OTHER-REGARDING PREFERENCES: OUTCOMES, INTENTIONS OR INTERDEPENDENCE?

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Abstract. If preferences and beliefs are appropriately parametrized, different theories of “other-regarding” preferences possess equilibria that are consistent with experimental results in a variety of settings. Our goal is to experimentally separate between those theories, by studying their comparative-statics performance in the neighborhood of the classic Ultimatum Game, whose results are extremely robust. In order to perform this exercise, we first characterize monotone Perfect Bayesian Equilibia in the Ultimatum Game if preferences are interdependent. We then show that in this model, setting a lower bound to the offer a proposer can make, may decrease the proposer’s offer and increase the responder’s acceptance probability. Outcome-based theories and intentions-based models have (weakly) opposite predictions. We then design and execute an experiment that facilitates almost instantaneous learning and convergence by both proposers and responders. The experimental results are consistent with the predictions of the interdependent-preferences model.

1. Introduction

The past twenty years have seen a surge in theories that depart from the benchmark of selfish preferences, motivated mainly by experimental evidence and introspection. Since the work of Levine [44] it has been shown that different theories may have a parametrization that results in equilibria among which there exists an equilibrium that is consistent with the experimental findings. The goal of the current study is

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to design and execute a simple experimental test that can differentiate among these theories. The Ultimatum Game (Güth et al [34]) is used as a benchmark, since it is a well studied game, with very robust outcomes. The ultimatum game has motivated many of the theories of "other-regarding" preferences, and all of them can account for its stylized properties. The experiment we conduct is a small perturbation of the original game: we study how offers made by proposers and responders' acceptance rate change when offers must be higher than some exogenously determined minimum.

The Ultimatum Game describes a simple and natural interactive decision problem that is inherent to almost every bargaining environment: a proposer makes an offer of p (normalized to lie between 0 and 1) to a responder. If the responder accepts, the responder receives p and the proposer receives $1-p$. If the responder rejects then both receive zero. A well known backwards induction argument predicts that a selfish responder should accept any positive offer and therefore a selfish proposer should make a minimal offer. As is now well known, the experimental evidence refute this prediction and several empirical regularities have been established. In particular, as the offer decreases - the conditional probability of acceptance decreases, and there is a substantial variation in offers being made in experiments: proposers do sometimes make low offers even though these offers are often rejected.

Models of other-regarding preferences that account for the experimental regularities in the ultimatum game and its variants (the dictator game, trust game, gift exchange game) can be broadly classified into three classes. Outcome-based models (Fehr and Schmidt [27], Bolton and Ockenfels [11]) assume that a player's utility may be a function of the resources allocated to other agents as well as to herself. These models incorporate heterogeneity across agents. Interdependent preferences models (Levine [44]) allow the agent's preferences to depend not only on her opponent's resources but also on her type.[1] Since players are heterogeneous, the opponent's action affects both the material allocation and the inference the agent makes about the opponent type.[2] Intention-based (reciprocity) models (Rabin [50]) assume the agent cares about her opponent's intentions (beliefs) and motives. The latter models use the "psychological games" (Geanakoplos, Pearce and Stacchetti [31])

[1]Kennan and Wilson [41] were, to the best of our knowledge, the first who suggested to use type-interdependence to model non-selfish behavior.

[2]Gul and Pesendorfer [33] provide a non-strategic foundation for reduced-form behavioral interdependence.

framework.[3] There exists some experimental evidence that points to the importance of intentions (e.g. Camerer [14] pages 110-113; Blount [10]; Falk et al [22, 23] and McCabe, Rigdon and Smith [47]). However, this evidence only excludes outcome-based models, which have their own appeal in their simplicity.

The experimental methodology we employ tests the equilibrium response of the different theories in close proximity to the most standard (and robust) experiment in this field, by investigating the effect of setting a lower bound to the offer a proposer can make.[4] The equilibrium response of outcome and intention-based models to our proposed comparative statics is straightforward. In outcome-based models, proposers that otherwise would offer below the minimum should make the minimal offer, while the rest of the offer distribution and the conditional acceptance rates do not change. In intention-based models, the perceived kindness of each offer (weakly) diminishes. As a result, the conditional acceptance rates (weakly) decrease and offers should (weakly) increase.

In order to evaluate the implications of the comparative statics when preference are interdependent, it is essential to first characterize the equilibrium of the ultimatum game. Following the approach of Levine [44], the game is modeled as a signaling game in which preferences are 'interdependent' in the sense that players' preferences depend on other players' types. Levine [44] assumed that proposers and responders are sampled from an identical distribution and have symmetric utility

[3]Many hybrid models that combine elements from the above models have been proposed (e.g., Charness and Rabin [15], Falk and Fischbacher [25]). Segal and Sobel propose a model where players' preferences depend on other players strategies, that might be more general than the preferences induced through the rankings of outcomes. There exists an interesting mapping between [57] and [31], and the former provides an axiomatic foundations to [50], but extends Rabin's model to account for situations in which it is limited because of the specific functional form it uses. Cox et al [17] proposed a nonparametric model of preferences defined over own and other's payoffs. In their model, a decision maker will become "more altruistic" if the budget set he is offered to choose from is "more generous". The model has the very nice feature that it naturally extends standard consumer theory to analyze important issues that arise in a variety of experiments. However, it is not suitable to analyze environments like the ultimatum game where the choice set available to the responder is not convex (although one can consider generalizations of the game, as in Andreoni et al [1] which fit into Cox et al's framework). Other explanations are based on evolutionary arguments and de-emphasize backwards induction reasoning (Binmore et al [30, 8, 7, 9]).

[4]An alternative approach would be to suggest a completely new environment, and to study whether the different models can account for equilibrium behavior in that experiment.

function. Although Levine was able to calibrate his model, we are not aware of a tight characterization of all equilibria in this framework.[5]

We find that the rich variety of behavior observed in the ultimatum game can be accounted for by a simple structure of interdependence, which we term *negative interdependence.* This means that the more eager the proposer is to have his offer accepted, the less interested the responder is to accept that offer. Intuitively, the payoff associated with an agreement presumably has both a monetary and non-monetary components. We interpret a high proposer type as a player who is primarily concerned with his own monetary payoff. Such a proposer values agreement since he cannot attain a payoff without one. A low type proposer, however, is more interested in the non-monetary payoffs. For example, a proposer who is primarily interested in creating a positive impression on the experimenter will likely make this impression with his offer alone, and will not particularly mind whether his offer is accepted or not. Alternatively, proposers who are simply curious about what may happen in the experiment may find a rejection of a low offer just as interesting as an acceptance of a higher offer, simply because it satisfies their curiosity. The predictions of our model stem from the assumption that responders do not like to accept offers made by proposers who they believe are mostly interested in their own private monetary payoff. Perhaps they view this as a type of greediness which they dislike.

Traditional explanations of behavior in the ultimatum game can be recast in terms of interdependence. For example, the type of the proposer could represent his greed. A responder will receive some utility from rejecting an offer from a greedy proposer rather than being concerned per se with the payoff difference. Similarly, the view that subjects employ in simple experimental settings rules of thumb that have developed in more complex but more common environments (as in Aumann [3] and Frank's [29] "rule rationality") can be formalized using the framework of interdependence. For example, responders and proposers may employ in a one-shot ultimatum game rules that were developed in an offer-counteroffer game that they usually play. A rejection of an unfair offer is the response that would work best in everyday bargaining situations in which the rejection would be followed up with a counteroffer. How effective it would be to reject such an offer depends on characteristics of the proposer that the responder can not know - his discount rate for example.

[5] Appendix A includes a characterization of equilibrium in an environment similar to Levine's.

Whatever behavioral arguments one wants to make about what motivates experimental subjects, the ultimatum game is of broader economic interest because it mimics the most basic economic problem of all - a seller who offers some good to a buyer at a price. The non-monetary gains to trade in exchange typically have to do with the unknown quality of a good, inside information about the value of a security and so on. In exchange contexts, it is exactly the sellers with low quality goods (high proposer types in our interpretation) who are most interested in making a sale. Of course, buyers are more reluctant to trade with these sellers than with less eager sellers. This is the environment our assumptions are designed to capture.

It should be emphasized that the current paper does not take a stand on the interpretation of negative interdependence, but allows a unified treatment of various motivations that have been suggested in the past and some new ones proposed above. More importantly, it provides an example how economic theory can be silent of the psychological motives of the economic actors, and yet provide testable predictions.

Negative interdependence is a very simple type of preference interdependence. The responder's preferences depend on the proposer's preference, but not on any higher order consideration since the proposer's preferences do not depend on the responder's preferences at all. Despite the fact that this simple formulation supports the rich set of behavior that has already been observed in ultimatum experiments, it is restrictive enough to provide testable implications. That is, we can provide a comparative statics result that differs from the results associated with outcome-based or intention-based models, giving the objective reader an opportunity to compare the performance of our model with some well-known alternatives.

We characterize the *monotone equilibrium*, which is the separating perfect Bayesian equilibrium in which the highest offer is accepted with certainty. This separation generates the dispersion of offers that is so commonly observed in experimental results. Since the proposers who are eager to have their offers accepted make high offers, lower offers must be accepted with lower probability to support proposer's incentive compatibility. This supports the increasing acceptance probability that is observed in experiments.[6]

[6]These results hold for all separating equilibria, but different equilibria have variable degrees of separation. For ease of exposition and consistency with the comparative-statics exercise that follows, we concentrate on monotone equilibrium.

We then perform the comparative statics investigation described above: we study how the equilibrium (distribution of offers and conditional acceptance rates) changes if we set a lower bound to the offer made by a proposer. As explained above, outcome and intention-based models predict concentration of offers on the lower bound, and decrease or no change (respectively) in the acceptance rate. We show that the monotone equilibrium with negative interdependence predicts lower offers and higher conditional acceptance rate. The intuition behind this prediction is that if the subset of low types who make low offers will not increase, then responders (who have low marginal utility of rejecting offers made by low types) would accept these low offers in certainty. To maintain an equilibrium, the subset of proposers who make low offers must increase, and in order to satisfy the incentive compatibility of the new pivotal proposer (who is of higher type) - the acceptance probability must increase. We find that the experimental results are consistent with the negative interdependence model proposed here.

One could argue that the experimental results are a consequence of anchoring; once an exogenous lower bound is set, all agents (proposers and responders) adjust their expectations to that bound. Therefore, if the bound is low - lower offers will be made and they will be accepted more frequently than in the baseline treatment. This line of reasoning assumes that a lower bound of 0 (as in the standard ultimatum) has no such anchoring effect. To separate between the equilibrium and anchoring hypotheses, we conduct another treatment in which the lower bound on offers is set very close to zero. While the anchoring hypothesis predicts that the frequency of low offers and the acceptance probability will be higher than in the original treatment, the monotone equilibrium reasoning predicts that the frequency of low offers and acceptance probability will be lower than in the original treatment. We find that the experimental findings are consistent with the equilibrium hypothesis.

The economic implications[7] of modeling interdependent preference in a bargaining environment and the comparative statics performed may be very important. Consider, for example, wage bargaining. Almost every bargaining model has an ultimatum component, to which we could apply the comparative statics result. Our theoretical and experimental results suggest that as a result of setting a minimum wage, the wage distribution may shift to the left. Similarly, prices are determined in a bargaining process which induces price dispersion. Setting a maximum

[7]These has been emphasized in previous applications of outcome or intention-based models as Rabin [50], Falk, Fehr and Zehnder [24] and many others.

price may shift the price distribution to the right.[8] Evidently, these environments are much more complex than the stylized ultimatum game studied here, but the latter is an important ingredient in the price (including wage) setting process. The current study suggests to apply caution when analyzing such environments, and to further investigate the implications of such policies on measured outcomes.

2. The Model

Consider an experiment that offers some monetary payoff to players who come to an agreement how to distribute a fixed amount of money, normalized to 1. The *proposer* offers some fraction $1 \geq p \geq p_{\min} \geq 0$ of this monetary payoff to a *responder* who can accept or reject the offer. If the offer is rejected, there is no agreement and the payoff (monetary and other) to both players is normalized to zero. The value of an agreement for both players depends on the proposer's type $s \in [\underline{s}, \overline{s}]$, which is drawn from a distribution G that fully supports $[\underline{s}, \overline{s}]$. This type is unknown to the responder.

We denote the payoff to a proposer of type s who made an offer of p (which was accepted) by $u(p, s)$, and the payoff to a responder who received an offer of p from a responder of type s, and accepted, by $v(p, s)$. We assume that u is increasing in s but decreasing and concave in p. That is: all proposer types would prefer a lower to a higher offer if both were accepted and exhibit diminishing marginal utility of the monetary payoff (risk aversion). Furthermore, a proposer of a higher type receives higher payoff from the same monetary payoff than a lower type proposer.[9] The payoff to the responder is assumed to be increasing in p and decreasing in s. Again, the first is a standard monotonicity assumption and the second specifies the direction of the interdependence

[8]Some empirical evidence to that effect may be found in Knittel and Stango [42] who study the credit market market. Their interpretation is that price ceiling serve as a focal point. Our third treatment shows that the effect may persist even when focal point is not established. Experimental studies by Isaac and Plott [39] and Smith and Williams [61] do not support the hypothesis that price controls away from the competitive equilibrium serve as focal points in a double auction environment, but find that controls close to the equilibrium may affect convergence. Other experimental papers are discussed below in 10.

[9]Monotonicity in p is inconsistent with models of other-regarding preferences in which a proposer's payoff may be increasing in p when p is low, because the proposer thinks that the responder's share is too small. Hence, the proposed model represents the necessary minimal departure from the selfish benchmark that is consistent with the experimental evidence and sequential rationality. A possible interpretation that the proposer is selfish but is worried from rejection to a varying degree (represented by his type) is consistent with this model.

analyzed in this section, which we term *Negative Interdependence*: for a given offer, as the proposer's type increases his utility of an accepted offer increases but the payoff to a responder from accepting the offer decreases.

The payoff associated with an agreement presumably has both a monetary and non-monetary components. We interpret a high proposer type as a player who is primarily concerned with his own monetary payoff. Such a proposer values agreement since he cannot attain a payoff without one. A low type proposer, however, is more interested in the non-monetary payoffs. For example, a proposer who is primarily interested in creating a positive impression on the experimenter will likely make this impression with his offer alone, and will not particularly mind whether his offer is accepted or not. Alternatively, proposers who are simply curious about what may happen in the experiment may find a rejection of a low offer just as interesting as an acceptance of a higher offer, simply because it satisfies their curiosity.

The predictive bite in our story comes from the assumption that responders don't like to accept offers made by proposers who they believe are mostly interested in their own private monetary payoff. Perhaps they view this as a type of greediness which they dislike.

Whatever behavioral arguments one wants to make about what motivates experimental subjects, the ultimatum game is of broader economic interest because it mimics the most basic economic problem of all - a seller who offers some good to a buyer at a price. The non-monetary gains to trade in exchange typically have to do with the unknown quality of a good, inside information about the value of a security and so on. In exchange contexts, it is exactly the sellers with low quality goods (high proposer types in our interpretation) who are most interested in making a sale. Of course, it is precisely the sellers who most want to make a sale who buyers are most reluctant to trade with. This is the environment our assumptions are designed to capture.

Generally, we expect that there will be offers that the responder will not want to accept and that acceptable offers will depend on the proposer's type. However, we will assume that there are always offers that will be accepted and offers that will be rejected. Furthermore, we assume that under complete information gains of trade are always positive.

Assumption 1. *There is an offer* $p' > 0$ *such that* $v(p', \underline{s}) < 0$ *and an offer* $p'' < 1$ *such that* $v(p'', \overline{s}) > 0$*. Furthermore, if* p *satisfies* $v(p, s) = 0$*, then* $u(p, s) \geq 0$.

That is, there exists a positive offer p' that is unacceptable to a responder even if he knew it came from a proposer of type $\underline{s}$ (let alone if it came from a proposer of higher type). Similarly there exist an offer p'' smaller than the full surplus that the responder will accept even if he knew it came from the a proper of type $\overline{s}$ (let alone if it came from proposers of lower type). The positive "gains of trade" component assumes that if a responder is just indifferent between accepting and rejecting an offer of p from a proposer of type s, then a proposer of type s weakly prefers the offer to be accepted. This implies that all higher type proposers strictly prefer p to be accepted. The following very typical single crossing assumption is used to separate proposers.

Assumption 2. *The proposer's payoff $u(p,s)$ satisfies*

$$\frac{\partial^2 u(p,s)}{\partial p \partial s} \geq 0$$

Remember that $u(p,s)$ is decreasing in p (if the proposer knows that his offer will be accepted then he prefers to make lower offers). The assumption above implies that the higher is the proposer's type, the less sensitive he is to an increase in the offer amount (that would arguably make the offer more acceptable). To put in other words: changes in the offer are less important to the proposer when his type is high (raising his offer has less impact on the proposer's payoff when his type is high). From this, the following result follows immediately:

Lemma 3. *Let $s > s'$ be two possible types for the proposer. Then for any pair of lotteries $(p,q) \geq (p',q')$ if*

$$qu(p,s') \geq q'u(p',s')$$

then the same inequality holds strictly if s' is replaced by s.

Consider two lotteries: one that pays p to the responder and $(1-p)$ to the proposer with probability q (and zero to both otherwise), and the other that pays p' to the responder and $(1-p')$ to the proposer with probability q' (and zero to both otherwise). Let $p \geqslant p'$ (hence $1-p \leqslant 1-p'$) and $q \geqslant q'$ with at least one strict inequality. Assumption 2 guarantees that if proposer of type s' weakly prefers (in the sense of expected utility) the higher offer (with the higher probability of acceptance) then a proposer of higher type strictly prefer the higher offer. That is, proposers with higher types are less inclined to gamble and are interested more in achieving an acceptance.

An obvious property of all equilibrium outcomes follows from monotonicity of payoffs:

Theorem 4. *Let $p' > p$ be two offers made on the equilibrium path. Then each proposer type who offers p' must believe that the offer p' is more likely to be accepted than the offer p.*

Separating equilibria have additional properties.

Theorem 5. *Let $p(s') > p(s)$ be two fully revealing offers made on the equilibrium path of some equilibrium which are both accepted with positive probability. Then $s' \geq s$.*

Proof. Suppose the contrary that $s > s'$. Since $p(s)$ is accepted with positive probability and the offer reveals the type of the proposer s, $v(p(s), s) \geq 0$. Then by monotonicity, $v(p(s'), s') > 0$ and the offer $p(s')$ is accepted for sure. Then since a proposer of s' weakly prefers the safe offer, the proposer of type s must strictly prefer it. So $p(\cdot)$ cannot be an equilibrium strategy. □

Despite the fact that all equilibria share these consistent properties, our game is still a signaling game, which means that in general it poses many equilibria. However, the whole point of our experimental exercise is to try to detect the unobservable type by disrupting a separating equilibrium, then using the incentive constraints to predict what should happen to outcomes. For this reason, we focus on separating equilibrium as much as we can. Since acceptance rates for moderate offers are quite high in all experimental results, we also restrict to equilibrium in which the highest equilibrium path offer is accepted for sure. We refer to this as *monotone equilibrium.* We won't try to match these with a refinement from the literature. We simply refer to the extensive experimental literature in which offers are widely distributed, and in which the highest offers are always accepted for sure.

To describe our equilibrium formally, let $p(s)$ be a solution to

$$v(p(s), s) = 0.$$

The solution is evidently monotonically increasing. By Assumption 1 $p(s)$ lies in $(0, 1)$. We assume p(s) is differentiable. If a proposer of type s makes the offer $p(s)$ and the responder believes that this offer has come from a proposer of type s, then he is just indifferent about whether or not to accept it.

Let $Q(p)$ denote the probability with which the offer p is accepted. The payoff to a proposer of type s who makes the offer $p(s)$ is

$$Q(p(s))\, u(p(s), s).$$

To support $p(s)$ as an equilibrium strategy, it is necessary that no proposer prefers to make an offer that is a best reply for some other proposer type. The necessary (first order) condition for this is

$$Q'(p(s))\,p'(s)\,u(p(s),s)+Q(p(s))\,u_p(p(s),s)\,p'(s)=0$$

or

$$Q'(p(s))=-\frac{Q(p(s))\,u_p(p(s),s)}{u(p(s),s)}. \tag{2.1}$$

Since p is monotonically increasing and differentiable, it has a differentiable inverse $s(p)$ on the interval $[p(\underline{s}),p(\overline{s})]$. Then rewriting

$$Q'(p)=-\frac{Q(p)\,u_p(p,s(p))}{u(p,s(p))}$$

is an ordinary differential equation. We assume that $\frac{u(p,s(p))}{u_p(p,s(p))}$ is bounded away from zero, so that the Lipschitz condition holds. Then, we assume, consistent with all known experimental results in ultimatum games, that $Q(p(\overline{s}))$ is accepted with probability 1, which gives an initial value, ensuring the existence of a unique solution for Q for (2.1) on the interval $[p(\underline{s}),p(\overline{s})]$.

Theorem 6. *When there is no lower limit on offers, the strategy rule $p(s)$ is part of a perfect Bayesian equilibrium. In this equilibrium, responders use the strategy rule*

$$x(p')=\begin{cases}Q(p) & \text{if } p\in[p(\underline{s}),p(\overline{s})]\\ 1 & p>p(\overline{s})\\ 0 & \text{otherwise.}\end{cases}$$

Proof. The responders' strategy is a best reply by the definition of $p(s)$ assuming that responders believe offers above $p(\overline{s})$ are made by proposers of type $\overline{s}$, while offers below $p(\underline{s})$ are made by proposers of type $\underline{s}$. It is straightforward that no proposer has an incentive to make offers above $p(\overline{s})$ or below $p(\underline{s})$. If responders believe that offers above $p(\overline{s})$ and below $p(\underline{s})$ are made by proposers with the highest and lowest types respectively, then the responders' strategy is a best reply to all offers.

To see that the first order condition is sufficient for maximization, observe that each proposer chooses a point on the graph of the function $Q(p)$ at which his indifference curve is highest. The slope of $Q(p)$ at p is given by

$$-\frac{Q(p)\,u_p(p,s(p))}{u(p,s(p))}.$$

On the other hand, the slope of the proposer's indifference curve at the point p is

$$-\frac{Q\left(p\right)u_p\left(p,s\right)}{u\left(p,s\right)}$$

which is decreasing in s (the numerator is falling by Assumption 2 while the denominator is increasing as s increases). For a proposer of type s, these slopes are the same at $p\left(s\right)$. Consider any price $p\left(s\right) < p' \leq p\left(\overline{s}\right)$ with corresponding probability $Q\left(p'\right)$. By construction, there is a type $s' > s$ whose indifference curve is tangent to the graph of $Q\left(p\right)$ at p'. By Assumption 2, the indifference curve at p' for a proposer of type s is strictly steeper than the graph of Q. A similar argument shows that the indifference curve of a proposer of type s at any offer $p\left(\underline{s}\right) \leq p' < p$ is strictly flatter than the graph of Q at p'. As a result, the point $\left(p\left(s\right), Q\left(p\left(s\right)\right)\right)$ maximizes the expected payoff of a proposer of type s. □

3. A Comparative statics Experiment: Theoretical Predictions

We now turn to an experimental investigation of the proposed equilibrium with negative interdependence. As demonstrated in the previous section, a Perfect Bayesian Nash Equilibrium of the ultimatum game with negative interdependence can account for the known experimental regularities of the game. We were able to characterize the equilibrium based on basic assumptions on the underlying preferences, without assuming a specific utility function. In this section we provide a testable implication that can differentiate it from other models of other-regarding preferences, and in particular models of intention-based reciprocity.

Consider the following slight variation of the ultimatum game: instead of allowing the proposer to offer anything between 0 and 1, only offers between p_{min} and 1 are allowed. That is, a lower bound on the offer is set. It is well known from the existing experimental literature that for low enough p_{min} (e.g. 0.1), only very few offers are made in the excluded interval.

The effect of truncating the range of offers within the models of social preferences (outcome based) is straightforward: proposers who would otherwise offer less than p_{min} would offer p_{min}, and the acceptance probability should not change.

Any model of intention-based reciprocity would predict that the conditional acceptance probability would (weakly) fall, and equilibrium offers would (weakly) increase. The intuition is simple: any offer (especially close to p_{min}) reflects lower kindness of the proposer, since the set of alternative high offers is smaller. Therefore, the responder will reciprocate to a given offer with a lower probability of acceptance. Although the intuition is clear, the details of the effect vary among models of reciprocity. The game is sequential, hence requires the responder to hold correct beliefs over the proposer strategy. In Dufwenberg and Kirchsteiger [20] the reponder's equitable payoff may be a function of the minimum offer, since if the proposer believes that the highest offer the responder will reject is strictly lower than the minimum offer, he cannot reduce her material payoff below p_{min}. As a result, if the responder's second order belief is such that she believes that the proposer believes that she will accept all feasible offers, for any given offer she believes that the proposer is less kind to her. In return, this may increase the range of (low) offers she will reject in every Sequential Reciprocity Equilibrium (SRE). As pointed out by Dufwenberg and Kirchsteiger [20] (see working paper version), the ultimatum game possesses many equilibria, even when requiring sequential rationality. One may argue, that in spite of the arguments above, theories of intention based reciprocity do not make unambiguous predictions in the comparative statics analyzed here, since the game poses many equilibria, and a change in p_{min} may affect the equilibrium being played. We view this argument as somewhat misleading, since the theory does not provide clear guidance how to select among SRE, much in the spirit of the fact that every offer that is accepted can be rationalized as a Nash equilibrium of the game (ignoring its sequential structure). More crucially, the effect identified above holds for *all* SRE.

In Falk and Fischbacher [25], the equitable reference payoff is 0.5 (equal material payoff). Therefore, independently of the minimum offer, every offer of less than 0.5 is viewed by the responder as intentionally unkind and will trigger negative reciprocity. In the perfect psychological Nash equilibrium of the game (the reciprocity equilibrium), a proposer makes an offers of less than 0.5 that is accepted with certainty, while a lower offer may be rejected. While the lowest offer that is accepted for sure depends on the responder's reciprocity parameter, the model assumes that this parameter is known to the proposer. In reality, however, this is the resonder's private information, and therefore the offer distribution may depend on the proposer's belief over this parameter. The only case in which a minimum offer may affect the observable behavior in this game, is if the proposer believes that the responder's reciprocity parameter is so low such that she will accept with certainty offers lower than p_{min}. In this case, if the proposer concern for equitable

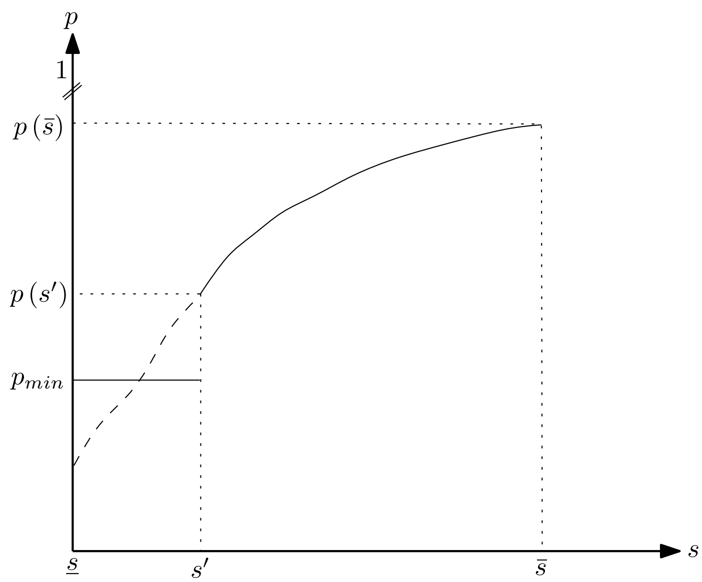

FIGURE 3.1. Comparative statics on monotone equilibrium

distribution is sufficiently low, he may make an offer below p_{min} without the constraint, but increase his offer to p_{min} with the constraint. The responder's behavior does not change, and therefore the conditional probability of acceptance does not change. Therefore, the behavioral response to imposing a minimum offer in Falk and Fischbacher [25] is either similar to the outcome-based models or the comparative statics does not affect behavior.

The effect of setting a lower bound on the proposer's offer in a monotone equilibrium with negative interdependent preferences is more subtle. Before we provide a formal proof of our comparative statics prediction, it helps to illustrate how it works with the help of Figure 3.1:

In a monotone equilibrium, the offer that a proposer makes is an increasing function of his type unless a limit makes this impossible. The equilibrium in the absence of any limit is given by the increasing curve in Figure 3.1, including the dashed segment at the bottom. The offer reveals the proposer's type. The limit offer is given by p_{min} in the Figure.[10] This lower bound will typically force some pooling of low

[10]This situation is quite different from Falk, Fehr and Zehnder [24] who study the effects of setting a lower bound on offers (using a minimum wage) that is *higher* than most offers made in its absence. Furthermore, their experiment is much more involved than the simple comparative statics exercise performed here (simultaneous uniform wage offers to up to three potential employees). Also, Brandts and Charness [13] study the effect of minimum-wage in a gift exchange game. They demonstrate that the results are inconsistent with outcome-based or intention-based

proposer types. In the figure, proposers whose types are in the interval $[\underline{s}, s']$ all make the offer p_{min}.

The figure illustrates our basic comparative statics result. The bound on offers evidently forces proposer types who would have made offers below the limit to offer p_{min}. However, if that were all that happened, the offer p_{min} would look much more attractive than it did in the fully separating equilibrium, since responders would believe that it was being offered by *all* proposers in the appropriate interval instead of just the proposer with the highest type in that interval, and therefore will accept p_{min} with certainty. But this cannot be incentive compatible for proposers of higher types who offered slightly more than p_{min} in the original monotone equilibrium: they could lower their offer to p_{min} and reduce the probability of rejection to zero. To support the equilibrium, some proposers of higher type must be pooled at p_{min} as well.

As our figure is intended to illustrate, there is an equilibrium after imposition of the bound such that for high enough proposer types, equilibrium offers are unaffected by the imposition of the bound. The marginal proposer type s' should be just indifferent between the offer p_{min} and his old offer $p(s')$. In the equilibrium without the bound, proposer s' would strictly prefer the offer $p(s')$ to p_{min}. So to support the equilibrium, it must be that p_{min} is accepted with higher probability after the imposition of the bound than it would be in the absence of the bound.

We can now show how the imposition of a lower limit on offers equal to p_{min} affects the equilibrium outcome.

Theorem 7. *If proposers are required to make offers that are at least p_{min}, then there is an $s' > \underline{s}$ and a perfect Bayesian equilibrium in which proposers whose types are above s' make offers $p(s)$ as described in Theorem 6, while proposers whose types are below s' make the offer p_{min}. The offer p_{min} is then offered more often than offers at or below p_{min} in the absence of the limit. Furthermore, the offer p_{min} is accepted with strictly higher probability than it was in the equilibrium without the limit.*

Proof. Choose s' such that $\int_{\underline{s}}^{s'} v(p_{\min}, \tilde{s})\, dG(\tilde{s}) = 0$. Then if proposers follow the strategy outlined above and pool at $p_{\min}$, responders will

models, but wages and effort levels do depend on the menu of possible wage-offers. In another work, Falk and Kosfeld [26] study the effect of allowing the receiver in a Dictator game to set a lower limit on the dictator's transfer. This is a considerably different problem than the game studied in this paper, although interdependent preferences could be applied there as well: in her decision whether to constrain the dictator, the receiver is able to signal her type, that affects the dictator's payoff.

be indifferent between accepting and rejecting $p_{\min}$. Let $Q_{\min}$ be the probability with which responders accept $p_{\min}$, chosen such that

$$Q\left(p\left(s'\right)\right)u\left(p\left(s'\right),s'\right)=Q_{\min}u\left(p_{\min},s'\right).$$

Responders' strategy in equilibrium will be

$$x\left(p'\right)=\begin{cases}Q\left(p'\right) & \text{if } p'\in\left[p\left(s'\right),p\left(\overline{s}\right)\right]\\ 1 & \text{if } p'>p\left(\overline{s}\right)\\ Q_{\min} & p'=p_{\min}\\ 0 & \text{otherwise.}\end{cases}$$

The optimality of the responders strategy follows as in Theorem 6. The optimality of the proposer's strategy follows from the argument in Theorem 6 and the single crossing condition.

The equality $\int_{\underline{s}}^{s'}v\left(p_{\min},\tilde{s}\right)dG\left(\tilde{s}\right)=0$ requires that $s'>s_{\min}$ where $p\left(s_{\min}\right)=p_{\min}$. From this it follows that $p_{\min}$ is offered more often in the equilibrium with the limit than without. Since a proposer of type s' strictly prefers the offer $p\left(s'\right)$ to the offer $p_{\min}$ in the equilibrium without the limit, it follows that $p_{\min}$ must be accepted with strictly higher probability in order to preserve indifference. □

These predictions[11] are in opposite directions to the predictions derived from models of social preferences and intention-based reciprocity, and serve as a simple experimental method to differentiate between these theories.

3.1. **Equilibrium or Focal Point?** A rejection of the predictions of outcome and intention-based models in favor of interdependent-preferences requires two essential components: to accept the equilibrium reasoning incorporated within the comparative-static exercise, and to assume that there are no other behavioral biases that may lead independently to an identical result. We will discuss the ways we tried to guarantee conditions for an equilibrium play and whether the outcomes are consistent with equilibrium in the following section, but here we present an elaboration of the comparative statics that permits to

[11]Notice that the comparative statics is performed on a monotone equilibrium. We don't have an equilibrium selection rationale that will suggest which equilibrium is being played. However, the interdependence (both positive and negative) framework is the only model that is consistent with decrease in offers and conditional rejection rate as a response to limiting the offer. Furthermore, in every PBE in which the limit will be binding (that is, higher than the lowest offer made in equilibrium), an identical rationale will lead to the same prediction.

separate between equilibrium considerations and a focal point argument, which is a natural candidate for a behavioral bias that could potentially result in outcomes similar to the equilibrium prediction.[12]

One source of a "focal point" argument may be that choices are a result of "anchoring and adjustment" bias identified in the behavioral decision theory literature (e.g. Slovic and Lichtenstein [60], Kahneman and Tversky [40], Tversky and Kahneman [63]). According to this explanation, imposing a minimum offer simply provides an anchor to the players, making low offers seem more "fair", thereby increasing their incidence and the respective acceptance probability. Differentiating this hypothesis from equilibrium reasoning is important in light of other mixed evidence on the effect of price controls. For example, Dufwenberg et al [19] show that in a Bertrand competition, introducing a price floor may lower prices.[13] However, other experimental studies do not find that setting a price ceiling leads to collusion through a "focal point" mechanism (for a recent example, see Engelmann and Müller [21]).[14]

Consider decreasing the minimum offer from p_{min} described in the previous section to $0 < p_{min_1} < p_{min}$. According to the focal point argument, the lower minimum offer will provide a lower anchor that will lead to lower offers and higher conditional acceptance rate. The comparative statics on the monotone equilibrium predicts opposite outcomes (see Figure 3.2): if for a minimum offer of p_{min} proposers of type $[\underline{s}, s']$ are pooled at p_{min}, the set of proposers who will pool at p_{min_1} is $[\underline{s}, s'_1]$ where $s'_1 < s'$. This is because the set of proposers who make an offer of at most p_{min_1} in the original monotone equilibrium is contained in the set of proposers who make the offer of at most p_{min}. To maintain equilibrium, there will be pooling beyond the original set who offered at most p_{min_1} (identical reasoning to the one used in Theorem 7), but the pivotal proposer type is s'_1 - which is lower than s'. As a consequence, proposers of type $s \in (s'_1, s')$ will offer $p(s)$ when the minimum offer is p_{min_1} but will offer p_{min} when it is the minimum offer [15]. The empirical

[12] We originally had another treatment (which is now contained in the Appendix B), but the current section and the later implementation follows a suggestion of the co-editor for which we are grateful.

[13] An important distinction between a price floor and a price ceiling (that we consider here) is the fact that a floor bounds the payoff of the price-setter away from zero while a price ceiling bounds the payoff of the receiver (responder) away from zero. It should also be noted that the effect found by Dufwenberg et al [19] was not as strong when they consider four competitors instead of two.

[14] Most of these studies use double auction markets, that empirically have strong convergence properties. Some (as [21]) intentionally abstract from other-regarding preferences considerations by simulating buyers.

[15] Notice that for some of the proposers in (s'_1, s'): $p(s) > p_{min}$

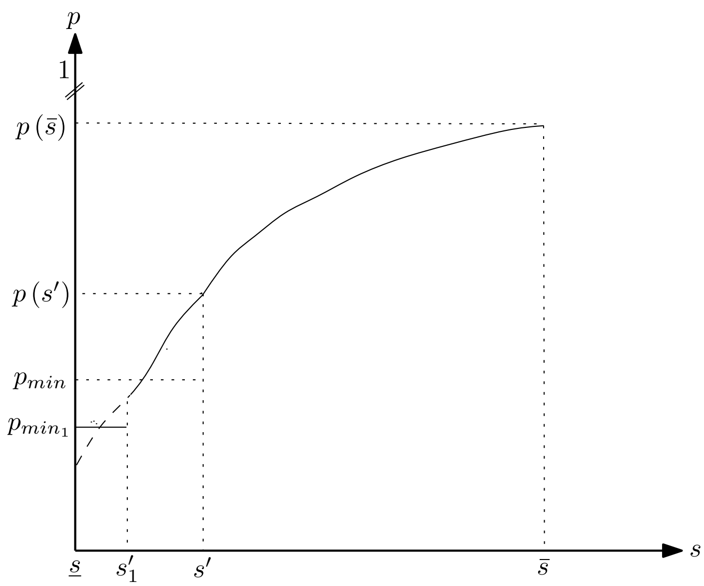

FIGURE 3.2. Changing the Minimum Offer

implication is that the CDF of the offer distribution with a minimum offer set at p_{min} could be *higher* (more frequent lower offers) than the CDF of the offer distribution with no limit or with a minimum offer set at $p_{min_1} < p_{min}$.

4. Experimental Evaluation

We conducted two sets of experiments. The original set, which was performed using pen and paper technology, is reported in Appendix B. In the second set, which includes four sessions, subjects interacted through a computerized system. We believe the latter implementation was superior (speed, data collection, replication) and report it below. Beyond the technology used, there were some additional differences between the two experiments (e.g. how to test for the "focal point" argument) that are reported in Appendix B.

4.1. **Experimental Design and Implementation.** Subjects were undergraduate students at the University of British Columbia who were recruited by an e-mail message sent by university administration to a random group of students. After signing a consent form, the instructions (as they appeared on their screen) were read by one of the authors. A table demonstrating the monetary payoff to proposers and responders for various offers and acceptance/rejection was explained and was projected in the computer lab throughout the experiment. After the instructions were read, subjects could ask the experimenters questions in private.

In order to allocate the subjects to "proposer" and "responder" roles, they all participated in a contest in which they were asked to estimate the number of diamonds in a rectangle. The contest treatment was implemented in earlier studies in order to legitimize the position of a proposer (e.g. Hoffman *et al* [37], Bolton and Zwick [12], List and Cherry [46]). Subjects who estimated the number of diamonds more accurately were designated a "proposer" and received \$5. The rest were designated a "responder." The motivation behind paying the proposers was to mitigate the property rights effect created by the contest: we did not want the contest treatment to interfere in creating a baseline comparable to previous ultimatum game experiments, but we felt that a random assignment (which is used in many studies) may be problematic as well, as it creates substantial ex-post asymmetries between ex-ante identical subjects.

The bargaining was over \$55, that were to be paid on top of the \$5 (a total of \$60). Although convergence to equilibrium strategies in ultimatum game is not the main focus of the current study, we acknowledge it is a non-trivial process. Previous studies (e.g. Roth et al [53], Slonim and Roth [59], List and Cherry [46]) used a sequence of random matching (without replacement) between proposers and responders. As there is learning on both sides, it creates a complex learning problem (Roth and Erev [52]).

We decided to implement a new matching technology in order to facilitate fast learning: each group (proposers and responders) was divided into two or three sub-groups. In the first round, each proposer made offers to only one sub-group of the responders (those offers could have been different). Each responder received offers from only one sub-group of the proposers and chose whether to accept or reject each offer. Then each proposer learned whether the offers he made were accepted or not (he did not know the offers made by other proposers, and the responses they received). In the second round, each proposer made offers to the second sub-group of the responders, and each responder received offers from proposers in a sub-group he had not interacted with before. If proposers or responders were divided into three groups, a third round took place in which each proposer made offers to the reminder of the responders, and each responder received offers from the third and last group of proposers he has not interacted with before. This method allows a proposer to experiment in the first (or second) round offers, an instantaneous learning among responders (who received various offers in the first round), and full learning by proposers in later rounds.

If the conditional acceptance rate of responders does not change between the first and the second (and third, if one took place) rounds, it would confirm the hypothesis that they fully learned in the first round. Therefore, we should not expect additional experience to alter the responders or proposers strategies. This conjecture is crucial for consistency with the common prior assumption incorporated in the Bayesian equilibrium.[16] Moreover, by running two baseline sessions that differ only in the number of rounds (two and three) we could test whether the offer distribution remained constant from the second to the third round, consistent with sufficient fast learning of the conditional acceptance probability after the first round. This design also allowed us to see whether proposers mixed among offers, and if they did - to determine how much of the mixing is strategic and how much is due to experimentation.

The payment was determined by choosing at random one match (out of the two or three rounds), and implementing the outcomes for the matched pair. For example, if a proposer (responder) made (received) 15 offers, one of them was chosen at random and the offer together with the responder's response determined the payments to both proposer and responder in this match. It follows that if a proposer chose to experiment in the first round, this is costly experimentation since it may affect his payment.

In the baseline treatment the offers were allowed to vary between \$0 and \$55, in the limit-5 treatment the offers were between \$5 and \$55 and in the limit-2 treatment the offers were allowed to vary between \$2 and \$55.[17]

The design maintained anonymity between proposers and responders (responders didn't know who made each offer, and proposers couldn't know the identity of the responder who received a specific offer). Furthermore, the recruiting strategy guaranteed that the probability that a subject will know other subjects was extremely low. The design

[16] Harrison and McCabe [36] used one-to-one matching but allowed the proposers to observe the distribution of the minimal acceptable offer of responders in the previous round. This strategic information is finer (and less costly) than the information proposers receive in the current design. Bellemare, Kröger and van Soest [6] showed (employing a logic similar to Nyarko and Schotter [48]) that utilizing subjective-stated probabilities of rejection allows an econometrician to better fit the data than by using observed frequencies of rejection from the game played. The current design is able to overcome this challenge by allowing proposers to estimate the (stable) probabilities of rejection in the first round.

[17] No show-up fee was paid since we felt it could distort the ultimatum structure of the game: with a positive show-up fee a responder who rejects still leaves the experiment with a positive payment.

kept the strategy and payoff of the subjects hidden from the experimenters: experimenters in the room could not see the offers and acceptance/rejection decisions of subjects, and the payment was distributed by another group of experimenters (not present in the room where the experiment took place) who placed the money in numbered sealed envelops.

A total of 112 subjects participated in four sessions. Two baseline sessions were conducted, one with 24 subjects (in two rounds) and the other with 30 subjects (using three rounds). Two treatments were administered: one with a minimum offer of \$5 (28 subjects, 2 rounds) and the other with a minimum offer of \$2 (30 subjects, 3 rounds).

4.2. **Results.** As a preliminary step, the two sessions of the baseline treatment were intended to test whether two underlying assumptions of the Bayesian model are satisfied in the experimental implementation, by allowing responders and proposers expedited learning. We hypothesized that responders will be able to learn the distribution of proposers (offers) in the first round, and therefore did not expect changes in the conditional acceptance rates in the second (or third) rounds. Furthermore, we conjectured that proposers will be able to derive sufficient information about conditional acceptance probability in the first round and there will not be a significant difference between the offer distribution in the later rounds of a two-round or three-round session. The experimental results are consistent with both conjectures: we could not find significant differences in the acceptance probability between rounds within a session and (when pooling the rounds within a session) between the two sessions (we used a Fisher exact test for different intervals of offers). Moreover, the offer distribution in round 2 of the two-round session is not statistically different from offers in rounds 2 and 3 of the 3-round session (p-value of the Epps-Singleton test for equality of distributions is 0.17448). We therefore report acceptance probability based on offers in all rounds, and pool offers from rounds 2 and 3 of the 3-round sessions below.[18]

Table 1 reports summary statistics of the baseline (B) treatments (with 2 and 3 rounds) and the limit treatments: a \$2 limit (L2) and a \$5 limit (L5). Each proposer in the baseline treatment made either 12 or 15 offers: in the two rounds implementation , 6 offers were made in each round, when the offers in round 2 (R2) were made after observing the acceptance/rejection of his offers in round 1 (R1); in the three-round implementation, 5 offers were made in each round, when the offers in later rounds were made to responders with whom the proposer

[18]The online Data supplement includes all data.

did not interact in earlier rounds. Similarly, each proposer in the limit-2 treatment made 15 offers - one third in each round, and each proposer in the limit-5 treatment made 7 offers, half in the second round.

	B-R1	B-R2+3	L2-R1	L2-R2+3	L5-R1	L5-R2
Number of proposers	12+15	12+15	15	15	14	14
Average offer	21.37	22.26	21.85	22.99	19.22	17.56
Average acceptance rate	0.69	0.78	0.71	0.79	0.74	0.78
Within SD of offers	3.38	2.63	2.69	2.48	2.44	1.63
Total SD of offers	8.94	6.52	8.59	6.72	9.28	6.38

TABLE 1. Summary Statistics

Table 1 points to the main finding of the investigation: setting a lower bound on the offer at \$5 caused the offer to fall by more than 20% from \$22.26 to \$17.56. In spite of the lower offers, the average acceptance rate did not change significantly, implying that the conditional acceptance rate increased significantly. However, when a limit of \$2 was implemented, there was no significant change in the offers or acceptance rate relative to the baseline. This evidence is consistent with the equilibrium model of interdependent preferences presented in the current study, is inconsistent with models of other-regarding preferences that are based on outcomes or intention-based reciprocity, and is inconsistent with an explanation in which setting a lower bound generates a focal point to proposers and responders.[19]

Table 2 reports the distribution of offers and acceptance rate. The table reveals the effect of setting a lower limits to the offers: setting a limit of \$5 increases the conditional acceptance rate of offers between \$5 and \$14 and increases the frequency of low offers, relative to the baseline: more than a quarter of the offers were made in this interval relative to less than 10% under the baseline, while their acceptance rate was more than doubled. Setting a \$2 limit to the offers, did not cause any such dramatic change in the offer distribution or acceptance rate. These finding are consistent with a model of interdependent preferences and are inconsistent with an explanation of the first finding that relies on the limit to provide a focal point.[20]

[19]The learning and experimentation from the first to the second round could be seen by the decrease in the within proposer standard deviation: many proposers experimented in the first round by submitting different offers, but used a single offer in the second round.

[20]Although Table 2 reports the results for intervals, it should be noted that 63% of offers were made in multiples of \$5.

offer	%	B-R1	B-R2+	L2-R1	L2-R2+	L5-R1	L5-R2
\$0 to \$4	offers	3	0	7	3	0	0
	acceptance	0		0	0		
\$5 to \$9	offers	10	4	4	3	16	10
	acceptance	14	11	33	0	19	40
\$10 to \$14	offers	7	5	7	3	12	17
	acceptance	20	27	0	50	58	41
\$15 to \$19	offers	11	17	8	9	12	24
	acceptance	56	50	67	71	67	88
\$20 to \$24	offers	19	24	13	19	27	28
	acceptance	64	79	50	71	92	89
\$25+	offers	51	50	61	63	33	20
	acceptance	95	97	94	91	97	100

TABLE 2. Distribution of Offers and Acceptance Rate by Treatment and Round

It is very important to note that although we introduced some new and unconventional design methods in the experiment, the results in the baseline treatment are comparable to existing experimental findings in the literature: offers below 25% of the pie (up to \$14) are accepted only 27% of the time, and 74% of offers are higher than \$20 (which are usually accepted). Furthermore, statistical tests that investigated the effect of the offer's rank on its acceptance probability (controlling for the offer's value), showed that receiving several offers at once (and being able to compare between them) had no significant effect on the conditional acceptance probability.

4.2.1. *Acceptance Rate.* As noted above, 63% of offers are made at multiples of \$5. This implies that using parametric assumptions would extends those observations to intervals were offers are less frequently being made. Instead, we compare (non-parametrically, using Fisher exact test) the acceptance rate at offers of \$5, \$10, \$15, \$20, \$25 between the baseline treatments (with 2 and 3 rounds) and the limit treatments. We then increase the width of each interval from 1 (the multiple of \$5) to 3 and to 5 in a symmetric manner until all subjects are included. For example, we first test whether there exists a significant difference between the acceptance rates of \$10 offers in the baseline, limit-2 and limit-5 treatments, an then increase the size of intervals to \$9-\$11 and to \$8-\$12. We use all rounds since, as noted above, we did not find significant differences in the conditional acceptance probability between rounds, within the same treatment (for both the baseline and the two limit treatments). As noted above, this result indicates that the first-round offers had sufficient variation to allow responders to learn the type distribution of proposers instantaneously. Since we simultaneously test 5 hypotheses, care should be taken not to reject the joint null hypothesis of "no limit treatment effect" when it is true. That is, the p-values need to be adjusted such that the probability that at least one of the tests in the family would exceed the critical value under the joint null hypothesis of no effect is less than 5%. We use the most conservative approach - the Bonferroni adjustment (Savin [55, 56]), in which each p-value is multiplied by the number of tests (four in our case). It should be noted that we take a very conservative approach of using the Fisher exact test and the Bonferroni adjustment, that treats the acceptance rate at different offers as independent.

Comparing the baseline to the limit-5 treatment, we find significant increase in the conditional probability of acceptance in the limit-5 treatment (even after adjusting for multiple tests).[21] However, there is no significant difference between the conditional acceptance rates in the baseline and the limit-2 treatments.

offer	B % Accept	L2 % Accept	L5 % Accept	B-L2	B-L5
0-2	0	0			
3-7	14.3	12.5	26.1		
8-12	19.2	12.5	42.9		*
13-17	48.9	72.2	78.8	*	***
18-22	74	67.9	87		*
23-27	91.4	87.7	97.8		

$* : p < 0.1, ** : p < 0.05, *** : p < 0.01$

TABLE 3. Acceptance Rate and Fisher Exact test (one-sided) for the effect of Limit Treatments on conditional acceptance probability

Remember that in the monotone equilibrium of the negative interdependent preferences model, the increase in responders' conditional probability of acceptance of low offers after imposing a minimum offer originates in the equilibrium requirement that the pivotal proposer who makes the minimum offer be indifferent between making this limit offer and his original (higher) offer. Obviously, when offers are not continuous and equilibrium is not fully separating, the effect of imposing a lower bound on offers will extend beyond the minimum. However, the logic behind this equilibrium argument resembles the counter-intuitive comparative statics properties of equilibrium in mixed strategies in the

[21]The fact that the difference in the probability of acceptance is insignificant for offers of \$3-\$7 is due to the fact that there are relatively few offers in this range (16 in the two baseline sessions and 23 in the limit-5 session).

matching pennies game studied experimentally by Ochs [49] and Goeree and Holt [32]. In these studies, although experimental play resembles the prediction of the mixed strategy Nash equilibrium in the symmetric game, changing asymmetrically the payoff to one player causes the manipulated player to alter his probability of mixing (though he should not) and the other player does not respond drastically enough to the change in the manipulated player's payoff to maintain the latter's indifference. If these cited experimental findings are robust, a legitimate question is how can we use the randomization argument invoked in the monotone equilibrium to account for the higher conditional probability of acceptance when a limit is imposed? We argue (as noted by Camerer [14], Chapter 3) that although mixing is a cognitively challenging process, it seems to account very well for aggregate outcomes in population games where players are matched. In other words, we can purify the game and assign to each responder a type. Each responder actually plays a pure strategy, but since the proposer does not know the type of the responder, the proposer treats it as mixed strategy.[22] The outcomes of the experiments are consistent with this interpretation. Since each responder receives multiple offers, it is evident that almost all of them are using a threshold strategy. Figure 4.1 plots the imputed probability of acceptance according to these thresholds[23] and demonstrates the effect of setting a minimum offer on the probability of acceptance. While the \$5-limit results in significantly higher probability of acceptance, the \$2-limit had no effect on the probability of acceptance.

4.2.2. *Offers.* Figure 4.2 plots the CDF of the offer distribution for the three treatments. We used second and third-round offers, since after the first round proposers learned the conditional acceptance probability (as established above, the responders used the same acceptance probability

[22]Considering responder types is essential in the case of positive interdependence studied in Appendix A, but is not essential for negative interdependence and just adds a layer of unnecessary notation.

[23]If there was an an interval of offers with no data, the probability of acceptance was interpolated linearly. Similarly, a Responder who accepted all offers, but the lowest offer they received was higher than the minimum was assumed to reject the lowest offer minus 1 and the probability of acceptance was extrapolated linearly (in a sense biasing the imputed probability against finding a treatment limit effect). 9 responders changed their threshold across rounds, so they were treated as different responders (with proportionally lower weight in the calculation of the acceptance probability). Only 2 subjects accepted a lower offer than the highest offer they rejected within a round, and they were assumed to use a mixed strategy in this interval, and the probability of acceptance was interpolated linearly.

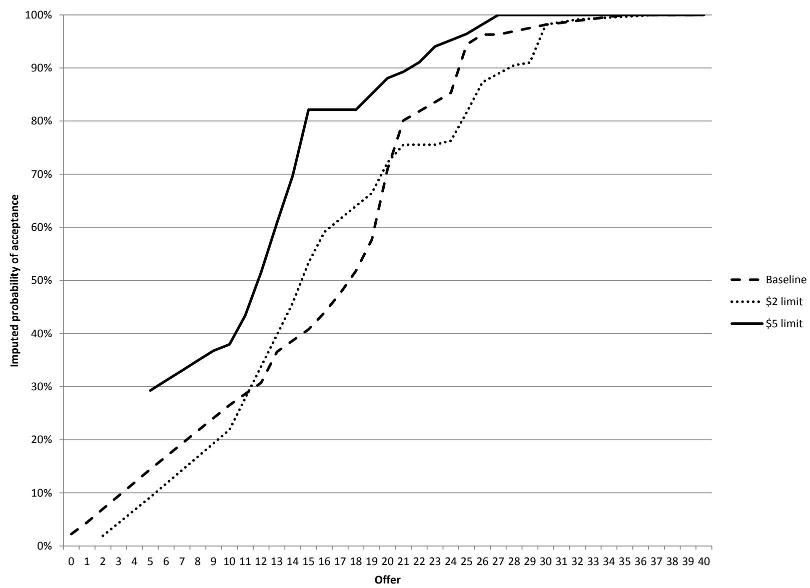

FIGURE 4.1. Imputed Probability of Acceptance from Cutoff Strategies

in the two rounds). Therefore, the later rounds are consistent with the common prior assumption underlying the Bayesian signaling game. Each curve describes the proportion of offers equal or lower than the offer value for a certain treatment. It is easy to see visually that the CDF of the offer distribution for the $5 limit lies above that of the baseline and $2 limit. That is, lower offers are more frequent in the $5 treatment.

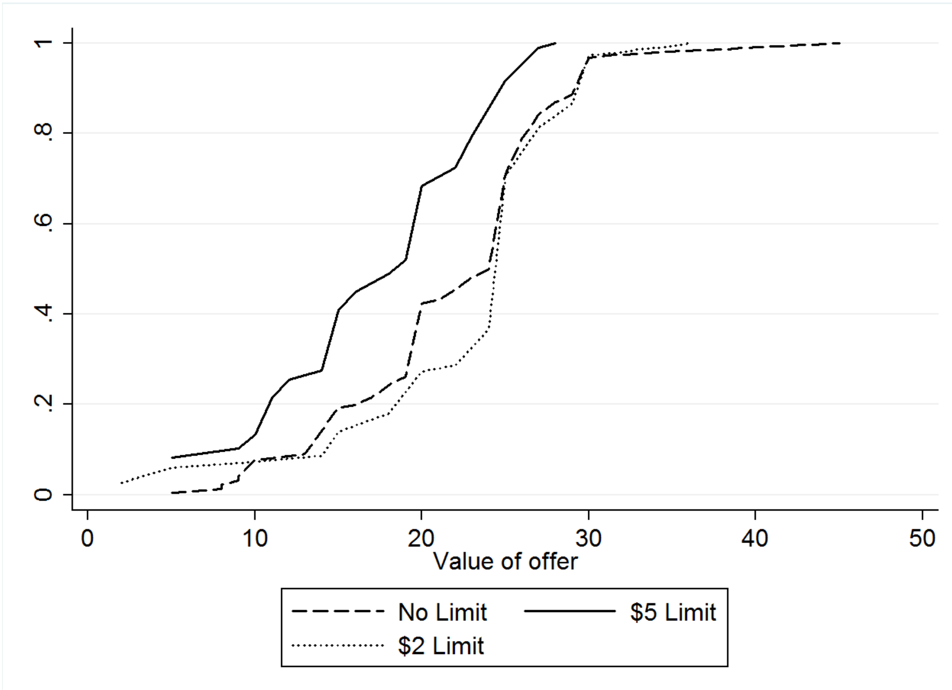

Figure 4.2. Offer Cumulative Distribution

To test whether the difference is significant we bootstrapped the offers distribution to generate confidence intervals, and tested for difference in the 5%, 10%, 15% and 20% quantiles. The results are reported in Table 4. The 10th quantile of the Limit-5 offer distribution is significantly lower than the baseline's offers and the 20th quantile of the limit-5 offer distribution is significantly lower than the Limit-2 offers.

Quantile	B	L2	L5	B-L2	B-L5	L2-L5
5th	9.02	4.01	4.02	5.01	5	-0.01
95% CI				$(-3.05, 20.11)$	$(-0.06, 12.05)$	$(-15.06, 9.02)$
10th	14.15	14.07	8.02	0.07	6.13	6.06
95% CI				$(-11.88, 10.27)$	$(0.32, 14.29)$	$(-3.02, 19.19)$
15th	14.22	15.03	10.12	-0.81	4.10	4.91
95% CI				$(-13.59, 7.69)$	$(-4.84, 9.24)$	$(-8.16, 16.77)$
20th	16.06	19.35	10.16	-3.30	5.89	9.19
95% CI				$(-12.28, 3.06)$	$(-2.12, 12.28)$	$(0.61, 19.45)$

Table 4. Quantile Differences in Offer Distribution

4.3. **Conclusion from the experiment.** It is important to note that the results reported in this section, replicate our original results (reported in Appendix B). We tried our best to design the experiment thoughtfully and carefully, the stakes were significant as subjects could have earned \$60 in less than an hour, and our results are highly significant even with a modest sample size. But even more important than the results in the specific experiment we performed, is the modeling exercise we executed: we suggested a revealed choice-based model of the ultimatum game, whose monotone equilibrium can rationalize the known experimental findings. We then suggested an *out-of-sample* comparative statics experiment on this equilibrium, that can differentiate our model from existing models of other-regarding preferences. Therefore, the study contributes new insights to the ongoing research and debate of how to model other-regarding preferences. More broadly, it answers in the affirmative whether game theory can provide the appropriate framework to study those preferences. More generally, it provides an example how economic theory can be agnostic of the psychological motives of the economic actors, and yet provide testable predictions.

5. Concluding comments

The arguments above illustrate that it is possible to interpret the results of the ultimatum game experiments using standard game-theoretic reasoning. We believe that it points to further complication that experimenters are well aware of, but theorists have not paid sufficient attention to: an experiment is actually a Bayesian game between the subjects and the experimenter. The experimenter is the one for whom the stakes in this game are actually the highest. The same sort of type dependencies ought to exist between the experimenter and subjects. Of course, a single experiment contains no variation in experimenter behavior that would make it possible to uncover this information, so the subjects' interpretation of the experimental design and its influence on them presents a much more complicated problem.

5.1. **The Dictator Game.** With this in mind, one may ask how the proposers modeled in the current study would play the Dictator game in which the proposer selects an offer, and the 'responder' simply accepts whatever the proposer offers. Since our proposers are better off with lower offers, conditional on them being accepted, they should presumably make the minimal offer possible in the latter experiment.[24] As noted above, we believe that the reason that this does not happen is that the same type dependence exists between the proposer and the experimenter - both the fact that the experimenter suggests

[24] One may want to relax this assumption, but it is essential for the construction of the monotone equilibrium we study in the current paper

a Dictator game, and the other characteristics of the experiment alter the proposer's perception of the payoffs in the experiment. For example, Hoffman, McCabe and Smith [38] and Cherry, Frykblom and Shogren [16] showed that implementing a subject-experimenter anonymity and generating the surplus through effort, led almost all dictators to make minimal transfers. These results stand in a sharp contrast to standard dictator experiments (without contest/earned income and experimented-dictator anonymity) where at least some of the dictators give substantial amounts. Those "standard" dictator games, stand also in contrast to the social-economic reality, were anonymous charitable giving is quite rare.[25] We believe that the apparent inconsistency between experimental outcomes (with random-assignment and without subject-experimenter anonymity) and actual charitable giving calls into doubt the main criticism of the monotonicity assumptions in the interdependent preference model (both in Levine's positive interdependent specification[26] and our model of negative interdependence). This inconsistency led us to adopt the contest-anonymity treatments in our experiment.[27] Furthermore, Bardsley [4] and List [45] showed that changing the dictator's strategy set to include negative giving (taking) caused almost all dictators to behave selfishly. Dana, Weber and Kuang [18] showed that many dictators were willing to leave the experimenter part of the surplus, instead of facing the choice of how much to allocate to a passive responder - possibly showing preference to share with the experimenter rather than with the other subject (see also Lazear, Malmendier and Weber [43]). It may be impossible to control all aspects, but using the theoretical methods described in the current study, it would presumably be possible to interpret the impact that the experimental design has on outcomes. Recently, Andreoni and Bernheim

[25]After all, how frequently do people share the content of their bank accounts with complete strangers and without anyone else knowing about it? It is not a coincidence that already in the twelve century, when Maimonides [51] enunciated eight distinctive levels of charitable giving, anonymous giving occupied the second-highest level of giving to the poor.The highest level of giving is someone who establishes a personal relationship with the needy person, helping him with a loan or a partnership in a way that does not make the latter a subordinate.

[26]Rotemberg [54] adds the responder beliefs into the dictator's payoff function to rationalize positive dictator offers.

[27]It is important to note that our baseline results, as previous experiments that implemented contest and anonymity (e.g. Hoffman et al [37], Bolton and Zwick [12]), fall within the standard range of outcomes in ultimatum experiments. That is, the strategic bargaining environment in the ultimatum game is robust to these manipulations, while the charitable giving environment studied in the dictator game is very sensitive to these treatments (see also Fershtman et al [28]).

[2] proposed a model of the dictator game that employs exactly this type of reasoning to explain transfers in the dictator game. In their framework, the dictator's payoff depends on an audience (which may include the receiver, the experimenter and possibly other parties) belief about his type. They analyze the signaling equilibrium in the standard game as well as in a game where the transfer may be determined by an external mechanism, and show that in the standard game there is pooling of dictators on the "fair" transfer, while when the probability of forced external transfer increases, more proposer types pool on that offer. Their model is an excellent example of the richness available in the Bayesian model of interdependent preferences to study important aspects of giving in experimental and real world setting.[28]

5.2. **Beyond experiments.** The interpretation of the ultimatum game as a Bayesian game between agents with interdependent preferences has applications beyond the experiments themselves. For example, it would seem possible to incorporate negative interdependence into a standard principal-agent incentive problem. Another possible application can be in an auction design. In this case it is reasonable to expect that the seller has some private information that is of interest to the buyers. Conditional on this private information which is of common interest, the buyers may have independent private valuations. The seller sets a reservation price that acts similarly to the demand in the ultimatum game. If a buyer accepts this reservation price, he can bid in the auction. The structure of negative interdependence lends itself naturally to this problem. The insights suggested by the analysis of the ultimatum game, and in particular the equilibrium played, can be applied to this problem.

Even more importantly, the direct economic implications of modeling interdependent preference in a bargaining environment and the comparative statics performed in the current study may have immediate implications for understanding price (including wage) negotiations and consequences of economic policy. Setting minimum wage in an environment where wage dispersion exists, may shift the wage distribution to the left.[29] Similarly, setting a maximum price for a commodity whose price distribution is not degenerate may shift the price distribution to the right. These examples suggest that policymakers should use caution

[28]The audience effect may be responsible to lower giving reported recently by Hamman et al [35] when dictators can delegate transfer decisions to agents who represent their interests.

[29]Notice that in Falk et al [24] the minimum wage is set higher than 92% of the offers.

when setting policies that are based on models of non-selfish agents. Naturally, much further investigation is required in order to incorporate interdependent preferences into more complex economic environments, where policy may depend not only on agents' preferences but also crucially on the specifics of the economic environment studied.

Appendix A. Equilibrium with Positive Interdependence

In this appendix, we analyze a model with positive interdependence. Positive interdependence means that as the proposer's type increases, both the proposer and the responder become less interested in having any given offer accepted. One example might be when the proposer's type is inversely related to his altruism. A less altruistic (higher type) proposer gets less utility from the payoff received by the responder, and therefore cares less about whether an offer is accepted. Responders are less inclined to accept offers by less altruistic proposers, especially when they are themselves less altruistic.

It is not difficult to show that if we simply replace negative interdependence with positive interdependence in our model, no more than two distinct offers can be supported in equilibrium. This is obviously inconsistent with experimental data. We can, however, support multiple offers by endowing responders with types. So we also use this appendix to illustrate how our approach is extended to one in which responders have private types. This technical exercise is valuable since, as discussed in the paper, purification of the mixed strategy used by the responders may be an important aspects in accounting for the empirical results.

We also use this appendix to illustrate the relationship of our model to the model of Levine [44], which uses positive interdependence. Levine interprets the proposer's type as a measure of his altruism. More altruistic proposers in Levine's model obtain higher utility from the payoff received by the responder. So for any given offer, the higher the proposer's type, the higher is the cardinal utility of acceptance. Responder's payoff in Levine's model increases the more altruistic the responder thinks that the proposer is.[30] The payoff to rejection is normalized to zero, so proposers' and responders' desire to have an offer accepted move in the same direction as the proposer's type changes, which corresponds to positive interdependence.

[30] It is interesting to compare to the rationale used by Cox et al [17]: in their model higher (more generous) offers make the responder more altruistic. Hence interdependence provides a structure through which this assumption can be justified.

To deal with positive interdependence, assume that the responder has a privately known type $t \in \left[\underline{t}, \overline{t}\right]$ which proposers believe is distributed according to some smooth distribution function F. The responder's payoff from acceptance depends on both his own type, and the proposer's type, and is given by $v(p, s, t)$. This payoff is decreasing in both s and t. The responder of type $\underline{t}$ is the most altruistic responder, the type $\overline{t}$ is the least altruistic responder. The payoff when an offer is rejected is normalized to zero for both the proposer and the responder.

In Levine's paper, the types $\tilde{t}$ and $\tilde{s}$ are measures of the players altruism (higher $\tilde{t}$ and $\tilde{s}$ means more altruistic players). The payoff function for the responder is given by

$$v\left(p, \tilde{s}, \tilde{t}\right) = p + \frac{\tilde{t} + \lambda \tilde{s}}{1 + \lambda}(1 - p)$$

where $0 < \lambda < 1$. Notice that, as $\tilde{t}$ rises, the responder cares more about the proposer's payoff. Furthermore, for any given offer, the responder's payoff is higher, the higher he believes that the proposer is. This is equivalent to our payoff function when types are transformed as

$$\tilde{s} = -\frac{2s - \overline{s} - \underline{s}}{\overline{s} - \underline{s}}$$

and

$$\tilde{t} = -\frac{2t - \overline{t} - \underline{t}}{\overline{t} - \underline{t}}.$$

In [44], the payoff to the proposer is given by the same formula with the share and types interchanged. However, to maintain some consistency with the body of the paper, we continue to assume that the proposer's payoff depends only on his own type. As before, the proposer of type $\underline{s}$ is the most altruistic proposer, while the proposer of type $\overline{s}$ is the least altruistic. The proposer's payoff when the offer p is accepted is $u(p, s)$.

We maintain the single crossing Assumption 2 and add the following:

Assumption 8. *The function $v(p, s, t)$ is monotonically increasing in p and supermodular in s and p uniformly in t. For every s, there is a $p > 0$ and a t such that $v(p, s, t) > 0$; $v(p, \overline{s}, t) < 0$ for some p; and $v(p, \underline{s}, \underline{t}) > 0$ for all $p \in P$.*

An increase in the proposer's offer has a bigger impact on the responder's payoff the higher the responder thinks the proposer's type is. The other parts of Assumption 8 are simply extensions of the gains to trade assumption we made in the first part of the paper. Alternatively, if a responder thinks the proposer has the highest type, there is some demand she will want to reject. Finally, the most altruistic responder dealing with the most altruistic proposer will want to accept any demand. Levine's payoff function satisfies these restrictions.

As with negative interdependence, there are multiple equilibria - for example a pooling equilibrium. However, we can try to reproduce the fully separating equilibria we described with negative interdependence. Further, we expect the separating equilibrium outcomes to have more altruistic proposers making more generous offers to responders. So let $p(s)$ be a monotonically decreasing offer function for the proposer, and define the function $t^*(p,s)$ as

$$t^*(p,s) = \begin{cases} t : v(p,s,t) = 0 & \text{if } v(p,s,\underline{t}) > 0; v\left(p,s,\overline{t}\right) < 0; \\ \underline{t} & \text{if } v(p,s,\underline{t}) \leq 0; \\ \overline{t} & \text{otherwise.} \end{cases}$$

If proposers are using the fully separating strategy $p(s)$, then an offer of $p(s)$ will be accepted by responders whose type is below $t^*(p(s),s)$ and rejected by higher responder types. The expected payoff to a proposer of type s using this strategy is

$$F(t^*(p(s),s))\,u(p(s),s),$$

or, assuming F is uniform to make the algebra simpler,

$$t^*(p(s),s)\,u(p(s),s).$$

A necessary condition for $p(s)$ to constitute an equilibrium strategy for the proposer is then:

$$\left[t_p^*(p(s),s)\,p'(s) + t_s^*(p(s),s)\right]u(p(s),s) + t^*(p(s),s)\,u_p(p(s),s)\,p'(s) = 0$$

which simply says that a proposer doesn't have an incentive to mimic the strategy of another proposer type. This gives a differential equation

$$\left[t_p^*(p(s),s)\,u(p(s),s) + t^*(p(s),s)\,u_p(p(s),s)\right]p'(s) = -t_s^*(p(s),s)\,u(p(s),s).$$

For an altruistic equilibrium (where more altruistic proposers make higher offers) to exist, this equation should have a solution with $p'(s) < 0$. With positive interdependence, higher responder types get smaller payoffs from acceptance, so $t_s^*(p(s),s)$ is negative. However, $t_p^*(p(s),s)$ is positive, so the sign of the left hand side of this expression is ambiguous. This means that a decreasing solution to this differential equation typically won't exist. As a consequence, fully separating equilibria with positive interdependence typically won't exist.

It is worth pointing out that with negative interdependence (which we assume in the main body of the paper), the signs of the terms $t_s^*(p(s),s)$ and $t_p^*(p(s),s)$ both switch, so that we can find solutions to the differential equation. In any case, we can overcome this problem and get some insight into positive interdependence by focusing on a pooling equilibrium in which there are a finite number of offers made on the equilibrium path. Focusing on this kind of pooling equilibrium also allows us to contrast our method to the method used by Levine [44]. His method starts with the assumption that equilibrium path offers and acceptance probabilities are all known. For example, these offers and acceptance probabilities are the outcomes of a particular experiment. He then fits type distributions to these outcomes which support altruistic equilibrium in which more generous offers are made by more altruistic proposers. We adopt this method here.

Let π^* be an interval such that for each $p \in \pi^*$, $v\left(p, s, \bar{t}\right) < 0 < v\left(p, s, \underline{t}\right)$ for each type s of the proposer. Offers that don't satisfy this property will never appear in equilibrium.

Let $p_1, \ldots, p_K$ be any decreasing finite sequence of offers from π^*. Suppose that the proportion Q_k of all offers which are equal to p_k is accepted. Evidently, Q_k must be a decreasing sequence. We construct an equilibrium in which proposers whose types lie below s_k make an offer that is at least p_k where s_k is chosen to satisfy $F\left(s_k\right) = \sum_{i=1}^{k} Q_i$. If the offer p_k is accepted with probability q_k, then q_k must be the proportion of responder types who find the demand acceptable.

Theorem 9. *Let $p = \{p_1, \ldots, p_K\}$ be a decreasing finite sequence such that each $p_k \in \pi^*$. There exist distributions F and G of proposer and responder types respectively such that the sequence is supported as an altruistic equilibrium if and only if the system*

$$q_k u\left(p_k, s_k\right) = q_{k+1} u\left(p_{k+1}, s_k\right) \tag{A.1}$$

has an increasing solution for each $k = 1, \ldots, K$.

Proof. We deal with two directions.

If part of the theorem: Let $\{s_1, \ldots, s_K\}$ be a solution to (A.1). Since the proportion of offers equal to p_k is given by Q_k, we have some distribution F of proposer types such that $F\left(s_k\right) = \sum_{n=0}^{k} Q_n$. Since K is finite, we can assume F is continuous. From Lemma 10 below, each array of types $\{s_1, \ldots, s_K\}$ can then be associated with a set of types $\{t_1, \ldots, t_k\}$ that satisfy (A.2). This means that given the distribution F, responder type t_k is just indifferent between accepting and rejecting the demand p_k. Since the payoff to acceptance is decreasing in responder type, it is a best reply for responder types $t' > t_k$ to reject p_k and for types $t' < t_k$ to accept it. If the system (A.1) has a solution, then $q_{k+1} < q_k$, and so there is some continuous distribution G such that $G\left(t_k\right) = q_k$ for each k.

It remains to show that proposers whose types are in the interval $[s_{k-1}, s_k]$ should offer p_k. It follows immediately from the single crossing assumption 2, that types in this interval prefer p_k to any other offer that occurs on the equilibrium path. So let $p_k < p < p_{k+1}$. Since $p \in \pi^*$, there is some type s such that $v(p, s, t_{k+1}) = 0$. Suppose that responders believe that a proposer who deviates to p has exactly this type. Then the probability with which the offer will be accepted is the same as the probability with which the offer p_{k+1} is accepted. Then all proposer types prefer the offer p_{k+1} to p, and according to the previous argument, they must prefer their equilibrium offers.

Only if part of the theorem: Let s_k be the highest type who makes the offer p_k in equilibrium. Since proposer's offers are decreasing in type, and each offer occurs with strictly positive probability, the types s_k are strictly ordered, and $s_K = \overline{s}$. If equality fails at any s_k then by continuity, some types will want to change their demands. □

Lemma 10. *For any continuous distribution F of proposer types, any decreasing sequence $\{p_k\}_{k=1,\ldots K}$ of offers from π^*, and any increasing sequence $\{s_1, \ldots, s_K\}$ of proposer types with $s_k = \overline{s}$, there is a decreasing sequence $\{t_1, \ldots, t_K\}$ such that*

$$\mathbb{E}_{s\in[s_{k-1},s_k]} v(p_k, s, t_k) = 0 \tag{A.2}$$

for each k, where $s_0 = \underline{s}$.

Proof. Begin with p_1. Since $p_1 \in \pi^*$

$$\mathbb{E}_{s\in[\underline{s},s_1]} v\left(p_1, s, \overline{t}\right) < 0 < \mathbb{E}_{s\in[\underline{s},s_1]} v\left(p_1, s, \underline{t}\right)$$

as the assumption holds uniformly in s. By the mean value theorem, there is a t_1 such that

$$\mathbb{E}_{s\in[\underline{s},s_1]} v(p_1, s, t_1) = 0.$$

Now replace p_1 with p_2, and the interval $[\underline{s}, s_1]$ with $[s_1, s_2]$. Since both these changes reduce the acceptance payoff to the responder of type t_1, we have

$$\mathbb{E}_{s\in[s_1,s_2]} v(p_2, s, t_1) < 0 < \mathbb{E}_{s\in[s_1,s_2]} v(p_2, s, t_1),$$

since $p_2 \in \pi^*$. The mean value theorem then gives t_2 such that

$$\mathbb{E}_{s\in[s_1,s_2]} v(p_2, s, t_2) = 0.$$

Repeat this procedure for the other offers. □

Whether the data from the experiment can be explained with an equilibrium in which more altruistic proposers make higher offers depends on whether or not (A.1) has a solution. This depends jointly on the offers p_k, the acceptance probabilities Q_k, and the payoff function u. For example, with Levine's formulation of the payoff function is

$$q_k u(p_k, s) = q_k \left((1 - p_k) - \frac{2s - \overline{s} - \underline{s}}{(\overline{s} - \underline{s})(1 - \lambda)} p_k \right)$$

which is linear in proposer type.[31] This function is flatter the lower is p_k (at least as long as q_k is higher the higher is p_k). Apparently (A.1) can have a solution in this case only if the sequence $q_k(1 - p_k)$ is decreasing. Since expected payoffs in experimental data are know to be hump shaped in offers, our model with positive interdependence cannot explain existing experimental results when the payoff function is linear in proposer type.

Assuming a richer utility function or monotonic expected payoff, our comparative statics exercise can be carried out in this special case by imposing a limit offer equal to the second lowest offer. The logic is then very similar to that with negative interdependence. The imposition of the limit forces all the greediest proposer types to raise their offer from p_K to p_{K-1}. If that is all that happens, very altruistic responders who were previously willing to accept p_{K-1} (but were not willing to accept p_K), are no longer willing to do so because p_{K-1} is now being offered by greedier proposers than previously. To compensate, more altruistic proposer types must be mixed in to the pool at p_{K-1}. So just as with negative interdependence, the lowest offer p_{K-1} is made more frequently that offers at or below p_{K-1} in the original equilibrium. As the new marginal proposer type at p_{K-1} is more altruistic than he was before, he needs a higher acceptance probability to prevent him from deviating to a more generous offer. So the offer p_{K-1} is more likely to be accepted than it was in the original equilibrium.

Appendix B. Original Experiment

This section reports the design and results of the original experiment we conducted. It used pen and paper and physically separated the proposers from responders, so the interaction was quite different from the one reported in the body of the paper. Recruitment was identical, using an e-mail sent by the Student Service Centre to a random group of students. After reading the instructions, subjects were asked to answer some questions to verify that they understood how the payment will be implemented. Those subjects who did not fully understand

[31] Here we have captured our special assumption that the proposer doesn't care about the responder's type by setting the responders type to zero in Levine's function.

the implementation, received a detailed explanation from a research assistant.

The contest to determine “proposer” and “responder” roles used an “I Spy” task. Subjects who scored higher in the contest were designated a “proposer” and received \$5. The rest were asked to move to a nearby room and were designated a “responder.”

The stakes (\$55) and the matching protocol were similar to the experiment described in the the body of the paper, except that each group was divided into two sub-groups only. In the baseline treatment the offers were allowed to vary between \$0 and \$55, and in the limit treatment the offers were between \$5 and \$55. The design maintained anonymity between responders, proposers and experimenters.

B.1. **Results.** Table 5 reports summary statistics of the baseline treatment and the limit treatment. A total of 52 subjects took part in the two sessions: 24 in the baseline (B) treatment and 28 in the limit (L) treatment.

	B-R1	B-R2	L-R1	L-R2
Average offer	19.07	21.21	15.31	15.00
Average acceptance rate	0.63	0.88	0.87	0.90
Within SD of demand	2.26	1.47	3.18	2.09
Total SD of demands	8.15	6.64	6.45	5.78

Table 5. Summary Statistics

Table 5 indicates the main finding of the experiment: setting a lower bound to the offer caused it to fall by almost 30% from \$21.21 to \$15. In spite of the lower offers, the average acceptance rate was marginally higher (90% in the limit treatment and 88% in the base treatment), implying that the conditional acceptance rate increased substantially. The learning and experimentation from the first to the second round could be seen by the decrease of about 35% of the within proposer standard deviation: many proposers experimented in the first round by submitting different offers, but used a single offer in the second round.

Table 6 reports the distribution of offers and acceptance rate. Although Table 6 reports the results for intervals, it is important to note that about 90% of offers were made in multiples of \$5. The table reveals the effect of setting a lower limit to the offers: the frequency of low offers and the conditional acceptance rates increase.

offer	%	Base-R1	Base-R2	Limit-R1	Limit-R2
\$0 to \$4	offers	0	0	0	0
	acceptance				
\$5 to \$9	offers	8	8	12	5
	acceptance	33	17	50	60
\$10 to \$14	offers	25	0	31	34
	acceptance	17		80	76
\$15 to \$19	offers	8	13	17	33
	acceptance	50	78	94	100
\$20 to \$24	offers	18	39	28	20
	acceptance	77	93	100	100
\$25+	offers	39	40	12	8
	acceptance	96	100	100	100

TABLE 6. Distribution of Offers and Acceptance Rate by Treatment and Round

Although we introduced some new and unconventional design methods in the experiment, the results in the baseline treatment are comparable to existing experimental findings in the literature: offers below 25% of the pie (up to \$14) are accepted only 20% of the time, and 79% of offers are higher than \$20 (which are accepted most of the time). Furthermore, statistical tests that investigated the effect of the offer's rank on its acceptance probability, showed that receiving several offers at once (and being able to compare between them) had no significant effect on the conditional acceptance probability.

B.1.1. *Acceptance Rate.* We compare (non-parametrically, using Fisher exact test) the acceptance rate at offers of \$5, \$10, \$15, \$20 between the base treatment and the limit treatment. We use both rounds since there is no significant difference between the conditional acceptance rates at different rounds, within the same treatment (for both the base and the limit treatments).

offer	B accept	B reject	L accept	L reject	p-value
5	2	6	6	5	0.208263
10	3	15	49	14	0.000003
15	6	2	46	1	0.052297
20	35	5	39	0	0.029196

TABLE 7. Fisher Exact p-value (one-sided) for the effect of Limit Treatment on conditional acceptance probability

As Table 7 clearly reveals, the null hypothesis that limiting the offer did not have an effect on the acceptance probability is rejected at 1% (even after the conservative Bonferroni adjustment). The strongest and most dramatic effect occurred at \$10: in the first round, 25% and 31% of the offers in the baseline and the limit treatments, respectively, were made at that level. However, the acceptance rate in the base treatment was only 17% while in the limit treatment the acceptance rate of those offers was 80%. The experimental design allowed the proposers to learn this behavior, and in the second round there were no offers of \$10 in the base treatment, while 34% of the offers in the limit treatment were made at \$10.

It is of interest to note that the proposer's expected revenue in the base treatment is maximized at an offer of \$20 (\$30.625) - which is the mode of the offer distribution, while in the limit treatment the expected revenue are maximized at an offer of \$15 (\$39.15), although the mode of the offer distribution is at \$10.

B.1.2. *Offers.* In order to test whether capping the demands has a significant effect on offers we conduct a feasible GLS regression. We used second-round offers since after the first round, proposers learned the conditional acceptance probability (as established above, the responders used the same acceptance probability in the two rounds). Therefore, the second round is consistent with the common prior assumption underlying the Bayesian signaling game. The negative effect of the limit treatment on second-round offers is significant at 1%.

# of observation=	170		Obs per group			
# of Groups=	26		min=	6		
Estimated covariances=	26		max=	7		
Panels: heteroskedastic;			Wald χ^2 (1) =	228.19		
no auto-correlation			$Prob > \chi^2 =$	0.0000		
offer	*coef*	*SE*	*z*	$P > \lvert z \rvert$	*[95%*	*CI]*
Limit treatment	-5.404759	0.35778	-15.11	0.000	-6.10601	-4.703506
Constant	20.42277	0.25102	81.36	0.000	19.9308	20.91476

TABLE 8. Second-Round Offers: Feasible GLS

As noted above, the standard deviation of offers decreased significantly between the first and the second round in both treatments (p<0.0001 in a random effect GLS controlling for treatment and round without interaction). This result is consistent with the hypothesis that proposers experimented in the first round, and after estimating the acceptance probability made less dispersed offers in the second round.[32]

B.2. **Equilibrium or Anchoring?** As discussed in Section 3.1, a skeptical reader may wonder whether the results of the experiment had anything to do with interdependent preferences, and may conjecture they are due to the "anchoring and adjustment" bias. We believe that the results in the main treatment are inconsistent with the latter conjecture: as clearly shown in Table 6 and Table 7 most of the response to setting a minimum offer of \$5 occurred at higher offers (\$10 and \$15). Furthermore, Table 6 reveals that the dramatic effect of setting a low bound to offers was on responders' acceptance rate (especially at \$10) in the first round. The proportion of proposers who offered this amount in the first round of the two treatments differed only slightly (25% in the baseline and 31% in the limit treatment), but the acceptance rate differed significantly (17% in the baseline and 80% in the limit treatment). As a result, proposers in the *baseline* treatment, did not make any offers in the interval of \$10-\$14 during the second round (the proportion of offers made in this interval in the limit treatment increased only marginally to 34% in the second round).[33] The model of negative interdependence can account for this change in acceptance probability: in the limit treatment, lower types (relative to the baseline treatment) made low offers, which decreased the responders' marginal utility of rejecting them. Therefore, the decrease in offers between the two treatment is due to lower acceptance rate of low offers by responders (results consistent with many other studies) and learning by proposers, both occurring in the baseline treatment. One of the general lessons from the anchoring and adjustment literature is that an initial high demand in a bargaining interaction will increase the proposer's final payoff. The conclusions from the experiment are the exact opposite: limiting the bargaining power of the proposer increases his expected payoff substantially.

In order to test for a focal point effect experimentally, we originally conducted a third treatment that was strategically equivalent to the limit treatment, but did not provide an anchor. As argued above the anchoring rationale can be applied only if a minimum offer of \$0 does not set an anchor. We therefore allowed the proposer to make an

[32] In the base treatment 67% of the proposers made 6 identical offers in the second round, and in the limit treatment 35% of proposers made 7 identical offers in the second round. We didn't find a treatment effect on the standard deviation of offers.

[33] This extreme behavior in the baseline was one of the reasons that led us to repeat the whole experiment.

	B-R1	B-R2	I-R1	I-R2
Average offer	19.07	21.21	16.82	17.81
Average acceptance rate	0.63	0.88	0.75	0.82
Within SD of demand	2.26	1.47	1.19	1.03
Total SD of demands	8.15	6.64	7.96	6.45

Table 9. Summary Statistics: the Incentive vs. Base Treatments

offer	B accept	B reject	I accept	I reject	p-value
5	2	6	4	10	0.63
10	3	15	41	24	0.000947
15	6	2	36	10	0.5754
20	35	5	71	3	0.099

Table 10. The Effect of the Incentive Treatment on Conditional Acceptance Probability: Fisher Exact one sided p-values

offer between \$0 and \$50, and paid the responder an additional \$5 if she accepted an offer (an "incentive"). 36 subjects participated in this treatment, that otherwise was identical to the base treatment. As is evident from Table 9 average offer in the incentive treatments was lower by \$3.40 than in the base treatment, and the average acceptance rate was about the same.

Table 10 compares the effect of the incentive design (that did not provide an anchor) on the conditional acceptance probability. As in the limit treatment, the conditional acceptance probability is higher in the incentive treatment, and the effect is especially strong at offers of \$10 (less than 20% of the pie).

The effect on offers is significant as well. A feasible GLS finds that an incentive lowers offers by \$2.5 relative to the base treatment (significant at 0.01%). Figure B.1 shows that there is almost a first order stochastic dominance between the offer distributions in the three treatments. That is, for almost any offer, the probability of receiving an equal or lower offer is highest in the limit treatment, followed by the incentive treatment and is lowest in the base treatment. Similar ranking is evident in the conditional probability of acceptance.

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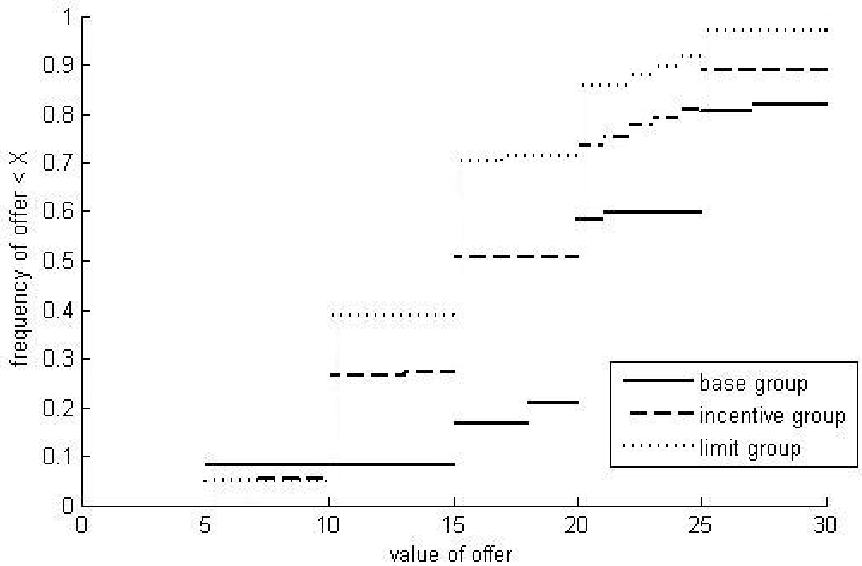

FIGURE B.1. Effects of the Limit and Incentive treatments on CDF of offers

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