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INFORMATION AND ASPIRATIONS IN TWO PERSON BARGAINING*

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Abstract: This paper considers the results of a series of two-person bargaining experiments, and identifies some anomalous effects which cannot be accounted for via conventional game theoretic variables. We consider some previously unanalyzed data which lends strong support to the hypothesis that some of this anomalous behavior can be explained by changes in the aspirations (as distinct from the expectations) of the players.

Each of the experiments in this series utilized an experimental design which permits the expected utility of each bargainer for each potential outcome to be determined. The first experiment in the series (Roth and Malouf, 1979) showed that bargaining theories which depend exclusively on the feasible utility payoffs to the bargainers are insufficiently powerful to explain the observed phenomena. In that experiment, a manipulation of information, which did not alter the set of feasible utility payoffs, nevertheless had a dramatic impact on the outcome of bargaining. The second experiment in the series (Roth, Malouf, and Murnighan, 1981) was designed to investigate the hypothesis that the effects observed in the first experiment could be explained by the different strategies available to the bargainers in the different information conditions. A design built around strategically equivalent games allowed this hypothesis to be rejected. The experiment of Roth and Schoumaker (1983) provides support for the hypothesis that the observed information effect can largely be explained by the influence of certain information on each bargainer's expectations concerning his opponent's behavior. However the experiment of Roth and Murnighan (1982), which was designed to explore the component causes of the observed information effect, also revealed some phenomena which cannot be fully explained by the expectations of the bargainers. The present paper considers data drawn from the beginning of the bargaining process which supports the hypothesis that these unexplained phenomena can be explained by the influence of certain kinds of information on the aspirations of the bargainers.

A fundamental assumption in much of game theory and economics is that the structural description of a game and the (possibly cardinal) utility functions of the players together constitute all the relevant information needed to determine rational play. Games in which the players possess this information are called games of complete information. Recent research suggests, however, that information absent from the classical models of games can systematically influence outcomes, even in games of complete information. This paper summarizes this research and examines the bargaining process to explore the causes of some of these findings. While the studies reviewed here have provided explanations for most of the observed bargaining behavior, one aspect

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of the experiment reported in Roth and Murnighan (1982) cannot be adequately understood until the concept of aspirations is introduced. In particular, one of the experimental manipulations in that study can be interpreted as altering the aspirations of the players. This paper will present an analysis of the initial stages of the negotiations which supports this interpretation and which provides an explanation for observed non-equilibrium behavior.

Experimental Results. To test theories that depend on the von Neumann-Morgenstern (1944) expected utilities of the players, experiments must permit the utility functions of the participants to be determined. A class of games that makes this possible was introduced in Roth and Malouf (1979).

In each game of that experiment, players bargained over the probability that they would receive a certain monetary prize, possibly a different prize for each player. Specifically, they bargained over how to distribute "lottery tickets" to determine the probability that each player would win his personal lottery (i.e., a player who received 35 percent of the lottery tickets would have a 35 percent chance of winning his monetary prize and a 65 percent chance of winning nothing). If no agreement was reached in the allotted time, each player received nothing. A player received his prize only if an allowable agreement was reached on splitting the lottery tickets and he won the ensuing lottery. Otherwise he received nothing. We will call games of this type binary lottery games.

To interpret the feasible outcomes of a binary lottery game in terms of each player's utility for money, note that if each player's utility function is normalized so that the utility for receiving his prize is 1, and the utility for receiving nothing is 0, then his utility for any lottery between these two alternatives is the probability, p, of winning the lottery; i.e., an agreement giving a player p percent of the lottery tickets gives him a utility of p. A change in the prizes is therefore equivalent to a change in the scale of the players' utility functions.

Since the set of feasible utility payoffs to the players equals the set of allowable divisions of lottery tickets, binary lottery games can be used to experimentally test theories 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 if the players know the allowable divisions of lottery tickets, the game is one of complete information, regardless of whether each player also knows the size of the other's prize.

having monetary value; each played four games under either high, intermediate, or low information conditions. In each condition, each player knew the number of chips in his own prize and their monetary value, but each player's information about his opponent's prize varied with the condition. In the high information condition, players knew both the number of chips in their opponent's prize and their monetary value. In the intermediate information condition, players only knew the number of chips in their opponent's prize. In the low information condition, players knew neither the number of chips in their opponent's prize nor 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 took advantage of two kinds of strategic equivalence relations. First, binary lottery games whose prizes are expressed in both chips and money are strategically equivalent in the low information condition to binary lottery games with the same monetary prizes whose prizes are expressed in money alone in the partial information condition of the previous experiment. Any legal message in one kind of game would be legal in the other: the strategy sets are the same, as are the utility functions and the underlying set of alternatives.

Second, the intermediate information condition is strategicially equivalent to the full information condition of the previous experiment, if the values of the prizes in each money game are in the same proportion as the number of chips in the prizes in the corresponding chip game. Again, 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). 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, then a similar difference should have been observed between the low and intermediate information conditions in the Roth, Malouf, and Murnighan study. The "strategic hypothesis" predicts that games in the low information condition should lead to agreements in which the players receive approximately equal probabilities of winning their prizes, while games in the intermediate information condition should lead to agreements giving the player with the smaller number of chips a significantly higher probability than his opponent of winning his prize.

Alternatively, the previous results may be due to social conventions among the bargainers, rather than to changes in their strategy sets. In conflicts involving a wide range of potential agreements, social conventions may serve to make some agreements and demands more credible than others. In particular, information about the monetary value of the prizes gives the low prize player the ability to argue for equal expected payoffs.

By "social conventions," we mean customs or beliefs commonly shared in a particular society. To be commonly shared, such conventions must concern familiar quantities. By stating the prizes in terms of a neutral commodity ("chips") which conveys no information about more familiar quantities such as the value of a given prize or a player's probability of winning it, this experiment introduced a quantity about which no social conventions apply. The "sociological hypothesis" predicts, therefore, that information about the number of chips in each prize should not affect the bargaining: the low and high information conditions of this experiment should replicate the partial and full information conditions of the previous experiments, respectively, and the intermediate information condition should not differ from the low information condition.

The observed results strongly supported the sociological hypothesis. Results in the low and high information conditions essentially replicated those observed in the partial and full information condition of the previous experiment, and intermediate information outcomes did not differ significantly from those in the low information condition (i.e., in the intermediate information condition, agreements tended to give both players equal probabilities, regardless of the size of their prize in chips). Thus information about chips did not affect the outcomes in the same way as did strategically equivalent information about money.

The results supporting the sociological hypothesis were somewhat unexpected: as with the previous study, the results cannot be explained by classical game-theoretic models. The experiment of Roth and Malouf (1979) demonstrated an information effect that could not be accounted for in terms of players' preferences over outcomes. The experiment of Roth, Malouf, and Murnighan (1981) showed the effect could not be accounted for by the set of available actions. If we continue to hypothesize that the players in these experiments acted approximately like Bayesian utility maximizers, it must be that the information effect is due to a change in the players' subjective beliefs. For instance, information about the prizes may influence the players' subjective beliefs about what agreements are likely to be acceptable to their opponents.

An experiment designed to test this hypothesis by directly manipulating players' expectations about their opponents' behavior is reported in Roth and Schoumaker (1983). In that experiment, subjects were unaware that they initially bargained with a series of programmed opponents, whose behavior was designed to alter their expectations about what kinds of agreements were likely to be acceptable. When bargainers were subsequently paired with bargainers with consistent expectations, the different expectations in the different experimental conditions led to different outcomes, consistent with those observed in the different information conditions of the experiments discussed above. So the results of this experiment support the hypothesis that the information effect observed in the above experiments is due to the effect of information on the players' expectations.

The experiment discussed next (Roth and Murnighan, 1982) was designed to explore the component elements of this information effect. It has, in addition, revealed some phenomena that cannot be fully explained in terms of the players' expectations.

In all of the previous studies either both players had information about each other's prizes, or they only had information about their own 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.

Also, in the previous experiments, it was "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 <u>he</u> knows, and so forth (cf. Aumann, 1975; Lewis, 1969; 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.

Information which is common knowledge does not have "deniability": neither player can credibly deny that he knows it. This experiment was designed to distinguish the effects of this kind of deniability by manipulating whether each player's awareness or ignorance of his opponent's prize is common knowledge. In addition, it was designed to give the players sufficient scope for strategic manipulation so as to permit at least a preliminary assessment of whether the observed outcomes result from equilibrium behavior. The bargaining outcomes from this study are reported in Roth and Murnighan (1982); introduction and analysis of the bargaining process and the strategies used by the players is presented for the first time here.

Method

Two players, one with a $20 prize and the other a $5 prize, played three identical binary lottery games, against different, anonymous opponents. 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 noncommon knowledge condition, the $20 player still knows both prizes, and the $5 player still knows only his own prize, but both players are told that the other bargainer may or may not know their prize.

Subjects. One hundred and seventy-six (176) students participated in this study. Almost all were recruited from Economics classes at the University of Illinois. Volunteers understood that they would be obtaining money in an experiment on bargaining, and that their exact outcome would be determined by their play in the games. Of the 264 negotiations, technical difficulties resulted in the loss of data from 1 negotiation; the results are based, then, on the remaining 263.

Procedure. Players were seated at visually isolated computer terminals. Background information including a brief review of probability theory was presented first. The procedures for sending messages and proposals were then introduced. A proposal was a pair of numbers, the first being the sender's probability of receiving his prize and the second the receiver's probability. The proposal was displayed on a graph of the feasible region, along with its expected monetary value. Proposals were binding on the sender, and an agreement was reached whenever one of the bargainers returned a proposal identical to the one he had just received. Messages were not binding. Bargainers could send any message they wished, with one exception. To insure anonymity, the monitor intercepted any messages that revealed the identity of the players.

Participants were instructed that "your objective should be to maximize your own earnings by taking advantage of the special features of each session." Players were informed of the time remaining, and were given 12 minutes to reach each agreement. The computer recorded all the messages, proposals, and agreements, and conducted the lotteries at the end of the experiment.

Previous Results

Table 1 displays the agreements reached (disagreements excluded) in the different conditions. The findings were clear: Providing the $5 player with information about the $20 player's prize leads to an average of the agreements that is very close to half way between 20-80 (the equal expected value payoff) and 50-50 (the equal outcome payoff). Indeed, the underlying distribution is bimodal, with almost equal frequencies of the 20-80 and 50-50 payoffs. On the other hand, when the $5 player had no information about the $20 prize, most of the agreements were 50-50.

Table 1: Mean Outcomes to the $20 and $5 Players in Each Information-Common Knowledge Condition When Agreements were Reached (disagreements excluded)

Information	Common Knowledge		Not Common Knowledge	
Neither knows	48.8	51.2	47.5	52.5
$20 knows	43.6	56.4	49.1	50.9
$5 knows	33.6	66.4	37.2	62.8
Both know	30.8	69.2	34.3	65.7

Note: Outcomes are the mean lottery percentages obtained by the $20 players (expressed first) and the $5 player when they reached agreement.

Analysis of the disagreements indicated that, in conditions where the $5 player knew both prizes and this information was not common knowledge, there were more disagreements than in the other six conditions ($F(1,258) = 7.27$, $p < .01$). The mean outcomes, including disagreements, are shown in Table 2.

Table 2: Mean Outcomes to the $20 and $5 Players in Each Information-Common Knowledge Condition Over All Interactions (disagreements included as zero outcomes)

	Common Knowledge		Not Common Knowledge	
Information	$20 Player	$5 Player	$20 Player	$5 Player
Neither knows	41.6_{ab}	43.3_{c}	43.5_{a}	48.2
$20 knows	34.9_{bc}	45.1_{bc}	40.9_{a}	42.4
$5 knows	27.2_{c}	53.6_{ab}	25.0_{b}	42.0
Both know	27.2_{c}	56.4_{a}	25.5_{b}	48.8

Note: Within a column, means with common subscripts are not significantly different from one another using the Mann-Whitney U test (α = .01); none were significantly different in the Not-Common-Knowledge conditions for the $5 player.

Comparison of these outcomes in the $20 Knows and the $5 Knows conditions showed that, in the not common knowledge conditions, the value of being informed is quite similar: When disagreement outcomes are included, both the $20 and the $5 players averaged approximately the same number of lottery tickets (40.9% vs. 42.0%). In the common knowledge conditions, however, the $5 player averaged 53.6% and the $20 player averaged only 34.9%. Thus, the $20 player was not making as good use of his monopoly on information as was the $5 player. Where the not common knowledge conditions appear to be in equilibrium with respect to the different players' usage of information, that is not the case in the common knowledge conditions. (See Roth and Murnighan, 1982, where this is discussed at length.)

New Analyses

Here we inspect the players' strategies to investigate the cause of the nonequilibrium behavior observed in the common knowledge condition. Specifically, we seek to explain why the $20 player in the $20 Knows condition bargained less effectively than the $5 player in the $5 Knows condition. Note that this result cannot be explained by hypothesizing that the informed players had different expectations concerning their opponent's behavior in these two information conditions. In each case the informed player is faced with an opponent who is not informed, and this fact is common knowledge. Likewise, in both conditions the uninformed player has the same information: he knows his own prize only, and that his opponent knows both prizes. Thus, the informed player's expectation about the uninformed player's actions should be the same in both cases, and vice versa.

One hypothesis to account for the difference in the two conditions is that information about both prizes affects the aspirations of the two players in different ways. The \$5 player, when he knows both prizes, may hope to overcome his lower prize by obtaining a much higher probability of winning his prize, while the \$20 player may simply hope to maintain his privileged position. If this hypothesis is correct, it should be reflected by differences in the strategies chosen by the players in the earliest stages of the negotiations. In particular, our analyses focus on the initial demands made by the players and the nature of the messages they send throughout their interaction.

Of the eight conditions in this experiment, only the two discussed above (the \$20 and \$5 Knows conditions when players had common knowledge) provide manipulations of aspirations that are potentially unconfounded by different expectations about opponents' behavior. For example, in the Both Knows-Common Knowledge condition, the \$20 player has the same information about the prizes that he does in the \$20 Knows condition. While his aspirations may be the same in both conditions, his expectations of his opponent's behavior will be influenced by his knowledge that his opponent knows both prizes. While the \$20 and \$5 players may have the same aspirations as they held when only they were informed, they must now consider how their opponent's information might affect his aspirations, and modify their expectations accordingly. In the not common knowledge conditions, even when one of the players is informed, that player is uncertain about whether the other player is also informed.

<u>New Results</u>

<u>Demands</u>. The players' first demands were analyzed in a 4 (information conditions) x 2 (\$20 vs. \$5 player) analysis of variance for the common knowledge condition, with information a between variable and player a within, repeated variable. Results showed a significant effect for players, $F(1,109) = 37.28$, $p < .0001$, and a significant information by players interaction, $F(3,109) = 6.98$, $p < .0002$. Post hoc tests of the interaction (see Table 3) indicated that the \$5 player demanded more in the common knowledge conditions where he had information about the \$20 player's prize; in all of the other conditions, the players' first demands did not significantly differ from one another.

Table 3. The Mean First Demands of the Players in the Different Information Conditions when the Players had Common Knowledge

Information Condition	Mean First Demands by $20 Player	$5 Player
Neither Knows	67.4_b	69.4_b
$20 Player Knows	67.6_b	71.7_b
$5 Player Knows	62.9_b	80.8_a
Both Know	61.6_b	83.8_a

Note: Cells with common subscripts are not significantly different from one another at the .05 level using the Newman-Keuls procedure.

Messages. Typically the $20 players chose one of two types of messages: those which make no mention of the prizes and those which misrepresent the value of their prize. Not mentioning the prizes was chosen more frequently. The number of misrepresentations were greatest in the $20 Knows-Common Knowledge condition.

The $20 players' outcomes did not vary significantly as a function of the type of message they sent. However, disagreements increased slightly when they misrepresented their prize, leading to lower overall outcomes. In addition, when used in the Both Know-Not Common Knowledge condition, many disagreements occurred. Misrepresenting your payoff when your opponent knows what it is, is not an effective strategy.

The $5 player primarily sent three types of messages: those which make no mention of the prizes (most frequent when neither knew), those which reveal his information (most frequent in the $5 and Both Know conditions), and those which misrepresent (infrequently). Players who were silent about the prizes obtained lower average payoffs when agreements were reached than did those who revealed, but they also were involved in fewer disagreements. The two types of messages resulted in the same average outcomes. The $5 players who misrepresented received both higher payoffs when they were included in agreements and had fewer disagreements; the relative infrequency of this type of message, however, makes conclusions regarding its effectiveness very tenuous.

These results focus on all eight of the conditions. In the two conditions of most interest for the aspirations hypothesis (the $20 Knows- and the $5 Knows-Common Knowledge conditions), the $20 player misrepresented often (13 times in 30 interactions) and the $5 player revealed his information often (13 times in 26 interactions). The fact that the players' outcomes appear to be more a function of their different demands, rather than these message types (which had little effect, in particular, on the $20 players' outcomes), highlights the importance of those demands.

Discussion

As negotiations proceed, each bargainer has the opportunity to revise his expectations as to what agreements his opponent may find acceptable. At advanced stages in the negotiations, the effects of the bargainers' initial aspirations presumably become more difficult to separate from the effects of their updated expectations concerning their opponent's behavior. Thus, our analysis concentrated on the first demand issued by each bargainer: these are the demands which most closely reflect their initial aspirations and expectations.

As was argued earlier, only the $20 Knows- and $5 Knows-Common Knowledge conditions potentially provide an unconfounded manipulation of the players' aspirations, since only in this pair of conditions is there no reason for the informed player to have different expectations about the uninformed player, or vice versa. Thus, the fact that the $5 players made significantly higher first demands than the $20 players, when they were informed, suggests that informed $5 players have higher initial aspirations than the informed $20 players. This in turn supports the hypothesis that the reason informed $20 players met with less success than did informed $5 players (as reflected by their final payoffs) is that they had lower initial aspirations.

The fact that higher aspirations can lead to "tougher" bargaining is consistent with findings reported by Siegel and Fouraker (1960). The fact that these opening demands result in higher payoffs for the $5 player is consistent with results reported in another context by Yukl (1974). They are also similar to results in the area of goal setting (Latham and Yukl, 1975), which show that a difficult but specific goal (such as obtaining an equal expected value outcome) leads to more effective performance than "doing your best" (which may be quite similar to the aspirations and motivations of the $20 player). Finally, the results are similar to findings in yet another context, bargaining in coalition situations (Murnighan, Komorita, and Szwajkowski, 1977), which indicated that a competitive reference group led to more competitive bargaining behavior.

References

Aumann, Robert J. (1976): Agreeing to Disagree, in The Annals of Statistics, 4, pp. 1236-1239.

Latham, Gary P., and Gary A. Yukl (1975): A Review of Research on the Application of Goal Setting in Organizations, in Academy of Management Journal, 18, pp. 824-845.

Lewis, David K. (1969): Convention: A Philosophical Study, Harvard University Press, Cambridge.

Milgrom, Paul (1981): An Axiomatic Characterization of Common Knowledge, in Econometrica, 49, pp. 219-221.

Murnighan, J. Keith, Samuel S. Komorita, and Eugene Szwajkowski (1977): Theories of Coalition Formation and the Effects of Reference Groups, in Journal of Experimental Social Psychology, 13, pp. 166-181.

Nash, John F. (1950): The Bargaining Problem, in Econometrica, 28, pp. 155-162.

Roth, Alvin E. (1979): Axiomatic Models of Bargaining, Springer, Berlin and New York.

Roth, Alvin E. and Michael W. K. Malouf (1979): Game-Theoretic Models and the Role of Information in Bargaining, in Psychological Review, 86, pp. 574-594.

Roth, Alvin E., Michael W. K. Malouf, and J. Keith Murnighan (1981): Sociological versus Strategic Factors in Bargaining, in Journal of Economic Behavior and Organization, 2, pp. 153-178.

Roth, Alvin E. and J. Keith Murnighan (1982): The Role of Information in Bargaining: An Experimental Study, in Econometrica, 50, pp. 1123-1142.

Roth, Alvin E. and Francoise Schoumaker (1983): Expectations and Reputations in Bargaining: An Experimental Study, in American Economic Review, forthcoming.

Siegel, Sidney, and L. E. Fouraker (1960): Bargaining and Group Decision Making, McGraw-Hill, New York.

von Neumann, John and Oskar Morgenstern (1944): Theory of Games and Economic Behavior, Princeton University Press, Princeton, New Jersey.

Yukl, Gary A. (1974): Effects of Opponent's Initial Offer, Concession Magnitude, and Concession Frequency on Bargaining Behavior, in Journal of Personality and Social Psychology, 30, pp. 332-345.