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## Expectations and Reputations in Bargaining: An Experimental Study

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Abstract

This paper studies the effect of bargainers' subjective beliefs on the outcome of bargaining. In an experimental setting we show that different mutually consistent expectations can be sustained: bargainers who have different expectations obtain different payoffs. This conclusion permits us to provide an explanation for some earlier experimental observations, and suggests some directions in which theoretical work is needed.

# 1. Introduction

One of the tasks of an economic theory of bargaining is to specify those factors which ultimately resolve the indeterminancy inherent in bargaining. That is, even if we expect bargainers to reach an agreement in the region of individually rational, Pareto optimal contracts--which Edgeworth (1881) called the contract curve--it is still necessary to analyze those factors which contribute to the selection of a specific agreement.

The modern literature contains a number of different approaches to this question. In the game-theoretic tradition, these models--both axiomatic and strategic[1]--rest upon the assumption that the outcome of bargaining among rational, fully informed agents is determined by the strategic possibilities available to the bargainers, and their preferences as represented by their von Neumann-Morgenstern utility functions. Indeed, games in which the players have this information are called games of complete information.

A longstanding obstacle to the empirical study of the descriptive power of these models of bargaining has been that proper implementation of the models requires the utility of the bargainers to be known for each potential agreement. An experimental design which permits this problem to be circumvented in a laboratory setting was introduced in Roth and Malouf (1979). Starting with this first experiment, the outcomes of bargaining under controlled conditions were observed to systematically deviate from the predictions of theory. Subsequent experiments were conducted to clarify and identify the nature and causes of these deviations. Together, these experiments indicate that the outcome of bargaining is decisively influenced by factors other than the strategic possibilities and the preferences of the bargainers. The hypothesis examined in this paper is that those missing factors concern the subjective expectations of the bargainers about the behavior of their opponents. By manipulating these expectations we will seek to investigate the hypothesis that distinct, stable, self-fulfilling sets of expectations are compatible with a given bargaining situation as determined by the preferences and strategic possibilities of the bargainers.

The organization of the remainder of this paper will be as follows. Section 2 will review three experiments (Roth and Malouf, 1979; Roth, Malouf and Murnighan, 1981; Roth and Murnighan, 1982) which isolate the cause of the observed deviations from the predictions of classical models, sufficiently so that a specific hypothesis can be proposed to account for these deviations, in Section 3. A new experiment is then proposed in Section 4, designed to test this hypothesis. Section 5 discusses the methods by which this experiment was implemented, Section 6 presents the results, and Section 7 concludes.

## 2. Review of Three Earlier Experiments

In order to test theories which depend on the von Neumann-Morgenstern expected utilities of the players, it is desirable to design experiments which permit the utility functions of the participants to be determined. A class of games which make this possible was introduced in Roth and Malouf (1979).

In each game of that experiment, players bargained over the <u>probability</u> that they would receive a certain monetary prize, possibly a different prize for each player. Specifically, they bargained over how to distribute "lottery tickets" that would determine the probability that each player would win his personal lottery (i.e., a player who received 40 percent of the lottery tickets would have a 40 percent chance of winning his monetary prize and a 60 percent chance of winning nothing). The rules of the game specified which distributions of lottery tickets were allowable. In the event that no agreement was reached in the allotted time, each player received nothing. In other words, a player received his prize only if an agreement was reached on splitting the lottery tickets in an allowable way, and if he won the ensuing lottery. Otherwise he received nothing. We will refer to games of this type, in which each player has only two possible monetary payoffs, as binary lottery games.

To interpret the set of feasible outcomes of a binary lottery game in terms of each player's utility function for money, recall that if we consider each player's utility function to be normalized so that the utility for receiving his prize is 1, and the utility for receiving nothing is 0, then the player's utility for any lottery between two alternatives is the probability of winning the lottery. That is, an agreement which gives a player p percent of the lottery tickets gives him a utility of p. Note that a change in the prizes is therefore equivalent to a change in the scale of the players' utility functions.

The set of feasible utility payoffs available to the players in such a game is equal to the set of allowable divisions of lottery tickets. Thus binary lottery games can be used to experimentally test theories of bargaining which depend on the set of feasible utility payoffs. Note that the set of feasible utility payoffs does not depend on the size of the prizes. Thus a binary lottery game in which the players know the allowable divisions of lottery tickets is a game of complete information, regardless of whether each player also knows the size of the other's prize.

Cooperative games of complete information are customarily modelled by specifying the set of feasible utility payoffs attainable by each non-empty subset of players for its members. Following Nash (1950), two-player bargaining games are modelled by a pair (S,d), where d is a point in the plane, and S is a compact convex subset of the plane which contains d and at least one point x such that $x > d$. The interpretation is that S is the set of feasible expected utility payoffs to the players, any one of which can be achieved if it is agreed to by both players. If no such agreement is reached, then the disagreement point d is the result. Thus in a binary lottery game normalized as above, the set S would be the set of allowable divisions of lottery tickets, while d would be the point (0,0).

Nash proposed that bargaining between rational players be modelled by means of a function called a solution, which selects a feasible outcome for every bargaining game. That is, if we denote the class of all two-player bargaining games by B, a solution is a function $f: B \to R^2$ such that f(S,d) is an element of S. Thus a solution is a model of bargaining which depends only on the information about the underlying game which is contained in the model (S,d).

Nash went on to characterize a particular solution to the bargaining problem, which along with a number of others has subsequently been the object of considerable study (see Roth (1979) for a survey). However, since a solution depends only on the pair (S,d), any solution is a model of bargaining which predicts that the outcome of a binary lottery game should not depend on whether the players know the size of their opponent's monetary prize.

The experiment reported in Roth and Malouf (1979) was designed to test this hypothesis, among others. Participants played binary lottery games under one of two information conditions: full information or partial information. In the full information condition, each player was informed of the value of his own potential prize and of his opponent's potential prize. In the partial information condition, each player was informed only of the value of his own prize.

The outcomes observed in the two information conditions exhibited dramatic differences. The observed outcomes in the partial information condition tended to be extremely close to an equal division of the lottery tickets, while the outcomes observed in the full information condition showed a pronounced shift in the direction of equal expected monetary payoffs. That is, in the full information condition, in games in which the bargainers had unequal prizes, the observed agreements tended to give a higher probability of winning his prize to the player with the smaller prize. Since the set of allowable lottery divisions, and hence the set of feasible utility payoffs, is not affected by the information condition, the observed difference between the two conditions suggests that theories which depend only on the pair (S,d) are insufficiently powerful to capture the complexity of this kind of bargaining.

Of course, there are other classical models of games which can potentially be used to describe a game in greater detail. In particular, the strategic (or normal) form of a game includes not only a description of the set of feasible utility payoffs, but also a description of the strategy choices available to the players, by means of which the feasible utility payoffs can be achieved. In the games described above, the strategy choices concern the formulation of messages and proposals in the course of the negotiations. Since the feasible strategies available to the players depend on the information which they possess, we must consider whether the observed results can be accounted for by the different strategies available to the players in the two information conditions. The experiment discussed next was designed to address this question.

The experiment reported in Roth, Malouf, and Murnighan (1981) involved binary lottery games whose prizes were stated in terms of an intermediate commodity. Each bargainer was told that the prizes would be expressed in "chips" having monetary value, and each player played four games under one of three information conditions: _high information_, _intermediate information_, or _low information_. In each of the three conditions, each player knew the number of chips in his potential prize and their monetary value, but the information each player was given about his opponent's prize varied with the information condition. In the high information condition, each player was informed of both the number of chips in his opponent's potential prize and their monetary value. In the intermediate information condition, each player was informed of the number of chips in his opponent's potential prize, but not of their monetary value. In the low information condition, neither player was informed of either the number of chips in his opponent's potential prize, or of their value. In the latter two conditions, players were prevented from communicating the missing information about the prizes. The games were counterbalanced in the sense that, in two of the games, the player with the higher number of chips also had a higher value per chip (and hence a higher value prize), while in the other two games, the player with the higher number of chips had a lower value per chip and a lower value prize.

The experiment was designed to take advantage of two kinds of strategic equivalence relations. First, binary lottery games whose prizes are expressed in both chips and money, played in the low information condition of this experiment, are strategically equivalent[2] to binary lottery games with the same monetary prizes whose prizes are expressed in money alone, played in the partial information condition of the previous experiment. This follows from the fact that, under the rules of the low and partial information conditions, any message which is legal for one kind of game would be a legal message for the other, and so the strategy sets are the same for both kinds of games, as are the utility functions and the underlying set of alternatives.

Second, games expressed in both chips and money, played under the intermediate information condition of this experiment, are strategically equivalent to games expressed in money alone played under the full information condition of the previous experiments, so long as the monetary values of the two prizes in each money game are in the same proportion as the numbers of chips in the prizes in the corresponding chip game. This follows from the fact that any legal message in one kind of game can be transformed into a legal message in the other kind of game by substituting references to chips for references to money (or vice versa) in any message concerning the value of the prizes.

Thus, if the observed difference between the partial and full information conditions of the previous experiment was due to the different strategy sets available to the players in the two conditions, then a similar difference should be observed between the low and intermediate information condition of this experiment. Specifically, the prediction of the "strategic hypothesis" is that games played in the low information condition will lead to agreements in which the players receive approximately equal probabilities of winning their prizes, while games played in the intermediate information condition will lead to agreements in which the player with the smaller number of chips will receive a significantly higher probability of winning his prize than will his opponent.

Contrary to the expectations of the experimenters, the observed results did not support the strategic hypothesis. The results observed in the low and high information conditions essentially replicated those observed in the partial and full information condition of the previous experiment, but the outcomes observed in the intermediate information condition did not differ significantly from those in the low information condition. That is, in the intermediate information condition, the observed agreements tended to give both players equal probabilities, regardless of the size of their prize in chips. Thus, information about the artificial commodity, chips, did not affect the outcomes in the same way as did strategically equivalent information about money.

Both of the above experiments thus revealed an effect of information which cannot be explained by existing models. A third experiment, reported in Roth and Murnighan (1982), was conducted to separate this effect into components which can be identified as resulting from the possession of specific information by specific individuals, and to assess the extent to which the observed behavior can be characterized as equilibrium behavior.

In the two earlier experiments, it either was the case that neither bargainer knew his opponent's prize, or that both bargainers knew their opponent's prize. The difference between the outcomes in the different information conditions could be an effect which depends on (i) whether the player with the higher prize knows both prizes; (ii) whether the player with the lower prize knows both prizes; or (iii) an interaction which occurs only when both players know both prizes. The third experiment was designed to separate out these possible effects, as well as those effects related to the fact that in the earlier experiments, it was always "common knowledge" whether the bargainers knew one another's prizes.

Information is common knowledge in a game if it is known to all of the players, and if, in addition, every player knows that all the players know, and that every player knows the others know that _he_ knows, and so forth. (The concept of common knowledge is formalized in Lewis (1969), Aumann (1976), and Milgrom (1981).) In general, two bargainers can be thought of as having common knowledge about an event if the event occurs when both of them are present to see it, so that they also see each other seeing it, etc. In these experiments, a set of instructions provides common knowledge to the bargainers if it contains the information that both of them are receiving exactly the same instructions.

Each game of the third experiment was a binary lottery game in which one player had a $20 prize and the other a $5 prize, and in which all possible divisions of lottery tickets were allowed. In each of the eight conditions of the experiment, each player knew at least his own prize. The experiment used a 4 (information) x 2 (common knowledge) factorial design. The information conditions were: (1) Neither knows his opponent's prize; (2) the $20 player knows both prizes, but the $5 player knows only his own prize; (3) the $5 player knows both prizes, but the $20 player knows only his own prize; and (4) Both players know both prizes. The second factor made this information common knowledge for half the bargaining pairs, and not common knowledge for the other half. For instance, when the $20 player is the only one who knows both prizes, then the (common) instructions to both players in the common knowledge condition reveal that the $20 player will know both prizes and that the $5 player will know only his own in the game about to be played. In the non-common knowledge condition, the $20 player still knows both prizes, and the $5 player still knows only his own prize, but each player is told that his prize may or may not be known by his opponent. After each bargaining session, players were assigned new opponents, with the same information, common knowledge, and prize.

The results of this experiment permitted three principal conclusions. First, the effect of information on what agreements are reached is primarily a function of whether the player with the smaller monetary prize knows the prizes. Second, whether this information is common knowledge influences the frequency with which disagreements occur, with more disagreements occurring in the non-common knowledge conditions. Third, in the non-common knowledge conditions, the relationship among the outcomes showed virtually no departure from equilibrium behavior. The fact that the information effect observed in the previous experiments can be observed to be in equilibrium supports the contention that it cannot be attributed simply to irrational behavior.

In summary, the results of these three experiments demonstrate that information about the prizes in binary lottery games influences their outcomes in a way which cannot be accounted for by the classical models of games. The bargaining conducted in the first experiment reviewed above met the assumptions of complete information in both information conditions, since the players always had sufficient information to determine their opponent's expected utility. The results demonstrated that additional information, irrelevant to the task of determining the players' utility fuctions, nevertheless had a decisive effect on the outcome of negotiations. The second experiment showed that this effect cannot be accounted for entirely in terms of the fact that the available negotiation strategies change as the information available to the players changes. Instead, information about a familiar commodity (e.g., money) was shown to have a different effect than information about an artificial commodity, even though the two kinds of information made possible equivalent negotiation strategies. The third experiment separated the effect into component parts, and showed that the frequency of disagreement is sensitive to subtle changes involving what is common knowledge, and that the observed effect is not a disequilibrium phenomena.

### 3. Subjective Beliefs in Bargaining

Taken together, these three experiments permit us to speculate fairly specifically on the cause of the observed information effects. The first experiment demonstrated an effect of information about the monetary prizes which could not be accounted for in terms of the preferences of the players over the set of consequences (lotteries). The second experiment showed that this effect could not be accounted for by the set of available actions (strategies). The third experiment showed that the effect is consistent with rational behavior. So, if we continue to hypothesize that the players are (approximately) Bayesian utility maximizers, it must be that the effect of information is due to a change in the players' subjective beliefs. Thus, for example, information about the monetary prizes, and whether this information is common knowledge, may influence the players' subjective probabilities concerning what agreements are likely to be acceptable to their opponents.

To see how the expectations of the bargainers might influence the outcome of the game, consider the following "thought experiment". A randomly selected individual plays some very large number of games in which he bargains over how to divide a certain sum of money. Although he doesn't know it, all of his opponents are confederates of the experimenter, and they all allow him to obtain, say, 80 percent of the available money. After he has gone through this experience, <u>you</u> have the opportunity of bargaining with him on your own behalf (i.e., not as a confederate). His past success is common knowledge. It will obviously be difficult to bargain with him on an equal basis, since he expects (and has every reason to expect) to receive 80 percent of the available money, and since he expects (and has every reason to expect) that you will concede it to him. Suppose that the rules of the game are that, after completing any negotiations, the players each separately write down their demands. They receive their demands if they are compatible, and otherwise receive nothing. Then, if this is the only time you will be bargaining with him, the fact that this randomly selected individual now expects to get 80 percent will make it very risky for you to write down a demand of more than 20 percent.

In order to make more precise how such subjective expectations enter into the decisions made by bargainers, consider a simple model of bargaining in a two-stage binary lottery game. In the first stage, each individual i makes a demand: i.e., he states the probability $p_i$ (of winning his prize) which he wants and thus he offers $1-p_i$ to his opponent. In the second stage, each bargainer chooses between repeating his demand or accepting his opponent's offer. An agreement occurs whenever the probabilities demanded do not add up to more than 1. No messages can be exchanged.

If in the first stage the two bargainers' demands add up to no more than 1, an agreement is reached at which each bargainer i wins his prize with probability $p_i$. However, if the probabilities in the first stage add up to more than 1, the outcome of the game will depend upon the players' decisions in the second stage. Should each choose to repeat his demand, a disagreement will result and each will have a zero probability of winning his prize. On the other hand if player i repeats his demand $p_i$ and player j accepts his opponent's offer, there will be an agreement on i's terms, that is: i will win his prize with probability $p_i$ and j will win his prize with probability $(1-p_i)$. The final possibility is for both i and j to accept the other's offer. In that case i will win his prize with probability $(1-p_j)$ and j will win his prize with probability $(1-p_i)$.

Having both stated their demands in the first stage, each bargainer is faced in the second stage with the problem of deciding whether to repeat his demand or to accept the other's offer. His expectations as to his opponent's behavior obviously play a crucial role. The hypothesis which the experiment described in the next section is designed to test is that the expectations of the bargainers can be manipulated independently of the strategic possibilities and feasible outcomes of the bargaining situation. This is at odds with the traditional view, which is perhaps most explicitly stated by Harsanyi (1977), who considers two stage bargaining games of essentially this form.

Consider the problem facing the bargainers at the second stage of the proposed two-stage binary lottery game, after players 1 and 2 have made incompatible demands $p_1$ and $p_2$, respectively. Let $q_i$ $(i=1,2)$ be the subjective probability of player i that his opponent (player j) will repeat his demand $p_j$, rather than accepting $p_i$. Then if player i elects to repeat his own demand, he is faced with a compound lottery whose utility is $q_i(0) + (1-q_i)p_i$. However, if he elects to accept his opponent's offer, he receives $1-p_j$ for certain. So if player i is a utility maximizer, he repeats his demand $p_i$ in the second stage whenever

$(1-q_i)p_i > 1-p_j$, and accepts his opponent's offer $1-p_j$ when the inequality is reversed.[3]

Consider the maximum subjective probability $q_i$ for which player i is prepared to risk a disagreement by repeating his own demand. Following Harsanyi, we denote this maximum probability by $r_i$ and call it player i's <u>risk limit</u>. It is easily verified that

$$r_i = \frac{p_i + p_j - 1}{p_i}$$

(Note that, since $p_i$ and $p_j$ are incompatible, $r_i \geq 0$, and $r_i \leq 1$ since $p_j \leq 1$). If player i is a utility maximizer, then he repeats his demand $p_i$ in the second stage if his subjective probability $q_i$ that his opponent will do likewise is less than $r_i$, while if $q_i$ is greater than $r_i$, he accepts his opponent's offer.

So far we have said nothing about how players might form their subjective probabilities. However, implicitly in the classical models of bargaining, and explicitly in Harsanyi's (1977) treatment (following Zeuthen, 1930) of Nash's solution is the assumption that the subjective probabilities $q_i$ and $q_j$ of rational players are determined from the data of the game. Specifically, the assumption which leads to Nash's solution as an equilibrium of the game[4] is that if $r_i < r_j$, then $q_i = 0$ and $q_j = 1$ so that only the player with the lower risk limit concedes. This is an equilibrium at which the players' expectations are fulfilled: i.e., the subjective probabilities by which the players estimate their opponent's behavior turn out to be correct descriptions of that behavior.

In contrast, the hypothesis which the experiment proposed next seeks to explore is that the anomalous results observed in the previous experiments are due to changes in the subjective expectations of the players. We propose to investigate whether the subjective probabilities $q_i$ of the bargainers can be manipulated to produce different stable, fulfilled-expectation equilibria.

## 4. The New Experiment

The agreements observed in the previous experiments tended to cluster around two divisions of the lottery tickets: one kind of agreement split the lottery tickets equally between the bargainers, the other kind of agreement gave the bargainers equal expected monetary payoffs (this bimodal behavior was most pronounced in Roth & Murnighan, 1982). This experiment investigates whether, by manipulating the expectations of the bargainers, one or the other of these two kinds of agreements can be obtained as a stable equilibrium.

In this experiment, each player played 25 identical two-stage binary lottery games, of the kind discussed in the previous section. Although players were told that they bargained with another individual in each game, each individual in fact played against a programmed opponent (the computer) in the first 15 games, as in the thought experiment. Half of the participants had a prize of $40.00 and half a prize of $10.00; players whose prize was $40.00 always bargained against players whose prize was $10.00 (each player had the same prize in all of the 25 games). The subjects were divided into three experimental conditions. The first was a "20-80" condition in which the computer was programmed in a manner described below, to promote a 20-80 division of the lottery tickets, which yields equal expected monetary payoffs. The second was a "50-50" condition in which subjects bargained with a computer programmed (see below) to promote the equal division of lottery tickets. The third condition was the control: subjects never bargained with the computer but always with other members of that group.

In trials 16 to 25, subjects in each group bargained with other members of that group. Each game was played with a different, anonymous, opponent. Bargainers also received some additional information, about their opponent's "reputation" as established in trials 11 through 15. They were told what their opponent's first demand was, whether he repeated it or accepted his opponent's offer and finally which agreement, if any, was reached in each of the trials 11 to 15, i.e., in the final five games played against the computer. In trials 16 to 25, every bargainers' experience against the programmed opponents was made common knowledge in this way, as in the thought experiment. (Until the conclusion of trial 15, bargainers were not aware that their reputation, as established in trials 11 through 15, would play any role in subsequent encounters.)[5]

In what follows, we describe how the programmed opponents were designed.

In the 20-80 condition, the agent whose prize was $40.00 bargained with a computer programmed to do the following: it randomly selected a first demand between 75 percent and 80 percent, and in the second stage it always repeated its demand. The programmed opponent of the $10.00 player, randomly selected a demand between 20 and 25 percent; in the second stage it accepted any offer giving it at least 20 percent of the lottery tickets.

In the 50-50 condition, the programmed opponent of the $40.00 player randomly selected a first demand between 70 and 75 percent of the lottery tickets and in the second stage accepted any offer giving it at least

50 percent. The $10.00 player bargained with a computer that randomly selected a first demand between 45 and 50 percent of the lottery tickets and in the second stage always repeated its demand.

In summary in both the 20-80 condition and the 50-50 condition, half of the bargainers observed that their opponents (they did not know that they were bargaining with a computer) essentially always gave in and the other half observed that their opponents never did.

As mentioned above, in the control condition, each $40.00 player bargained with a $10.00 player from the beginning; bargainers never played against the computer. At game 16, reputations were introduced and $40.00 players bargained with $10.00 players in every condition.

Note that two elements influence the expectations of a pair of bargainers: their experiences and their reputations. Consider a typical pair in the 20-80 condition, at trial 16. The $40.00 player has never obtained from the computer an agreement in which he received more than 25 percent of the lottery tickets. He knows that his opponent is aware of his reputation as established in games 11 to 15. So a $10.00 player, whose own experience has led him to expect that his opponent will capitulate to a demand for equal expected monetary payoffs, has his expectations reinforced when he confronts a $40.00 player whose reputation indicates that he has, in the past, given in to such demands. Similarly a $40.00 player, whose experience is that opponents are adamant about an equal division of expected monetary payoffs, will have his expectations confirmed by a reputation indicating that his current opponent has previously behaved in this way.

The experiment is designed to permit us to distingish between two competing hypotheses. The classical game-theoretic hypothesis, which states that the outcome of a game can be predicted from the set of feasible utility payoffs and strategic possibilities, implies that, in this experiment, the different experimental conditions should have no continuing effect. Since the games in all three conditions are identical, the prediction of the classical hypothesis is that, starting when the players are matched against one another in trial 16, the three conditions should not result in significantly different outcomes. Specifically, if this is correct, we would expect to observe that, starting with trial 16, any differences between the two experimental conditions and the control condition would begin to disappear and the outcomes in the three conditions should converge over time, as continued play removes any transient effects due to the initial experience of players in the 20-80 and 50-50 conditions.

If, on the other hand, the expectations of the players have a critical role in determining the outcome, as suggested indirectly by the earlier experiments, then we should expect to see divergent outcomes, established in the first 15 trials, persist in a stable fashion in each of the three conditions.

Specifically, we would expect that the first condition's mean agreement will be near 20-80 and the second condition's will be near 50-50. The control condition's mean agreement would be somewhere between these two. This would be consistent with the hypothesis that the expectations of the players were the uncontrolled factor that accounts for the results observed in the previous experiments.

## 5. Method

Each participant was seated at a visually isolated terminal of a computer-assisted instruction system developed at the University of Illinois, called PLATO, whose features include advanced graphic displays and interactive capability. The experiment was conducted in a room containing over 70 terminals, 30 of which were occupied by participants in the experiment, with the rest occupied by participants in other experiments. Participants were seated by the experimenter in order of their arrival at scattered terminals throughout the room, and for the remainder of the experiment they received all of their instructions, and conducted all communication, through the terminal. There were 10 participants in each of the three conditions, which were conducted simultaneously.

The subjects were drawn from undergraduate classes in the College of Commerce of the University of Illinois. Pretests were run with the same subject pool to make sure that the instructions to participants were clear and easily understandable.

Background information including a brief review of probability theory was presented first. The main tools of the bargaining were then introduced. A demand $p_i$ was a number which was the sender's probability of winning his prize; $1-p_i$ was the probability offered to one's opponent. As in the previous experiments, probabilities were presented in terms of the division of lottery tickets. PLATO computed the expected monetary value of each demand and associated offer for both bargainers. After being made aware of these computations, a bargainer was given the option of cancelling his demand before its transmittal. As soon as both demands were transmitted, the second stage of the bargaining would begin. PLATO computed the expected monetary value of both demands for both bargainers. In the second stage, each player had the choice of repeating his own demand or accepting his opponent's offer. When both decisions were made, the bargainers were informed of the outcome.[6] Participants were told that they bargained with a different individual in each game. In both stages, the bargainers were not informed of their opponent's decision until their own decision had been transmitted.

To verify their understanding of the basic notions, the subjects were given some drills followed by a simulated bargaining session with the computer. As soon as all the participants finished reading the instructions the experiment began.

The bargainers in the 20-80 and 50-50 condition were paired with the appropriate programmed opponent for the first 15 trials. The instructions of course led them to believe they were bargaining with other individuals. The members of the control group were paired with other members of the control group.

After completing trial 15, new instructions appeared on the screen and introduced the notion of reputation. Note again that as a bargainer was establishing his reputation, in trials 11 to 15, he did not know he was doing so. Trial 16 began with each bargainer having displayed on his screen both his own reputation and his opponent's. In trials 16 to 25, in all three conditions, $40.00 players were paired with $10.00 players. Since each group was composed of 10 individuals, the pairing was such that each $40.00 player bargained twice with each $10.00 player.

After the 25th game was completed, the monetary payoffs were computed as described in the initial instructions: for each bargainer, one of games 1 to 25 was randomly selected; the lottery corresponding to that game was then conducted with the specified prizes--$0 or $40.00 for the high-prize player; $0 or $10.00 for the low-prize player--and the probabilities agreed upon in that randomly selected game. The players were directed to the monitor who paid them.

## 6. Results

Figure 1 shows the mean agreements, by trial, for each of the three conditions for the $40 player. The figure makes clear that the agreements reached in the three conditions are markedly different from one another.

Preliminary analyses yielded no significant effects for trials for the total set of bargaining outcomes and for the set that excluded disagreements. Thus, the remaining analyses pooled over the 10 bargaining sessions.

Analyses of variance for players (high prize vs. low prize) and condition (20-80, 50-50, and control) were conducted for the outcomes over all negotiations (including disagreements), for the outcomes excluding disagreements, and for the first and second offers made by the players. All of the findings were very similar: significant effects for condition and for the interaction between players and reputation (F-ratio's in each case exceeded 16, with $p < .001$ in each case). The means for the outcomes are shown in Tables 1 and 2. The results of post hoc tests on the significant interactions are also shown in the tables, indicating that, in each case, the outcomes of players in the 20-80 condition were significantly different from 50-50's and control's and that the agreements reached by the controls (with disagreements

Figure 1: Average percentage of lottery tickets obtained by the $40.00 player when an agreement was reached. Trials 16 to 25.

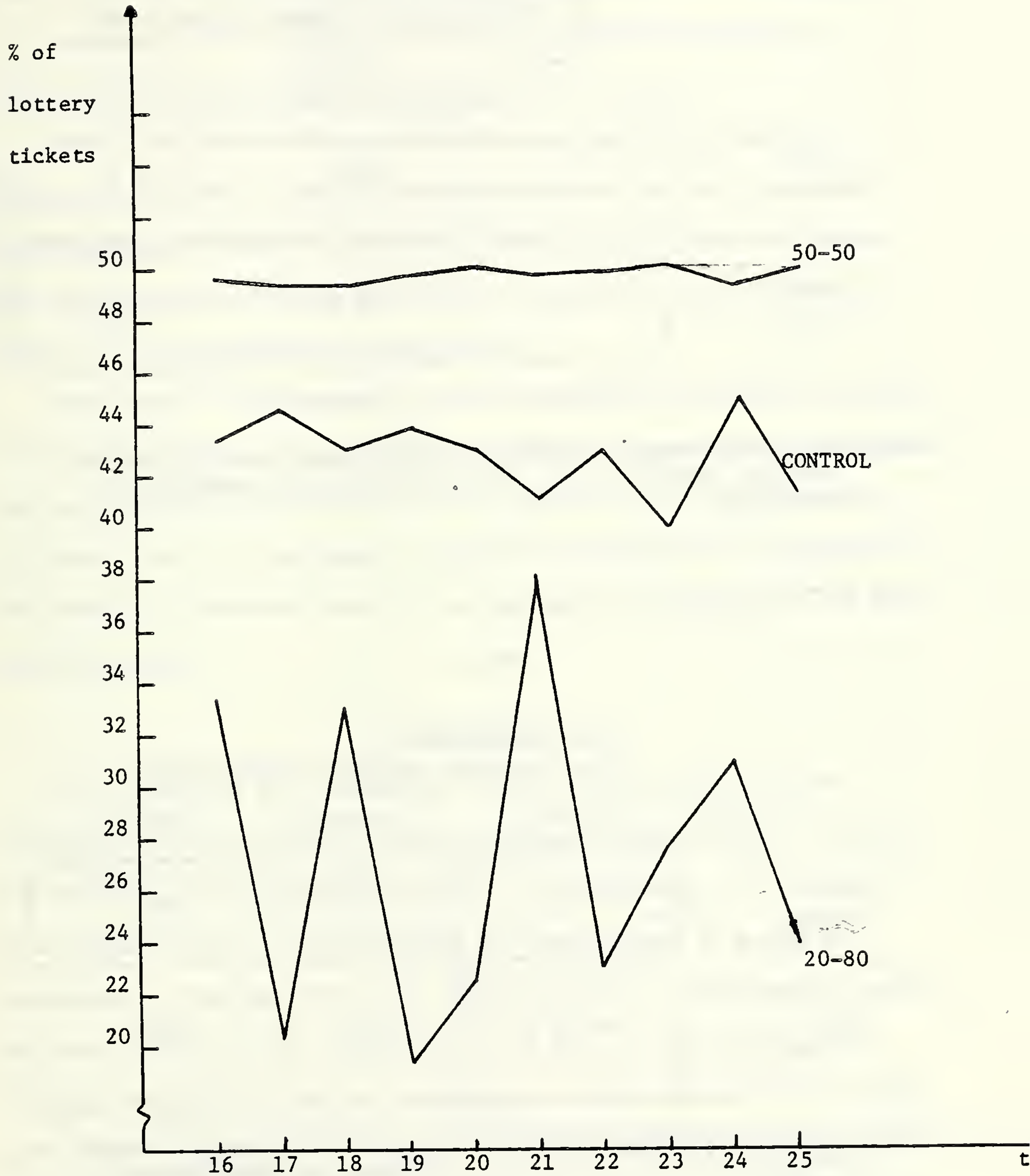

Table 1

Mean Outcomes
All Negotiations Included (trials 16-25)

| | 20-80 | Control | 50-50 | |
|---|---|---|---|---|
| $40 Player | $22.4_c$ | $30.2_{bc}$ | $40.8_b$ | 31.1 |
| $10 Player | $57.0_a$ | $39.0_b$ | $41.1_b$ | 45.7 |
| | 39.7 | 34.6 | 40.9 | |

Note: Cells with common subscripts are <u>not</u> significantly different from one another at the .05 level using the Newman-Keuels procedure.

Table 2

Mean Agreements
Disagreements Excluded (trials 16-25)

| | 20-80 | Control | 50-50 |
|---|---|---|---|
| $40 Player | $27.3_e$ | $43.2_d$ | $49.7_c$ |
| $10 Player | $69.5_a$ | $55.7_b$ | $50.2_c$ |

Note: Cells with common subscripts are <u>not</u> significantly different from one another at the .05 level using the Newman-Keuels procedure.

excluded) were between those of the other two conditions. The compelling nature of a 50-50 agreement in the 50-50 condition is highlighted by the extremely low variance in the 50-50 condition (see Table 3, which lists all of the final outcomes).

The offers made by the players showed a similar pattern, with the players in the 20-80 condition demanding the most on the first round, and conceding the most on the second. Generally, the offers reflected the reputations established (see Table 4): in the control condition, most of the offers centered around 50-50.

There were 9 disagreements in each of the 50-50 and 80-20 conditions, and 15 disagreements in the control condition. Although these frequencies are not significantly different from one another ($\chi^2(2) = 2.18$), they do suggest that the experimental conditions contributed to a reduction in the number of disagreements and to an increase in efficiency of the bargaining process.

## 7. Discussion

The results of this experiment provide strong support for the hypothesis that the outcome of the bargaining is influenced not only by the preferences and strategic options of the bargainers, but also by their expectations. By manipulating the expectations of groups of bargainers in this experiment, it proved possible to consistently produce outcomes which differed significantly from those observed when the players' expectations were not manipulated. Furthermore, the fact that there was no significant difference over trials indicates that these expectations were self-reinforcing, so that the outcomes which resulted in the experimental conditions were stable and self-sustaining. Players who expected their opponents to expect equal monetary payoffs (or an equal division of lottery tickets) continued to meet such opponents, and to consequently reinforce those expectations.[7]

These results also lend support to the hypothesis put forward in the first paragraph of section 3 to explain the results of the previous experiments. Of course, since those experiments involved no artificial manipulation of the bargainers' expectations, it must be that the (common) expectations which bargainers formed when different kinds of information were available resulted in large measure from their previous experience. This suggests that there must be many kinds of potential conflict in which individuals have common expectations which permit them to efficiently reach agreement. The benefits to a society of fostering such common expectations are obvious, since otherwise many bargaining situations would end in disagreement.

The data from the present experiment suggest that individuals entered the experiment with more or less mutually consistent prior expectations about what kinds of agreements would result, and that they updated these expectations in response to their experience in the experiment. These prior expectations, as reflected in the control condition, yielded outcomes closer to 50-50 than to 20-80. It is perhaps for this reason that the outcomes in the 50-50 condition showed so much smaller variance than those in the 20-80 condition.

These results have several implications for the development of the theory of bargaining. The most striking of these is that it may be necessary to incorporate the expectations of the bargainers into any description (or definition) of equilibrium outcomes, and that there may in general be multiple equilibria supported by different sets of mutually consistent expectations. Some models consistent with this suggestion have already been explored, and the notion that agents' beliefs play a role in determining outcomes is not a new one.[8] However, the results of this experiment suggest that, because of the role which agents' beliefs play in determining the outcome of bargaining, it may be necessary to look to "culture-dependent" models, in which at least some elements of the players expectations will be empirically determined exogenous variables.

Table 3: Data

| Trial | Control Outcome | Control Player # ($40-$10) | 50-50 Outcome | 50-50 Player # ($40-$10) | 20-80 Outcome | 20-80 Player # ($40-$10) |
|---|---|---|---|---|---|---|
| 16 | 44-52 | 1-6 | 0-0 | 1-10 | 20-80 | 1-10 |
| | 45-55 | 3-8 | 50-50 | 3-2 | 50-50 | 3-2 |
| | 0-0 | 5-10 | 0-0 | 5-4 | 0-0 | 5-4 |
| | 0-0 | 7-2 | 50-50 | 7-6 | 25-75 | 7-6 |
| | 42-58 | 9-4 | 49-51 | 9-8 | 0-0 | 9-8 |
| 17 | 47-53 | 1-10 | 50-50 | 1-8 | 22-62 | 1-2 |
| | 50-50 | 3-2 | 53-47 | 3-10 | 35-50 | 3-4 |
| | 45-50 | 5-4 | 0-0 | 5-2 | 30-70 | 5-6 |
| | 40-60 | 7-6 | 50-50 | 7-4 | 25-60 | 7-8 |
| | 40-60 | 9-8 | 45-51 | 9-6 | 20-80 | 9-10 |
| 18 | 50-50 | 1-2 | 50-50 | 1-6 | 20-79 | 1-8 |
| | 45-55 | 3-4 | 0-0 | 3-8 | 0-0 | 3-10 |
| | 0-0 | 5-6 | 50-50 | 5-10 | 30-70 | 5-2 |
| | 40-60 | 7-8 | 50-50 | 7-2 | 50-50 | 7-4 |
| | 37-63 | 9-10 | 48-52 | 9-4 | 25-70 | 9-6 |
| 19 | 45-53 | 1-4 | 0-0 | 1-4 | 20-80 | 1-6 |
| | 50-50 | 3-6 | 50-50 | 3-6 | 0-0 | 3-8 |
| | 0-0 | 5-8 | 50-50 | 5-8 | 12-88 | 5-10 |
| | 35-65 | 7-10 | 50-50 | 7-10 | 21-79 | 7-2 |
| | 46-50 | 9-2 | 49-51 | 9-2 | 25-70 | 9-4 |
| 20 | 41-59 | 1-4 | 50-50 | 1-10 | 22-65 | 1-4 |
| | 50-50 | 3-6 | 50-50 | 3-2 | 25-50 | 3-6 |
| | 35-65 | 5-8 | 50-50 | 5-4 | 25-70 | 5-8 |
| | 0-0 | 7-10 | 50-50 | 7-6 | 21-79 | 7-10 |
| | 46-50 | 9-2 | 0-0 | 9-8 | 20-80 | 9-2 |
| 21 | 34-66 | 1-10 | 50-50 | 1-2 | 20-80 | 1-6 |
| | 50-50 | 3-2 | 0-0 | 3-4 | 50-50 | 3-8 |
| | 0-0 | 5-4 | 50-50 | 5-6 | 0-0 | 5-10 |
| | 45-50 | 7-6 | 50-50 | 7-8 | 50-50 | 7-2 |
| | 35-65 | 9-8 | 49-51 | 9-10 | 32-65 | 9-4 |
| 22 | 50-50 | 1-2 | 50-50 | 1-6 | 0-0 | 1-10 |
| | 45-55 | 3-4 | 50-50 | 3-8 | 11-89 | 3-2 |
| | 0-0 | 5-6 | 50-50 | 5-10 | 33-66 | 5-4 |
| | 0-0 | 7-8 | 50-50 | 7-2 | 0-0 | 7-6 |
| | 34-66 | 9-10 | 49-51 | 9-4 | 25-65 | 9-8 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 23 | 40-55 | 1-6 | 50-50 | 1-4 | 21-78 | 1-2 |
| | 0-0 | 3-8 | 0-0 | 3-6 | 35-50 | 3-4 |
| | 0-0 | 5-10 | 50-50 | 5-8 | 30-70 | 5-6 |
| | 0-0 | 7-2 | 50-50 | 7-10 | 25-75 | 7-8 |
| | 0-0 | 9-4 | 50-50 | 9-2 | 0-0 | 9-10 |
| 24 | 0-0 | 1-8 | 0-0 | 1-8 | 20-80 | 1-8 |
| | 45-55 | 3-10 | 50-50 | 3-10 | 0-0 | 3-10 |
| | 50-50 | 5-2 | 50-50 | 5-2 | 24-76 | 5-2 |
| | 45-55 | 7-4 | 50-50 | 7-4 | 50-50 | 7-4 |
| | 41-58 | 9-6 | 47-53 | 9-6 | 30-70 | 9-6 |
| 25 | 50-50 | 1-2 | 50-50 | 1-2 | 20-80 | 1-10 |
| | 0-0 | 3-4 | 50-50 | 3-4 | 20-80 | 3-2 |
| | 40-60 | 5-6 | 50-50 | 5-6 | 30-70 | 5-4 |
| | 0-0 | 7-8 | 50-50 | 7-8 | 25-75 | 7-6 |
| | 34-66 | 9-10 | 49-50 | 9-10 | 25-75 | 9-8 |

For each condition, for each trial, each line gives the outcomes for the player (with the $40 player's outcome first) and the players' number. Notice that odd numbered players are the $40 ones. For example the first line in the control condition reads: ($40) player 1 bargained with ($10) player 6 and the outcome was 44% of the lottery tickets for 1 and 52% of the lottery tickets for player 6.

Table 4: Reputation

(Odd numbered players had a $40 prize, even numbered players had a $10 prize)

| Player # | Trial | Control First Demand | Control Second Demand | Control Outcome | 50-50 First Demand | 50-50 Second Demand | 50-50 Outcome | 20-80 First Demand | 20-80 Second Demand | 20-80 Outcome |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11 | 62 | 35 | 35 | 50 | 50 | 50 | 20 | 20 | 20 |
| | 12 | 55 | 55 | 55 | 51 | 51 | 0 | 20 | 20 | 20 |
| | 13 | 55 | 51 | 51 | 50 | 50 | 50 | 23 | 20 | 20 |
| | 14 | 47 | 47 | 0 | 51 | 51 | 0 | 23 | 20 | 20 |
| | 15 | 55 | 35 | 35 | 50 | 50 | 50 | 23 | 20 | 20 |
| 2 | 11 | 49 | 49 | 49 | 35 | 51 | 51 | 84 | 79 | 79 |
| | 12 | 49 | 49 | 49 | 55 | 52 | 52 | 77 | 77 | 77 |
| | 13 | 49 | 49 | 49 | 55 | 52 | 52 | 86 | 78 | 78 |
| | 14 | 49 | 49 | 49 | 55 | 50 | 50 | 92 | 79 | 79 |
| | 15 | 55 | 50 | 50 | 55 | 53 | 53 | 80 | 80 | 80 |
| 3 | 11 | 50 | 50 | 50 | 50 | 50 | 50 | 70 | 21 | 21 |
| | 12 | 50 | 50 | 0 | 55 | 55 | 0 | 80 | 24 | 24 |
| | 13 | 50 | 50 | 50 | 50 | 50 | 50 | 100 | 20 | 20 |
| | 14 | 50 | 40 | 40 | 51 | 51 | 0 | 50 | 25 | 25 |
| | 15 | 50 | 50 | 50 | 50 | 50 | 50 | 65 | 21 | 21 |
| 4 | 11 | 68 | 68 | 68 | 55 | 51 | 51 | 80 | 79 | 79 |
| | 12 | 62 | 62 | 62 | 55 | 51 | 51 | 65 | 65 | 65 |
| | 13 | 85 | 50 | 50 | 80 | 52 | 52 | 100 | 75 | 75 |
| | 14 | 65 | 65 | 0 | 80 | 80 | 0 | 100 | 78 | 78 |
| | 15 | 56 | 56 | 50 | 80 | 52 | 52 | 100 | 79 | 79 |
| 5 | 11 | 51 | 32 | 32 | 55 | 55 | 0 | 29 | 29 | 0 |
| | 12 | 51 | 51 | 0 | 50 | 50 | 50 | 70 | 70 | 0 |
| | 13 | 51 | 51 | 0 | 72 | 27 | 27 | 40 | 40 | 0 |
| | 14 | 50 | 40 | 40 | 60 | 29 | 29 | 35 | 35 | 0 |
| | 15 | 50 | 45 | 45 | 50 | 50 | 50 | 46 | 20 | 20 |
| 6 | 11 | 75 | 75 | 0 | 54 | 53 | 53 | 82 | 82 | 0 |
| | 12 | 75 | 45 | 45 | 53 | 53 | 0 | 80 | 80 | 80 |
| | 13 | 75 | 75 | 0 | 52 | 52 | 52 | 80 | 80 | 80 |
| | 14 | 60 | 50 | 50 | 65 | 52 | 52 | 80 | 80 | 80 |
| | 15 | 60 | 56 | 56 | 59 | 52 | 52 | 80 | 80 | 80 |
| 7 | 11 | 90 | 90 | 0 | 50 | 50 | 50 | 27 | 20 | 20 |
| | 12 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 23 | 23 |
| | 13 | 55 | 40 | 40 | 51 | 51 | 0 | 27 | 20 | 20 |
| | 14 | 75 | 75 | 0 | 50 | 50 | 50 | 26 | 22 | 22 |
| | 15 | 55 | 44 | 44 | 50 | 50 | 50 | 30 | 20 | 20 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | 11 | 65 | 65 | 0 | 51 | 51 | 51 | 85 | 78 | 78 |
| | 12 | 60 | 60 | 0 | 51 | 51 | 51 | 80 | 74 | 74 |
| | 13 | 60 | 60 | 60 | 49 | 49 | 49 | 90 | 78 | 78 |
| | 14 | 60 | 60 | 60 | 50 | 50 | 50 | 80 | 80 | 80 |
| | 15 | 65 | 65 | 65 | 51 | 51 | 0 | 80 | 79 | 79 |
| [illegible] | 11 | 45 | 45 | 0 | 52 | 52 | 0 | 30 | 20 | 20 |
| | 12 | 44 | 38 | 38 | 47 | 28 | 28 | 35 | 20 | 20 |
| | 13 | 43 | 43 | 0 | 49 | 49 | 49 | 35 | 24 | 24 |
| | 14 | 50 | 50 | 50 | 49 | 49 | 49 | 55 | 20 | 20 |
| | 15 | 44 | 40 | 40 | 49 | 49 | 49 | 33 | 20 | 20 |
| [illegible] | 11 | 65 | 65 | 65 | 54 | 53 | 53 | 82 | 82 | 0 |
| | 12 | 70 | 70 | 0 | 54 | 52 | 52 | 80 | 80 | 80 |
| | 13 | 76 | 76 | 0 | 52 | 52 | 52 | 80 | 80 | 80 |
| | 14 | 66 | 66 | 0 | 53 | 53 | 53 | 81 | 81 | 0 |
| | 15 | 69 | 50 | 50 | 54 | 51 | 51 | 80 | 80 | 80 |

FOOTNOTES

1. For a review of the literature on axiomatic models, see Roth (1979). For some illuminating recent results using strategic models, see Rubinstein (1982) and McLennan (1981).

2. When we say that two games are strategically equivalent, we essentially mean that they can both be represented by the same game in strategic form. Thus, any theory of games which depends only on the strategic form of a game yields the same prediction for strategically equivalent games. This is discussed at greater length in Roth, Malouf and Murnighan (1981).

3. Utility maximization alone does not determine what action a player takes in the case of equality.

4. See Harsanyi (1977) for a full treatment.

5. Consequently, reputation in this experiment serves only as an indicator of a player's past bargaining experience (in periods 11-15). This is in contrast with some models in the literature in which the players know in advance that they are building up a reputation. For example, Rosenthal (1979), and Rosenthal and Landau (1979) consider repeated games with complete information in which players can strategically build and maintain reputations in the course of play, in order to influence future encounters. Kreps and Wilson (1981b), Milgrom and Roberts (1980), and Kreps, Milgrom, Roberts, and Wilson (1981) consider games of incomplete information in which players may seek to play in early encounters in such a way as to build a reputation which will mislead future opponents about their true utility function. However, in the games played in this experiment, the fact that players are not aware that they are building a reputation in periods 11-15, and that they cannot subsequently alter the reputation established in those periods, removes any possibility that an incentive to alter his reputation can influence a player's bargaining behavior.

6. There was a time limit of two minutes for the first stage and one minute for the second stage.

7. The experimental conditions can be interpreted as having changed the <u>strategic risk posture</u> of the players, as measured by the certain payoff which they would regard as equivalent to the (risky) opportunity to engage in the bargaining. The notion of strategic risk posture (introduced in Roth (1977a, 1977b) and studied in the context of bargaining games in Roth (1978, 1979)) plays a role parallel to ordinary risk posture in determining an individual's utility for engaging in a game.

8. An interesting paper in which a general definition of equilibrium in games is proposed which explicitly involves certain beliefs of the players is Kreps and Wilson (1981a).

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