Behavior in Ultimatum Games with Multiple Proposers

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Abstract

We report the results of an experiment designed to explore proposer and responder behavior in an ultimatum game with multiple proposers. We predict that responders will be more likely to reject offers in a multiple proposer setting compared to the single proposer setting. This prediction is based on the notion that proposers have diminishing marginal utility for wealth and that their utility for rejecting unreasonable offers is separable by proposer. Experimental results support our prediction. Specifically, responders set lower rejection thresholds in the multiple proposer compared to the single proposer setting. We also find that proposers are reasonably sophisticated in their ability to strategically anticipate responders' rejection behavior. These findings are robust to differences in the knowledge setting, as they obtain regardless of whether the surplus size is common knowledge or known only to the proposer.

JEL classification: C92; C72.

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1. Introduction

The ultimatum game is a simple and frequently studied bargaining game. The bargainers in this game, labeled proposers and responders, interact in the following manner. The proposer is endowed with a sum of money, the “surplus.” The proposer moves first by making an offer to the responder for a portion of the surplus. The responder moves next by either accepting or rejecting the proposer’s offer. If the responder accepts, she receives the amount of the offer and the proposer receives the residual share. If the responder rejects the offer, both parties receive nothing. This study investigates whether proposer and responder behavior in ultimatum games differs across single and multiple proposer settings.

While a rich literature in experimental economics examines behavior in the ultimatum game, these examinations have generally assumed the simple, dyadic version of the game described above. The main purpose of this paper is to investigate the effect of a multiple proposer setting on the behavior of both proposers and responders. Our multiple proposer setting involves one responder, who essentially plays several ultimatum games simultaneously. Thus, our investigation focuses on the effect of the multiple proposer setting *per se*, without considering additional structural features that may be associated with that setting.

Results show that responders have a lower threshold for rejecting offers (i.e., are more willing to reject offers) in the multiple proposer setting than in the single proposer setting. We also find that proposers apparently anticipate the differences in responder behavior, because they make higher (i.e., more generous) offers in the multiple proposer setting than in the single proposer setting. These results are robust to settings where the responder knows the actual surplus as well as where the responder only knows the probability distribution of the surplus.

2. Background

If individuals care only about their monetary payoffs and prefer more money to less, then proposers possess nearly all of the bargaining power in the ultimatum game. In particular, the unique subgame perfect equilibrium prediction, regardless of the number of proposers, is that the proposers will offer the smallest strictly positive share to the responder and that the responder will accept all offers. Hence, the proposers capture nearly the entire available surplus. Contrary to the equilibrium prediction, robust findings on behavior in ultimatum game experiments demonstrate that proposers offer considerably more than the smallest positive share to responders and that responders reject some positive offers. In fact, offers typically average about 40 percent of the total surplus, and the modal offer is frequently an equal split.[1]

The initial interpretation of these results was that proposers exhibit altruistic behavior or have preferences for fairness. Subsequent investigation of behavior in ultimatum games provides evidence that proposers' apparent generosity is due, in part, to strategic motivations, namely beliefs with respect to the rejection behavior of responders. For instance, Winter and Zamir (1997) explore strategic interaction among proposers and responders in an environment populated by real and virtual players. They find that proposers adapt their offers to the rejection behavior of responders and that responders adapt their rejections to the behavior of the proposers. In a comparison of behavior in the ultimatum game across four countries, Roth et al. (1991) find that proposers' offers are

[1] For surveys of the ultimatum game literature see Guth and Tietz (1990), Camerer and Thaler (1995), and Roth (1995).

close to a best reply to the actual rejection behavior of responders. These findings suggest that proposers act in a sophisticated, profit-maximizing manner by anticipating the actual pattern of rejections by responders. In other words, as Camerer states, "…the tail that wags the proverbial dog is the rejections by responders, which forces proposers to make generous offers (Camerer 2003, p. 56)."

The rejection of positive offers by responders could be explained either by irrationality or by a utility for something other than wealth. Analysis of responder behavior in ultimatum games suggests that departures from the play of the subgame perfect equilibrium are not due to irrationality or confusion. Responders appear to understand the game and their monetary incentives (Roth, et al. 1991; Winter and Zamir 1997; Costa-Gomes and Zauner 2001). Costa-Gomes and Zauner explain the behavior in the experiments of Roth et al. (1991) with a social utility model. They demonstrate that the behavior of both responders and proposers is motivated by their own monetary payoffs as well as the monetary payoffs of their partners.

More generally, behavioral economists have begun to incorporate various types of social preferences into formal models (e.g., Rabin 1993; Fehr and Schmidt 1999; Bolton and Ockenfels 2000; Mittendorf 2005 a, b). Consistent with the notion of utility for social preferences, numerous experimental studies have supported the proposition that individuals are willing to incur a monetary cost to punish others perceived to be violating social norms of fairness and equity (see Camerer 2003; Gintis, Bowles, Boyd and Fehr 2003 for reviews). In fact, experimental studies (Kahneman, Knetsch and Thaler 1986; Fehr and Fischbacher 2004) find that even third parties, who are themselves unaffected economically by the actions of other experimental participants, are willing to incur a monetary cost to punish participants who violate social norms.

Following this trend, we assume the responder's utility function consists of two components, a utility from wealth and a utility from rejecting offers that are deemed unreasonable (or equivalently, a disutility from inequitable outcomes). Therefore, when deciding whether to accept or reject an offer, a responder must consider the tradeoff between these two sources of utility. Further, if the responder experiences diminishing marginal utility for wealth, then as her wealth increases (through acceptance of reasonable offers) it is more likely that the utility from rejecting an unreasonable offer will outweigh the utility from wealth associated with accepting the offer. This reasoning suggests that a responder who faces multiple proposers simultaneously may exhibit different rejection behavior than if she faced any of those proposers individually. More specifically, we predict that, *ceteris paribus*, the responder's propensity to reject offers will be greater with multiple proposers than with a single proposer. This prediction relies on the assumption that, because wealth is fungible, the utility for wealth is not separable by proposer. Thus, each additional offer acceptance leads to diminishing marginal utility from wealth. On the other hand, we assume that utility for rejecting unreasonable offers is separable by proposer.[2]

Next, we examine a dimension of proposer sophistication – strategic anticipation. In particular, if moving from a single to a multiple proposer setting affects the rejection tendencies of responders, will proposers recognize these tendencies? That is, will proposers correctly anticipate the rejection patterns of responders and respond with

[2] Our assumption of separability is consistent with Fehr and Schmidt (1999) and Falk and Fischbacher (2006), who model utility for equity and reciprocity, respectively, as separable by individual. Whereas experimental evidence is generally consistent with the utility functions proposed in these papers (e.g., Falk, Fehr and Fischbacher 2005; Falk and Fischbacher 2005), the specific assumption of separability has not been extensively tested. Falk and Fischbacher (2005) review the relevant literature and conclude that in building a model of reciprocity (and retribution) involving more than two players, the best approach assumes separability. Therefore, our assumption that the responder's utility for norm enforcement is

strategically determined offers? Consistent with prior research, we expect that they will. Therefore, we predict that offers will be more generous in the multiple proposer setting than in the single proposer setting.

Finally, we examine the robustness of our results to different knowledge settings. Rapoport and Sundali (1996) report the results of single proposer ultimatum games in which responder uncertainty was manipulated by varying the range of the surplus while holding the expected value constant. Rapoport and Sundali find that responders are more likely to reject offers of a given dollar amount when the surplus range is narrower. These results suggest that responders are less willing to reject an offer when they are less certain that the offer is unreasonable. Recall that in predicting the effect of the multiple proposer setting on responder behavior, we rely critically on the assumption that responders will be willing to reject unreasonable offers. If the proposer cannot be certain that the offer is unreasonable, this assumption may be called into question by Rapoport and Sundali's (1996) results. Therefore, we investigate the effect of the multiple proposer setting on responder behavior under two knowledge settings, common knowledge and one-sided uncertainty. In the common knowledge setting, both the proposer and the responder know the surplus amount. In the one-sided uncertainty setting, the responder knows her own payoff and the distribution of the surplus, but only the proposer knows the actual surplus amount. Thus, the responder is unable to determine with certainty whether the offer is unreasonable or not.[3]

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separable by proposer is consistent with the current state of the literature, and our results provide some of the early evidence on the plausibility of this assumption.

[3] Hannan, Rankin and Towry (2007) found results similar to our predictions in a one-sided uncertainty setting. The Hannan et al. experiment differs from ours in two ways. First, they investigated the one-sided uncertainty context exclusively. Second, although their experiment was structured as an ultimatum game, they used a context in which offers of less than 100 percent of the surplus required lying. Thus, their setting had an ethical dimension that is absent from ours as well as from the typical ultimatum game experiment.

3. Experimental Design and Procedures

We conducted a fully-crossed 2 x 2 experimental design, in which we manipulated the number of proposers matched to each responder (single vs. multiple proposer) and knowledge (common knowledge vs. one-sided uncertainty). The details of these manipulations are discussed below. Participants were recruited from undergraduate courses at a large university and were randomly assigned to each of the four conditions as well as to the proposer or responder role, which they maintained throughout the experiment. One hundred forty-four participants were assigned to the proposer role (48 in each of the knowledge conditions in the multiple proposer condition and 24 in each of the knowledge conditions in the single proposer condition). Eighty participants were assigned to the responder role (16 in each of the knowledge conditions in the multiple proposer condition and 24 in each of the knowledge conditions in the single proposer condition).

Six single proposer sessions (three with common knowledge and three with one-sided uncertainty) and eight multiple proposer sessions (four with common knowledge and four with one-sided uncertainty) were conducted. Experimental sessions consisted of the same basic procedures for each condition, as follows. At the beginning of each session, we distributed instructions and read them aloud to the participants. All participants were required to pass a quiz to ensure that they understood the experiment before we began the actual experiment. In order to maintain anonymity, participants interacted over a computer network.

Sessions consisted of eight periods. At the beginning of each period, each proposer was matched with a responder. Each proposer made an offer to the matched responder, who decided whether to accept or reject the offer. The proposer learned the responder's decision and period payoffs were recorded. Offers and acceptance/rejection decisions were private information known only to the proposer and responder dyad.

The process by which the responder decided whether to accept offers differed between periods one through four and periods five through eight. In the first four periods, the responder decided whether to accept or reject an offer *after* receiving it. In the last four periods, the minimum acceptable offer method was used.[4] This method allows us to gather data on the responder's reaction to all possible offers. Specifically, this method required the responder to set a binding threshold for accepting an offer *before* observing the actual offer. If an offer was greater than or equal to the threshold amount, the offer was accepted; otherwise, it was rejected. Importantly, proposers only learned whether their offers were accepted or rejected and never learned the responder's threshold amount. Thus, the information known by the proposer was identical across both acceptance elicitation methods.

Participants were paid privately in cash at the end of the experiment. To prevent any wealth effects across periods, one period was selected at random for payment. Each participant received a participation fee of $10.00 in addition to earnings from the experiment.

3.1 Number of Proposers Manipulation

In the single proposer condition, each responder was matched with a single proposer, and so single proposer sessions consisted of eight proposers and eight responders. Each proposer submitted one offer to a responder each period and each responder received only one offer each period. The matching protocol, which was

[4] For a discussion of the minimum acceptable offer method see Roth (1995).

common information among participants, ensured that each proposer was matched with each responder only once during the session.

In the multiple proposer condition, each responder was matched simultaneously with three proposers, and so multiple proposer sessions consisted of twelve proposers and four responders. In these sessions each proposer submitted one offer to a responder, who received offers from three proposers simultaneously each period. The matching protocol, which was common information among participants, ensured that each proposer was matched with each responder only once during periods one through four and once during periods five through eight. Further, proposers were re-grouped each period. There was no limit to the number of offers that a responder could accept. Therefore, the responder could potentially accept and receive a payoff from all three offers each period, and so proposers did not need to explicitly compete with one another.[5]

3.2 Knowledge Manipulation

In the common knowledge condition, proposers were endowed with $30.00 each period, and this amount was common knowledge to proposers and responders. In the one-sided uncertainty condition, each proposer's surplus was drawn independently each period from the uniform distribution {$0, $1, …, $60}, resulting in the same expected value ($30.00) as the surplus in the common knowledge condition. The realized amount of the surplus was known only by the proposer. That is, responders knew the range and distribution of the surplus but not its realized amount.

Within the one-sided uncertainty condition, we used the same random, but predetermined, sequence of realized surpluses for the single and multiple proposer

[5] Implicit competition could occur if proposers believe that the presence of other proposers reduces the likelihood of their own offers being accepted. Note, however, that proposers never learned whether other proposers' offers were accepted, and so the "winner" of any implicit competition was never revealed.

sessions. Specifically, we randomly generated twelve sets of surpluses, one for each proposer in the multiple proposer sessions. These same sets were used in the single proposer sessions. Because there were only eight proposers in each single proposer session, we used eight of the twelve surplus sequences in each session, rotating the sequences to ensure that each sequence was used twice over every three single proposer sessions. Because the surplus amounts were determined independently, the proposers' private information was uncorrelated. Further, this procedure ensured that the mean realized surplus was the same each period for both of the knowledge conditions. The overall mean realized surplus in the one-sided uncertainty condition was $29.79, which is comparable to the surplus of $30.00 in the common knowledge condition.

4. Results

Table 1 reports offer and rejection data by experimental condition. The single proposer results are consistent with past results from ultimatum games.[6] Specifically, with a single proposer and a known surplus of $30.00, the mean offer is $11.18 or about 37 percent of the available surplus. Responders reject about 21 percent of offers and the mean rejected offer is $9.18, which is about 31 percent of the surplus. With a single proposer and one-sided uncertainty, the mean offer is $9.13 or about 30 percent of the expected surplus. Responders reject about 31 percent of offers and the mean rejected offer is $4.87 or about 16 percent of the expected surplus. We do not have benchmarks for comparing the multiple proposer results. With multiple proposers and a known surplus of $30.00, the mean offer is $12.99 or about 43 percent of the surplus. Responders reject about 25 percent of offers and the mean rejected offer is $10.52, which is about 35 percent of the surplus. With multiple proposers and one-sided uncertainty, the mean offer is $10.99 or about 37 percent of the expected surplus. Responders reject about 36 percent of offers and the mean rejected offer is $6.48 or about 22 percent of the expected surplus.

4.1 Responder Behavior

As described above, we predict that the responders' propensity to reject offers will be greater in the multiple proposer than in the single proposer condition. The pattern of acceptances in Figure 1, Panels A and B, suggests that this is the case, regardless of the knowledge condition. Our cleanest statistical test uses the responders' stated acceptance thresholds in periods five through eight. A higher acceptance threshold implies a greater willingness to reject offers. As reported in Panel A of Table 2, the threshold is higher in the multiple proposer condition than in the single proposer condition. This relation holds regardless of the knowledge condition. Specifically, with common knowledge, the mean threshold is $12.84 in the multiple proposer condition compared to $9.71 ($t = 6.30$, $p < 0.01$ *one-tailed*) in the single proposer condition.[7] Similarly, with one-sided uncertainty, the mean threshold is $12.00 in the multiple proposer condition compared to $8.90 ($t = 4.59$, $p < 0.01$ *one-tailed*) in the single proposer condition. Thus, we support our prediction that responders will be more willing to reject offers in the multiple proposer setting than in the single proposer setting.

We use the data from periods one through four to provide supplemental tests of the responders' willingness to reject. The first alternate measure we use is the highest offer that each responder rejects across these periods. This measure provides a proxy for the lower bound of each responder's acceptance threshold. As reported in Panel B of

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[6] The most directly comparable results from ultimatum games with one-sided uncertainty are those from condition 1 in Rappaport and Sundali's (1996) study.

Table 2, the mean highest rejected offer is higher in the multiple proposer condition than in the single proposer condition. However, this relation is statistically significant only with one-sided uncertainty (mean of $8.00 in multiple proposer condition vs. $4.55 in single proposer condition, *t = 3.13, p < 0.01 one-tailed)*. With common knowledge, the mean highest rejected offer is $10.13 in the multiple proposer condition compared to $9.38 in the single proposer condition *(t = 0.73, p = 0.24, one-tailed).*

Our second alternate measure is the lowest accepted offer of each responder in periods one through four. This measure provides a proxy for the upper bound of each responder's acceptance threshold. As reported in Panel C of Table 2, the mean lowest accepted offer is greater in the multiple proposer condition than in the single proposer condition. This relation holds regardless of the knowledge condition. Specifically, with common knowledge, the mean lowest accepted offer is $10.38 in the multiple proposer condition compared to $9.39 in the single proposer condition *(t = 1.66, p = 0.05, one-tailed)*. Similarly, with one-sided uncertainty, the mean lowest accepted offer is $9.00 in the multiple proposer condition compared to $7.75 in the single proposer condition *(t = 2.19, p = 0.02, one-tailed).*[8]

In summary, our results show that responders' willingness to reject offers is greater in a multiple proposer setting than in a single proposer setting. This finding is consistent with diminishing marginal utility for wealth combined with the separability of a utility for rejecting unreasonable offers. Further, this result is robust to whether the responder knows the surplus or only its distribution.

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[7] To appropriately calculate the degrees of freedom, we treat each proposer (rather than each offer) as an independent observation.

[8] An ANOVA confirms that there is no interaction between knowledge and number of proposers using threshold *(p = 0.98)* or lowest accepted *(p = 0.75)* as dependent variables. Although there is a marginally significant interaction for highest rejected *(p = 0.08)*, the pattern of means indicates that it is an ordinal interaction and thus inferences from *t*-tests are not affected.

4.2 Proposer Behavior

We next move to the behavior of proposers, examining whether they are reasonably sophisticated strategic players. That is, we test whether proposers correctly anticipate the rejection patterns of responders when moving from a single to multiple proposer setting. Recall that our analysis of responder behavior indicates that responders are more likely to reject offers in the multiple compared to the single proposer condition. Thus, if proposers anticipate this behavior, their offers will be higher (more generous) in the multiple proposer condition. Consistent with anticipatory behavior, the presence of multiple proposers increases the mean offer by about 16 percent with common knowledge and by about 20 percent with one-sided uncertainty. Specifically, with common knowledge, the mean offer of $11.18 (about 37 percent of the surplus) in the single proposer condition is less than the mean offer of $12.99 (about 43 percent of the surplus) in the multiple proposer condition ($t = 4.05$, $p < 0.01$, *one-tailed*). With one-sided uncertainty, the mean offer of $9.13 (about 30 percent of the surplus) in the single proposer condition is less than $10.99 (about 37 percent of the surplus) in the multiple proposer condition ($t = 5.01$, $p < 0.01$, *one-tailed*).[9]

The cumulative distributions of offers are illustrated in Figure 2, Panels A and B. Consistent with the means reported above (and regardless of whether there is common knowledge or one-sided uncertainty), the distribution of offers made in the single proposal condition is to the left of the distribution in the multiple proposer condition. The null hypothesis that the distributions of offers are the same in the single proposer condition and the multiple proposer condition is rejected using a Kolmogorov-Smirnov

[9] An ANOVA indicates that there is no interaction between knowledge and number of proposers ($p = 0.98$)

test *($p < 0.01$* for each knowledge condition *).* Thus, the distributions bolster the evidence that proposers anticipate the rejection behavior of responders.

4.3 Common Knowledge vs. One-Sided Uncertainty Setting

The primary purpose of our manipulating the knowledge setting was to test the robustness of the results related to the single vs. multiple proposer settings. However, a secondary contribution of this study is to investigate whether the findings of Rapoport and Sundali (1996) replicate. Rapoport and Sundali's results suggest that responders are less willing to reject an offer when they are less certain whether the offer is unreasonable. These results replicate in our experimental setting, as indicated by the *t*-tests reported in Table 2. Specifically, regardless of the number of proposers, the willingness to reject offers is greater with common knowledge than with one-sided uncertainty, using thresholds as well as the two other proxies. This finding suggests that the positive utility from rejecting an offer is greater when the offer is known to be unreasonable than when it is only suspected to be so. However, even with one-sided uncertainty, responders are willing to reject offers they believe to be unreasonable. In fact, over 30 percent of the offers in the one-sided uncertainty condition were rejected.[10] Recall that our predictions on the effect of the multiple proposer setting on responders' rejection behavior are predicated on the assumption that responders will be willing to reject unreasonable offers. The fact that responders were willing reject offers even with one-sided uncertainty helps explain why the effect of the multiple proposer setting (discussed earlier) obtains even with one-sided uncertainty.

[10] The rejection rate is actually higher with one-sided uncertainty than with common knowledge. We attribute this pattern of results to the fact that proposers were apparently optimistic about the effect of uncertainty on the responders' willingness to reject. That is, the offers were considerably lower with one-sided uncertainty than with common knowledge.

If proposers anticipate the responders' behavior, we would expect their offers to be higher in the common knowledge condition than in the one-sided uncertainty condition. Consistent with anticipatory behavior, the presence of common knowledge increases the mean offer by about 22 percent in the single proposer condition and by about 18 percent in the multi-proposer condition. Specifically, within the single proposer condition, the mean offer of $11.18 in the common knowledge condition is greater than the mean offer of $9.13 in the one-sided uncertainty condition *($t = 3.67$, $p < 0.01$, one-tailed).* Likewise, within the multiple proposer condition, the mean offer of $12.99 in the common knowledge condition is greater than the mean offer of $10.99 in the one-sided uncertainty condition *($t = 6.58$, $p < 0.01$, one-tailed).*

5. Conclusion

There has been extensive exploration of the ultimatum game across many disciplines. As researchers study variants of the basic ultimatum game and submit data to increasingly sophisticated analysis, the interpretation of proposer and responder behavior evolves. The contemporary interpretation of behavior in the ultimatum game is that responders are motivated by their monetary payoffs as well as various social factors, such as fairness and equity. The current view also holds that proposers make offers that are close to a profit-maximizing best reply to the rejection patterns of responders. We test a direct implication regarding this interpretation of the rejection behavior of responders. We further explore whether proposers correctly anticipate the rejection tendencies of responders. Hence, our goal is to increase the general understanding of the motivations of both proposers and responders in ultimatum games.

We find that responders are more willing to reject unreasonable offers when they face multiple proposers than when they face a single proposer. This result is consistent with our prediction that if responders experience diminishing marginal utility for wealth, their propensity to reject offers will be greater with multiple proposers than with a single proposer. This effect occurs because as a responder accepts offers, her utility for additional wealth decreases, making it more likely that the utility she receives from rejecting unreasonable offers will outweigh the utility that she receives from additional wealth. This main result occurs both when responders know the amount of the surplus (and thus can evaluate the reasonableness of offers with certainty) and when the responders have uncertainty regarding the surplus size. The robustness of our results to a setting with one-sided uncertainty follows from the finding that responders are willing to reject offers they only suspect to be unreasonable (albeit, less willing than they are to reject offers they know to be unreasonable).

Finally, we find evidence that proposers' offers are the result of reasonably sophisticated strategic behavior. In particular, they appear able to anticipate the different rejection patterns of responders depending on whether there is a single proposer or multiple proposers and whether the size of the surplus is known or unknown by the responder. The result of this strategic anticipation is that offers are more generous in the multiple proposer setting than in the single proposer setting. Likewise, offers are more generous in the common knowledge setting than in the one-sided uncertainty setting. These results support the general notion that proposers think about the strategic situation from the responder's point of view, which, in turn, affects their offers.

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Table 1
Proposer offers and responder rejections

Panel A All offers

	Single Proposer mean *(s.d.)* N	**Multiple Proposers** mean *(s.d.)* N	**T-test *** t stat *one-tailed p-value*
Common Knowledge	11.18 *(2.68)* 192	12.99 *(2.22)* 384	4.05 *(<0.01)*
One-Sided Uncertainty	9.13 *(4.15)* 192	10.99 *(4.84)* 384	5.01 *(<0.01)*
T-test * t stat *one-tailed p-value*	3.67 *(<0.01)*	6.58 *(<0.01)*	

Panel B Rejected offers

	Single Proposer mean *(s.d.)* N [% offers rejected]	**Multiple Proposers** mean *(s.d.)* N [% offers rejected]
Common Knowledge	9.18 *(2.94)* 40 [20.8%]	10.52 (1.79) 95 [24.7%]
One-Sided Uncertainty	4.86 *(3.29)* 59 [30.7%]	6.48 *(4.19)* 139 [36.2%]

* T-tests reported in Panel A use the mean of the mean offer for each individual proposer so that the observations used for the statistical tests are independent.

Table 2
Responders' willingness to reject offers

	Panel A Threshold (periods 5-8)		
	Single Proposer mean, *(s.d.)*, N	**Multiple Proposers** mean, *(s.d.)*, N	**T-test** (*t* stat, *one-tailed p-value*)
Common Knowledge	9.71 *(1.77)* 24	12.84 *(1.11)* 16	6.30 *(<0.01)*
One-Sided Uncertainty	8.90 *(1.83)* 24	12.00 *(2.45)* 16	4.59 *(<0.01)*
***t*-test** (*t* stat, *one-tailed p-value*)	1.56 *(0.06)*	1.27 *(0.11)*	

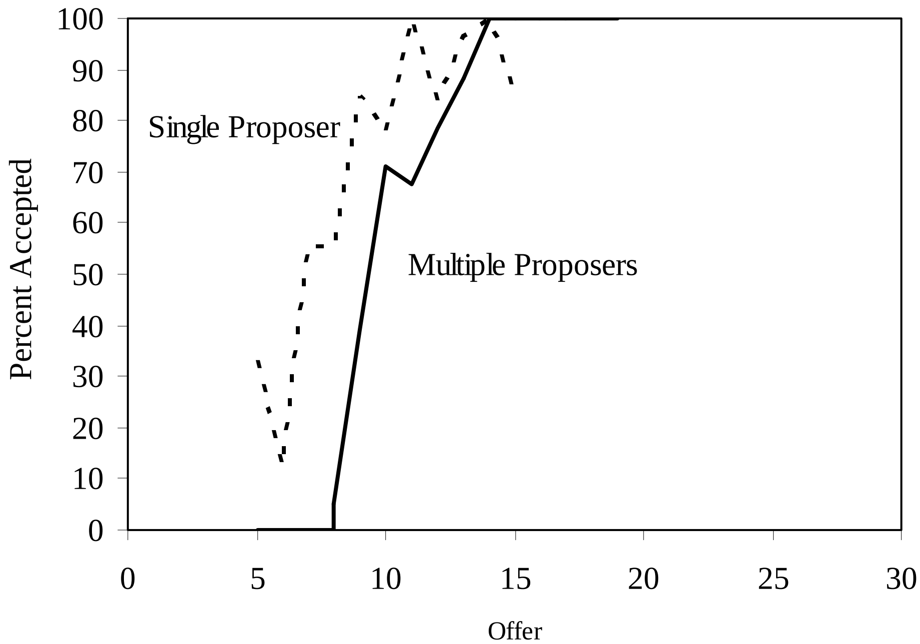
	Panel B Highest rejected offer (periods 1-4)		
	Single Proposer mean, *(s.d.)*, N	**Multiple Proposers** mean, *(s.d.)*, N	**T-test** (*t* stat, *one-tailed p-value*
Common Knowledge	9.38 *(3.73)* 13	10.13 *(1.46)* 16	0.73 *(0.24)*
One-Sided Uncertainty	4.55 *(3.20)* 20	8.00 *(3.39)* 16	3.13 *(<0.01)*
***t*-test** (*t* stat, *one-tailed p-value*)	3.97 *(<0.01)*	2.31 *(0.01)*	

	Panel C Lowest accepted offer (periods 1-4)		
	Single Proposer mean, *(s.d.)*, N	**Multiple Proposers** mean, *(s.d.)*, N	**T-test** (*t* stat, *one-tailed p-value*
Common Knowledge	9.39 *(2.25)* 23	10.38 *(0.89)* 16	1.656 *(0.05)*
One-Sided Uncertainty	7.75 *(1.94)* 24	9.00 *(1.46)* 16	2.193 *(0.02)*
***t*-test** (*t* stat, *one-tailed p-value*)	2.68 *(<0.01)*	3.22 *(<0.01)*	

Mean Highest Rejected (Lowest Accepted) is the mean of the highest (lowest) offer that was rejected (accepted) by each individual responder. Mean Threshold is the mean of the mean threshold each individual responder set over the four periods. T-tests use the mean for each responder so that the observations used for the statistical tests are independent.

Fig. 1
Percentage of offers accepted

Panel A: Common knowledge condition



Panel B: One-Sided uncertainty condition

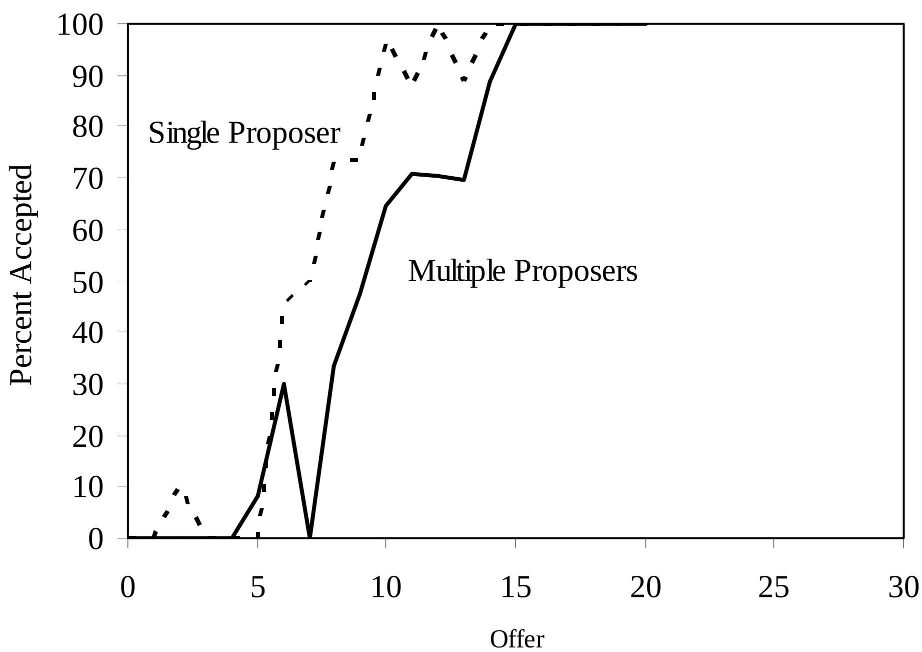
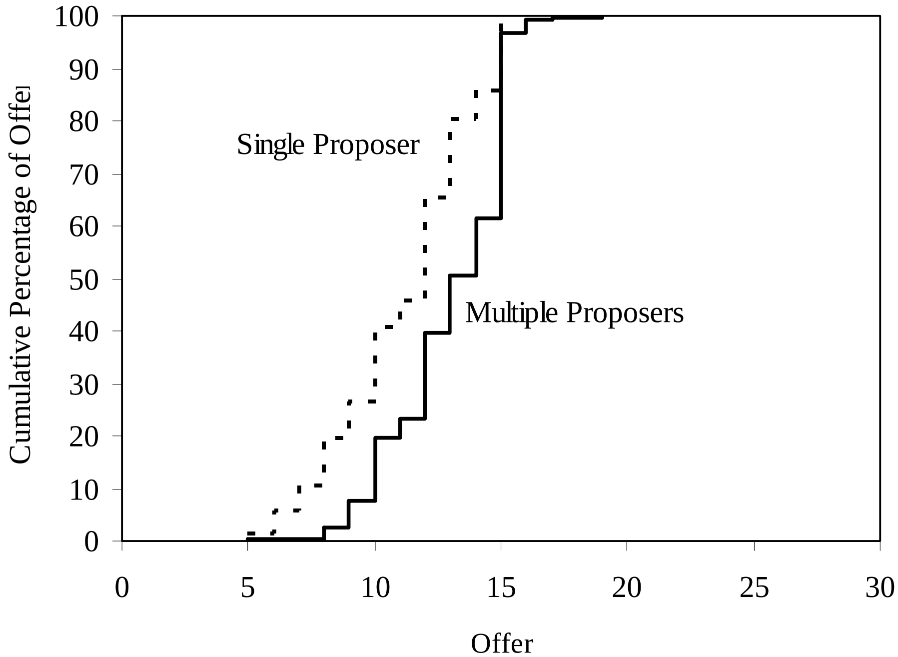


Fig. 2
Cumulative distribution of offer amounts

Panel A: Common Knowledge Condition



Panel B: One-sided uncertainty condition