# Bilateral Bargaining of Heterogeneous Groups – How Significant are Patient Partners?[☆]

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## Abstract

Although many real bargaining situations involve more than one person on each side of the bargaining table, much of the theoretical and experimental research concentrates on two single players. We study a simple extension: Bilateral bargaining of four people (two two-person groups) with different patience. One might think that the outcome should depend only on the most patient members of each group. The impatient members agree anyway and are, hence, irrelevant. We find, however, that the less patient player has at least some impact on the outcome. As an explanation we suggest a decrease in uncertainty about responder behaviour if a group is clearly asymmetric.

*Keywords:* bargaining, experiment, heterogeneity, groups
JEL Classification: C78, D74

## 1. Introduction

Bargaining is prevalent in many areas of social interaction. Labour unions bargain with employers, political parties bargain with other political parties, families negotiate jointly with the seller of their new home, entire governments haggle with other governments about trade agreements, etc. These bargaining situations

[☆]The paper circulated earlier under the title "Bargaining with Two-Person Groups—On the Significance of the Patient Partner". We thank seminar participants at the Max Planck Institute of Economics, from the International Max Planck Research School on Adapting Behavior in a Fundamentally Uncertain World, from the CESifo Area Conference on Behavioural Economics and two anonymous referees for useful comments. Discussions with Ekaterina Demidova, Pierfrancesco La Mura, Nadine Chlaß and Christoph Vanberg were very helpful. Vincent Hannibal, Markus Prasser, Henning Prömpers, Martin Singer and Severin Weingarten provided valuable assistance in conducting the experiments. Funding from the University of Jena is gratefully acknowledged.

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are non-trivial for two reasons: First, we know that already in very simple bargaining situations like the ultimatum game (Güth et al., 1982) but also in richer bargaining situations (Güth and Tietz, 1988) behaviour differs markedly from the game theoretic solution and behavioural motives matter a lot. Second, much of the bargaining literature models bargaining parties as individuals (see Osborne and Rubinstein, 1990, for a theoretical and Roth, 1995, for an experimental overview), although much of the real bargaining is done by groups. We know that groups can behave more competitively than individuals (see Wildschut et al., 2003, and Wildschut and Insko, 2007, for an overview of evidence on the inter-individual – inter-group discontinuity effect). Thompson et al. (1996) argue that groups are more successful than solo negotiators. Chae and Moulin (2010) show axiomatically that group bargaining leads to different outcomes than individual bargaining. Evidence from individual bargainers can, thus, not easily be generalised to bargaining groups. Still, there are only few bargaining experiments where at least one bargaining party consists of more than one person.

Some of these studies are not essentially interested in groups but, rather pragmatically, use groups as a device to elicit spontaneous conversations which reveal motives and processes of bargaining individuals. Hennig-Schmidt et al. (2002) and Hennig-Schmidt and Li (2005) compare alternating offers bargaining of 3-person-teams in Germany to 3-person-teams bargaining in China. Geng and Hennig-Schmidt (2007) analyse communication and quasi-communication in 3-person-groups in ultimatum games. Hennig-Schmidt et al. (2008) analyse non-monotonic strategies of 3-person-groups in ultimatum games. These studies use homogeneous groups.

More related to our experiment is Messick et al. (1997) who study how individuals perceive processes within an opponent group. In their bargaining experiments groups have to use different decision rules. Messick et al. find that the solo counterparts of these groups do not anticipate the impact of the decision rules. As in Messick et al., we want to study how the bargaining position of a group is perceived by the group's opponents. In contrast to Messick et al. we keep the decision rule in groups constant and focus on the heterogeneity within groups.

While Messick et al. manipulate the processes within a group, Bornstein and Yaniv (1998) compare the behaviour of individuals with 3-person-groups in the ultimatum game. They observe that proposer groups make higher demands than individuals while acceptance rates are equal among groups and individuals and conclude that, hence, groups are more rational players than individuals.

Both experiments illustrate two major differences between individual and inter-group bargaining: Groups consist of several players with potentially heterogeneous interests and different power to influence the outcome. Furthermore, groups have identities which may be different from individual identities. In our experiment we will address these issues. We change the number of players who are just members of the group, the number of players who can affect the outcome and the heterogeneity of their preferences.

To simplify matters we exclude face-to-face interaction as well as within and between group discussions. Technically we extend Rubinstein's alternating offers bargaining game (see Rubinstein, 1982, 1985) to the simplest possible group case, namely to two two-person-groups.[1]

## 2. The bargaining game

### *2.1. Selfish individuals*

In a Rubinstein bargaining game with complete information (see Rubinstein, 1982), two players divide a pie of size one. Players alternate in making offers how to divide the pie. If the responder accepts, the offer is implemented and the game ends. In each round without agreement, payoffs are discounted by individual factors $d_i \in (0, 1)$ for the two players $i \in \{1, 2\}$. In the subgame perfect equilibrium of this game, player 1 offers in the first round $(1 - d_2)/(1 - d_1 d_2)$ for herself and $1 - (1 - d_2)/(1 - d_1 d_2)$ for player 2. This offer will immediately be accepted by player 2.

### *2.2. Selfish groups*

Demidova and La Mura (2010) extend this situation to three players: player 1, player $2A$ and player $2B$ with individual discount factors $d_i$ ($i \in \{1, 2A, 2B\}$). Players $2A$ and $2B$ form a couple (or a two-person group).[2] Players have to split a pie of size one between player 1 and the couple. The members of the couple enjoy their share of the pie as a public good. As in the Rubinstein game parties alternate in making offers. Once a party accepts, the offer is implemented and the game ends. The couple decides unanimously. Offers are accepted only if both members accept. When both members of a couple make an offer, only the offer that is better for the couple counts. It is easy to show that the equilibrium of this game is equivalent to the equilibrium of a game where player 1 bargains with the more patient member of the couple. If, e.g. player $2A$ is less patient than player $2B$ ($d_{2A} < d_{2B}$), then in the subgame-perfect equilibrium player 1 will receive a share of $(1-d_{2B})/(1-d_1 d_{2B})$ and the couple will receive a share of $1-(1-d_{2B})/(1-d_1 d_{2B})$. The preferences of the impatient player $2A$ do not matter at all.[3]

[1] Demidova and La Mura (2010) analyse a situation where all group members are involved in each decision. Perry and Samuelson (1994), for instance, take another theoretical approach. They analyse a situation with two bargaining parties, one representing a (possibly large) constituency.

[2] Since using the word "group" for only two people might be problematic (see Harris et al., 2009), we will use the terms "two-person-group" or "couple" in the following.

[3] Demidova and La Mura (2010) extend these two situations to scenarios under one-sided incomplete information about time preferences which we will not consider in this paper.

*2.3. Groups with social preferences*

We consider a variant of Demidova and La Mura (2010) with four players. Players $1A$ and $1B$ make the first proposal (only player $1A$ takes decisions, player $1B$ is passive and obtains the same payoff as player $1A$), players $2A$ and $2B$ are the responders in the first round. We introduce player $1B$ to avoid efficiency concerns that would arise with an unequal number of players on the two sides. Since players need not necessarily be selfish, let us assume that similar to Charness and Rabin (2002) or Fehr and Schmidt (1999) player $i$ maximises $x_i - \frac{\alpha}{3}\sum_{j\in\{1,2,3,4\}}\max(x_j - x_i, 0) - \frac{\beta}{3}\sum_{j\in\{1,2,3,4\}}\max(x_i - x_j, 0)$.[4] As in the selfish case we solve the game by backward induction (see Binmore, 1987). Different from the selfish case we can not exploit that all rounds are essentially symmetric. Since the pie shrinks over time, a division which is unacceptably unequal at time $t$ becomes more equal and more acceptable at $t + 2$ since the pie is smaller at $t + 2$ and, as a result, inequity is reduced. We can only calculate a numerical solution.[5] First round equilibrium shares for player 1 as a function of $\alpha$ and $\beta$ for the discount factors we use in our experiment are shown in Figure 1. The left part of the figure show the *homogeneous* situation where both members of the second couple have the same discount factor $d_{2A} = d_{2B} = 0.8$. The middle part of the figure shows the case where the second couple is *heterogeneous*, $d_{2A} = 0.8$ and $d_{2B} = 0.95$. In this case for values of $\alpha > 0$ and, in particular, small values of $\beta$ equilibrium outcomes are not monotonic in $\alpha$. The reason is that for later stages of the bargaining process inequity becomes large and the second couple prefers to wait to reduce inequity. In this situation agreements can be reached only during a finite number of initial bargaining rounds while the pie is still large and inequity is still low. The right part of the figure shows the *homogeneous* situation where both members of the second couple have the same discount factor $d_{2A} = d_{2B} = 0.95$, i.e. they are more patient than the first couple.

As to be expected positive values of $\alpha$ and $\beta$ lead to more egalitarian outcomes (the most egalitarian possible is $\frac{1}{2} : \frac{1}{2}$ in the top right corner of each graph) while negative values of $\alpha$ and $\beta$ imply outcomes where the stronger, i.e. more patient, player obtains almost the entire pie (player 1 in the left and the couple $2A$ and $2B$ in the middle and the right graph). We will come back to Figure 1 in the discussion of our experimental results.

[4]Since in the experiment participants bargain over lottery tickets, social preferences are not about *outcomes* but rather about *procedures* (see, e.g. Bolton et al., 2005; Sebald, 2010).

[5]We solve the game by backward induction for 160801 different combinations of $\alpha$ and $\beta$ (which is in each case identical for all players), always starting from a different and random division in round 250. As we can see from the sharp contours in Figure 1 (or sometimes the regular sawtooth pattern in the middle graph) and similar to the analysis in the selfish case the randomness in round 250 does not visibly affect the result.

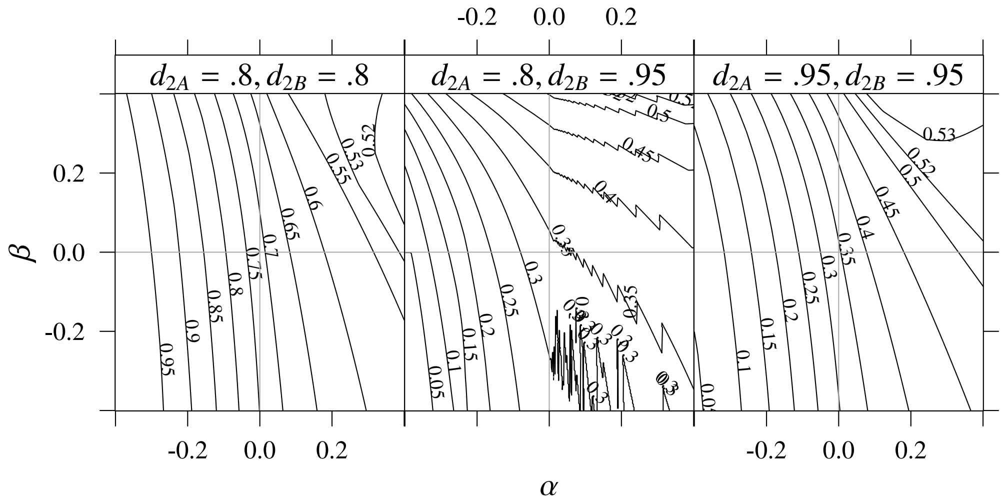


Figure 1: Equilibrium shares and social preferences

We assume that player $i$ maximises $x_i - \frac{\alpha}{3}\sum_{j\in\{1,2,3,4\}}\max(x_j - x_i, 0) - \frac{\beta}{3}\sum_{j\in\{1,2,3,4\}}\max(x_i - x_j, 0)$ and that $\alpha$ and $\beta$ are the same for all players. Contour lines show first round equilibrium shares for player 1 with $d_1 = 0.9$. We use a numerical approximation that starts the backward induction in round 250. The sawtooth pattern in the contour lines of the graph in the middle is due to the different lengths of the (discrete) number of rounds during which agreements are possible. Contour lines are equidistant, except that we added contours at 0.52 and 0.53 to give more detailed information about the rather flat region in the top right part of the graphs.

## 3. Experiment

When we move from two-person bargaining to bargaining of heterogeneous two-person groups we change several parameters. In the experiment we will study these changes separately and compare five treatments (see Table 1).

To control for concerns for efficiency we have always the same number of players on both sides: In the 2playerSingle treatment one player bargains with one other player. In the remaining treatments two players on one side bargain with two other players. Among the $1A$ and $1B$ players only the $1A$ player makes decisions. Player $1B$ obtains the same payoff as $1A$ but takes no decisions. The purpose of this passive player is to make sure that all divisions are equally efficient and only distributional concerns matter. Treatments are called 2playerSingle, 2player, 3playerSym, 3playerAsym and 3playerPatient. The numbers in the names refer to the number of *active* players in each treatment. Sym and Asym refer to the (a)symmetry of bargaining power within the couple consisting of player $2A$ and player $2B$.

**2playerSingle** In the baseline treatment, two individuals bargain with each other. Player 1 has a discount factor of $d_1 = 0.9$, player 2 of $d_2 = 0.8$.

Table 1: The five treatments

| Treatment | Discount factors of players... | | | | Equilibrium shares [%] | |
|---|---|---|---|---|---|---|
| | **1A** | 1B | **2A** | 2B | odd rounds | even rounds |
| 2playerSingle | **0.9** | - | **0.8** | - | (71.4,28.6) | (64.3,35.7) |
| 2player | **0.9** | 0.9 | **0.8** | 0.8 | (71.4,28.6) | (64.3,35.7) |
| 3playerSym | **0.9** | 0.9 | **0.8** | **0.8** | (71.4,28.6) | (64.3,35.7) |
| 3playerAsym | **0.9** | 0.9 | **0.8** | **0.95** | (34.5,65.5) | (31.0,69.0) |
| 3playerPatient | **0.9** | 0.9 | **0.95** | **0.95** | (34.5,65.5) | (31.0,69.0) |

Note: In all treatments players would under the subgame-perfect equilibrium agree in round 1. In the experiment, we call the player 1s "red" and the player 2s "blue" to avoid that participants perceive an order of players according to the numbers 1 and 2. Bold type is used for active, normal type for passive players.

**2player** In the second treatment, we add one passive player on each side: player 1*B* and player 2*B*. Player 1*A* and player 2*A* can make offers and accept or reject, the *B*-players are passive and receive the same payment as their partners. Both player 1s have a discount factor of $d_1 = 0.9$, both player 2s of $d_2 = 0.8$.

**3playerSym** In the third treatment, player 2*B* is an active player, too. When player 1*A* makes an offer, both player 2*A* and player 2*B* have to accept it for the game to end. If at least one of them rejects the offer, both make independent counter-offers. Player 1*A* learns both offers, but can only accept or reject the offer that is lower for herself. In this treatment, player 2*A* and player 2*B* have the same discount factor $d_2 = 0.8$.

**3playerAsym** In the fourth treatment, the only thing we change compared to 3playerSym is player 2*B*'s discount factor which is now $d_{2B} = 0.95$.

**3playerPatient** Also the fifth treatment is very similar to 3playerSym, except that both player 2's discount factors are $d_{AB} = d_{2B} = 0.95$.

In the first three treatments, 2playerSingle, 2player, and 3playerSym, the selfish equilibrium is always the same: player 1 obtains 71.4% of the pie. In the 3playerAsym and 3playerPatient at least one of players 2*A* and 2*B* has a high discount factor and, thus, a strong bargaining position. Player 1 should only get 34.5%. Hence, we hypothesise the following:

> First round demands are lower in the 3playerAsym and the 3player-Patient treatment than in the other treatments. There is no difference

between 3playerAsym and 3playerPatient.

Between November 2009 and October 2013, we conducted 18 experimental sessions at the economics laboratory at the University of Jena, Germany. We always conducted two treatments per session: To introduce the game, the first treatment was always 2playerSingle. The second treatment was then either 2player, 3playerSym, 3playerAsym or 3playerPatient. 16 people participated per session, adding up to a total of 288 subjects. Appendix A provides an overview. To control for risk preferences we use the binary lottery technique to pay participants (see Roth and Malouf, 1979). Participants were invited with ORSEE (Greiner, 2004). The experiment was programmed and conducted with z-Tree 3.3.6 (Fischbacher, 2007). Figure D.6 in the appendix shows an example screenshot. The average earning was 10.80€. The data was prepared and analysed with R 3.0.2 (R Core Team, 2013).

## 4. Results

In this section, we will discuss first round demands, acceptance thresholds, and the number of rounds needed to reach an agreement. Appendix A gives an overview of the number of sessions and participants for the different treatments. Since most negotiations (58.3%) conclude during the first round we will concentrate on behaviour in the first round. Divisions are always given as shares of player 1 unless stated otherwise.

### *4.1. Descriptives*

Figure 2 shows how first round demands develop during the experiment and for the different treatments. All sessions started with five periods of 2playerSingle. Thereafter, participants played one of the 2player, 3playerSym, 3playerAsym and 3playerPatient treatments. In our analysis we can not (and do not want to) distinguish whether differences between 2playerSingle and the other four treatments are actual treatment effects or due to learning during the experiment.

If participants follow the (selfish) equilibrium we should expect for all treatments, except 3playerAsym and 3playerPatient, a first round demand of 71.4%. Only in 3playerAsym and in 3playerPatient the demand should be as low as 34.5%. Indeed, the average demand in 3playerAsym is smaller than the demand in 2player and in 3playerSym. The only difference between 3playerAsym and 3playerPatient is one impatient player 2 which should, theoretically, not matter since this player would always be overruled by the patient player 2. We see, however, that first round demands in 3playerAsym are higher than in 3playerPatient (where both player 2s are patient).

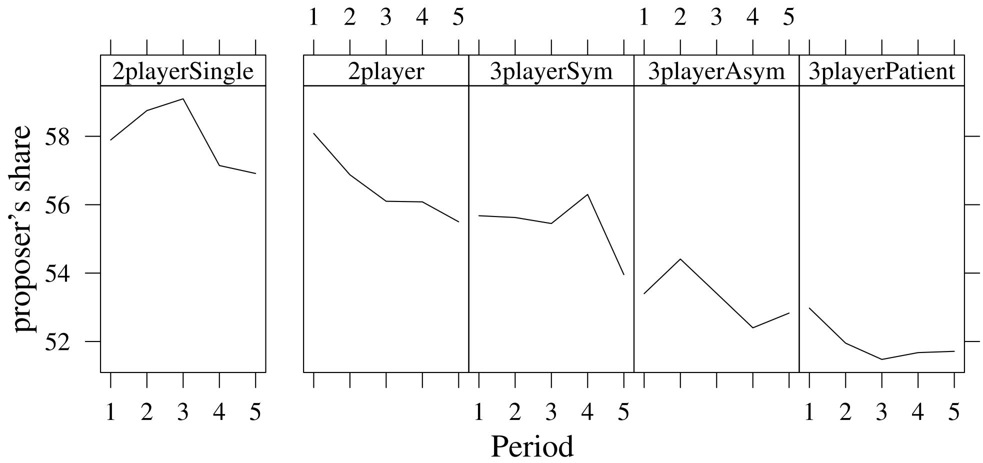


Figure 2: First round average demands
The experiment always started with five periods of 2playerSingle, followed by five periods of one of the other four treatments.

### *4.2. First round demands*

To compare the first round demands more precisely we estimate the following mixed effects model for each treatment $t$ separately:[6]

$$\text{firstRoundDemand}_t = \beta_0 + \epsilon_k + \epsilon_i + \epsilon_{i\tau} \tag{1}$$

We include random effects for the session $\epsilon_k$ and for the individual $\epsilon_i$, and the standard residual $\epsilon_{i\tau}$. Detailed results are shown in Appendix C.1. HPD[7] confidence intervals for the coefficients are shown in Figure 3.

Differences in first round demands are given in Table 2. Moving from 2player to 3playerSym gives the player 2B, who was idle in 2player, the power to reject proposals and to make own proposals. This increases the share for players 2A and 2B by a small (1.13), but insignificant, amount. Although the difference between first round demands in the 3playerSym and in the 3playerPatient case is with only 3.44 much smaller than the difference we should expect in equilibrium (36.95), the decrease in demands is significant. In the 3playerAsym treatment, where we

[6]Since the distribution of demands is highly skewed, different treatments (with different mean offers) have different distributions for the random effects. This is why we have to estimate each treatment separately.

[7]HPD intervals are (frequentist) highest posterior density intervals for the estimated values based on a bootstrap with 10000 replications. For the bootstrap and for the estimation we use the `lme4` (Version: 0.999999-2) package from R version 3.0.2 (2013-09-25).

[8]See footnote 7.

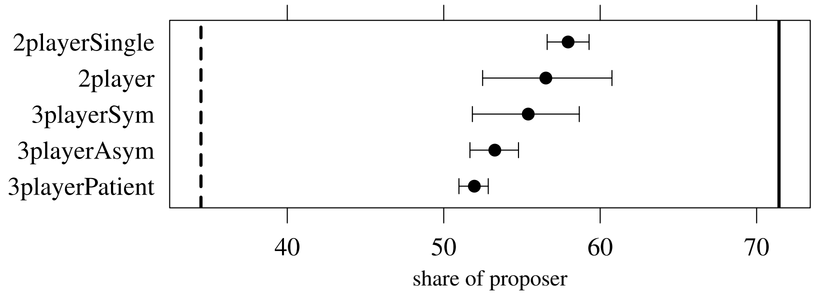


Figure 3: First round demands (Equation 1)
95% HPD[8]confidence intervals for $\beta_0$ from Equation (1). Vertical lines indicate the equilibrium shares (dashed 34.5% for 3playerAsym and 3playerPatient, and solid 71.4% for all other treatments).

| | mean | 95% -conf.int. | | p-value |
|---|---|---|---|---|
| 2player-3playerSym | 1.13 | -4.16 | 6.48 | 0.3103 |
| 3playerSym-3playerPatient | 3.44 | -0.04 | 7.10 | 0.0262 |
| 3playerAsym-3playerPatient | 1.31 | -0.50 | 3.16 | 0.0620 |
| 3playerSym-3playerAsym | 2.14 | -1.56 | 5.83 | 0.1120 |

Table 2: Difference in first round demands (Equation 1)
$p$-values are based on a bootstrap with 10000 replications and refer to a Null-hypothesis of no difference between the treatments and an alternative of a positive difference (as theoretically predicted for the comparison of 3playerSym with 3playerPatient and 3playerAsym).

should find the same demand as in 3playerPatient, players 2A and 2B obtain 1.31 units less than on the 3playerPatient treatment. This difference is, however, only weakly significant.

The behaviour in the symmetric treatments is consistent with a moderate amount of inequity aversion while the asymmetric treatment would require a remarkably large degree of inequity aversion. Comparing our results with Figure 1, we see that the average demand we find in 3playerSym (55.4) is in line with values of, e.g., $\alpha = \beta \approx 0.196$. Also the average demand for 3playerPatient (51.96) can be rationalised with, e.g., $\alpha = \beta \approx 0.216$. The average demand in the asymmetric treatment 3playerAsym (53.27), however, would require values of $\alpha$ and $\beta$ both larger than 0.4.

### *4.3. Accepting offers in the first round*

In the preceding section we have seen that demands by player 1 react to the presence of one more patient player (third line of Table 2). We have also seen that

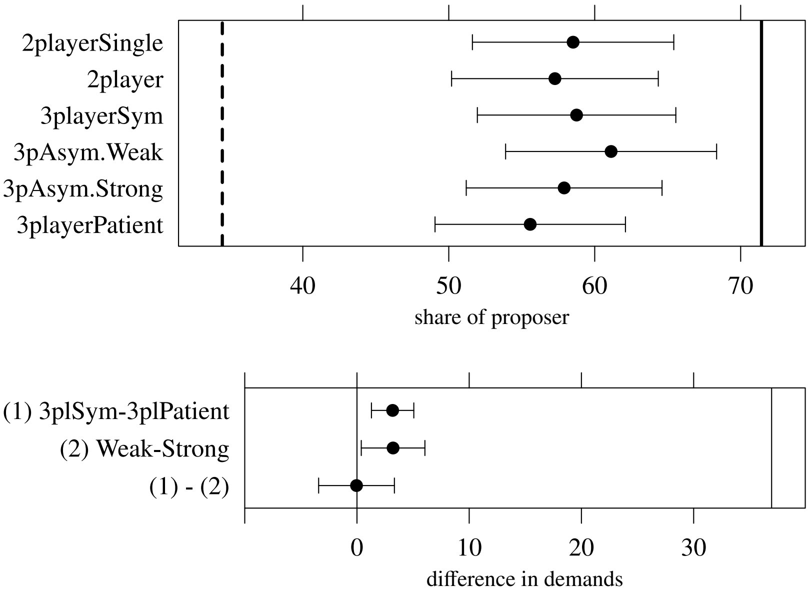


Figure 4: First round response (Equation 2)
95% HPD confidence intervals for $-\beta_t/\beta_o$ (top graph) and differences in $-\beta_t/\beta_o$ (bottom graph) from Equation (2). Vertical lines indicate the equilibrium shares (dashed 34.5% for 3playerAsym and 3playerPatient, and solid 71.4% for all other treatments) in the top graph and the theoretically expected difference of 36.9 in the bottom graph.

this reaction is smaller than predicted and also smaller than the reaction to a homogeneous change in patience of the player 2s (second line of Table 2). Can this behaviour of player 1 be explained as the anticipation of acceptances and rejections by player $2A$ and $2B$? To better understand this, we estimate the following mixed effects logistic model.

$$P(\text{firstRoundAccept}) = \mathcal{L}\left(\beta_o \cdot o + \sum_{t\in\text{Type}} \beta_t \cdot d_t + \epsilon_k + \epsilon_i\right) \tag{2}$$

Here $\mathcal{L}$ is the logistic function, $o$ is the offer made by player 1, $d_t$ is a dummy for the treatment and the type of the player in the 3playerAsym case (strong for the 2B player with $d_{2B} = 0.95$ and weak for the 2A player with $d_{2A} = 0.8$), $\epsilon_k$ and $\epsilon_i$ are random effects for the session and the individual, respectively. In Figure 4 we show confidence intervals for $-\beta_t/\beta_o$, i.e. for the threshold where the probability to accept is just $1/2$.[9] As above we should expect that this threshold is 71.4 for

[9] Solving $1/2 = \mathcal{L}(\beta_o \cdot o + \beta_t)$ for $o$ yields $o = -\beta_t/\beta_o$.

all treatments and players except for 3playerPatient and for the strong player 2 in 3playerAsym, where the threshold should be 34.5. Indeed, these two seem to have a lower threshold than their counterparts. The lower graph in Figure 4 shows the difference between 3playerSym and 3playerPatient and the difference between the weak and the strong player in the heterogeneous group. Both differences should have the same value of 36.9. We see that both differences are, indeed, positive (and significantly so). The confidence interval (1)-(2) shows the difference between the homogeneous and the heterogeneous effect. Here we find no significant difference (the confidence interval includes the zero).

We can summarise that in heterogeneous as well as in homogeneous groups discount factors matter significantly, although much less than they should in the selfish equilibrium. The impact seems to be the same in heterogeneous and in homogeneous groups. Regardless whether we make both player 2A and 2B more patient (as in the comparison of 3playerSym and 3playerPatient) or whether we compare one patient player 2B with an impatient 2A (as in 3playerAsym), the magnitude of the effect is almost the same. It is, hence, surprising, that decisions of player 1 seem actually to make a difference between these two. We will offer one explanation in the next section.

### *4.4. Noisy acceptance thresholds as a reason for first round demands*

In the previous section we saw a lot of heterogeneity in the individual acceptance thresholds. It is easy to see that this heterogeneity can rationalise the difference in demands between 3playerAsym and 3playerPatient we observed above. Let us assume that acceptance decisions by player 2A and player 2B can be described by an individual treshold $x_2$ which is unknown to player 1. Player 1 only knows a distribution $x_2 \sim F(x_2)$. If player 1 demands less than $x_2$, the demand is accepted by the respective player 2. If player 1 demands more than $x_2$, the demand is rejected. If players 2A and 2B are symmetric and independent (as it is the case in 3playerPatient or 3playerSym), then the probability of a proposal $x$ to be accepted is $F(x)^2$, hence the expected payoff of player 1, who demands $x$, is $x \cdot F(x)^2 + x_c \cdot (1 - F(x)^2)$, where $x_c$ is the payoff player 1 expects to obtain if the game continues in the second round.

If player 2A is less patient than 2B (as in 3playerAsym), she is likely to accept proposals which are not acceptable for 2B. Let us assume for simplicity that, whenever 2B accepts, 2A accepts as well. In such a situation the expected payoff of player 1 is $x \cdot F(x) + x_c \cdot (1 - F(x))$.

It is easy to see that any increase in the variance of $F$ leads to an increase in the difference between the demands in 3playerAsym and 3playerPatient. If we assume for illustration that $F(x)$ is a uniform distribution with $F(x) = \min(1, \max(0, 1/2 + (\bar{x}_2 - x)/\Delta_2))$ where $\bar{x}_2$ is the demand which just 1/2 of all player 2s would accept and $\Delta_2$ is a measure for player 1's uncertainty about player 2's actual threshold

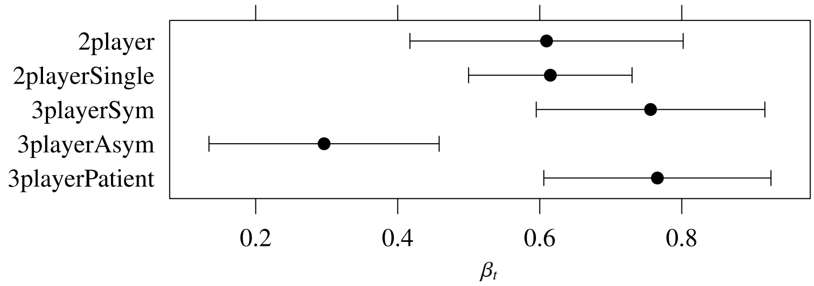


Figure 5: Number of rounds to reach an agreement (Equation 3)

$x_2$, such that $\sigma_F = \Delta_2/(2\sqrt{3})$, then (as long as $\bar{x}_2 - \Delta_2 \leq x_c \leq \bar{x}_2 + \Delta_2/2$) the difference between the proposals that maximise the expected payoff of player 1 in the asymmetric situation and in the symmetric situation is $(\bar{x}_2 - x_c)/6 + \Delta_2/12$. Here an increase in the standard deviation $\sigma_F$ of player 2's acceptance threshold by one unit translates into a difference in offers between 3playerAsym and 3playerPatient of $1/(2\sqrt{3}) \approx 0.29$. If the distribution is not, as assumed above, uniform but normal, this number becomes approximately 0.4. The difference of 1.31% that we have found above between offers in 3playersAsym and 3playerPatient could, hence, be rationalised as a rather small uncertainty about player 2's acceptance threshold.

### *4.5. Number of rounds to reach an agreement*

To assess the number of rounds players need to reach agreements, we estimate a mixed effects Poisson model:

$$\text{numberOfRounds} \sim \text{Poisson}(\lambda = \sum_{t \in \text{Treatm.}} \beta_t \cdot d_t + \epsilon_k + \epsilon_i) \tag{3}$$

Here, $n$ is the number of rounds needed to reach an agreement or until participants are stopped[10] for each treatment. As above, $d_t$ is a dummy for the treatment, $\epsilon_k$ and $\epsilon_i$ are random effects for the session and the individual, respectively. Detailed results are shown in Appendix C.3. Confidence intervals for the coefficients are shown in Figure 5. We see that participants need, on average, approximately the same number of rounds in 2playerSingle, 2player and 3playerSym, and fewest rounds in 3playerAsym.

[10]In the estimation we also include decisions of participants who were stopped in the bargaining process because they took more than the allowed time or number of rounds to reach an agreement. Depending on the treatment this affects between 3.33% and 7.41%. In cases in which participants were stopped we add one round to the round in which they were stopped as these participants could have agreed one round after they were stopped at the earliest.

## 5. Discussion and conclusion

In this paper we study two two-person-group bilateral bargaining. Unlike Messick et al. (1997), who focus on the interaction of one individual against a homogeneous group, we study the impact of three factors on bargaining behaviour: (1) the number of payoff-dependent, passive people, (2) the number of active people and (3) heterogeneous power among players who belong to one small group.

Several of the factors which, according to the game theoretic equilibrium, should have no effect, such as the number of payoff-dependent, passive people and the number of active people, had, indeed, no significant effect.

The changes in patience did have a smaller effect than what we should expect in equilibrium. This is not entirely unexpected. We know from experiments with single decision makers that players do not react too much to changes in discount factors (see, e.g., Ochs and Roth, 1989, for a discussion). In terms of Figure 1 inequity averse players will tend to settle on divisions which are closer to 50:50 which is what we observe in all treatments of our experiment. Indeed, for the symmetric treatments in our experiment, moderate amounts of inequity aversion seem to be consistent with the demands we observed. However, social preferences are a less convincing explanation in the asymmetric treatment where demands can only be rationalised by a surprisingly large degree of inequity aversion.

In section 4.2 we saw that heterogeneity within a group can play a role when, according to equilibrium predictions, it should not. Although only the most patient member of a group should determine the strength of the team and although an increase in the number of these patient players should not matter we see at least a small effect. Therefore, taking on board weak partners in a bargaining situation may actually weaken the own bargaining position. The responder behaviour that we studied in section 4.3 does not really offer an explanation. We did not see that strong responders are "loyal" towards weak responders. In section 4.5 we could also rule out that proposers should fear a lengthy struggle to reach an agreement. On the contrary, in heterogeneous groups the number of rounds to reach an agreement is exceptionally low. In section 4.4 we could, however, explain how two strong responders can achieve more than a single strong responder — at least, when there is some uncertainty about responder behaviour. And, as we saw in section 4.3, this uncertainty clearly exists. The major driving force for our results would then be uncertainty, perhaps motivated as uncertainty about social preferences, but not loyalty per se.

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## Appendix A. Number of sessions and participants

The following table shows the number of sessions and participants for the different treatments. In each session, 2playerSingle was followed by one of the other treatments.

| | 2playerSingle | 2player | 3playerSym | 3playerAsym | 3playerPatient |
|---|---|---|---|---|---|
| sessions | 18 | 3 | 5 | 5 | 5 |
| participants | 288 | 48 | 80 | 80 | 80 |

## Appendix B. Summary statistics

| | 2pl.Single | 2pl. | 3pl.Sym | 3pl.Asym | 3pl.Patient |
|---|---|---|---|---|---|
| Mean first demand (%) | 57.96 | 56.53 | 55.40 | 53.37 | 51.96 |
| Mean second offer (%) | 44.87 | 44.27 | 44.82 | 48.66 | 45.89 |
| Mean number of rounds | 2.10 | 2.02 | 2.03 | 1.67 | 2.10 |
| Stopped participants (%) | 6.38 | 3.33 | 6.99 | 7.41 | 7.00 |

## Appendix C. Estimation results

### *Appendix C.1. Equation (1)*

| | $\hat{\beta}_0$ | $\hat{\sigma}_\beta$ | 95% - conf.int. | | $Pr(>\lvert\hat{\beta}_0\rvert)$ | $\hat{\sigma}_i$ | $\hat{\sigma}_k$ |
|---|---|---|---|---|---|---|---|
| 2playerSingle | 57.95 | 0.67 | 56.61 | 59.29 | 0.0000 | 5.88 | 1.75 |
| 2player | 56.53 | 2.08 | 52.49 | 60.75 | 0.0000 | 3.77 | 1.99 |
| 3playerSym | 55.40 | 1.75 | 51.83 | 58.66 | 0.0000 | 5.18 | 2.10 |
| 3playerAsym | 53.27 | 0.79 | 51.68 | 54.78 | 0.0000 | 3.53 | 0.00 |
| 3playerPatient | 51.96 | 0.47 | 50.97 | 52.85 | 0.0000 | 1.37 | 0.00 |

*Appendix C.2. Equation (2)*

| | Estimate | Std. Error | z value | Pr(>\|z\|) |
|---|---|---|---|---|
| offer | -0.43 | 0.026 | -16.36 | 0.0000 |
| 2playerSingle | 25.27 | 1.520 | 16.63 | 0.0000 |
| 2player | 24.74 | 1.560 | 15.85 | 0.0000 |
| 3pAsym.Strong | 25.01 | 1.478 | 16.92 | 0.0000 |
| 3pAsym.Weak | 26.40 | 1.593 | 16.57 | 0.0000 |
| 3playerPatient | 24.00 | 1.438 | 16.70 | 0.0000 |
| 3playerSym | 25.38 | 1.498 | 16.94 | 0.0000 |

| Groups | Name | Variance | Std.Dev. |
|---|---|---|---|
| i | (Intercept) | 3.5 | 1.87202 |
| k | (Intercept) | 2.95e-14 | 1.72e-07 |

*Appendix C.3. Equation (3)*

| | Estimate | Std. Error | z value | Pr(>\|z\|) |
|---|---|---|---|---|
| 2playerSingle | 0.61 | 0.059 | 10.47 | 0.0000 |
| 2player | 0.61 | 0.098 | 6.21 | 0.0000 |
| 3playerSym | 0.76 | 0.082 | 9.20 | 0.0000 |
| 3playerAsym | 0.30 | 0.083 | 3.58 | 0.0003 |
| 3playerPatient | 0.77 | 0.082 | 9.38 | 0.0000 |

| Groups | Name | Variance | Std.Dev. |
|---|---|---|---|
| i | (Intercept) | 0.0898 | 0.3 |
| k | (Intercept) | 0.0266 | 0.163 |

## Appendix D. Experimental procedures

Between November 2009 and October 2013, we conducted 18 experimental sessions at the economics laboratory at the University of Jena, Germany. 16 people participated per session, adding up to a total of 288 subjects.[11] Participants were invited using ORSEE (Greiner, 2004). 93% of our participants were students from Jena, about 58% were female and 42% male participants. The average age was 23 years. As part of the lab policy and to ensure that participants understood the instructions, only subjects that had passed a short German language test took part in the experiment. To ensure that participants had approximately the same level of experimental bargaining practice, only persons without prior experience in bargaining experiments in Jena were invited. Subjects participated in only one session of the experiment.

An experimental session proceeded as follows. Upon arrival, participants were randomly assigned to cubicles were they read the instructions. Participants were not allowed to talk to each other. Questions of participants were answered privately in their cubicle. All sessions of the experiment were programmed and conducted with z-Tree 3.3.6 (Fischbacher, 2007). Figure D.6 in the appendix shows an example screen. At the beginning of the experiment, participants had to answer five control questions. After the control questions, the bargaining started.

We conducted two treatments per session. To introduce the game, we always started with 2playerSingle. The second treatment was then either 2player, 3playerSym, 3playerAsym or 3playerPatient. Players did not change their roles ($1A$, $1B$, etc.) during the experiment. A player 1 in the first treatment could only be a player $1A$ or player $1B$ in the second treatment. A player 2 in the first treatment could only be a player $2A$ or player $2B$ in the second treatment. Each treatment was played for five periods. A period consisted of one or more bargaining rounds. At the end of each period, participants were asked to copy the results of this period into a table so that they had a record of the experiment's history.

Participants were randomly rematched after each period. To approximate the infinite horizon of the game as closely as possible, we did not explicitly limit the number of bargaining rounds. Similar to Rapoport et al. (1990), we told subjects that they could take their time. However, if they needed "unexpectedly long", the computer would interrupt the current period. In fact, the computer was programmed to interrupt a period if more than 200 seconds (400 seconds in period 1, 300 seconds in period 2) had elapsed or if all other groups had already reached agreement and the last group was already in round 8 or 9 (The round was drawn as a random number). In case of such an interruption, the payoff was then calculated as if these players had, after the interruption, behaved like the average group of players. E.g., if bargaining was interrupted in round 8 and the average group of players in that session had reached an agreement of 50:50 in round 4, then the "interrupted" players would get 50:50, too, now discounted by 12 rounds.

We had a small technical problem which, in our opinion, does not compromise the validity of our results: Participants were assisted by a visual tool when they made their choices. This tool would allow them study the bargaining situation in an arbitrary round in the future. In some situations the number of lottery tickets shown by this tool was slightly too small for both players. Furthermore, in some situations the irrelevant of the player 2's offers was not transmitted correctly. Excluding the potentially affected data (7.2%) does not change qualitative results for the shares. Such an exclusion would, however, complicate the analysis for the number of rounds tremendously, since these technical problem could only occur after specific choices.

After the five bargaining periods, one period was chosen randomly for payment and a winning number was drawn to determine the winners of a prize. The experiment ended with a questionnaire

[11] See Appendix A for on overview.

in which we asked for demographic data. Each participant was then paid in private and dismissed. A session lasted on average about one and a half hours. Every participant received a 6€ show-up fee plus a potential prize of 10€ . On average, a participant earned 10.80€ . during a session.

The following is a translated version of the German instructions for 2playerSingle. The instructions for 2player, 3playerSym, 3playerAsym and 3playerPatient appeared on the screen after 2playerSingle was finished. Apart from the number of players and discount factors, respectively, they are very similar to those for 2playerSingle and are available from the corresponding author upon request.

*Instructions.*

**Welcome to this experiment!**

By participating, you support our research and you can earn money in return. The amount you will earn depends on your and on the other participants' decisions. The experiment is financed by the Friedrich Schiller University Jena. It is important to read the following instructions very carefully in order to understand how the experiment will proceed. None of the other participants will receive any information on your decisions or on your payoffs. All data will be treated confidentially and will be used exclusively for research.

**Questions** Should you have questions at any point in time, please raise your hand. We will answer your question privately. Please do not ask your question in a loud voice. If a question is relevant for all participants, we will repeat it in a loud voice and answer it.

**General rules** All participants of this experiment have received the same instructions. However, the information that participants will see on their screens during the experiment is only intended for the respective participant. Therefore, please do not look at other screens and do not talk to other participants. Please turn off your mobile phones now. You will be excluded from the experiment if you break any of these rules. In this case, you will not be paid.

**Procedure and payment** The experiment consists of two parts and a concluding questionnaire. Every *part* consists of several *periods*, which in turn can consist of several *rounds*. You will learn the respective number during the experiment. In the end, all participants will receive a show-up fee of 6.00 €, irrespective of the decisions they will have made during the experiment. In addition, we will raffle several prizes of 10.00 € at the end of the experiment. Your chances to win one of these prizes depend on your and the other participants' decisions during the experiment and will be explained in the following paragraphs.

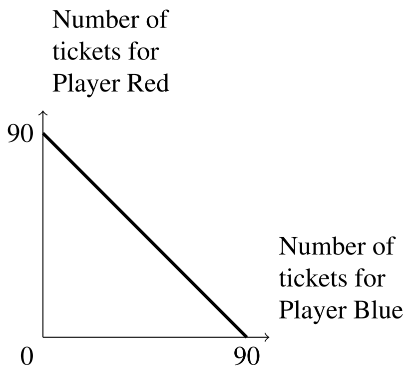
**Part 1** The first part consists of five periods. There are two roles: Player Red and Player Blue. First, the computer will determine randomly, who of you will become Player Red and who will become Player Blue. (You will keep these roles during the whole part 1. This means, if you are Player Red in the first period, you will stay Player Red in the following periods and if you are Player Blue in the first period, you will stay Player Blue in the following periods.) In each period, every two participants play together: one Player Red and one Player Blue. At the beginning of each period, the computer matches you anonymously and randomly with another participant. Your task is to divide (initially) 90 lottery tickets between you and the other participant. The more lottery tickets you own in the end, the higher your probability to win a prize of 10.00 €.

The first period starts with round 1 and Player Red proposes a proportion how to divide the lottery tickets between himself and Player Blue, i.e., x % for himself and (100 - x) %

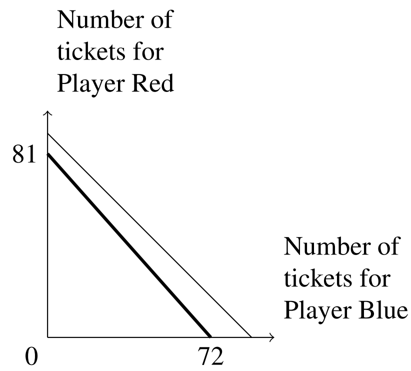
lottery tickets for Player Blue. (x does not have be integer, also fractions can be divided.) Player Blue can now accept or reject the proposal. If he accepts, the 90 lottery tickets will be divided accordingly and the first period will end in round 1.

However, if Player Blue rejects the proposal, round 2 starts. At the beginning of round 2, the maximum number of available lottery tickets is reduced: by 10% for Player Red, by 20% for Player Blue. Player Blue now makes a counterproposal according to which proportion the remaining lottery tickets should be divided between himself and Player Red. Subsequently, Player Red can accept or reject this proposal. If he accepts, the lottery tickets are divided accordingly and the first period ends in round 2.

**Possible divisions of tickets (rd. 1)**




**Possible divisions of tickets (rd. 2)**




The diagrams illustrate the possible divisions in round 1 and in round 2. The points *on* the thick lines represent all possible divisions. Example: In round 2, Player Red could receive 100% of his maximum number of available lottery tickets (81 tickets), consequently, Player Blue would receive 0% of his maximum number of available lottery tickets (72 tickets). Or Player Red could receive 0% of his maximum number of available lottery tickets (81 tickets), consequently, Player Blue would receive 100% of his maximum number of available lottery tickets (72 tickets). All divisions in between that add up to 100% are also possible.

If Player Red rejects Player Blue's proposal, round 3 starts and the number of lottery tickets is reduced like in the previous round: by further 10% for Player Red, by further 20% for Player Blue. Player Red then makes a counterproposal according to which proportion to divide the remaining lottery tickets between himself and Player Blue. Subsequently, Player Blue can accept or reject this proposal like in round 1 and so on. The maximum number of available lottery tickets is reduced by 10% for Player Red and by 20% for Player Blue at the beginning of each new round, i.e., every time a proposal is rejected. A period will end only if a proposal is accepted.

When the first period will have ended, the second period will start. The task will be the same, namely to divide (initially) 90 lottery tickets between you and the other participant.

We have planned enough time for each period and you can take your time to reach an agreement with the other participant. However, if you take unexpectedly long to reach an agreement, the computer will interrupt the current period. In this case, you will receive from your remaining lottery tickets in that round the proportion that the other participants received on average. In case all other participants should also not yet have reached an agreement, the computer will determine a division.

**Part 2** You will receive the instructions for part 2 including your player role after part 1 has ended.

**Drawing** When all parts of the experiment will have ended, two things will be drawn: the period relevant for payment and the participants winning a prize of 10.00 €.

1. First, out of all periods one period relevant for payment will be drawn. For this purpose, a volunteer will draw a table tennis ball out of a container with as many table tennis balls as there are periods. The number of the drawn ball determines the payoff relevant period for all participants. The other periods will not be considered when paying the participants.
2. Subsequently, the participants winning a prize will be drawn. Assume that Player Red has received x lottery tickets and Player Blue has received y lottery tickets in the payoff relevant period with $x+y \leq 90$. First, each player's lottery ticket interval is determined. Player Red receives the interval from 0 (inclusive) to x (inclusive), Player Blue receives the interval from x (exclusive) to x+y (inclusive). (Player Blue's interval ranges up to 90 maximum since only 90 can be divided.) If two participants agreed on 3 lottery tickets for Player Red and 4 lottery tickets for Player Blue, Player Red would receive the interval from 0 (inclusive) to 3 (inclusive). Player Blue's interval would range from 3 (exclusive) to 7 (inclusive). Afterwards, the winning number (the same for all participants) is drawn. For this purpose, a volunteer draws a table tennis ball six times with replacement out of a second container. Ten table tennis balls numbered from 0 to 9 are in this second container.

   The number of the first ball determines the tens digit of the winning number.

   The number of the second ball determines the units digit.

   The number of the third ball determines the first digit after the decimal point.

   The number of the fourth ball determines the second digit after the decimal point.

   The number of the fifth ball determines the third digit after the decimal point.

   The number of the sixth ball determines the fourth digit after the decimal point.

   For each pair consisting of Player Red and Player Blue it is checked in which interval the winning number is located. The player whose interval contains the winning number will receive one of the prizes of 10.00 €, the other will not. In case a winning number larger than 90 is drawn, a new winning number will be drawn. In case a winning number smaller or equal 90 is drawn but is is not in the range of neither Player Red's nor Player Blue's interval, no member of this couple will receive a prize. (This possibility exists since the number of available lottery tickets is reduced each round.)

Please wait until all participants have finished reading the instructions. We will announce the start of the experiment.

**We wish you success in the experiment!**

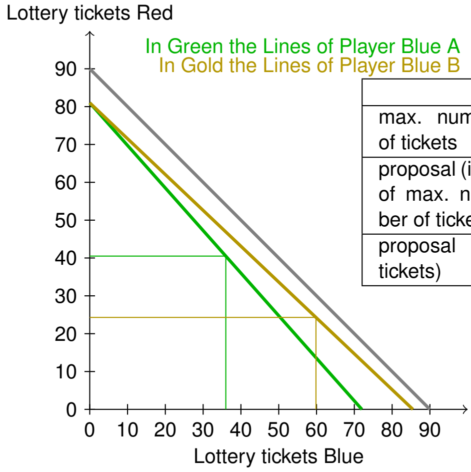
*Part 2 of the instructions. [[ This part would only be displayed after participants had completed part 1 ]]*

The next part consists of five periods, too. The task will be the same for each period.

**There are four player roles: Player Red A, Player Red B, Player Blue A and Player Blue B.**

Period: 6 of 10 Round 2

Player Blue A and player Blue B made the following proposals how to divide the lottery tickets among you and the blue pair. Only the proposal which gives your pair fewer lottery tickets counts.
Do you accept this proposal or do you reject it?




| | Red | Blue A | Blue B |
|---|---|---|---|
| max. number of tickets | 81.0000 | 72.0000 | 85.0000 |
| proposal (in % of max. number of tickets) | 30.0000 | 50.0000 | 70.0000 |
| proposal (in tickets) | 24.3000 | 36.0000 | 59.8500 |

preview next round

reject accept

Figure D.6: Example screen

At the beginning of this part, the computer will split the Players Red from part 1 randomly into Players Red A and Players Red B. The Players Blue from part 1 will be split randomly into Players Blue A and Players Blue B. You will keep these roles during this whole part. At the beginning of each period, the computer matches you anonymously and randomly with three other participants, such that always one Player Red A, one Player Red B, one Player Blue A and one Player Blue B are playing together. Player Red A and Player Red B form a couple (the red couple). Player Blue A and Player Blue B form another couple (the blue couple). Your task is to divide (initially) 90 lottery tickets between your and the other couple. The more lottery tickets you own in the end, the higher your probability to win a prize of 10.00 EUR.

Players Red A as well as Players Blue A and Players Blue B proceed like Players Red and Players Blue from part 1. The first period starts with round 1 and Player Red A proposes a proportion how to divide the lottery tickets between the red couple and the blue couple. Player Blue A and Player Blue B now accept or reject the proposal independently from each other. **If Player Blue A and Player Blue B accept the proposal, the 90 lottery tickets will be divided accordingly and the first period will end in round 1.**

**However, if at least one partner from the blue couple rejects the proposal, round 2 starts.** At the beginning of round 2, the maximum number of available lottery tickets is reduced: **by 10% for the red couple, by 20% for Player Blue A and by 5% for Player Blue B.** Player Blue A and Player Blue B now each make a counterproposal independently from each other according to which proportion the remaining lottery tickets should be divided between themselves and the red couple. **Subsequently, Player Red A can accept out of the two proposals the one which contains less lottery tickets for the red couple.** (Assume that Player Blue A proposes 3 lottery tickets for the red couple, Player Blue B, however, proposes 2 lottery tickets for the red couple. Player Red A can then accept Player Blue B's proposal only.)

If Player Red A accepts, the lottery tickets are divided accordingly and the first period ends in round 2. If Player Red A rejects, round 3 starts and the number of lottery tickets is reduced like in the previous round: by further 10% for the red couple, by further 20% for Player Blue A and by further 5% for Player Blue B. Player Red A then makes a counterproposal how to divide the remaining lottery tickets between the blue and the red couple. Like in round 1, Player Blue A and Player Blue B accept or reject this proposal independently from each other and so on. The maximum number of available lottery tickets is reduced by 10% for the red couple, by 20%for Player Blue A and by 5% for Player Blue B at the beginning of each new round, i.e., every time a proposal is rejected. A period will end only if a proposal is accepted.

**Player Red B is not able to make proposals or to react to proposals during this whole part. Nevertheless, he learns what Player Red proposed to the blue couple and how he reacts to the blue couples' proposals.**

| Player | Red A | Red B | Blue A | Blue B |
|---|---|---|---|---|
| At the beginning of each round, the maximum number of available lottery tickets to be divided will be reduced by… | 10% | 10% | 20% | 5% |
| Makes and reacts to proposals | Yes | No | Yes | Yes |

**Drawing** If the period relevant for payment should be a period from this part, the winners of the pizes of 10.00 EUR will be drawn like in part 1. Assume that the red couple receives the interval from 0 (inclusive) to x (inclusive). Player Blue A receives the interval from x (exclusive) to x+y (inclusive). Player Blue B receives the interval from x (exclusive) to x+z (inclusive). **If the winning number is located within the red couple's interval, Player Red A as well as Player Red B will each receive one of the 10.00 EUR prizes. If the winning number is located within Player Blue A's and Player Blue B's interval, Player Blue A as well as Player Blue B will each receive one of the 10.00 EUR prizes. If the winning number is located within Player Blue B's interval, but not within the range of Player Blue A's interval, only Player Blue B will receive one of the 10.00 EUR prizes.** In case a winning number smaller or equal 90 is drawn but is not within the range of any player's interval, no-one will receive a prize. (This possibility exists since the number of available lottery tickets is reduced each round.)