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Ultimatum Game Experiments

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Abstract

We study behavior in three-person ultimatum games where one proposer and two responders have to divide a given sum of money. We show that different division rules lead to different behavior although the subgame perfect equilibrium remains the same. The results demonstrate that, first, when unanimous rejection from responders was required to punish the proposer, lower offers were accepted than in the case where one-sided punishment was effective. Second, when unanimous acceptance was needed to get the offer through, the proposals were close to equal division. Finally, when acceptance implied the responder got her share, regardless of the other responder's action, she almost always accepted the offer.

JEL Classification: C72, C91

Keywords: behavioral game theory, ultimatum game, experimental economics.

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1 Introduction

The study is based on a bargaining game called ultimatum game. In the game, two players, a proposer and a responder, bargain over a division of, for example, a given sum of money. The proposer first makes an offer how to split the sum between two players. The responder can then either accept or reject the offer; if she accepts the money is divided between the players according to the offer, but if she rejects neither player gets anything. The game has a unique subgame perfect equilibrium where the proposer suggests the responder the smallest amount possible and the responder accepts. Güth et al. (1998) conducted an experiment to test behaviour in the ultimatum game and their results did not give support to the game theory prediction. In the experiment, like in the numerous experiments that followed Güth at al. (1998) study[1], proposers offered non-negligible amounts and responders rejected positive offers.

Fischbacher et al. (2003) have studied how competition affects behaviour in the ultimatum game. They conducted a series of experiments where one proposer made an offer to more than one (two or five) responders. The results of their experiments show that the addition of just one competing responder has a large impact on behaviour in the game; the average share of responders reduced from 42 percent to 20 percent. In the case of five competing responders, the average share further fell to 12-14 percent.

In the Fischbacher et al. (2003) experiment, the proposer made the offer to two responders but the suggestion was implemented only between two players: the proposer and the responder who accepted the offer. If both responders accepted the offer, the sum was divided between the proposer and a randomly chosen responder. In a three player bargaining game, other sharing rules are also possible. For example, the proposer could suggest a share to both responders when the impact of unanimity on behaviour can be studied. Krishna and Serrano (1996) studied the effect of unanimity in the three player version of Rubinstein's bargaining game. If only unanimous agreements can be executed, the game has many perfect equilibria.[2] Krishna and Serrano (1996) show that if the unanimity assumption is relaxed, that is, if the players can exit the game with "partial agreements" the game has a unique perfect equilibrium. One of our three player bargaining experiments can be interpreted as one period version of Krishna and Serrano game.

In our experiment, we first study how competition between responders affect behaviour. Then, we examine the effects of different sharing rules on behaviour in a three player ultimatum game. We

[1] See Camerer, 2003.

[2] See e.g. Osborne and Rubinstein (1990).

show that albeit all games have a unique subgame perfect equilibrium, different sharing rules induce behavioral changes between the games.

In Section 2, we sketch the design of the experiment. In Section 3, we descride the equilibria of the games. The main results we present in Section 3, and, finally in Section 4, we provide some discussion and conclusions.

2 The design

We conducted four different treatments in one session with 18 participants[3]. Subjects were students from the Faculty of Social Sciences at the University of Helsinki, Finland. In the first treatment, the subjects played the standard ultimatum game where two players, a proposer and a responder, have to divide a sum of money, here 12 euro, between them. First, the player nominated as a proposer makes an offer to the other player, a responder. The responder can then either accept or reject the offer. If she accepts the offer, the money is divided according to the proposal; if she rejects, neither player gets anything. All subjects played three rounds of the ultimatum game and, in every round, all subjects first played in the role of a proposer and then in a role of a responder.

The three other treatments varied from the standard ultimatum game in that one more responder was added to the game. First we wanted to study the implications of responder competition on the results of the ultimatum game. We conducted an experiment where the proposer made her offer simultaneously to both responders. 12 euro was then divided between the proposer and the responder who accepted the proposal, or, if both responders accepted it, between the proposer and a randomly chosen responder. While in the standard ultimatum game the responder can punish proposer's behavior by rejecting the offer, in this experiment, the responders no longer have this kind of power of veto. By rejecting, the responders can quarantee a zero payoff only for themselves.

With the last two experiments, we examined how different sharing rules affect the results in three-player bargaining. In the third treatment, the proposer again made her offer to two responders but now she was asked to propose a division among all three players. Implementation of the proposal required unanimity; 12 euro was divided according to the proposal only if both responders accepted it. The proposer was not obliged to make the same offer to both responders, but both responders saw the whole offer, that is, both responders also knew the share suggested for the other responder. In the fourth treatment, unanimity was no longer required. The fourth treatment differed from the third one in that

[3]The design of the experiments is described in detail in Appendix B.

the responder who accepted the division got her share but the proposer only if both responders took up the offer. Responders were hence able to exit the game with "partial agreements", like in Krishna and Serrano (1996). In all three treatments with two responders, all subjects played in a role of the proposer once and in a role of the responder twice.

3 Equilibrium

To make discussion easier we refer to the first treatment, the standard ultimatum game, by UG, to the second treatment, the ultimatum game with responder competition, by RC, to the third treatment, the first modification of responder competition, by RCM1, and to the fourth treatment, the second modification of responder competition, by RCM2. As it is well known, UG has an infinite number of Nash equilibria but only one subgame perfect equilibrium. In the subgame perfect equilibrium, the proposer offers the smallest (non-zero) amount possible and the responders accepts the offer[4]. It is better for the responder to accept any positive offer than reject and get zero; the proposer knows this and gives the responder the smallest amount.

In the other three experiments, three players bargain over 12 euro. The structure of the game tree is the same in all three games but the sharing rule is not, and therefore the payoffs differ between the games. Figure 1 depicts the game tree and payoffs associated with RC, RCM1, and RCM2. We can see from the figure that the player three always chooses accept (A); picking on A yields always at least as high payoff as picking on R. Knowing the player three will accept, the player two also accepts. In the subgame perfect equilibrium of the three player games, the player 1 then offers the other players the smallest (non-zero) amount and the responders accept the offer.

[Figure 1 here]

4 Results

In the sub-game perfect equilibrium of all four bargaining games we experimented, the proposer offers the responders the smallest amount possible and the responders accept the offer. Game theory thus offers same prediction about the play of all four games. This is not, however, what we observed in the

[4]The responder is indifferent between accepting and rejecting when the proposer offers her zero. Here we assume that, in the case of indifference, the responder rejects the offer.

experiment. In this section, we present the main results. In each subsection, we discuss proposer and responder behaviour separately. Figures 2 and 3 summarize the main statistics behind the results.

[Figure 2 here]

[Figure 3 here]

4.1 Standard ultimatum game

In the UG experiment, the task of the subjects was to divide 12 euro. One subject proposed a division, for example, offered the other subject from 12 euro 4 euro; the other subject then either accepted or rejected the proposal. A given proposal was executed only if the responder accepted it. 18 subjects played three rounds of the UG, both in the role of proposer and responder, but in every round with a randomly selected opponent. They thus always made their proposal to a different respondent. This resulted in 54 offers and 54 responses.

4.1.1 Proposer behaviour

Figure 2 summarizes the results from all three rounds of the UG. As the figure shows, the proposal size varied from 1 to 8, 1 and 6 being the most popular offers made. The mean proposal was 3.61 (appr. 30%) which is in line with earlier findings[5]. The mean was below the median proposal of 4. There was no significant correlation between the proposals received in the first period and the proposals made in the second period. Neither there was any significant correlation between the acceptance of the proposal received in the first period and the proposal made in the second period. These results indicate that the subjects understood and believed the part of the instructions where it was explained that that they would not play with the same opponent more than once. Hence the subjects did not use any punishment strategies. Finally, the proposers played the two last rounds of the game very similarly, the correlation between the second and third round proposals being 0.72 (p-value 0.0007), while the first round proposals had only a slight correlation with the proposals made in the second and in the third round.

[5] Camerer (2003) report the results from several experiments. In the experiments, mean offer varied between 13 and 52 per cent.

4.1.2 Responder behaviour

The mean of the accepted proposals was 4.47 and the median 5. In all rounds, the overall relative acceptance rate was approximately 0.7, which is also in line with earlier findings. Naturally, there was a positive correlation between the size of a proposal and its relative acceptance rate. However, the correlation was not as strong as it could have been and small proposals were also accepted quite frequently. The acceptance rate of the size 1 proposal varied from 0.5 to 0.2, whereas the size 4 proposal was rejected only once and proposals above it were never rejected.

Like in the earlier experiments, responders rejected positive offers. By rejecting the responders not only give up their share but also prevent the proposers from getting a positive payoff. In the standard UG, the responders can thus punish the proposers for an unfair offer. One theory is that some responders reject positive offers because they receive as much, or more, satisfaction from punishing the proposer as they would from having extra money from the division.[6]

4.2 Ultimatum games with two responders

After the ultimatum game experiment, we conducted three experiments where we had modified the standard UG by adding one more responder to the game. Depending on the set-up, 12 euro was divided either between the proposer and one responder or among the proposer and both responders. In the fourth treatment, there was also the possibility that if only one responder accepted the offer, only she received her share: the other two players received nothing. In the following three treatments, all participants played once in a role of proposer and twice in a role of responder, resulting in 36 proposals and 36 responses in total. First we analyse the ultimatum game with responder competition, RC.

4.2.1 RC experiment

In the RC experiment, like in the UG, the proposer was again asked to make a proposal how to divide 12 euro between two players. The RC experiment differed from the UG experiment in that the proposer made the same offer to two responders. The proposal was implemented if at least one responder accepted it. 12 euro was then divided between the proposer and the responder who accepted the offer. If both responders accepted the offer, the receiving responder was selected randomly.

As a whole, proposer and responder behaviour in the RC experiment did not differ much from the

[6] See e.g. de Quervain et al. (2004).

behaviour in the UG experiment.[7] The mean proposal was 3.22 and the median 3, both slightly lower than in the UG. The most frequent proposal was again 1 and its relative frequency was even higher than in the UG. On the other hand, the frequency of size 6 proposal was now lower than in the UG. The proposals were also less dispersed in the RC than in the UG, varying only from 1 to 6.

As Figure 2 shows, less than 20% of size 1 proposals were accepted. The acceptance rate of the size 5 proposal was 80% and all other proposals were accepted with certainty. However, the overall acceptance rate decreased only a little and actually maintained approximately at the same level as in the UG. The mean and the median of the accepted proposals were 4.04 and 4, respectively. Responder competition thus decreased the average offer made and the average offer accepted, but the effects were smaller than in the Fishbacher et al. study.

Surprisingly, the proposal size and the relative acceptance rate did not correlate significantly in the RC experiment, like in the UG experiment. The responders perhaps rather accepted the offer and got their share with probability 0.5 than tried to punish the proposer by rejecting the offer. In other words, it seems that the responders understood the difficulty of punishing the proposer for making a low offer. The punishment would have been actualised if and only if both responders were willing to punish.

4.2.2 RCM1 experiment

The RCM1 experiment differed from the previous treatments in that now the proposer had to suggest how to divide 12 euro among three players. In order to go through, the proposal required unanimity, the acceptance of both responders. If one or both responders rejected the offer, none of the players got anything. In addition, the proposer no longer was obliged to make the same offer to both responders. Hence, punishing the proposer was made easier in the RCM1 experiment than in the RC experiment.

The proposer behaviour in the RCM1 experiment differed from the proposer behaviour in the previous treatments. We found only a slight insignificant correlation between the offers made in the RCM1 and those made in the RC. The mean of the proposals, 2.64, was lower than in the previous treatments, while the median was 3, the same as in the RC experiment. The proposal size varied from 0 to 4. Clearly, the average proposal size was smaller than in the previous treatments due to the fact that 12 euro was now divided among three instead of two players. The most frequent proposal was now 3 and the least frequent 0. Size 4 proposal was also quite frequent. In the RCM1 experiment, more than in the previous treatments, the proposals thus headed in a direction of equal division.

[7] The correlation between the offers made in the UG and in the RC was 0.887 (p-value 0.0001).

The mean of the accepted proposals was 3.04, and the median was 3. The only proposal size that was accepted with certainty was the size 4 proposal while all the other proposals were rejected, rejection rate varying from 0.13 to 1. In seven out of eight proposals that were not executed, the reason for the proposal not getting through was one sided rejection. All other offers were either accepted or rejected by both responders. In most of the rejected proposals, the proposer offered the responders 3 or less. One reason for the relatively large proportion of one sided rejection (87.5%) could be heterogeneity in player preferences. Even though the proposer had the possibility to offer the responders different shares, only one proposer used that possibility and both responders accepted her offer.

4.2.3 RCM2 experiment

In the RCM2 experiment, if a responder accepted the offer, she always got her share; if a responder rejected the offer she and the proposer did not get anything. Otherwise the setup in the RCM2 was the same as in the RCM1 experiment. The proposer in the RCM2 also had a chance to make a different offer to two responders but a rejection now punished only the proposer and the responder that rejected the offer, not the other responder.

The proposer behavior in the RCM2 experiment was very similar with the proposer behaviour in the RCM1 experiment and quite similar with the behaviour in the RC experiment.[8] The mean and the median of the proposals were 2.56 and 3, respectively. Hence, the mean of the proposals was lower than in the RCM1. The proposals varied from 0 to 4 and were now more uniformly distributed over that range. The most frequent proposal was 4, the proposal 1 being almost as frequent. Shares 0 and 2 were offered less frequently.

The responder behaviour was slightly different in the RCM2 experiment than in the RCM1 experiment. The mean of the accepted proposals was 2.83 and the median 3. Thus, compared with the other treatments, smaller proposals were now accepted. Size 2 and 4 proposals were accepted with certainty while size 3 proposal was accepted in with 80% probability and size 1 proposal with a 60% probability. Size 0 proposals were rejected with certainty. 12 out of 18 proposal pairs were accepted by both responders. In only one out of six proposal pairs that were not accepted by both responders, the proposal was rejected by both responders. In all the rest five proposals, the other responder received her share while the proposer and the responder who rejected the offer did not get anything.

On average the proposals were smaller in the RCM2 than, e.g., in the RCM1. Perhaps the proposer

[8] The correlation between the offers made in the RCM1 and those made in the RCM2 was 0.91 (p-value 0.0000); and the offers made in the RC and those mad in the RCM2 0.65 (p-value 0.0155).

thought accepting to be responders' dominant strategy since the responder who accepted the offer always got her share. However, there was quite high frequency of one sided rejections, reflecting the abandoning of the responder's own share. If there had been more than two proposals where the responders were offered different shares, the resulting rejections would be easier to understand as a punishment strategy. Further, only one of those was one-sidedly rejected, and hence only in one case the different shares could be inferred to make the responder reject the offer to punish the proposer.

5 Conclusion

We conducted experiments where we studied behavior in three-person ultimatum games where one proposer and two responders bargain over a division of a given sum of money. We showed that different sharing rules implied different behavior although changing sharing rules did not affect the subgame perfect equilibrium of the game. Especially unanimity had a large impact on results and is certainly worth a further research. For example, responders accepted smaller offers when the choice of the other responder did not affect their payoff. They were thus less willing to punish the proposer when, by accepting, they were able to acertain a positive payoff.

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Appendix

A Figures

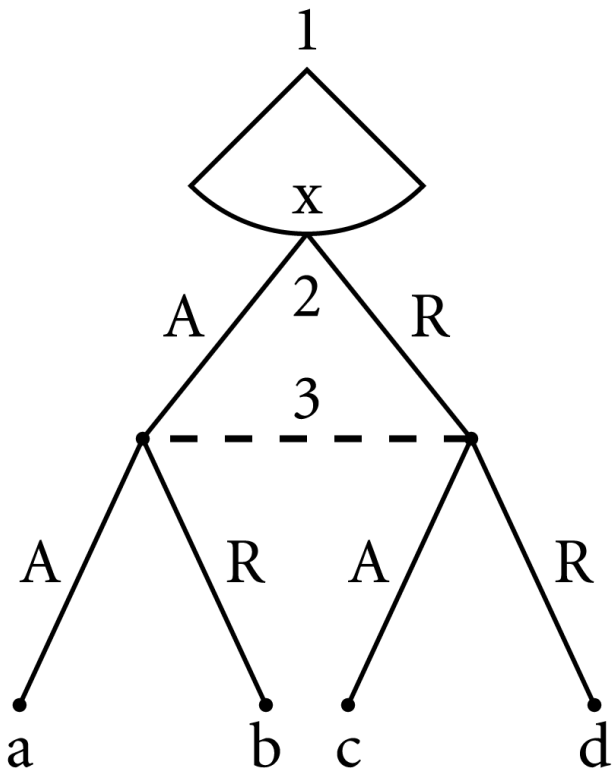

Figure 1: The game tree associated with RC, RCM1 and RCM2. In RC, $x = (x_1, x_2)$ such that $x_1 + x_2 = x$; in RCM1 and in RCM2, $x = (x_1, x_2, x_3)$ such that $x_1 + x_2 + x_3 = x$. **(i)** Payoffs in RC: a) $(u_1(x_1), \frac{1}{2}u_2(x_2), \frac{1}{2}u_3(x_2))$, b) $(u_1(x_1), u_2(x_2), u_3(0))$, c) $(u_1(x_1), u_2(0), u_3(x_2))$, d) $(u_1(0), u_2(0), u_3(0))$. **(ii)** Payoffs in RCM1: a) $(u_1(x_1), u_2(x_2), u_3(x_3))$, b) $(u_1(0), u_2(0), u_3(0))$, c) $(u_1(0), u_2(0), u_3(0))$, d) $(u_1(0), u_2(0), u_3(0))$. **(iii)** Payoffs in RCM2: a) $(u_1(x_1), u_2(x_2), u_3(x_3))$, b) $(u_1(0), u_2(x_2), u_3(0))$, c) $(u_1(0), u_2(0), u_3(x_3))$, d) $(u_1(0), u_2(0), u_3(0))$.

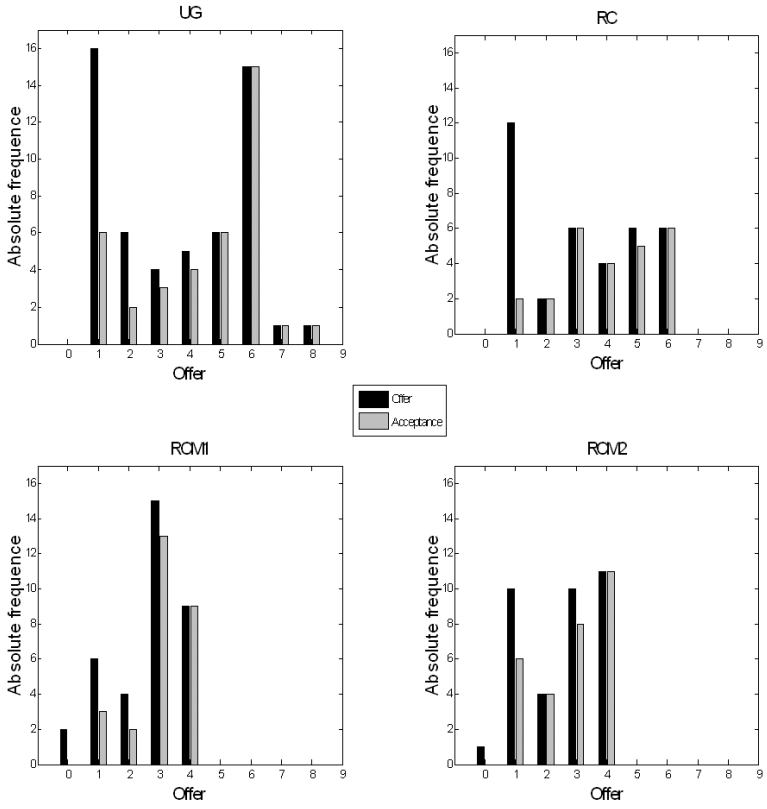

Figure 2: Absolute offer and acceptance frequences in different treatments.

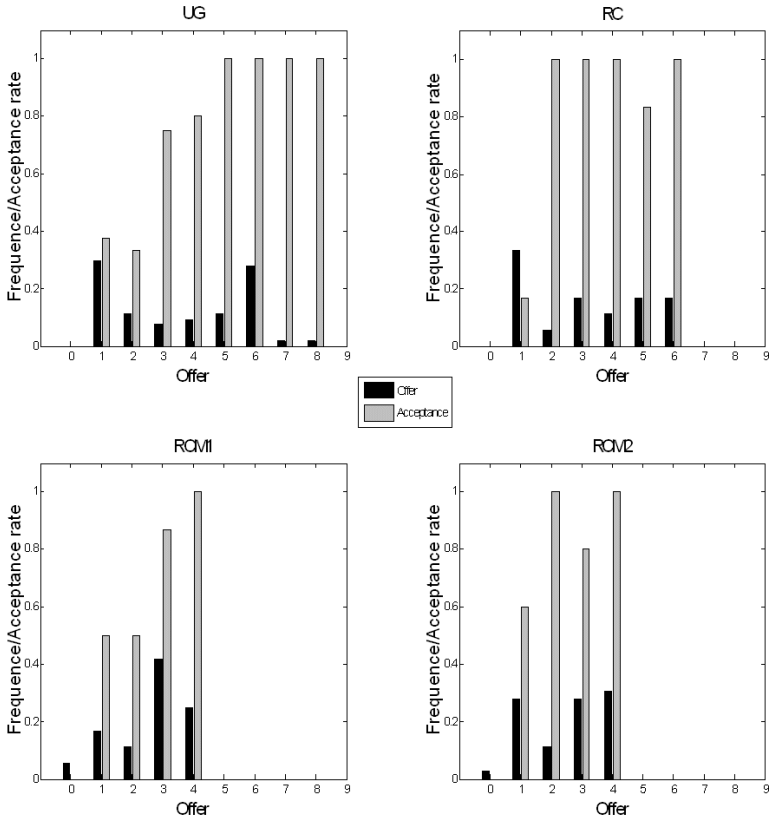

Figure 3: Relative offer and acceptance frequences in different treatments.

B Experimental design

The experiment was conducted at the University of Helsinki, Finland. Participants were 18 students from the Faculty of Social Sciences, 67% of them were male. Participants were recruited by putting up announcements on students' noticeboards and by informing students about the experiment on their net page. Subjects signed up via e-mail. Upon arrival to the experiment, participants were randomly separated to three different classrooms and, in the classrooms, to six numbered desks. In each room, a researcher of RUESG conducted and monitored the experiment. In the beginning, subjects were asked to write their name and desk number on a given sheet of paper and they were told that the information was needed only for the payment. Names of the subjects were never connected with their decisions. Next, general instructions were read out and delivered to the subjects. In the instructions, they were told that the experiment will incude several different interactive choice situations. The situations will be described them on paper. In the same choice situation with a subject there will be either one or two other subjects. The same opponent will be in the same choice situation with the subject only once. Subjects in the same classroom will never be placed in the same choice situation. In the instructions it was also told that after the experiment the subjects will be paid in cash a 5 euro show-up fee plus an extra payment that will depend on the choices they will make in the experiment. Subjects were then allowed to ask questions. The first experiment was started only after the set-up was clear to everybody.

The first treatment was a version of the standard ultimatum game. In the game, two subjects, a proposer and a responder, had to divide 12 euro between them. First, all subjects played in a role of a proposer. Papers were distributed to the subjects and the decision problem was also read out to them. Participants wrote down their offers and the monitors collected the papers and redistributed them among subjects. Participants then played in a role of a responder and answered to the proposal made by some other subject. This procedure was repeated three times, that is, all subjects played three times in a role of a proposer and three times in a role of a responder.

The second treatment was like the standard ultimatum game but with two responders. Unlike in the standard ultimatum game, the proposer now made her offer to two responders. 12 euro was divided between the proposer and a responder who accepted the proposal, or, if both responders accepted it, between the proposer and a randomly chosen responder. Papers were again distributed to the subjects and the decision problem was also read out to them. First all subjects played in a role of a proposer and then in a role of a responder. Only one round of this game was played.

The third treatment was a modification of the second treatment. The proposer again made her

proposal to two responders but now she was asked to divide 12 euro among all three players. The sum was divided among the proposal and the responders if both responders accepted the proposal. Papers were again distributed to the subjects and the decision problem was also read out to them. First all subjects played in a role of a proposer and then in a role of a responder. This game was also played only once.

The fourth treatment was also a modification of the second treatment. The proposer made her proposal to two responders and again she was asked to divide 12 euro among all three players. If a responder accepted the proposal, she got her share but the proposal only if both responders accepted it. Papers were again distributed to the subjects and the decision problem was also read out to them. First all subjects played in a role of a proposer and then in a role of a responder. This game was also played only once.

The experiment lasted about two hours. After the experiment, the participants were paid their compensation anonymously. The extra payment was determined on the basis of the first treatment results (UG, the second and the third round). The profits earned by the participants ranged from 10.50 euro to 19.00 euro, with an average of 15.36 euro and a standard deviation of 2.77. For taxation reasons the upper limit of a payment was 20 euro.

After the experiment, the subjects were asked a permission to use their decisions in the neuroeconomic experiment that was conducted later at the AMI Centre, Helsinki University of Technology. From the 18 subjects of this experiment, 12 was chosen to act as virtual proposers, namely, the offers they made here were shown to the responders in the neuroeconomic experiment. Those 12 proposers were later paid according to the decisions the subjects of the neuroeconomic experiment made.