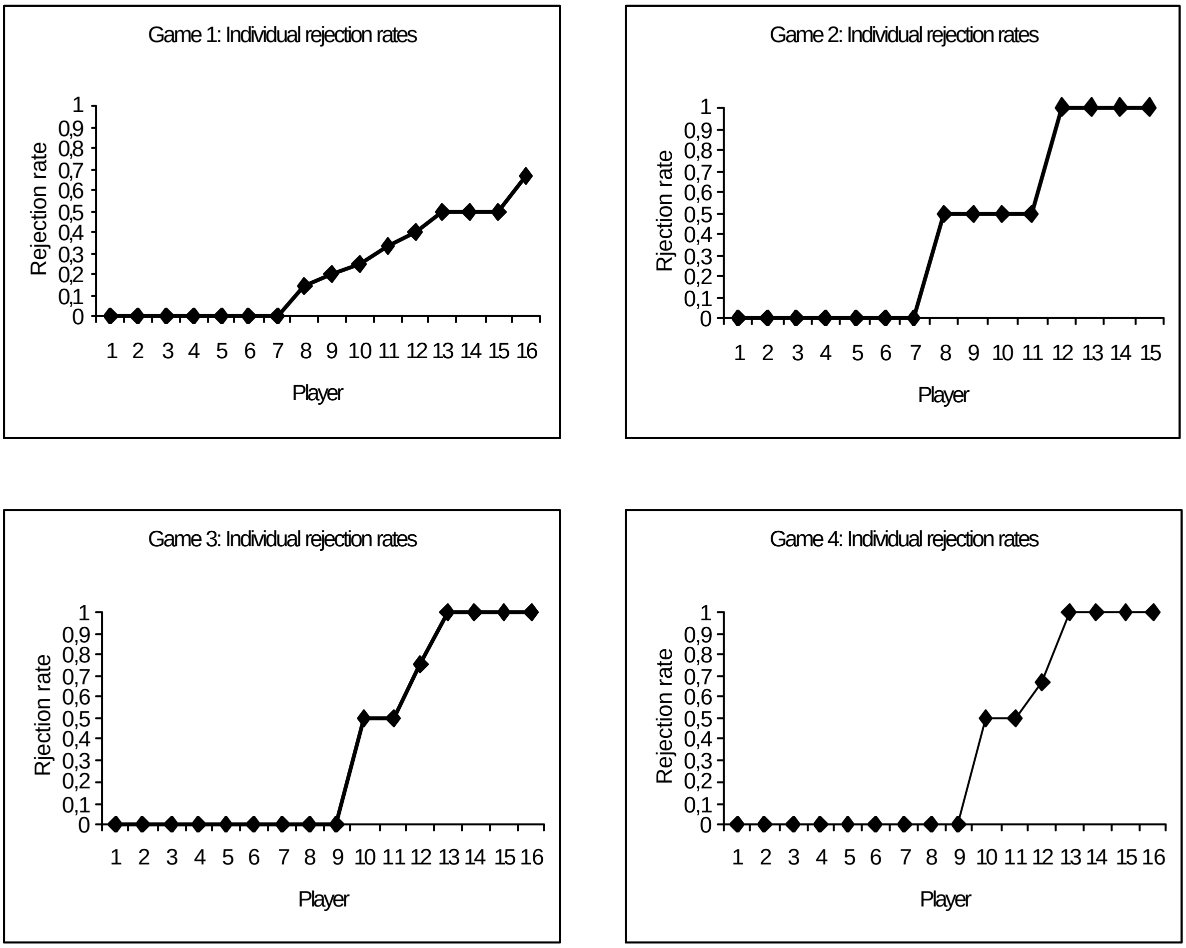


Figure 4.4: Individual rejection rates for each game, ordered from lower rejection rate to higher.

It proceeds now to comment on the results that come from the comparison across treatments. We will use individual rejection rates instead of aggregate rejections to ensure that we use independent observations. Inspection of the mean rejection rates in Table 1 would indicate that our data point to the direction of rejecting the research hypothesis of relative payo® considerations, since a higher relative payo® in Game 1, with respect to Game 2 does not generate higher rejections but, on the contrary, it leads to higher individual rejection rates. Observation of Figure 4.4, however shows that both games present similar behavior at the individual level. The direction of the possible change in the rejection rates between these two games was stated in research hypotheses H1 and H2. Hypothesis H1 presents what would be the e®ect in negative reciprocity (conversely, the frequency with which player 2 plays his/her SPE strategy) of changes in player 2 relative payo® at the reference point in negative reciprocity. Research hypothesis H2 predicts the e®ect on negative reciprocity across Game 1 and 2 of increasing the joint payo® at the reference point.

The null hypothesis, H0 is that if the manipulation introduced in the reference points do not in°uence negative reciprocity, then we should observe no di®erence in rejection rates between Game 1 and Game 2. We do obtain that the di®erence between these two games is not signi¯cant at any con¯dence level using a Mann-Whitney test. Further, using a Fisher exact probability test in which we classify subjects in two categories: those that reject at least once and those that never reject the SPE o®er, we ¯nd again no signi¯cant di®erence between the individual rejection rates for these two games. If we pool individuals according to the criterium of rejecting less than 50% of the times or 50% or more, a Fisher exact test reveals a weak e®ect (p=0.1055) in support of the research hypothesis H2 (joint payo® hypothesis). Hence the casual impression obtained from the descriptive results is not generally supported. We can not say that relative payo® considerations, neither joint payo® considerations separately a®ect signi¯cantly the distribution of individual rejection rates between these two games.

Note that, comparing Game 1 versus Game 3, we do observe a higher mean rejection rate in Game 3 and, further, Game 3 and Game 4 present similar mean rejection rates. This particular direction of the summary data was stated as research hypothesis H3. Research hypothesis H3 and H4 predict the e®ect on negative reciprocity of manipulations at the reference point across Games 1, 3 and 4 according to the possible in°uence of absolute payo® and joint considerations at this point. As we said, summary data point to research hypothesis H3 that predicted, according to the possible in°uence of absolute payo® considerations, a higher rejection rate in Game 3 with respect to Game 1 because the absolute loss that the second player faces in the SPE o®er with respect to the reference point is higher in Game 3. Moreover hypothesis H3 states that we should observe no di®erence between Game 3 and Game 4 if just absolute payo® considerations matter. Figure 4.4 again shows that these three games present an almost identical pattern of individual behavior. Again the Mann-Whitney test reveals no statistical di®erence between Game 1, Game 3 and Game 4. The Fisher exact probability test using the classi¯cation of players that separates those that do not reject never and the rest neither shows signi¯cant di®erences. Finally, grouping individuals by their frequency of rejections below 50% or above 50% we don't ¯nd signi¯cant di®erences between these games at any conventional signi¯cance level.

4.6 Conclusions

In this paper we analyze extensive two-person games and the presence of negative reciprocity. Negative reciprocity is considered as the player's choice of an action that reduces the payoff of the other player. This action may be taken in response to a situation considered as unfair. For the cases studied in this paper negative reciprocity implies a punishment that reduces both players' payoffs.

Negative reciprocity is affected by certain manipulations of a reference point, as shown in Brandts and Solà (2000). A reference point is an outcome of the game that gives information to a player on the fairness or desirability of other outcomes. In the games proposed here we study how manipulations in a Nash Equilibrium of a game, the reference point, affect negative reciprocity at the Subgame Perfect Equilibrium. This influence may also be considered as menu dependence. The manipulations involve varying the relative payoff or the absolute payoff of the second player at the reference point across games and the joint payoff at the reference point.

Relative payoff considerations at the reference point does not appear to be a separately important force driving significant differences in the rates with which second movers play their part of the Subgame Perfect Equilibrium strategy. Moreover, evidence on joint payoff considerations and absolute payoff considerations is not significant. This ambiguous evidence concerning the manipulations introduced makes us think that no definitive conclusions can be reached at this point about it. To explain the results obtained, we can probably attribute them to the conservative magnitude of the payoff manipulations involved in the experiment. It would be interesting to manipulate these payoff with larger variations to detect the possible in°uence of the absolute payo® for the second player at the reference point. This conservative approach may be what distinguishes the results presented here and the results found in Chapter 2.

The lack of signi¯cant di®erences between treatments observed in this experiment may be attributed to di®erent causes. One potential source could be the relatively small payo® changes introduced across treatments. Comparing the results of this experiment with the results obtained in Chapter 2, we can observe clear di®erences in the payo® variations at the reference point. In Chapter 2 the relative payo® to player two for the ¯ve games was 0.14, 0.33, 1, 3 and 7, respectively. This means that the relative payo® was at least doubled from game to game. Not all these games presented signi¯cant di®erences among them. In particular there was a signi¯cant di®erence between those games with relative payo®s of 0.14 and 3. In this chapter we base the relative payo® hypothesis in observing di®erences in a payo® variation that goes from 0.8 (Game 2) to 1 (Game 1) in the relative payo® to player 2. Clearly, this implies demanding much more than what it was observed in Chapter 2. Additionally, consider that the changes in reference point outcomes of Chapter 2 entailed both increases in the relative payo® and the absolute payo®, while in this Chapter we separate both concepts.

The absolute payo® hypothesis was based in the possibility of observing di®erences between two treatments that implied moving from 200 to 225, a 12.5% of increase in the absolute payo® to player two at the reference point. In Chapter 2, in contrast, signi¯cant di®erences were found between treatments that entail an increase in the absolute payo® from 50 to 300, a 600%. Notice that the joint payo® hypothesis was also based in a conservative conjecture. The increase in the joint payo® between those games that established the comparison, Game 1 and Game 3 or Game 1 and Game 2 was from 400 to 450, a 12.5%. We do not have a basis for comparing this payo® change with the experiment in Chapter 2 but the scale of the change in other variables was higher, as described above.

Another possible origin of the lack of signi¯cant di®erences in this chapter may be the compensating e®ects that may arise when analyzing the relative payo® hypothesis. Since we simultaneously change the relative payo® and the joint payo® in opposite direction between Game 1 and Game 2 we may induce two counteracting forces that compensate each other. That is we may have obtained that relative payo® is a signi¯cant source of variation between Game 1 and Game 2 but also that the joint payo® is a signi¯cant force driving behavior. Then both forces could compensate each other.

Another conclusion which can be drawn from the present experiment is the extreme variation observed in individual behavior. In three out of the four games analyzed, about half of the players never reject the SPE and the other players reject the SPE 50% of the times or more. From our point of view, this evidence suggest that models of economic behavior should consider explicitly the di®erent types of individuals and their motivations, in line with some recent models like Bolton and Ockenfels (2000) and Fehr and Schmidt (1999).

Chapter 5

The Sequential Prisoner's Dilemma Game: Reciprocity and Group Size E®ects

5.1 Introduction

Sequential prisoners' dilemma games may be interpreted as formalizations of many everyday situations which involve a trade-o® between the private and the collective interest. Sequentiality in the interaction between people is a feature that seems more appropriate as a representation of the type of situations I want to study in this paper than the perhaps more standard case of simultaneous decisions. Examples of these situations are donations to some fund-raising campaigns when donors can observe what other people previously donated, e®orts to provide some collective goods in the society with volunteers by listing participants, or teamwork production in a firm where workers observe their co-workers' efforts.

The prisoner's dilemma game is a simple, structured tool to approach these problems and additionally allows us to study some fundamental behavioral questions. Similar approaches include the gift exchange game, the investment game and public good games. We think that our approach allows us to increase both the control over the players' perceptions and the comprehension of the situation of interest. We will discuss further the other approaches and their main results.

The possible explanations of behavior observed for these kind of situations, with deviations from self interest, come from different models of interdependent preferences. These models incorporate in the utility function distributional components. In this paper, we want to make a close inspection of relevant models for these situations and study a specific conjecture that departs from purely distributional models. We will analyze a model that includes inequality aversion in the utility function, the ERC model of Bolton and Ockenfels (2000) and a model of linear altruism that follows the one proposed by Ledyard (1995) and considered by Anderson, Goeree and Holt (1998) for the case of incomplete information.

Reciprocity has been proposed as a concept that may explain behavior in this kind of situations where people appear to cooperate more than what would be rational if players just consider their pecuniary interests. Sugden (1984) introduces a general definition of reciprocity and Rabin (1993) proposes a model of fairness for simultaneous games that conceptually could be interpreted as a model of reciprocity, in the sense that an agent may be willing to reward expected good intentions and to punish expected bad intentions. We consider reciprocity as the propensity to reward perceived good intentions and to punish perceived bad intentions based on observed actions from the other players. Reciprocity is naturally interpreted when subjects deal with sequential economic situations. Simultaneous situations need from agents a more sophisticated reasoning based on expectations that may interact with reciprocity considerations. We think that a simple sequential situation will allow a direct test of reciprocity considerations.

Also, the paper presents an analysis of group size e®ects for the sequential prisoner's dilemma game. We are not aware of any experimental evidence on this e®ect for the type of games that we use. There is a controversy on the e®ect that changes on the size of the group providing a public good may have on contributions. An initial conjecture derived from Olson (1971) was that larger groups would provide the public good less e±ciently[1]. On the other hand, group size may be an important issue to have in mind if reciprocity drives certain behaviors. That is, the propensity to reciprocate some previous action may be quite di®erent if this previous action have been taken by a small group or by a large group of people. Following Elster (1989)[2], this group size e®ect can arise because of the possible interpretation of actions by large groups as an increased perceived obligation to reciprocate. We will implement a simple experimental design that will allow us to analyze this point. The interest to include this aspect is also that increasing the size of the group allows us to separate the model of relative concerns used in this paper with the interpretation we

[1] Though the main economic reasons that Olson provides are neutralized in experiments that study this issue, for example by keeping the MPCR constant. Olson also argues that "social reasons" will also strenght the economic reasons to justify that small groups will organize and succeed in providing the public good more frequently than large groups.

[2] In Elster's terminology, this is the "norm of fairness". Given the generalized use of the terms "reciprocity" and "fairness", I continue with the de¯nitions of these concepts used in the Introduction.

have just given of the interaction between reciprocity considerations and the dimension of a group.

The paper is organized as follows. Section 5.2 presents part of the accumulated experimental evidence to motivate the direction of this paper. Section 5.3 incorporates the framework and derives predictions according to the models of behavior referred to before. Section 5.4 delineates the experimental design and Section 5.5 presents the results and discusses the validity of the predictions of the models. Finally, Section 5.6 concludes.

5.2 Previous Experiments

There has been extensive research on prisoners' dilemma situations and public good games. Ledyard (1995) reports that splitting of resources between the public good and the private good in the first periods and cooperation rates in the one-shot simultaneous prisoners dilemma game far from 0% and 100% are consistently found in the literature and cites relevant communication, MPCR and repetition as the factors that strongly affect behavior. This literature is mainly concerned with simultaneous situations.

A considerable amount of research has been devoted to understand what are possible explanations for this apparent contradiction between first period results and the standard prediction of no cooperation. A possible explanation may be that individuals are altruistic [see for example Ledyard (1995) and Rotemberg (1994) for alternative approaches to altruism]. Andreoni (1995) designed an experiment to separate errors from altruism as explanations of splitting by paying each player according to the rank of the player's earnings. He finds that about 50% of the contributions observed in his experiment can be explained by altruism or kindness. Anderson, Goeree and Holt (1998) introduce a model that incorporates errors and altruism to explain behavior observed in these games. Palfrey and Prisbey (1998) also analyze altruism.

Evidence for another kind of behavior that we can refer to as reciprocal behavior also appears in the experimental literature using games di®erent from the prisoner's dilemma. Fehr, Gachter and Kirchsteiger (1997) explore it in experimental labor markets, Berg, Dickhaut and McCabe (1995) in the trust game and Croson (1998) in simultaneous public good games. Croson (1998) tests the explanatory power of altruism versus reciprocity in simultaneous public good games. She designed several experiments studying the relationship between the expectation of the other agents' contribution and the individual contribution in each round, and the other agents' actual contribution and the individual contribution. Her results show that the subjects' behavior can be interpreted as acting accordingly to a matching rule and not to a model of altruism by ¯nding positive correlations for most of the players between the variables mentioned, also in a case where reputation e®ects are removed. In this last case, the proportion of players that appear to behave according to reciprocity rules, the minimum of her experiments, is about 70%.

For sequential public good games the experimental literature is less extensive. Erev and Rapoport (1990) present evidence for sequential step-level prisoner's dilemma games, where it is rational for some players to cooperate at certain stages. This type of game is neither equivalent to the linear public good game, nor to a prisoner's dilemma. Dorsey (1992), and Kurzban, McCabe and Smith (1999) present experimental results with real time revisions of decisions in the context of linear public good games. Dorsey (1992) observes that for the linear public good game technology, allowing real time revisions drastically decreases the contributions and that allowing for revisions just to increase the individual contribution produces similar results to simultaneous games. Kurzban, McCabe and Smith (1999) explore further this revision mechanism in a linear public good game to study reciprocity considerations by individuals. Their consideration of reciprocity includes the basic rule of matching others' contributions and two modifications: intolerance of defectors and beliefs about the reciprocity considerations of the other players. Unanimity and expectations, hence become important and they design an experiment to predict through changing these two factors, the amount of contributions to the public good. The treatments differ then in the information available on the other players announced contributions and the possibility to increase/decrease contributions or only to increase them. Their main results are that full information about the others' proposals and an increase-only mechanism for revisions increase the contributions to the public good and that the mean of the contributions from the other players is a better predictor of the individual contribution than other measures.

The experimental literature concerning the effect of changing the size of the group, in public good games, in the levels of contribution is not extensive. In simultaneous games, Isaac and Walker (1988) and Isaac, Walker and Williams (1994) explored the group size effect by means of manipulating the MPCR and the size of the group providing the public good. Isaac and Walker (1988) designed an experiment with four treatment cells, MPCR equal to 0.3 or 0.75 and group size equal to 4 or 10. Note that increasing the group size while keeping the MPCR constant increases the benefits to the group of providing the public good. The MPCR effect was clear and the group size effect was ambiguous, in the sense that for a low MPCR, a group of 10 people were more successful in providing the public good but for a high MPCR there was almost no di®erence. The traditional conjecture by Olson (1971) that large groups would have more di±culties in providing a public good can be supported by the fact that a low MPCR generates lower contributions. A pure number e®ect was not found. They continued the research in Isaac, Walker and Williams (1994) with larger groups, of 40 and 100 subjects. Their main results are that, for low MPCR , 0.3, groups of size 40 and 100 provide the public good at higher levels of e±ciency than groups of 4 and 10 subjects and for high MPCR, 0.75 they ¯nd no e®ect of increasing the group size. On the other hand, the MPCR had no e®ect in these large groups. Anderson, Goeree and Holt (1998) in their model of altruism and costly errors predict an increase in total contributions when the size of the group increases.

As we said before, di®erent theories of behavior may explain part of the evidence, we referred to altruism and reciprocity. Other experiment-based theories that explain a wide variety of results from di®erent kinds of experiments incorporate a relative payo® component in the utility function. Bolton (1991) initially introduced a model that incorporated a relative payo® consideration in a model of complete information. Bolton and Ockenfels (2000) introduce a model that generalizes the relative payo® concerns of the individual in a incomplete information setting. Fehr and Schmidt (1999) present a model of inequality aversion. Bolton and Ockenfels (2000) present a model, ERC, that can accommodate different patterns of behavior, including what from their perspective has been interpreted as reciprocal behavior. They focus on the tension that an individual faces between her own payo® and a certain preference for collective payo®s. In particular, to explain results of cooperative decisions in the sequential prisoner's dilemma game this model assumes that individuals dislike inequality in the ¯nal distribution of payo®s between agents, thus is a model that incorporates self-centered inequality aversion. It is important to notice that inequality refers to one's own payo® with respect to the average payo® in the society. Also, the individual dislikes equally inequality that favors her and inequality that disfavors her with respect to the average payo® in the society[3]. Notice that this argument refers to the ¯nal distribution of payo®s from a given situation and not to the choice process that leads to this outcome, a process that may have relevant e®ects on the propensity to reciprocate[4].

Our approach will consist of analyzing two sequential prisoner's dilemma games that di®er in the number of subjects playing the game. For these games we can obtain predictions of behavior in each game and across games for the models of altruism and inequality aversion. Altruism generates di®erent predictions from what one would obtain from reciprocity or inequality aversion considerations in each game. Predictions based in inequality aversion or considerations of reciprocity are indistinguishable in each game. Reciprocity and inequality aversion, however can be separated by introducing the comparison between two games of di®erent sizes, i.e. by increasing the size of the group we can reduce the inequality generated by a defective action after preceding cooperative actions. This would induce more defective actions in larger groups after preceding cooperative actions than in smaller groups. On the contrary, reciprocity considerations could induce players to cooperate more frequently when a large group of preceding players cooperated.

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[3]This is in contrast to Fehr and Schmidt (1999) that present a similar model where agents dislike more the inequality that disfavors them.

[4]Brandts and Solà (1998) present results where this process is relevant for subjects in simple sequential situations and reciprocal actions change with the choice process.

5.3 Models and Predictions

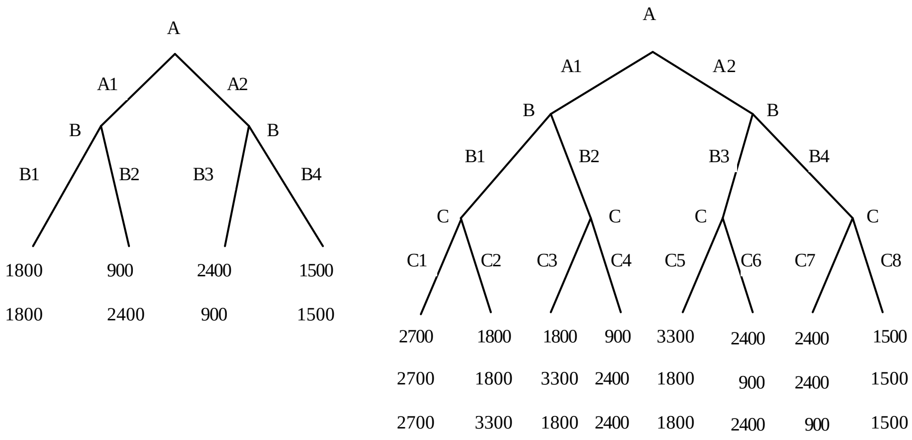
We will use a basic sequential prisoner's dilemma game in which each subject decides whether to contribute or not to a public good project with all of her resources. Consider the situation where N individuals are endowed each of them with z monetary units. Each of these individuals will decide sequentially whether to invest her whole endowment in a public good, yielding a return of mz to every individual or keeping the endowment for herself, with a return per unit normalized to 1. Setting $m \in \left(\frac{1}{N}; 1\right)$ we obtain the standard parametrization of the problem. The payoff to each individual i can be summarized by the following payoff function, where the contribution to the public good of agent i, x_i; is a binary decision $x_i \in \{0; z\} \forall i$ and we denote the contribution of the rest of the group, $x_{-i} = \sum_{j \neq i} x_j$:

$$\pi_i(x_i; x_{-i}) = (z - x_i) + m \sum (x_i + x_{-i}) \qquad (5.1)$$

Given that each individual knows the structure of the problem and the decisions of the previous players, there is a unique SPE where every subject decides to keep her endowment. This result is clearly inefficient (recall that $m \cdot N > 1$).

In this paper we will use both a two-person sequential game and a three-person sequential game with the same relevant parameters. These games and the specific values of the parameters are reproduced in Figure 5.1.

We can study this setting on the basis of a modelization that incorporates into the utility function a inequality aversion concern as proposed by Bolton and Ockenfels (2000)



Game 1: Two person sequential prisoner's dilemma game.

Game 2: Three person sequential prisoner's dilemma game.

Figure 5.1: Two-person game and three-person game.

with the ERC model. This model is able to predict a wide variety of results for di®erent experiments run up to now. It assumes individuals that trade-o® the pecuniary payo® and the relative payo®[5]. Moreover, each individual may trade-o® these two forces with di®erent weights and individual weights are private information. Hence, they present a model of incomplete information about the preferences of other individuals. We will not make an extensive analysis of this model, we will rather use it to the situation we described above to derive the predictions of this model .

5.3.1 Inequality aversion

Bolton and Ockenfels (2000) present a general motivation function that describes the characteristics mentioned above. To compare predictions across di®erent models we

[5]Bolton and Ockenfels (2000) consider that the relative payo® captures a basic element of the motivation of individuals. The motivation function includes the pecuniary payo® and the relative payo® through di®erent functional forms.

will use a specific motivation function that they propose. This specific function simplifies the analysis and the intuitions while keeping the qualitative characteristics of the general motivation function. As we said before, the reason to select this motivation function is that is consistent with reciprocal behavior in the two-person sequential prisoner's dilemma game. We will adapt their specific motivation function to the notation introduced above. The motivation function v for individual i is:

$$v_i(\pi_i;\pi_{-i}) = a_i\pi_i - \frac{b_i}{2}\left(\frac{\pi_i}{\sum(\pi_i + \pi_{-i})} - \frac{1}{N}\right)^2;\ \forall i \tag{5.2}$$

Hence, each agent can be characterized by $\frac{a_i}{b_i}$ and the authors assume a distribution $F\left(\frac{a}{b}\right)$ common knowledge to all agents. Notice that π_i is defined in Equation 5.1 and that $\pi_{-i} = \sum_{j \neq i} \pi_j$.

The Perfect Bayesian equilibrium analysis for the specific games that we will introduce shortly is left for the Appendix. It is more relevant to mention certain characteristics of equilibrium behavior and to derive predictions for the games we are interested in.

Bolton and Ockenfels (2000) briefly describe the characteristics of the equilibrium for the two-person sequential prisoner's dilemma. The second player behavior in equilibrium will be never to cooperate after defection from the first player. The reason being that this decision will hurt both her monetary payoff and her relative payoff. After observing cooperation from the first player, the second mover's decision depends on her type. A second player will cooperate if she values sufficiently the inequality aversion component with respect to her payoff. The first player knows that defection will be responded with defection, therefore, she has to compare the outcome of full defection with the expected gain from cooperating. Inequality aversion considerations would drive to defection because with defection the agent ensures an equitable outcome, which is not true if she cooperates (because player 2 can defect). As a consequence, it is the monetary incentive what can drive the first mover to cooperate. It is interesting to notice that for the outcome (C, C) to appear as an equilibrium, the first player should have a relatively high interest in the pecuniary payoff, because a cooperative decision can be understood only due to the individual pecuniary gain derived from the possible full cooperation outcome if she cooperates with respect to the sure full defection outcome if she defects (the relative outcome is the same).

In the three-player case, equilibria obey the same reasoning described above. In equilibrium the only outcome which can be ruled out is cooperation by the third player after two defections. Any other outcome is possible a priori, depending on the types of players. A characterization of equilibria in the three-person prisoner's dilemma game is left for the Appendix.

We will use the two-player game and the three-player game and compare individual behavior in equilibrium across the two games. This will be used to derive predictions that will be used as hypotheses to be tested with experimental data. We are mainly interested in studying how players will behave in the sequential prisoner's dilemma and, in particular, how behavior may change when the group of players is of different sizes. Therefore, it will be useful to derive predictions, according to the ERC model.

Since behavior depends on the type of player we face, this generates probabilities that each player contributes or not at a given node of the game, given complete information on previous actions. Two kinds of predictions can be derived: intra-game and inter-game.

By intra-game we mean a comparative analysis of behavior of players in each game. Inter-game analysis will generate predictions about the differences in behavior between players across games. Not all players will be compared, we will rather focus in some comparisons that are relevant to study reciprocity considerations.

Claim 5 (ERC-2) a)In the two-player game, the probability of cooperation by player 2 after observing cooperation is equal or higher than the probability of cooperation by player 1. b) The probability of cooperation by player 2 after cooperation is equal or higher than the probability of cooperation after defection, the later equals to zero. a) $P_2(C/C) \geq P_2(C)$. b) $P_2(C/C) \geq P_2(C/D) = 0$. (The subindex refers to the two-player game).

After observing cooperation by the first player, the second player can ensure an egalitarian payoff by cooperating. This, of course, has a monetary cost and the specific type of the player will determine the probability that she would cooperate in this case. On the other hand, the first player can not ensure an egalitarian payoff by cooperating because the second player can defect, as we just said, and she has the monetary cost of cooperating. As a consequence, the first player has less incentives to cooperate because this action can still be followed by a defection generating inequality. We already mentioned why the second player will never cooperate after defection. Both her monetary and her relative payoff components of the utility function drive her towards defection.

Proof: See the appendix. ■

Claim 6 (ERC-3) In the three-player game, following the reciprocity model, a) The probability of cooperation by player 3 after observing player 1 and player 2 cooperating is equal or higher than the probability of cooperation by player 2 after observing cooperation by player 1 b) The probability of cooperation by player 3 after observing cooperation by player 1 and defection by player 2 is equal or lower than the probability of cooperation by player 2 after observing cooperation by player 1. c) The probability of defection by player 3 after observing player 1 and 2 defecting is equal to 1. d) The probability of cooperation by player 3 after a cooperative choice from the first player and a defective choice from the second player is equal to the probability of cooperation of the third player if the order of previous choices is reversed, i.e., player 1 defects and player 2 cooperates a) $P_3(C/C \cap C) \geq P_3(C/C) \geq P_3(C).$ b) $P_3(C/C \cap D) \leq P_3(C/C).$ c) $P_3(C/C \cap C) \geq P_3(C/D \cap D) = 0.$ d) $P_3(C/C \cap D) = P_3(C/D \cap C).$

Part a) of the claim follows the argument of the two-player case. Given previous cooperative actions, subsequent players have more incentives to cooperate because their cooperative action increases the probability to obtain an equitable payoff with respect to the previous player for the same monetary cost. Part b) follows because by cooperating after defection, the second player introduces directly inequality in the distribution of payoffs, while a cooperative action after cooperation from the first player can be followed by a cooperative action from the third player, thus obtaining an egalitarian payoff. c) This part of the claim follows directly from an extension of the argument developed in the two-player case. The third player, after observing two defective choices will never cooperate because this will hurt both her monetary and her relative payoff. Part d) of the claim illustrates the fact the ERC is insensible to some aspects of the choice process. From player's three point of view, it is irrelevant the sequence of decisions if the sequences result in the same trade-off between the monetary payoff and the relative payoff component of the utility function.

Proof: See the Appendix. ■

Claim 7 (ERC 2-3) a) The probability of cooperation of player 3 after observing player 1 and 2 cooperating is lower than the probability of cooperation by player 2 in the two-player game after cooperation by player 1. b) The probability of cooperation by player 2 in the three-player game after observing cooperation is smaller than the probability of cooperation by player 2 in the two-person game after observing cooperation. a)$P_2(C/C) \geq P_3(C/C \cap C)$: b) $P_2(C/C) \geq P_3(C/C)$:

Note that across the two games we keep the MPCR constant, hence the private incentive for the last player is the same across game. These predictions, hence, come from the self-centered inequality aversion component of the utility function. The inequality that could be generated by a defection after a cooperative action in the two player game is higher than the inequality that would generate a defective action by the third player after two cooperative actions. The parameters of the game are such that each player contributes to produce the public good by cooperating, therefore when two of them contribute a defection has an effect which is not as drastic as in the two player case in the decay in efficiency and, consequently, inequality decreases. The propensity to cooperate is higher in the player case to avoid the comparative higher inequality. When we compare the second player in the games after a cooperative action by the first player, the previous argument is still valid. Here the second player will defect more frequently because after a defection is still possible a cooperative action by the third player that would generate an outcome less unequal. Even if player three would defect this is the case. Hence, player two in the two player case has more incentives to cooperate to avoid this higher inequality.

5.3.2 Altruism

We already mentioned that altruism has been the object of some debate concerning the possible motivations that lie behind observed behavior in public good games. Altruism could be defined as a concern for the other players' welfare, with some variations, altruism has been discussed by Andreoni (1995), Palfrey and Prisbey (1997) and Anderson, Goeree and Holt (1998), that include warm glow, the satisfaction from the act of contributing. We will introduce a simple utility function that introduces linearly pure altruism. This particular form has been adapted from by Ledyard (1995).

$$u_i(\pi_i; \pi_{-i}) = \pi_i + \alpha_i \sum \pi_{-i}, \quad \alpha_i \in (0; 1]; \forall i. \tag{5.3}$$

As can be seen, altruism here is introduced as a concern for the payoff of the other members. The parameter α indicates the weight that agents give to other's payoffs. We rule out $\alpha = 0$; because in this case we are left with strict egoism, the standard assumption mentioned above. Suppose that α_i is private information but there exists a distribution function $G(\alpha_i)$; common knowledge to all agents.

Claim 8 (Altruism) The probability that a player cooperates in the sequential prisoner's dilemma is independent of the previous decisions by the other players. b) All players in the sequential prisoner's dilemma cooperate with the same probability. c) The probability of cooperation is higher in the three-person prisoner's dilemma than in the two-person prisoner's dilemma game. a)$P_2(C) = P_2(C|C) = P_2(C|D) \leq P_3(C) = P_3(C|C) = P_3(C|D) =$

$P_3(C=C \setminus C) = P_3(C=C \setminus D) = P_3(C=D \setminus C) = P_3(C=D \setminus D):$

Proof: See the Appendix. ■

We will start with the two-player case to clarify this claim. When deciding whether to cooperate or defect, player two will trade-o® the monetary loss of cooperation, 1 ¡ m; with the increase in payo®s to the other members of the group, in this case m: No other consideration is relevant from the utility function described in 5.3 and this trade-o® is the same independently of the decision of the previous player. Player 1 hence, will not a®ect the decision of player two with her decision, so the trade-o® is again the same in any possible branch of subsequent play, all of them with the same probability to be reached for a given type of the other player. Consequently, player 1 reduces her problem to the same basic trade-o® described before for player 2. The reasoning for the three-player case is the same. The unique di®erence is that now a cooperative action generates a payo® to the group of 2m. Hence the propensity to cooperate for the same type of player in a 3-player game increases, because the monetary cost of cooperating is the same, but the payo® to the group increases.

5.4 Experimental design

The benchmark game we use in this paper is a two-person sequential prisoner's dilemma like the one in Figure 5.1. Observe that, in this game, z = 1500 and m = :6. The payo®s, expressed in pesetas that appear in this ¯gure will be exactly the same as in the experiment.

The reason to select a two person prisoner's dilemma, instead of a richer environment is that this game allows us to study, in a simple framework, how reciprocity may play a role in sequential games. Also, other theories can be addressed and compared with reciprocity. The players in the experiment will play this simple game once. Moreover, we will use in the experiment the strategy method. Subjects in the experiment will be asked to make decisions simultaneously, that is, the ¯rst player will be asked to choose between A1 and A2 and the second player will be asked to select between B1 and B2 and between B3 and B4. After decisions are collected, random matching between players of type A (¯rst movers) and players of type B (second movers) will determine the e®ective outcome that a given pair reaches in the game. This method will allow us to obtain complete data on the strategy that the second mover is using in the experiment. This method was ¯rst proposed by Selten (1967) because in sequential situations it allows us to obtain data for every branch of the game without using deception. Moreover, Brandts and Charness (1999) show that players, for the same action by a previous mover, do not respond di®erently with the strategy method.

The second game that we will use in the experiment is a three-person sequential prisoner¶s dilemma. This game is also represented in Figure 5.1 . Observe that $z = 1500$ and $m = :6$, as in the two-player game. We will compare this game with Game 1. This comparison will allow us to study the e®ects of increasing the group size in a sequential game on the outcomes of the game and, in particular, on reciprocal behavior. Increasing the group size to more than three players could be more interesting in order to ¯nd strong group size e®ects. This game, however, will be used because it is still simple for using the strategy method. Moving to four-player games or more would increase the number of decisions for the last player excessively from our point of view. Another possibility could be to use a simpli¯ed strategy method in which we would ask each subject to make a decision for cases that di®er in the number of previous players that cooperated. This method would ignore the possible e®ects of order and, as a ¯rst step, it seems more appropriate to start with the strict strategy method[6].

We will present the results obtained from four sessions run at the Universitat Autonoma de Barcelona in April 2000. We recruited students of di®erent majors by posting billboards in the campus. The billboards asked for university students with the incentive to obtain some monetary compensation. A total of 157 university students participated in the experiment. We run two sessions of each of the games presented before. We have 32 groups of two people and 31 groups of three people.

As we have said above, subjects played one of the games presented before once using the strategy method. The sessions started by assigning randomly players to di®erent seats in a big classroom. Then subjects had in each seat a set of instructions. The experimenter read aloud the instructions and, after questions were answered, the assistants, three people, gave to each subject a decision form. In this decision form each subject could observe the randomly assigned role in the game. That is, role A or B in the two player game or role A, B or C in the three player game. Then all subjects simultaneously made their decisions and the assistants collected them. The experimenter and the assistants then matched randomly the decision forms of di®erent types of players until completition of the groups. Since we asked subjects to make their decisions using the strategy method, the next task was to follow the e®ective decisions in each group, that is we registered the decision of

[6] If the results in this experiment would show that order of previous decsions is not important, the next step would be to go from these games to four-player games and ten-player games.

	Two-person game		Three-person game	
	Obs.	Rel. Freq.	Obs.	Rel. Freq.
Full Cooperation	1	0.031	1	0.032
High Cooperation			4	0.129
Low Cooperation	4	0.125	10[a]	0.322
Full Defection	27	0.843	16	0.516
Total	32		31	

Table 5.1: E®ective results of both the two-person and the three-person games

the player with role A, the decision of the player with role B corresponding to the e®ective decision of A and, in the three-player game, the decision of player C corresponding to the e®ective decisions of players A and B. After all decisions were registered we paid privately to each subject and the experiment ended. The sessions lasted between 30 minutes and 45 minutes and subjects' average earnings were approximately $10.

5.5 Results

We ¯rst present the main descriptive results of the experiment. From the e®ective outcomes of the games, full defection was, by large, the most common result in both games. In the two-player game this outcome appeared in 27 of the 32 groups, whereas in the three-player game this proportion goes down to 16 out of 31. Full cooperation just happened once in each game, therefore partial cooperation succeeded relatively more in the three-player game, this partial cooperation was more often the result of just one player cooperating. Table 5.1 presents these results.[7]

These results show that cooperation is less common in the sequential two-person

[7] In this table, "low cooperation" means just one player cooperating and high cooperation, just two players cooperating. [a] Five of these cases pertain to a subcase where the last player cooperated after two defections.

prisoner's dilemma than in the three-person game. The reason to use the strategy method in this experiment is that this data alone do not provide much information on behavior. Another kind of evidence that can help to get a more reasonable picture of the results are individual data. From this kind of data, the most clear impression can be derived from the percentage of behavior according to the standard prediction of no cooperation in every decision point and for every player[8]. Figure 5.2 reproduces the percentage of behavior corresponding to a strategy of defection in every information set. Observe that these percentages decrease as the order of play increases for both games. In the two-player game, 87.5% of the ¯rst movers always defect versus a 68.8% of the second players. In the three-player case, if we move from the ¯rst players to the third players, these percentages of free-riding are, respectively, 87%, 61% and 48%. In general, the percentage of free-riders is smaller in the three-player case, 78.1% versus 65.5%. It seems that players deviate from standard assumptions on behavior and importantly they deviate more as more rich can be their behavior. We think that this points out at a certain structure in behavior that can be addressed with di®erent behavioral models.

Table 5.2 presents the complete results of the experiment. Notice that the standard game theoretical prediction would be a table of zeros. It is apparent that this prediction is not supported by the data. All but the proportion of cooperative choices by the second player after defection in the two-player game are signi¯cant at a level of signi¯cance of 1%. More than this, the reader can observe that there appears to be a certain pattern that would

[8]As a ¯rst approximation, providing free riding behavior may be more transparent than cooperative behavior. Even if we know what every player chooses in each position, how to interpret ¯srt mover choice of a cooperative action? it may be because of altruism or inequality aversion considerations. Third mover "cooperative behavior" also introduces problems of comparison because the possibilities of cooperation are higher that in the two player case i.e., di®erent strategies could be compatible with a general idea of "cooperative behavior".

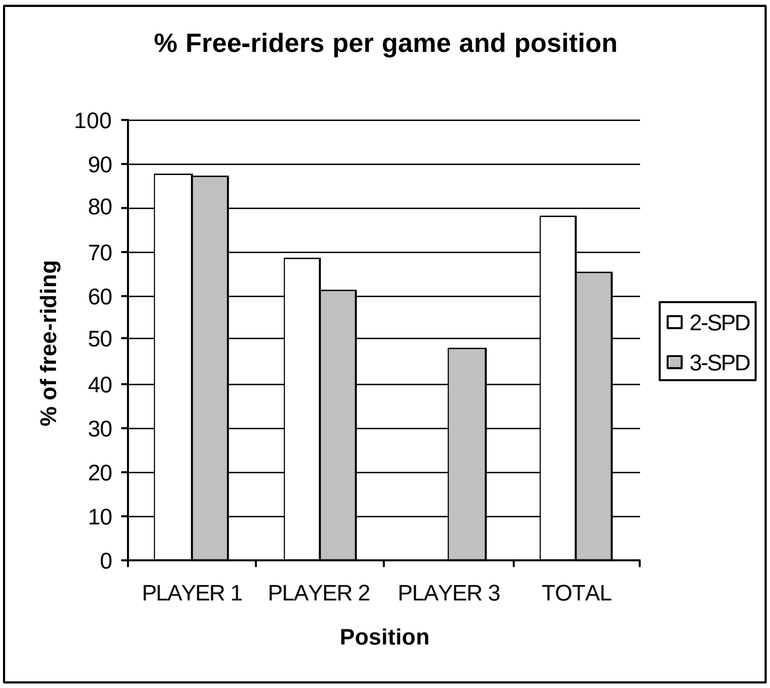


Figure 5.2: Free-riders per game and position.

indicate the presence of reciprocity in the observed behavior. This apparent success of a reciprocity based theory however, is poorly significant. We proceed to examine the specific predictions presented in the previous section.

Claim 5 (ERC-2) stated the predictions according to the ERC model for the two-player case. One can observe that the data obtained are consistent with those predictions. a) The proportion of cooperative choices from the second player after a cooperative choice is higher than the proportion of cooperative choices from the first player (0.281 versus 0.125) though not significantly. b) The proportion of cooperative choices from the second player after cooperation is significantly higher than the proportion after defection (0.281 versus .0.062) at a 5% significance level. (Binomial test, p=0.03). c) Finally, the proportion of

		Two Person Game	Three-Person game	
	Obs. (n=32)	Rel. freq.	Obs. (n=31)	Rel. freq.
C	4	.125	4	.129
C=C	9	.281	12	.387
C=D	2	.062	7	.225
C=C \ C			13	.419
C=C \ D			7	.225
C=D \ C			12	.387
C=D \ D			5	.161

Table 5.2: Observed frequencies of cooperative behavior per game and position.

cooperative choices after defection from the first player, 0.062, is not significantly different from zero.

Claim 6 (ERC-3) stated the research hypotheses of reciprocity for the three-person game. a) The proportion of cooperation by player 2 after observing cooperation is significantly higher than the proportion of cooperation of player 1 (0.387 versus 0.129) at a 2.5% (p=0.02). Also, the reciprocity model predicted an equal or higher proportion of cooperative choices by player 3 after observing player 1 and player 2 cooperating than the proportion of cooperative choices of player 2 after cooperation. The difference obtained in our experiment, 0.387 versus 0.419 does not allow us to reject the null of no difference. b) The proportion of cooperative choices by player 3 after observing player 1 cooperating and player 2 defecting should be equal or lower than the proportion of cooperative choices of player 2 after cooperation. We can not reject the null of no difference at 10%. c) The proportion of cooperative choices after two cooperative choices is higher than the proportion of cooperative choices after two defections. The difference between both proportions, 0.419 versus 0.161, is significant at 5%. d) The proportion of cooperative choices from the third player after a cooperative choice from the first player and a defective choice from the second player is not signi¯cantly higher than the proportion of cooperative choices from the third player if the order of choices from the previous players is reversed, 0.387 versus 0.225. This result may have procedural importance for subsequent experiments. This result may be interpreted by saying that closeness between players seems to a®ect reciprocal actions, though not signi¯cantly. However, this interpretation should be taken with caution and probably replicated in a di®erent design. The possible procedural importance is that this result may preclude to use a simpli¯ed strategy method, by just asking decisions contingent on number of previous cooperative choices, if larger groups want to be used while keeping the complexity of decisions at a low level.

Claim 7 (ERC-2-3) stated the predicted di®erences according to the ERC model due to the change in the size of the group. a) We should expect a proportion of cooperative choices by the second player after observing cooperation equal or higher than the proportion of cooperative choices by player three after observing two cooperative choices. The direction of the data is in the opposite direction, 0.281 versus 0.419, although the opposite directional hypothesis is not signi¯cant. b) This second part of the claim states that, after observing cooperation by player 1, we should expect that the proportion of cooperative choices by the second player would be higher in the two person game. Again, our data go in the opposite direction. The proportion of cooperative choices after a cooperative action is higher in the three-person game, 0.387 versus 0.281, but not signi¯cantly. The ERC model used here is consistent with the data obtained for each game but the comparison between games shows results that point out a problem of the inequality concerns hypotheses to explain what we observe.

Claim 8 (Altruism) stated the research hypotheses that would generate a simple altruism model. None of them is supported by our data. As we already said the proportion of cooperative choices appears to be significantly different in some cases depending on the previous decisions observed, as the ERC model predicted. Moreover, and closely related, the order of play appears as an important aspect in the observed proportion of cooperative choices. Finally, the altruism model generated a prediction of higher probability of cooperation in the three-person game. For some cases, this prediction appears to go in the correct direction, but not significantly.

5.6 Conclusions

This paper presents experimental data concerning sequential prisoner's dilemma games. The objective was to study whether inequality aversion or altruism could account for the evidence.. We selected a particular model that accommodates reciprocal behavior in other games, the ERC model of Bolton and Ockenfels (1998), because of its success in explaining a wide variety of experimental results and a simple model of altruism proposed by Ledyard (1995). The key of the design was to introduce the group size as an experimental factor because from our point of view, the size of the group could modify the behavior of an individual by reciprocity considerations in a way that would not be explained neither by altruism neither by the inequality aversion model used.

This paper hypothesized that a perceived intention from a group is more influential in behavior than a perceived intention from an individual. The reason being that, in anonymous exchanges, a group may generate a perceived norm to follow. We do not observe intentions and perceptions of intentions, hence we must rely in actions and responses to certain actions.

The experiments reported in this paper concern two-person and three-person sequential prisoner's dilemma games. The main results of this paper point out at two directions. First, it is observed from the data that reciprocity considerations play a quantitatively signi¯cant role. The use we make of the ERC model by Bolton and Ockenfels accounts for the results observed in each game. A simple model of altruism is not consistent with behavior, in particular, altruism does not explain why people respond di®erently to certain actions from previous players. From the point of view of altruism, a player should be insensible to what other players did before or what the following players may do in the future.

The second important point that can be concluded from this experiment is that increasing the number of players in a sequential prisoners dilemma game, even if we just change the size of the group from two players to three players, has e®ects in behavior. We observe that increasing the size of the group, even if we just do it from two players to three players, produces results contradictory with what we should expect from a model that incorporates inequality aversion, as the ERC model.

When comparing the two-person game and the three-person game, ERC predictions rely on the desire to avoid inequity. Players do not seem to be guided by a desire to avoid the higher inequality that would generate a defection after a cooperative action in the two-person prisoner's dilemma game. Though, not signi¯cantly, they cooperate more in the three-person dilemma game after cooperative actions. While this result may be consistent with a reciprocity consideration, it is not with an inequality aversion consideration.

Reciprocity may drive the second player in the three-person prisoner's dilemma game to cooperate after cooperation more than in the two-person game because he/she may expect the third player cooperating also after cooperation. That is, she may be trying to induce cooperation by reciprocity. On the other hand, the third player cooperates more after two cooperative choices than the second player in the two-person game after a cooperative choice. ERC would predict in this case that the last player in the two-person game would cooperate more because a defection generates more inequality. Observed behavior, on the other hand point out at a sensibility to the number of cooperative choices observed. If the tendencies observed here could be con¯rmed in future research, our pessimistic view of the model by Bolton and Ockenfels (2000) could be extented to the the model of inequality aversion by Fehr and Schmidt (1999), since they assume that the number of players do not a®ect the individual degree of inequality aversion. On the other hand, Selten and Ockenfels (1998) found experimental evidence contradictory with pure inequality aversion models that would incorporate a consideration of the number of players in the utility function.

In conclusion, inequality aversion models like ERC partially accommodate data in each game presented here and fail to accommodate the observed changes in behavior due to changes in the group size. To incorporate these results it seems appropriate to incorporate reciprocity considerations directly in the models. An example of it would be Dufwenberg and Kirchsteiger (1998). Of course, further research would be also necessary to delineate what kind of modelization would be desirable.

5.7 Appendix

5.7.1 Equilibrium behavior according to the ERC model

Three-player prisoner's dilemma analysis. It will be useful to provide a game form that reproduces the payo®s of the players in the parametric form previously described.

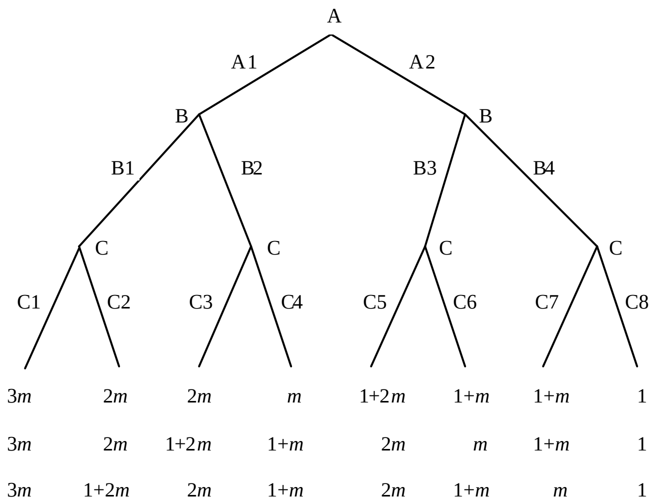


Figure 5.3: Parametrized three-person game.

Notice that there is incomplete information on others' agents types but these types are irrelevant to the subsequent players for their decisions. That is, their utility does not depend upon the type of player that they face. Hence, player three will choose her best response to each possible information set where she plays, that a practical level is a singleton. Given these optimal responses, player two will consider her optimal response, at each node where a decision must be taken. In the same way will be analyzed player's one behavior.

Third Player:

1) Player 1 Defects and Player 2 Defects.

We compare the utility of player 3 by cooperating (left-hand side) with the utility from defection (right hand side): Player 3 will cooperate iff:

$$ma_3 - \frac{b_3}{2}\left(\frac{m}{2+3m} - \frac{1}{3}\right)^2 \geq a_3. \tag{5.4}$$

Since a_3 and b_3 are positive and $m < 1$, this is a contradiction, so player 3 will always defect if both player 1 and player 2 defect.

2) Player 1 Defects and Player 2 Cooperates.

Player 3 will cooperate iff:

$$2ma_3 - \frac{b_3}{2}\left(\frac{2m}{1+6m} - \frac{1}{3}\right)^2 \geq (1+m)a_3 - \frac{b_3}{2}\left(\frac{1+m}{2+3m} - \frac{1}{3}\right)^2. \tag{5.5}$$

This equation holds if $\frac{a_3}{b_3} \leq \frac{2}{9(1-m)(1+6m)^2}$.

Consequently, player 3 will cooperate in this case with probability

$$p_{31} = F\left(\frac{a_3}{b_3}\right) = F\left(\frac{9m^2-1}{6(1-m)(2+3m)^2(1+6m)^2}\right). \tag{5.6}$$

3) Player 1 Cooperates and Player 2 Defects.

Notice that this case is identical to case 2 because this model does not incorporate considerations of the decision process. The relevant information is contained in the final distribution of payoffs. From this point of view, player three is in the same situation when one player cooperated and one player defected, irrespectively of who defected and who cooperated.

Notice that $\frac{2}{9(1-m)(1+6m)^2} > \frac{9m^2-1}{6(1-m)(2+3m)^2(1+6m)^2}$; therefore $p_{32} > p_{31}$.

4) Player 1 Cooperates and Player 2 Cooperates.

Player 3 will cooperate iff:

$$3ma_3 \geq (1+2m) - \frac{b_3}{2}\left(\frac{1+2m}{1+6m} - \frac{1}{3}\right)^2: \tag{5.7}$$

This equation holds when $\frac{a_3}{b_3} \leq \frac{9m^2-1}{6(1-m)(2+3m)^2(1+6m)^2}$: Therefore, player 3 will cooperate in this case with probability

$$p_{32} = F\left(\frac{a_3}{b_3}\right) = F\left(\frac{2}{9(1-m)(1+6m)^2}\right): \tag{5.8}$$

Player 2:

1) Player 1 Cooperates: In this case, player 2 will consider the best responses for player 3 that apply after cooperation or defection by player 2. Player 2 will cooperate iff:

$$(3ma_2)\,p_{32} + \left(2ma_2 - \frac{b_2}{2}\left(\frac{2m}{1+6m} - \frac{1}{3}\right)^2\right)(1 - p_{32}) \geq$$
$$\left((1+2m)\,a_2 - \frac{b_2}{2}\left(\frac{1+2m}{1+6m} - \frac{1}{3}\right)^2\right) + \left((1+m)\,a_2 - \frac{b_2}{2}\left(\frac{1+m}{2+3m} - \frac{1}{3}\right)^2\right)$$

Observe that if player 2 cooperates, inequality will arise just if player 3 defects (because if player 3 cooperates the game will end up in the efficient outcome, which does not generates inequality), whereas by defecting, since player 1 already cooperated, inequality will always arise in the utility function. This will drive results in this section.

The previous condition will generate two cases. First if $m(p_{32} - p_{31} + 1) - 1 > 0$, player 2 will cooperate. We will call $m(p_{32} - p_{31} + 1) - 1 = ENG_{c=c}$ (Expected Net Gain from Cooperation if player 1 cooperated). If this expected pecuniary payoff is positive, player 2 will cooperate because in the decision rule described above the expected relative payoff in the motivation function would drive behavior towards cooperation. The expected inequality generated by cooperation is smaller than the expected inequality by defecting.

$$\left(\frac{2m}{1+6m}-\frac{1}{3}\right)^2(1-p_{32}) < \left(\frac{1+2m}{1+6m}-\frac{1}{3}\right)^2 p_{31} + \left(\frac{1+m}{2+3m}-\frac{1}{3}\right)^2(1-p_{31}) \qquad (5.9)$$

To see this inequality, recall that $p_{32} > p_{31}$. Hence, if $ENG_{c=c} > 0$; both the monetary payoff and the relative payoff drive behavior towards cooperation.

If $m(p_{32}-p_{31}+1)-1 = ENG_{c=c} < 0$; then the relative payoff must be important enough in the motivation function to drive behavior towards cooperation.

From the initial condition in this case, we derive the following extra condition for cooperation in case that the expected net gain from cooperation is negative.

$$\frac{a_2}{b_2} \leq \frac{1}{-ENG_{c=c}}\left(\left(\frac{1+2m}{1+6m}-\frac{1}{3}\right)^2 p_{31} + \left(\frac{1+m}{2+3m}-\frac{1}{3}\right)^2(1-p_{31}) - \left(\frac{2m}{1+6m}-\frac{1}{3}\right)^2(1-p_{32})\right)$$

$= A$

In this case, the probability that player 2 cooperates when player 1 cooperated and the expected net gain from cooperation is negative is $p_{22} = F\left(\frac{a_2}{b_2}\right) = F(A)$:

2) Player 1 Defects: Player 2 will cooperate in this case iff:

$$\left(2ma_2 - \frac{b_2}{2}\left(\frac{2m}{1+6m}-\frac{1}{3}\right)^2\right)p_{31} + \left(ma_2 - \frac{b_2}{2}\left(\frac{m}{2+3m}-\frac{1}{3}\right)^2\right)(1-p_{31}) \geq$$

a_2

Notice that if player 2 defects, the game will end up in the full free riding outcome because player 3 will always defect after player 1 and player 2 defect. Moreover, the relative payoff part of the motivation function will drive behavior towards defection, because the full free riding outcome is fully egalitarian, whereas a cooperative action by player two will always generate inequality. Hence, to obtain cooperation by player two in this case, it is necessary a player sufficiently motivated by the pecuniary payoff that she may obtain by cooperating. This means that the Expected Net Gain from cooperation must be positive, that is, $ENG_{C=D} = 2mp_{31} + m(1 - p_{31}) - 1 > 0$ it is necessary condition for cooperation. Moreover, it is also necessary that

$$\frac{a_2}{b_2} \geq \frac{1}{2ENG_{C=D}}\left(p_{31}\frac{1}{9(1+6m)^2} + (1-p_{31})\frac{4}{9(2+3m)^2}\right).$$

So, if $ENG_{C=D} > 0$, the probability that player 2 cooperates when player 1 defected is:

$$p_{21} = 1 - F\left(\frac{a_2}{b_2}\right) = 1 - F\left(\frac{1}{2ENG_{C=D}}\left(p_{31}\frac{1}{9(1+6m)^2} + (1-p_{31})\frac{4}{9(2+3m)^2}\right)\right)$$

Player 1:

Case 1: $ENG_{C=C} = m(p_{32} - p_{31} + 1) - 1 < 0$

$ENG_{C=D} = 2mp_{31} + m(1 - p_{31}) - 1 > 0$

Player 1 will incorporate the optimal rules of player 1 and player 2 into her decision problem. Player 1 will cooperate iff:

$$3ma_1p_{22}p_{32} + \left(2ma_1 - \frac{b_1}{2}\left(\frac{2m}{1+6m} - \frac{1}{3}\right)^2\right)[p_{22}(1-p_{32}) + (1-p_{22})p_{31}] +$$
$$\left(ma_1 - \frac{b_1}{2}\left(\frac{m}{2+3m} - \frac{1}{3}\right)^2\right)(1-p_{22})(1-p_{31}) >$$
$$\left[(1+2m)a_1 - \frac{b_1}{2}\left(\frac{1+2m}{1+6m} - \frac{1}{3}\right)^2\right]p_{21}p_{31} +$$
$$\left[(1+m)a_3 - \frac{b_1}{2}\left(\frac{1+m}{2+3m} - \frac{1}{3}\right)^2\right]p_{22}(1-p_{31}) +$$
$$a_3(1-p_{21}) = B.$$

This inequality turns out to be the following two conditions for cooperation:

$$ENG_C = p_{22}(p_{32} - p_{31} + 1) - p_{21}m(1 + p_{31}) + (mp_{31} + m - 1) > 0$$

and

$$\frac{a_1}{b_1} \geq \frac{1}{2ENG_C}\left[p_{22}\frac{1-p_{32}}{9(1+6m)^2} + (1-p_{22})\left(\frac{p_{31}}{9(1+6m)^2} + \frac{4(1-p_{31})}{92+3m)^2}\right) - p_{21}\left(\frac{4p_{31}}{9(1+6m)^2} + \frac{1-p_{31}}{9(2+3m)^2}\right)\right].$$

The probability that a player 1 one will cooperate will be $p_1 = 1 - F\left(\frac{a_1}{b_1}\right).$

Case 2: $ENG_{C=C} = m(p_{32} - p_{31} + 1) - 1 > 0$

$$ENG_{C=D} = 2mp_{31} + m(1 - p_{31}) - 1 > 0$$

Player 1 will incorporate the optimal rules of player 1 and player 2 into her decision problem. Player 1 will cooperate iff:

$$3ma_1p_{32} + \left(2ma_1 - \frac{b_1}{2}\left(\frac{2m}{1+6m} - \frac{1}{3}\right)^2\right)(1 - p_{32}) > B.$$

This generates two additional necessary conditions for cooperation:

$ENG^*_C = m(p_{32} + 2 - p_{21}p_{31} - p_{21}) - 1 > 0$ and

$$\frac{a_1}{b_1} \geq \frac{1}{2ENG^*_C}\left[\frac{1}{9(1+6m)^2}(1 - p_{32}) - p_{21}\left(\frac{4p_{31}}{9(1+6m)^2} + \frac{1-p_{31}}{9(2+3m)^2}\right)\right].$$

In this case, the probability that player 1 would cooperate would be $p^*_1 = 1 - F(\frac{a_1}{b_1})$.

5.7.2 Proof of Claim 5:

We will proof the claim by comparing what player 1 would obtain by cooperating in the case that player 2 would cooperate with certainty and in the case that player would defect with certainty.

Player 2 cooperates with certainty:

Net monetary gain from cooperation: $m - 1$

Inequality change by cooperation: $\frac{1+m}{1+2m} - \frac{1}{2}$

Player 2 defects with certainty:

Net monetary gain from cooperation: $m - 1$

Inequality change by cooperation: $-\left(\frac{m}{1+2m} - \frac{1}{2}\right)$

Player 2:

If player 1 cooperates, then:

Net monetary gain from cooperation: $m - 1$

Inequality change by cooperation: $\frac{1+m}{1+2m} - \frac{1}{2}$

Observe that player 1 has the same incentives to cooperate than player 2 (after observing cooperation) if player 2 would cooperate with certainty but less incentives if player 2 would defect with certainty. In this last case, the monetary incentive is the same but player one creates inequality by cooperating. The inequality aversion, then drives this result. Player 2 will cooperate with probability p_{22} (obtained above) This means that, in any case, player 1 will cooperate less often than player 2.

The second part of the claim, that states that player two will defect for sure after observing defection is justified because by cooperating player two looses $1 - m$, and, moreover, creates inequality. Hence, both parts of the utility function drive behavior towards defection.

5.7.3 Proof of Claim 6:

a) This part of the claim states that the probability of cooperation by player 3 after observing player 1 and player two cooperating, is higher than the probability of cooperation by player 2 after observing cooperation by player 1.

As before, we will compare the incentives to cooperate of both players in the different situations.

Player 2:

If player 3 would cooperate with certainty, the incentives to cooperate by player 2 would be:

Net monetary gain from cooperation: $m - 1$

Inequality change by cooperation: $-\left(\frac{1+2m}{1+6m} - \frac{1}{3}\right)$

If player 3 would defect with certainty:

Net monetary gain from cooperation: $m - 1$

Inequality change by cooperation: $\left(\frac{2m}{1+6m} - \frac{1}{3}\right) - \left(\frac{1+m}{2+3m} - \frac{1}{3}\right)$

Player 3:

Net monetary gain from cooperation: $m - 1$

Inequality change by cooperation: $-\left(\frac{1+2m}{1+6m} - \frac{1}{3}\right)$

Observe that the incentives of player 2 to cooperate are equal or smaller than the incentives that player 3 has. Since player with cooperate with certain probability after player's 2 possible decision to cooperate, we deduce the statement of part a9 of the claim.

b) This second part of the claim states that the probability of observing cooperation by player 3 after player cooperated and player 2 defected is smaller than the probability of observing cooperation by player 2 after cooperation by player 1. We will look just at the incentives that face player 3 because player 2's incentives are the same as in the previous case.

Player 3:

Net monetary gain from cooperation: $m - 1$

Inequality change by cooperation: $\left(\frac{2m}{1+6m} - \frac{1}{3}\right) - \left(\frac{1+m}{2+3m} - \frac{1}{3}\right)$

Notice that in this case player 3 has the same or smaller incentives, hence the probability of observing cooperation by player 3 in this case is smaller than probability of observing cooperation by player 2 after player 1 cooperated.

c) This part was proved above when describing equilibrium behavior.

5.7.4 Proof of Claim 7:

a) Supposing the distribution function $F\left(\frac{a_i}{b_i}\right)$ does not change with the number of players, we can compare the probabilities of cooperation between games. The monetary incentive to cooperate for both players is the same, $1 - m$: On the other hand, the relative payoff component is not the same:

Reduction in inequality by cooperating: Player 3 (3 -player case): $\frac{1+m}{1+2m} - \frac{1}{2}$

Reduction in inequality by cooperating: Player 2 (2 -player case): $\frac{1+2m}{1+6m} - \frac{1}{3}$

Direct inspection shows that the inequality reduction is higher in the two player case for $m > \frac{1}{10}$: Recall that we set $m = .6$, therefore player 2 in the two-player case will cooperate with higher probability.

b) Remember that we have shown that $P_2(C=C) \geq P_3(C=C \cap C)$: Moreover, in Claim 6 (ERC-3) we showed that $P_3(C=C \cap C) \geq P_3(C=C)$: Hence, $P_2(C=C) \geq P_3(C=C)$:

5.7.5 Proof of Claim 8:

Given the utility function defined, the equilibrium characterization is similar to the one used with the reciprocity model. We will analyze the equilibrium behavior by using backwards induction.

We will start first with the two player case.

Second player:

a) If player 1 cooperated, player 2 would cooperate iff:

$$2m + \alpha_2 2m \geq 1 + m + \alpha_2 m \Rightarrow \alpha_2 \geq \frac{1-m}{m}.$$

The probability that player 2 cooperates in this case is $p_{21} = 1 - G\left(\frac{1-m}{m}\right).$

b) If player defected, player 2 would cooperate iff:

$$m + \alpha_2 (1+m) \geq 1 + \alpha_2 \Rightarrow \alpha_2 \geq \frac{1-m}{m}.$$

Hence, the probability of cooperation is the same in this case. We will call this common probability $p_2 = 1 - G(\frac{1-m}{m}).$

First Player:

The first player will cooperate iff:

$$(2m + \alpha_1 2m)\, p_2 + (1 + m + \alpha_1 m)\, p_2 + (m + \alpha_1 (1+m))\,(1 - p_2) \geq (1 + \alpha_1)\,(1 - p_2)$$

$$\Rightarrow \alpha_1 \geq \frac{1-m}{m}.$$

Hence, the probability that player 1 cooperates equals the probability that player 2 cooperates, $p_1 = p_2.$ We will call this probability $\hat{p} = 1 - G(\frac{1-m}{m})$

Three-player game

Third Player:

a) If Player 1 cooperated and player 2 cooperated:

Player 3 will cooperate iff:

$$3m + \alpha_3 6m \geq (1 + 2m) + \alpha_3 4m. \tag{5.10}$$

So, player 3 will cooperate in this case whenever:

$$\alpha_3 \geq \frac{1 - m}{2m}: \tag{5.11}$$

The probability that player 3 cooperates in this case is $p^a_{31} = 1 - G\left(\frac{1-m}{2m}\right):$

b) If Player 1 cooperated and player 2 defected:

The condition for cooperation is:

$$2m + \alpha_3(1 + 4m) \geq (1 + m) + \alpha_3(1 + 2m) \tag{5.12}$$

This generates the condition of equation 5.11. So the probability of cooperation in this case is $p^a_{32} = p^a_{31}:$

c) If player 1 defected and player 2 cooperated:

This case is analogous to the previous one, consequently the condition is the same and the probability of cooperation, $p^a_{33} = p^a_{32} = p^a_{31}:$

d) If both player 1 and player 2 defect, player 3 will cooperate iff:

$$m + \alpha_3(2 + 2m) \geq 1 + 2\alpha_3 \tag{5.13}$$

The condition on α_3 is the same as the previous conditions and, hence, the probability of cooperation in this case, $p^a_{34} = p^a_{33} = p^a_{32} = p^a_{31}:$

This proves that player 3 will cooperate always with same probability, we will call this probability $p^a_3:$

Second Player:

a) If player 1 cooperated, player two would cooperate when:

$$(3m + \alpha_2 6m)\, p_3 + (2m + \alpha_2 (1 + 4m))\, (1 - p_3) \geq (1 + 2m + \alpha_2 4m)\, p_3 +$$

$$(1 + m + \alpha_2 (1 + 2m))\, (1 - p_3)$$

The condition on α_2 is:

$$\alpha_2 \geq \frac{1 - m}{2m}$$

The probability of cooperation for player 2 in this case is $p^*_{21} = 1 - G\left(\frac{1-m}{2m}\right).$

b) If player 1 defected, player 2 would cooperate if:

$$(2m + \alpha_2 (1 + 4m))\, p^*_3 + (m + \alpha_2 (2 + 2m))\, (1 - p^*_3) \geq (1 + m + \alpha_2 (1 + 2m))\, p^*_3 +$$

$$(1 + \alpha_2 2)\, (1 - p^*_3)$$

This condition reduces to the same condition on α_2 as in the previous case. Hence, the probability of cooperation in this case is equal to the probability of cooperation when player 1 cooperated, $p^*_{22} = p^*_{21}.$ As was stated in Claim 1, the second player also cooperates with the same probability, whatever the action of player 1. We will call this probability $p^*_2.$ Moreover, observe that this probability is the same that the probability that player 3 cooperates. To simplify notation, we will call this common probability p^*_{-1}

c) Player 1 will cooperate iff:

$$(3m + \alpha_1 4m)\, p_{-1}^2 + (1 + 2m + \alpha_1 4m)\, p_{-1}^2 +$$

$$2\,(2m + \alpha_1\,(1 + 4m))\,(p_{-1}\,(1 - p_{-1})) +$$

$$+\,(m + \alpha_1\,(2 + 2m))\,(1 - p_{-1})^2 \geq 2\,(1 + m + \alpha_1\,(1 + 2m))\,(p_{-1}\,(1 - p_{-1})) +$$

$$(1 + 2\alpha_1)\,(1 - p_{-1})^2$$

This condition can be rewritten as $\alpha_1 \geq \frac{1-m}{2m}$. Therefore player 1 cooperates with same probability that player 2 and player 3. We call this probability $\widetilde{p} = 1 - G(\frac{1-m}{2m})$.

From this analysis we get results a) and b) stated in Claim 1. If we consider the formalization of altruism introduced here, all players in each game cooperate with the same probability, independently of the previous players' decisions.

Part c) of Claim 1 can be checked easily by noting that $\widetilde{p} \geq \widehat{p}$. That is, the probability of cooperation by any player in the sequential 3-person prisoner's dilemma is higher than the probability of cooperation in the two-person game.

$$\frac{1-m}{2m} < \frac{1-m}{m} \Rightarrow \widetilde{p} = 1 - G\left(\frac{1-m}{2m}\right) \geq 1 - G\left(\frac{1-m}{m}\right) = \widehat{p}$$

5.7.6 Written instructions for the two-person sequential game

GENERAL:

Welcome. The object of this session is to study how people make decisions in a given situation. At any time you can raise your hand and a monitor will come to answer your questions. From now on, it's important that you do not communicate with other people in this session. The number that appear in this folder will be used to pay you at the end of the session.

In this session you will make money. This money will be paid to you at the end. Payments are con¯dential: no other participant in this session will know how much money you make.

Half of the people that came today will play the role of A and the rest will play the role B. In this session you will be paired with another person with a di®erent role from your own role. Nobody will know the identity of the other person in his/her pair.

DECISION TASKS:

In each pair there will be a participant with role A and a participant with role B. The money you'll make depends on your decisions and the decisions of the other participant in your pair, and nobody will know at the time of taking decisions what the decisions if his/her pair are. The participant designated as A will make a decision between two alternatives: A1 or A2. The participant designated as B will make two decisions. B will not know what person A decides, hence B will make a decision for each possible election of A. B will decide between B1 or B2 for the case in which A would have chosen A1 and B will decide between B3 and B4 for the case in which A would have chosen A2. Each combination of decisions between the two participant in a pair results in di®erent payments in pesetas for each member in the pair. The ¯nal result will follow the e®ective decisions of both participants.

In order to illustrate the situation, the following graphical representation describes how is the decision process and you will be able to see the consequences of the decisions of both participant in a pair in terms of payments in pesetas.

(Here a representation of Game 1)

Explanation of the graphical representation:

The letters A and B that appear in the graph indicate where the decision for each member takes places.

The participant with role A decides between A1 and A2.

The person with role B chooses between B1 and B2 for the case in which A would have chosen A1 and chooses between B3 and B4 for the case in which a would have chosen A2.

The pairs of numbers that appear in the inferior part of the graph indicate the consequence of each pair of decisions. The number above corresponds to payment in pesetas for A and the number below to the payment in pesetas for B. Hence, if A chooses A1 and B chooses B1 in that case, participant A gets pta. 1500 and participant B gets pta. 1500, whatever the decision of B for the case in which A would have chosen A2. (etcetera for each combination in the instructions).

As you can see, your decisions and the decisions of the other member in your pair determine the payment that each member will receive.

It's very important that you understand perfectly how the process of decisions imply payments in pesetas. If at this point, you are not con¯dent with it, you can raise your hand and a monitor will clarify the situation.

DEVELOPMENT OF THE SESSION:

When everybody will ¯nish to read and revise the instructions, decision tasks will start. The monitors will give a decision form to each participant in the session. In this registration form it will appear your identi¯cation number and the role that you have been assigned, A or B. In this decision form there will be a graphical representation identical to the one explained before. You will use this decision form to register the decisions that you will choose according to your role. That is, if you have role A you will have to choose between A1 or A2 marking the letter corresponding to the alternative that you prefer in the graphical representation. If you have assigned role B, you must mark either B1 or B2 for case in which A would have chosen A1 and you should also mark either B3 or B4 for the case in which A would have chosen A2.

After decisions have been made, you will be able to ¯ll the receipt with your personal data. You can not put in the receipt the amount of money that we pay you because you still don't know it.

The monitors will get all the decisions form from participant and they will proceed in the following way: they will mix the decision forms from participants with role of A and, separately, those with the role of B. Then they will select one decision form of each type randomly until all pairs will be completed. After this process is completed they will observe for each pair what is the decision of the participant A and what is the decision of participant B that corresponds to the decision of A. So that the complete sequence of e®ective decisions can be completed. When this process will be ¯nished for all pairs, monitors will call apart each participant (identi¯ed by the personal identi¯cation number in the folder). Each participant will take the folder with all pages inside all she/he will paid individually.

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