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Fairness in Ultimatum Games with Asymmetric Information and Asymmetric Payoffs*

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Players bargained over chips with different exchange rates and with different information regarding these exchange rates. Offers generally reflected a self-serving definition of fairness. There is ample evidence that relative income shares entered players utility functions, resulting in predictable variations in both rejection rates and offers. However, offers were significantly more likely to be rejected when first-movers intentionally offered unequal money splits compared to when comparable offers were clearly unintentional. When both players were fully informed and first-movers had higher exchange rates, conflicting fairness norms developed, resulting in unusually high rejection rates. *Journal of Economic Literature* Classification Numbers: C72, C78, C92.

Questions regarding the role of “fairness” in sequential bargaining games have been raised as a result of observed deviations from subgame perfect equilibrium outcomes in favor of more even distributions of income. In this debate, fairness has sometimes been interpreted as an altruistic impulse (“trying to be fair”), sometimes as a strategic response to bargainers’ willingness to refuse insultingly

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low offers, and sometimes as having no role to play (Guth *et al.*, 1982; Binmore *et al.*, 1985; Ochs and Roth, 1989; Bolton, 1991; and Roth *et al.*, 1991).[1] This paper looks at this issue in an ultimatum game experiment with asymmetric payoffs and varying information regarding these payoffs.

In an ultimatum game one bargainer (player 1) makes a proposal on how to divide a sum of money with another bargainer (player 2) who has the opportunity to either accept or reject the proposed division. If the proposed division is accepted, each bargainer earns the amount proposed. If player 2 rejects, then both bargainers earn zero. In this game the unique subgame-perfect equilibrium (under the assumption that bargainers seek to maximize their own income) is that player 1 will receive all the money (or almost all of it, if payoffs are discrete). However, experimental evidence indicates that in games with symmetric payoffs and full information for both players regarding these payoffs, median returns to player 1 are 60% of the total or less (Guth *et al.*, 1982; Roth *et al.*, 1991; Prasnikar and Roth, 1992). Hence, there are arguments regarding the role of "fairness" in determining outcomes.

In our ultimatum game, players bargained over chips (100 chips), where the chips had different monetary payoffs to the two players ($0.10 or $0.30 per chip). In addition, players had different information regarding chip payoffs: In some treatments only one player knew both payoffs and in others both players know both payoffs. In all cases, players knew their own payoffs and it was "common knowledge" whether bargainers knew each other's payoffs.[2]

The subgame perfect equilibrium outcome for our game (assuming bargainers seek to maximize their own income) is unaffected by the differences in players' payoffs and information regarding these playoffs. Subgame perfectness means that the second bargainer will accept any positive offer, no matter how small, rather than reject it and earn zero. Therefore, at equilibrium, no player 1 will offer player 2 more than one *chip*, since even that amount will surely be accepted. Thus there are two subgame perfect equilibria. In one of them player 1 offers player 2 one chip and player 2 accepts (but would have rejected a proposal in which player 1 offered zero chips). In the other equilibrium player 1 offers player 2 zero chips, keeping everything for himself, and player 2 (nevertheless) accepts. Note that neither equilibrium is affected by the players' payoffs for the chips or their information regarding these payoffs.

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[1] This is only the tip of the iceberg. See Roth (forthcoming) for a thorough review of the experimental literature on this topic.

[2] When one player did not know the other's conversion rate, they were completely ignorant regarding possible conversion rates. The instructions simply read: All players 1 have the same conversion rate and all players 2 have the same conversion rate. While player 1 knows his own conversion rate, player 2 knows both conversion rates. A partial conversion table is provided to player 1 converting chips into dollars only for player 1, while a full conversion table is provided to player 2 converting chips into dollars for both players (underlining in the instructions).

Through varying players' information and payoffs we hoped to gain insight into the nature of fairness considerations underlying behavior. If the strong deviations from the subgame perfect equilibrium outcome in ultimatum games is rooted in an altruistic impulse ("trying to be fair") we would expect that when player 1s have relatively higher payoffs, and they are the only ones fully informed, chip offers to player 2s would approach the equal dollar-split value. On the other hand, if an altruistic fairness norm is modified by concern for maximizing social surplus, then the underlying money offers, while favoring player 1s when they have relatively higher payoffs, should favor player 2s when the payoff advantage is reversed. However, neither of these outcomes is observed. Rather, when only player 1s were fully informed, they offered roughly equal chip splits when they had the higher payoff, and offered very unequal chip splits (resulting in roughly equal money splits) when they had the lower payoff. This behavior is consistent with the notion that player 1s are motivated by self-serving notions of fairness ("trying to be fair to me and my family"), while taking strategic considerations into account, since lower chip offers are more likely to be rejected (Ochs and Roth, 1989; Bolton, 1991; Roth *et al.*, 1991; Lowenstein *et al.*, 1993).[3]

When only player 2s are fully informed we can directly determine if relative income comparisons play a role in their decisions to reject positive income offers as Ochs and Roth (1989), Roth *et al.* (1991), and Bolton (1991) argue. When player 2s have the lower payoff, we would anticipate higher rejection rates when they are the only ones informed, compared to when only 1s are fully informed (although these rejection rates might be tempered by the fact that player 2s know that 1s do not know the relative payoffs). In contrast, when player 2s have the higher payoff, we would anticipate lower rejection rates when they are the only ones informed, compared to when only player 1s are fully informed. Both of these prediction are confirmed in the data.

When both players are fully informed there is an opportunity for self-interested players to develop conflicting "fairness" norms: an equal chip norm for the player with the higher payoff and an equal money split norm for the player with the lower payoff. With player 1s having the higher payoffs, just this sort of conflict is observed in the first several periods of play, with players 1s offering equal chip splits and player 2s rejecting these offers more than 50% of the time. Further, holding money offers constant, when player 1s have higher payoffs, rejection

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[3] This is not to say that altruism ("trying to be fair") plays no role in ultimatum games. Our experiment is not designed to pin down when or whether there is *any* altruistic impulse. For this see Forsythe *et al.* (1994) who study dictator games, games in which player 1 decides on an allocation which player 2 has no opportunity to reject, and Bolton *et al*. (1993) who examine in detail the motivational forces underlying the positive offers found in dictator games. On the evidence reported, we believe that for some subjects at least, *part* of the deviation from subgame perfection in ultimatum games represents "trying to be fair."

rates are significantly higher than when only player 2s are fully informed. That is, player 2s are more likely to reject offers when they know that players 1s are intentionally offering very unequal money splits, compared to when player 1s are unaware of this fact. This is consistent with the notion that fairness considerations depend not only on players' relative payoffs but on their beliefs regarding the intentionality of the other players actions (Rabin, in press, and references cited therein). In contrast, when both players are fully informed, but 2s have higher payoffs, player 1s propose equal money splits and rejection rates are relatively low. This apparent lack of conflict when player 2s have higher payoffs more than likely reflects the bargaining power player 1s have in ultimatum games (and player 2s recognition of their disadvantageous position).

1. PROCEDURES

Subjects participated in 10 bargaining periods against different opponents with each bargaining pair learning only the results of their own negotiations. Subjects were paid conditional on their bargaining outcomes for one period, selected randomly at the end of the session. Bargaining position as player 1 or 2 remained constant throughout a session.[4] All bargainers had a table that converted chips into dollars for their own payoff and, in cases where they knew their rival's payoffs, for converting both players' chip values into dollars.

Sessions 1–6 all had a practice bargaining period that did not count in determining payoffs, while sessions 7 and 8 did not (for reasons to be explained later). Subjects were from undergraduate classes in economics in sessions 1–3 and from undergraduate psychology classes in sessions 4–8. Although Carter and Irons (1991) report some differences between undergraduate economics majors and nonmajors in playing a related ultimatum game, as shown below, we find no consistent differences between our two sample populations.

2. EXPERIMENTAL RESULTS

Figure 1 details the experimental design and reports mean offers (and the dispersion in these offers) by bargaining period and rejection rates for each experimental cell.

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[4] Questions inevitably arise concerning the saliency of payoffs in games of this sort. Although our experiment does not deal directly with this issue, the procedures employed (paying off in 1 out of 10 trials) and the amount of money bargained over are comparable to most of the other experimental research in this area.

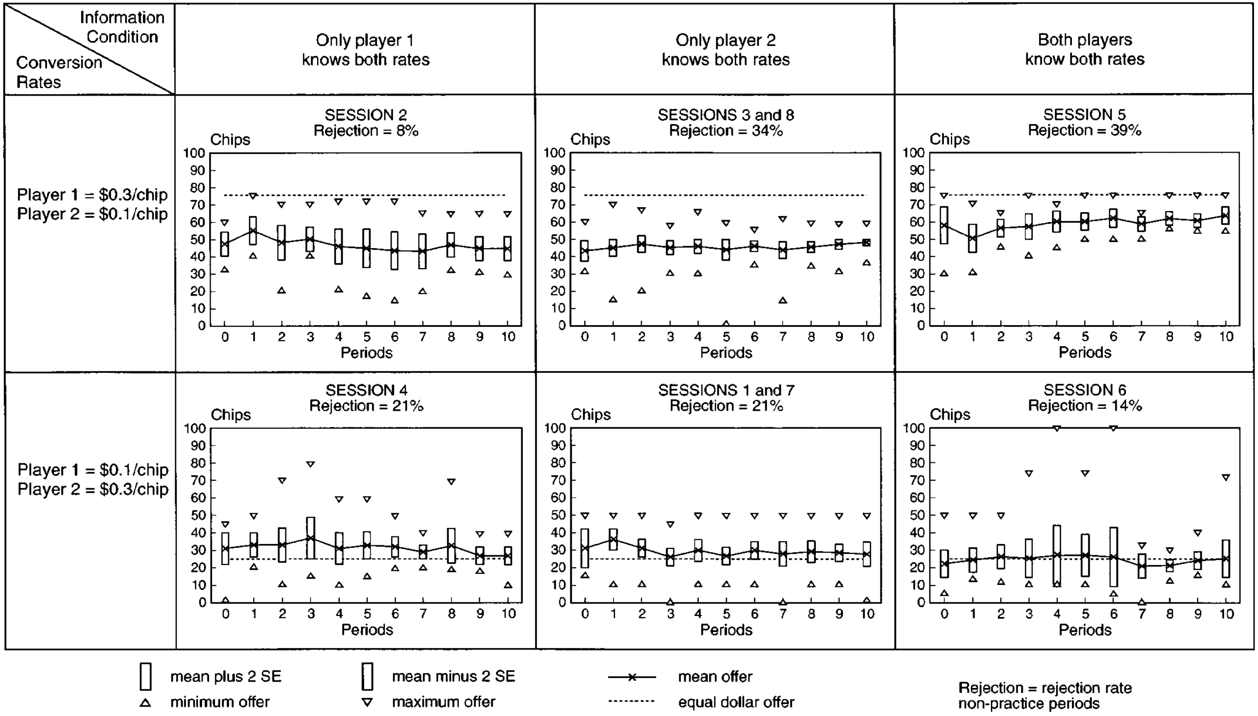

FIG. 1. Effects of information and conversion rates on offers and rejection rates.

A. *Only Player* 1 *Is Fully Informed*: *Trying to Be Fair*?. When player 1 knows both payoffs and receives the higher conversion rate (session 2), trying to be fair out of a sense of altruism calls for offering 75 chips. Mean offers never approach this level, averaging 46.9 chips over periods 1–10 and 45.3 chips in period 10. This translates into somewhat more than a three-to-one income difference in favor of player 1. Further, outside of period 1, no player offered an equal money split. Rejection rates were the lowest for this treatment, averaging 8% for the session as a whole.

The unequal money splits offered in session 2 did not result from subjects sharing a fairness norm defined in terms of equal chip splits or by altruistic considerations adjusted for social surplus considerations. This can be seen from session 4 where only player 1 was fully informed, but had the lower conversion rate. Mean offers were well below the equal chip level averaging 31.4 chips for periods 1–10 and 26.7 chips for period 10. The latter is within 1.7 chips of an equal money split and is significantly below the mean chip offer in period 10 of session 2 (Mann–Whitney U test, $p < .01$).

The more unequal chip offers in session 4 resulted in a 21% rejection rate, significantly higher ($Z = 2.52$, $p < .01$) than the rejection rate under this same information condition when player 1 had the higher conversion rate (session 2). The detailed offer and rejection data indicate that these differences resulted exclusively from lower chip offers in session 4. A probit regression controlling for chip offers confirms this as rejection rates were inversely and significantly ($p < .01$) associated with the size of the chip offer, while a conversion rate (treatment) dummy variable was not significant at conventional levels ($p = .65$).[5] Thus, the primary message from these two treatments is that player 1s are trying to be fair to themselves while (accurately) accounting for the fact that lower chip offers result in higher rejection rates.

Finally, note that the rejection rates in session 2 are substantially lower than rejection rates commonly reported in ultimatum games when both players are fully informed and have equal money payoffs. For example, Roth *et al.* (1991) in their USA data use the same subject population and very similar instructions (we adapted their instructions), and report average rejection rates of 28% in ultimatum games with $10 and $30 to be divided between the players. Income splits, as far as player 2s could tell, were roughly the same between their game and ours: In Roth *et al.*, player 1s offered at least 40% of the money 90% of the time in period 1 and 86% of the time in period 10. In our session 2, chip offers of 40% or more were made 100% of the time in period 1 and 88% of the time in period 10. A probit regression shows that controlling for the (observable) share of the pie offered,

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[5] All probits use all nonpractice period data and include a continuous variable for chip offers, dummy variables for each bargaining period, and dummy variables for the relevant treatment conditions.

rejection rates were significantly lower in our game ($p < .01$).[6] This suggests that with unknown money payoffs, player 2s were willing to give player 1s some benefit of the doubt regarding the equity of the underlying money payoffs.

B. *Only Player* 2 *Is Fully Informed*: *Relative Income Effects*. When player 1s had the higher conversion rate but only player 2s knew both conversion rates (sessions 3 and 8), chip offers averaged 45.7 over all 10 bargaining periods and 49.1 in period 10. These are similar to the offers in session 2 which had the same relative payoffs but where player 1 knew both payoffs. However, with player 2s knowing they were getting highly unequal money splits rejection rates were substantially higher, averaging 34% in sessions 3 and 8 compared to 8% in session 2 ($Z = 4.55$, $p < .01$).[7] The higher rejection rates in sessions 3 and 8 suggest an instinctive reaction on the part of player 2s to unequal money splits, as player 2s knew that player 1s were unaware of the income differences. (Looking ahead, when player 2s knew that 1s were aware they were making highly unequal money offers (session 5), the rejection rate increased significantly.) However, the higher rejection rates in sessions 3 and 8 did not induce player 1s to increase their offers above the 50 chip mark, as they had no basis, other than the chip metric, to gauge relative income shares.

When player 2s had the higher conversion rate and only they knew both conversion rates (sessions 1 and 7), chip offers averaged 29.7 over all 10 bargaining periods and 28.3 in period 10. These less equitable chip offers were rejected less often than the more equitable chip offers of sessions 3 and 8 ($Z = 2.75$, $p < .01$). This is not surprising because in sessions 1 and 7 lower chip offers resulted in substantially higher dollar offers in both absolute and relative terms.[8]

Relative income comparisons should also affect rejection rates between session 4 and sessions 1 and 7, since player 2s lack of information in session 4 would make it appear that the unequal chip offers involved unequal money splits as well. Although the average rejection rate was the same across these two treatments (21%), a probit regression indicates that, controlling for chip offers, rejection was *more* likely in session 4 than in sessions 1 and 7, although the t-statistic falls short of conventional significance levels ($p = .13$). Thus, the differential rejection rates across the sessions reported so far are all consistent with the argument that relative income comparisons play a role in player 2s' decision to reject positive income offers (Ochs and Roth, 1989; Roth *et al.*, 1991; Bolton, 1991).

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[6] This probit employs pooled data from our sessions 2 and 4 compared to pooled data from the three USA sessions in Roth *et al*. (1991).

[7] In all cases probits were run to check for treatment (information) effects compared to the chip offer effects. These are only reported in cases where they help clarify the conclusions reached on the basis of aggregate rejection rates.

[8] Using period 10 offers, player 2s averaged $8.37 in sessions 1 and 7 compared to $7.21 for player 1s, while player 2s averaged $4.91 in sessions 3 and 8 compared to $15.27 for 1s.

Our initial analysis indicated one possible problem with these results however. Comparing period 1 offers between sessions 1 and 3 shows significantly lower offers in session 1 (32.4 vs 50.4 in session 3, $p = .03$ Mann–Whitney U test), as if player 1s knew that they had a poorer exchange rate. However, practice period offers were more comparable between these two sessions (31.4 in session 1 vs 42.9 in session 3, $p = .09$ for the Mann–Whitney U test), so that some of the movement could be attributed to the reaction to the practice period offers. To check this, we replicated these two treatments, eliminating the practice period. In the replication, period 1 mean offers were nearly identical, 39.0 in session 7 vs 40.5 in 8. And the relatively higher frequency of rejected offers in session 8 versus session 7 (34% vs 18%) resulted in pushing these offers apart, so that by period 10 they were significantly different (average offers of 29.9 in session 7 vs 46.9 in 8, $p = .01$, Mann–Whitney U test).

These replications also permit us to test for differences between the two subject populations—students from undergraduate economics classes (sessions 1 and 3) and those from psychology classes (sessions 7 and 8). Comparing behavior in period 10, offers were modestly lower in session 1 compared to 7 (25.9 vs 29.9 chips, $p = .36$, Mann–Whitney U test) but were modestly higher in session 3 compared to 8 (51.3 vs 46.9 chips, $p = .04$, Mann–Whitney U test). Rejection rates were virtually the same in sessions 3 and 8 (36% vs 34%), but were somewhat higher in session 1 compared to 7 (27% vs 18%, $Z = 1.42$, $p = .16$). Carter and Irons' (1991) data suggest lower offers *and* lower rejection rates for economics majors compared to nonmajors. Thus, our results fail to support theirs.[9]

C. *Both Players Are Fully Informed*: *Self-Serving Definitions of Fairness.* When both players were fully informed and player 1 had the higher conversion rate (session 5) mean offers averaged 54.4 chips in period 1–3 as player 1s self-servingly tried to define a fairness norm in terms of equal chip offers. High rejection rates (52% in periods 1–3) for such unequal money splits resulted in a gradual upward drift in offers so that by period 10 mean offers averaged 63.7 chips, significantly different from mean offers in period 1 (Mann–Whitney U test, $p = .01$). Rejection rates were higher than when only player 2s were fully informed (39 vs 34%). A probit regression controlling for chip offers shows this difference to be statistically significant ($p < .01$). In other words, intentionally

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[9] Note, however, that students drawn from undergraduate classes in economics are unlikely to all be economics majors (we did not record students' majors) and those in introductory psychology classes are surely not all psychology majors. In addition, there are important differences between our game and the one Carter and Irons (1991) used. Finally, Carter and Irons (p. 177) express some skepticism regarding the differences they report (the differences reported are far from overwhelming) and call for further study of this issue.

low money offers generated more rejections than unintentionally low offers (see Rabin, in press, and references cited therein).

Reasonably fair money splits in symmetric-payoff, full-information ultimatum games are often interpreted as resulting from player 1s accounting for 2s likely reactions to unequal money offers (Roth *et al.*, 1991; Bolton, 1991; Prasnikar and Roth, 1992). Given this interpretation, it is somewhat surprising that in session 5 player 1s would even try for an equal chip split. Player 1s apparently failed to predict that 2s would overwhelmingly reject such a self-serving "fairness" norm. In contrast to our setting, in symmetric-payoff, full-information games there is no plausible alternative "fairness" norm for player 1s to try to dictate.

When both players were fully informed and player 2 had the higher conversion rate (session 6), period 1 offers averaged 24.2 chips, not materially different from the equal money split offer. There was essentially no movement in these offers over time, with period 10 offers averaging 25.1 chips. Overall rejection rates were marginally lower than when only player 2s were fully informed, averaging 14% ($Z = 1.47$, $p = .07$). However, a probit regression controlling for chip offers shows that an offer was significantly less likely to be rejected in session 6 than in session 4 ($p < .01$) or in sessions 1 and 7 ($p < .01$). The differential rejection rate between sessions 6 and 4 is hardly surprising given a role for relative income comparisons in player 2s rejection decisions. The difference between session 6 and sessions 1 and 7 suggests that in sessions 1 and 7 at least some player 2s interpreted the low chip offers as intentionally low offers, since player 1s had no information regarding player 2s payoffs, and decided to punish player 1s even though the money offers were relatively equitable.

The rejection rates reported in the first several periods of session 5 (over 50%) are, as far as we are aware, substantially higher than the rejection rates reported in other ultimatum experiments. They are substantially higher than the 28% rejection rate in the Roth *et al.* (1991) USA sessions using the same subject population. However, the very high rejection rates in the first several periods of session 5 are associated with average relative income offers of 28%, much lower than the average relative income offers in Roth *et al.* Further, looking at the detailed data from Roth *et al.*, we find rejection rates of 76% when player 2s were offered a relative income share of 35% or less (most of these offers were between 30–35%). This suggests that the high rejection rates in the first part of session 5 resulted from the relatively uneven offers this treatment condition fostered. Probit regressions confirm this suggestion, since after controlling for relative income shares offered, rejection rates were, if anything, lower in our sessions (with both players fully informed) then in Roth *et al.*'s.

3. RESULTS IN RELATIONSHIP TO NASH BARGAINING GAMES

The information and payoff conditions employed here are similar to those used in Roth and Murnighan (1982) for Nash bargaining games. In the Nash games, players bargain over a fixed number of points which determine the probability each will win a positive money prize. Unlike the ultimatum game, offers are exchanged until both players reach an agreement or time runs out. If no agreement is reached both players receive nothing. In the bargaining game any mutually agreeable outcome is an equilibrium.

Roth and Murnighan (1982) found that with common knowledge regarding what information each player had about the other's prize, disagreement rates did not vary significantly between treatments. With respect to payoffs players with the larger prize obtained higher expected value payoffs, on average, across all information conditions. However, when the player with the smaller prize knew the other player's prize (players always knew their own prize), they did relatively better than when only the higher prize player was fully informed.

Our results differ from these in several respects, all attributable to differences in the structure of the two games. First, disagreement rates varied significantly with changes in information conditions and in player conversion rates in the ultimatum game but not in the Nash game. This difference is partly attributable to the ability to communicate directly and make offers and counteroffers *within* a bargaining period in the Nash game, an opportunity which is not available in the ultimatum game. For example, when both players were fully informed in the ultimatum game, it was only in response to frequent rejections of inequitable money offers that the higher exchange rate player 1s moved toward an equal money split (session 5). In contrast, with full information in the Nash game, the opportunity for cheap talk apparently allows lower prize players to convince higher prize players that they will reject very inequitable money offers, the net result being lower average rejection rates.

A second difference is that, unlike the Nash game, in the ultimatum game higher exchange rate players do not always walk away with more money. The cases in point are sessions 4 and 6, when player 1s had the lower exchange rate and achieved essentially the same payoffs as the higher exchange rate player 2s. This, no doubt, reflects the bargaining advantage player 1 enjoys in the ultimatum game. There is no comparable asymmetry in bargaining positions in the Nash game. However, player 1s are not always able to take advantage of their superior bargaining position in the ultimatum game. When player 1s are uninformed and have the lower exchange rate (sessions 1 and 7), they obtained smaller returns, on average, than the fully informed player 2s (1s earned $6.70 on average compared to $9.90 for 2s).[10] But information regarding payoffs is not necessary for player 1s to exploit their bargaining advantage in the ultimatum game. In sessions 3 and 8, when player 1s had the higher exchange rate and were uninformed, they did substantially better than the lower exchange rate, fully informed player 2s (earning $15.30 on average, compared to $4.90). These uninformed player 1s also

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[10] Calculations of dollar earnings throughout this section are based on period 10 offers for those pairs where the offers were accepted.

did relatively better than the fully informed player 1s when both players were fully informed (session 5, where player 1s accepted demands averaged \$9.99 compared to \$6.67 for player 2s). Thus, although player 1s have an inherent bargaining advantage in the ultimatum game, this does not always enable them to obtain higher returns than player 2s.

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