Backward induction or forward reasoning? An experiment of stochastic alternating offer bargaining

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Backward Induction or Forward Reasoning?
– An Experiment of Stochastic Alternating Offer
Bargaining –

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Abstract

Bounded rationality questions backward induction, which however, does not exclude such reasoning when anticipation is easy. In our stochastic (alternating offer) bargaining experiment, there is a certain first-period pie and a known finite deadline. What is uncertain (except for the final period) is whether there is a further period. Whereas backward induction requires information about all later pie sizes and probabilities, forward reasoning is expected to consider only the immediate prospects. Rather than relying only on decision data, we try to assess the cognitive approach such as forward reasoning of backward induction by control of information retrieval. We find that participants who begin with the shortest games before playing possibly longer games, initially resort to backward induction before switching to forward-looking behavior.

Keywords: backward induction, forward reasoning, bargaining
JEL classification: C70, C72, C91

1 Introduction

In alternating offer bargaining one player, the proposer, offers a distribution of the presently distributable pie to the other player, the responder. The responder can then decide whether to accept or reject the offer. If the responder rejects and the period is the terminal one, conflict results; otherwise, the next period begins. Now both players switch roles, i.e., the proposer (responder) from the preceding period is now responder (proposer). Usually one assumes that the distributable pie is smaller than in the preceding period. Conflict means that

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both receive a disagreement payoff. The variant of the game lasting one period is called ultimatum game. Longer lasting games are known as alternating offer games (e.g., Ståhl (1972); Rubinstein (1982)).

In alternating offer games, implausible threats allow for a wide variety of equilibria, similar to the multiplicity of the equilibria in the ultimatum game. However, only one such equilibrium is subgame perfect, i.e., does not rely on implausible threats. One can derive this equilibrium by backward induction: in the last period, the responder will accept any offer marginally above the conflict payoff, and the proposer will offer exactly this amount. In the preceding period, the proposer, who is the responder in the last period, will anticipate this and offer the reduction of the pie from the second-last to the last period to the responder. Applying this principle repeatedly until the first period determines an initial offer which the first responder should accept. In consequence, alternating offer play last for just one period.

Sequential bargaining games are central in experimental economic research and reveal clear differences between theoretically predicted and experimentally observed behavior (see Güth et al. (1982); Binmore et al. (1985) for early experiments and Roth (1995) for a survey). Whereas the intensively studied ultimatum game mainly motivated the ongoing discussion of social preferences (see, e.g., Loewenstein et al. (1989); Fehr and Schmidt (1999); Bolton and Ockenfels (1998, 2000)), alternating offer bargaining games have recently not attracted as much attention. This is surprising since alternating offer bargaining games with shrinking pies and unique subgame perfect equilibria allow to test aspects of bounded rationality. For only boundedly rational participants backward induction must be substituted by some form of forward thinking when the horizon is rather long. To study when participants switch from backward induction to forward thinking and which form of forward thinking they use, we increase complexity by increasing the number of periods played as well as by studying stochastic rather than deterministic alternating offer games which end with positive probability after a non-terminal period without agreement. Let us review the main former studies before arguing how such a design may help to study such topics experimentally.

Binmore et al. (1985) conducted an alternating offer experiment lasting for two periods which was repeated once. Although initial offers in the first play were close to half of the first pie size, they observed a clear shift toward backward induction play in the repetition and concluded that learning results in offers closer to the theoretical benchmark by backward induction.

In response to Binmore et al. (1985), Güth and Tietz (1986) find that participants do not play the backward induction solution, if the backward induction outcome is unfair.

Neelin et al. (1988) reacted to Binmore et al. (1985) by another set of experiments, varying both the duration and the pie sizes. They found that behavior is neither in line with fairness nor with backward induction. In their experiments, the modal initial offer is the pie size distributable in the second period.[1]

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[1] Binmore et al. (1988) replied to Neelin et al. (1988).

Ochs and Roth (1989) find that a substantial percentage of first offers is rejected and that several of these rejections were followed by disadvantageous counterproposals. They confirmed that first-period offers lie between the theoretical benchmark and equal division of first-period pies. Binmore et al. (2002) explore experimentally a two-period alternating offer game as well as its subgames and find that the behavior violates both subgame and truncation consistency.[2]

Finally, Johnson et al. (2002) try to separate the impact of three different decision rules in a three-period alternating offer game: (1) instantly offering 40% of the pie; (2) assuming that the responder in period 1 will offer 50% of the remaining pie in period 2 and reason back (Stahl and Haruvy (2003)); (3) backward induction. To observe all different "cognitive styles," they monitor when and which information is retrieved throughout the game. They confirm (1) and question backward induction (3) by not observing its necessary information retrieval. In an additional treatment, they let participants interact with robots, playing according to the backward induction solution and observe that this leads to backward induction play.

To sum up, the results are partly contradictory. A convincing and consistent explanation of observed behavior is still missing. But, of course, there may be heterogeneity in playing such games. By monitoring information retrieval, Johnson et al. (2002) demonstrated different attitudes in the same experiment. This heterogeneity could partly result from differences in mental abilities. To explore this in our experiment, participants successively play four different alternating offer games with an increasing number of periods, starting with a two-period game and ending with a five-period game. In this way, we hope to identify individual switching from backward induction to forward reasoning. To vary the difficulty of backward induction, we employ stochastic alternating offer games, i.e., after each non-terminal period without an agreement a random draw determines whether the game continues or conflict results. To access the cognitive styles, participants decide before the first offer which information they want to use during play. This information, for which the participants have to pay, is available throughout the experiment, hopefully revealing what participants react to.

Independent of the length of the stochastic alternating offer game, about a third of all participants resorts to equal splits. Of the remaining participants most rely on backward induction when it is socially acceptable and the game is limited to two periods. They switch to forward-looking behavior when the game lasts for up to three periods. In even longer games, participants resort to equal splits without considering end play behavior.

In section 2, we formally introduce the stochastic alternating offer games. Section 3 describes the experimental protocol. We introduce different reasoning modes from literature in section 4. After describing and analyzing the data statistically in section 5 we conclude in section 6 where we link our main findings

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[2]Subgame consistency means that subgame play is independent of how the subgame is embedded in the larger game context. Truncation consistency means that play does not change when a subgame is substituted by its solution payoffs (see Selten and Güth (1982)).

to the related literature.

2 Stochastic Alternating Offer Games with Information Retrieval

Without loss of generality, the initial pie Π_1 is set equal to 100. We assume that Π_1 is available with certainty but not the later pies Π_t for $t > 1$. The class $\mathcal{G}$ of stochastic alternating offer games G is defined by

$$G = (T, \ (\Pi_t, p_t)_{1 < t \leq T}), \quad \text{with } 2 \leq T < \infty$$

where $T \geq 2$ is the maximum number of periods with alternating offers. The continuation probability $p_t \in (0,1)$ specifies how likely it is that, in case of not reaching an earlier agreement, in later periods t with $1 < t \leq T$ the amount Π_t, the pie Π_t in period t, can be distributed. With probability $(1 - p_t)$ nothing is available in period t, meaning that bargaining ends in period $t - 1$ without an agreement. Here we restrict attention to shrinking pies[3] in the sense of $\Pi_t > \Pi_{t+1}$ for all $1 \leq t < T$.

In odd (even) t, player 1 (2) proposes the share $\mathcal{O}_t \in [0, \Pi_t]$ of the pie Π_t, offered to the other player, who then decides whether to accept or refuse. If she accepts, bargaining ends with the responder earning $\mathcal{O}_t$ and the proposer collecting the residual $\Pi_t - \mathcal{O}_t$. If she refuses, she has to make a counteroffer in the following period $t + 1$, provided that $t + 1 \leq T$ and that chance allows distributing Π_{t+1}. Otherwise, the game ends in conflict with conflict payoffs of 0 for both.

Players can voluntarily retrieve information before the first period $t = 1$. At this time, players 1 and 2 know only $\Pi_1 = 100$ and T but not yet Π_t and p_t for $t = 2, ..., T$ where the pie sizes Π_t are not equidistant and the probabilities p_t not constant. For each information, i.e., each information request for Π_t or p_t, the player faces costs of 1, which are subtracted from her earnings. Once an information has been retrieved, it remains available for the whole play[4] with at most T alternating offer periods. Players decide initially which information they want to buy. Whereas they can completely neglect probability information, they must buy information about Π_t when period t is actually reached to state an offer $\mathcal{O}_t$ in the range $[0; \Pi_t]$. Of course, players can buy this information already before the first period. We intentionally limit all voluntary information requests to the time before $t = 1$ to simplify the classification of cognitive styles.

The minor fee (of one token) for each piece of information is mainly imposed to limit information retrieval for the sake of curiosity, which may be especially strong since we do not provide full information after playing. Of course, curiosity may be still strong enough to accept the minor information costs, but at least in

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[3] In stochastic alternating offer games even increasing pie sizes may render later agreements less efficient when efficiency is measured by expected payoffs.

[4] Here we deviate from Johnson et al. (2002) who control for how often, how long, and in which sequence a certain information is looked up and who provide information at no cost.

later plays, we expect participants to retrieve only information which, according to their cognitive style, they deem necessary.

Period		T_2	T_3	T_4	T_5
1	Π_1	100.0	100.0	100.0	100.0
2	p_2, Π_2	0.6, 60.0	0.4, 84.0	0.6, 61.0	0.5, 72.0
3	p_3, Π_3	-, -	0.6, 40.0	0.7, 36.0	0.6, 42.5
4	p_4, Π_4	-, -	-, -	0.3, 20.0	0.5, 29.0
5	p_5, Π_5	-, -	-, -	-, -	0.7, 20.0

Table 1: Games used in the experiment

In Table 1 we summarize the games used in our experiment, all of which let the pie Π_t shrink irregularly and probability p_t vary across $2 \leq t \leq T$ to render information retrieval worthwhile.

3   Experimental Protocol

We conducted the experiment in the experimental laboratory of the Max Planck Institute in Jena[5] with 248 participants. When recruiting, we ensured that none of them had previously participated in any ultimatum or bargaining experiment.

In each of our 8 sessions, we randomly paired participants and assigned 8 participants to one matching group (7 sessions with 4 matching groups, one with 3 matching groups). All participants faced a different participant in each game, changing their role after each game, e.g., participants who were player 1 in the first (and third) game were player 2 in second (and last) game. Each participant played all four bargaining games (see Table 1), starting with shortest horizon ($T = 2$) and increasing the planning horizon after each game. Since each matching group generated one independent result, we obtained altogether 31 independent (matching group) observations.

Participants received a hard copy of the instructions, which were read aloud to make them common knowledge. Then participants played the games using a computer terminal.

After participants had played all four games, we paid them in private. All participants received a show up fee of €2.50 and an additional €0.50 to compensate potential losses when buying information and not reaching an agreement. For each point a participant earned, he received €0.05. Participants earned €11.27 on average (minimum: €3.00, maximum: €15.90). A session lasted approximately 1 hour, including 15 minutes each for reading the instructions and paying participants.

4   Reasoning Modes

Let us describe the main reasoning modes, as suggested by the data of earlier experiments as well as our own experiment, whose various predictions will be

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[5]For all methodological and technical details and the instructions, see Appendix B

tested both by the negotiation data and the information requests.

4.1 Backward induction

To calculate the backward induction solution (based on opportunism[6]) for a stochastic alternating offer game, assume that the proposer in the last-period offers 0 to the responder. For the game lasting 5 periods (see column "T_5" in Table 2) this implies for $t = 5$ the offer $\mathcal{O}_5^* = 0$. In $t = 4$, the proposer knows that her fellow player will allot the whole pie Π_5 to herself and therefore offer her Π_5 discounted by the continuation probability p_5, i.e. $\mathcal{O}_4^* = p_5 \cdot \Pi_5$. The proposer in $t = 3$ will anticipate this and offer the difference $\Pi_4 - \mathcal{O}_4^*$ discounted by p_4 to her fellow player. This form of backward reasoning continues until the proposer in $t = 1$ derives $\mathcal{O}_1^*$. The solution play is that player 1 offers $\mathcal{O}_1^*$, which is then accepted by player 2, the responder in period $t = 1$. Thus – which is typical of alternating offer bargaining with shrinking pies – parties do not alternate in offering agreements but agree immediately and hence efficiently.

Obviously, a player resorting to backward induction needs to know all continuation probabilities and all pie sizes. Table 2 summarizes the backward induction offers for all games in Table 1. We designed the games such that the backward induction offer $\mathcal{O}_1^*$ was / would be around 25.0 for all experiments. The exception is T_2 where $\mathcal{O}_1^*$ is slightly higher.[7]

Period		T_2	T_3	T_4	T_5
1	$\mathcal{O}_1^*$	$0.6 \cdot 60.0$ $= 36.0$	$0.4 \cdot (84.0 - 24.0)$ $= 24.0$	$0.6 \cdot (61.0 - 21.0)$ $= 24.0$	$0.5 \cdot (72.0 - 21.0)$ $= 25.5$
2	$\mathcal{O}_2^*$	$= 0.0$	$0.6 \cdot 40.0$ $= 24.0$	$0.7 \cdot (36.0 - 6.0)$ $= 21.0$	$0.6 \cdot (42.5 - 7.5)$ $= 21.0$
3	$\mathcal{O}_3^*$	-	$= 0.0$	$0.3 \cdot 20.0$ $= 6.0$	$0.5 \cdot (29.0 - 14.0)$ $= 7.5$
4	$\mathcal{O}_4^*$	-	-	$= 0.0$	$0.7 \cdot 20.0$ $= 14.0$
5	$\mathcal{O}_5^*$	-	-	-	$= 0.0$

Table 2: Backward induction offers $\mathcal{O}_t^*$ for the games in Table 1

4.2 Equal split

Since former studies of alternating offer bargaining found evidence for equal split offers (see, e.g., Binmore et al. (1985)), we also expect equal split offers in $t = 1$, i.e., $\mathcal{O}_1 = 0.5 \cdot \Pi_1 = 50.0$. A player making an equal split offer would not need any additional information and could therefore refrain from buying any information.

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[6]Each player is opportunistic in the sense of maximizing her own monetary payoff expectation, which is commonly known. Common knowledge can obviously be weakened since it depends on T how often one has to assume that players know that players know... that both players are opportunistic in this sense.

[7]In a game lasting at most two periods, either p_2 or Π_2 would need to be very low to reach such a value.

4.3 (Expectation based) forward reasoning

Several forward reasoning patterns are possible and partly supported by evidence of former experiments. We give an overview of these patterns and name for easy reference later.

Offer $(p_2)\Pi_2$: Neelin et al. (1988) observe that most proposers (independent of the duration of the game) offer the second-period pie $\mathcal{O}_1 = \Pi_2$ to the first responder, which player 2, the first responder, accepts. In our games, this corresponds to $\mathcal{O}_1 \geq p_2\Pi_2$, where we assume that $\mathcal{O}_1$ is not less than half of the first-period pie.[8] A player offering the second-period pie would only be interested in Π_2. In our experiments, the second-period pie is always above half the size of the first-period pie, i.e., $\Pi_2 > \Pi_1/2$ holds. Hence, we do not expect to see many participants resorting to this pattern. For $\mathcal{O}_1 = p_2\Pi_2$ one would, of course, have to know both p_2 and Π_2.

Offer $(p_2)\Pi_2/2$: Johnson et al. (2002) claim that some proposers in the first period expect the responder to offer them half of the second-period pie. By reasoning back, the proposer keeps not only the difference between the first and the second pie for herself, but also half of the second pie. Hence, her offer is only $\mathcal{O}_1 = \Pi_2/2$ respectively $\mathcal{O}_1 = p_2\Pi_2/2$.

Of course, forward thinking as illustrated by cognitive styles "Offer Π_2" and "Offer $\Pi_2/2$" may be questioned by strategic reasoning. Player 1, for instance, could gain by informing herself about Π_3 and applying her reasoning also to the behavior of player 2. In consequence, she would ask for an even larger fraction of the pie in the first period. The longer a player looks ahead, the lower the offer she will have to make to her fellow player, but the more complex the decision problem will turn out to be. Hence, we expect cognitive styles will involve more periods being employed less often.

4.4 Socially acceptable forward reasoning

According to Ochs and Roth (1989), participants perceive offers below a certain threshold as "insultingly low" and reject them. We see similar rejection rates in our experiment (for details see Section 5). If we interpret the alternating offer game as a lottery $[p_r(\mathcal{O}_1), \mathcal{O}_1; 1 - p_r(\mathcal{O}_1), 0]$ with $p_r(\mathcal{O}_1)$ as the rejection probability for offer $\mathcal{O}_1$, unfair offers yield low expected payoffs (see Fig. 1 visualizing the expected payoffs).[9] Interestingly, the expected payoff of the first proposer decreases the lower the first period offer. Only in two cases does this payoff lie above 50 (in games T_2 and T_4 for offers in the range [45;50[).

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[8]In the deterministic alternating offer games, this would require $\Pi_2 \leq \Pi_1/2$. Only for such games were offers $\mathcal{O}_1 = \Pi_2$ observed by Neelin et al. (1988) and Güth and Tietz (1986); i.e., first proposers hardly ever offered more than $\Pi_1/2$ to the responder even when $\Pi_2 > \Pi_1/2$.

[9]To derive probabilities even for less frequent offers, we grouped all offers. The expected payoff is the minimum offer in the group multiplied with the rejection probability in the group. This means the values represent the maximum payoff the first period proposer could expect in the group.

**Result 1:** First-period offers below 45 do not pay.
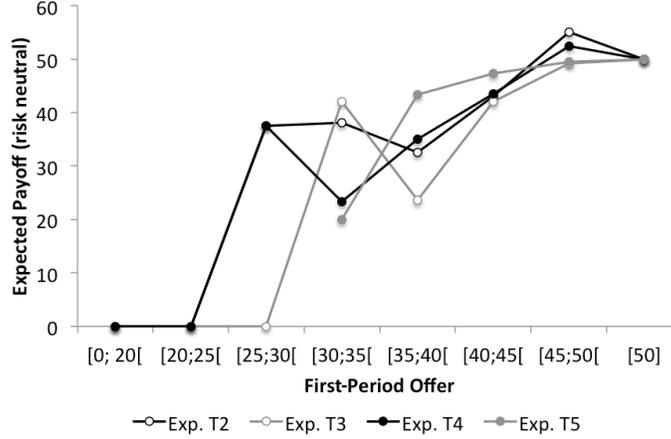
Figure 1: Expected payoff vs. first-period offer

Notice that Figure 1 assumes that all participants correctly anticipate rejection probabilities. In all four games, expected payoffs drop below 40 for offers around 35. In addition, across all games offers between 35 and 40 are rejected with a probability of 50%. Hence, we expect participants to make offers of 35 and higher. Participants resorting to this strategy gather only as much information as they need to justify that offers $\mathcal{O}_1) \geq 35$ are reasonable.

For the "cognitive styles" Table 3 presents the initial offers $\mathcal{O}_1$ suggested by the former (with highest offers displayed first). The games were designed in a way that first-period offers differ as much as possible.

Cognitive Style	T_2	T_3	T_4	T_5
Offer Π_2	60.0	84.0	61.0	72.0
Equal split	50.0	50.0	50.0	50.0
Socially acceptable	35.0	35.0	35.0	35.0
Offer $\Pi_2/2$	30.0	42.0	30.5	36.0
Offer $p_2\Pi_2$	36.0	33.6	36.6	36.0
Backward induction	36.0	24.0	24.0	25.5
Offer $p_2\Pi_2/2$	18.0	16.8	18.3	18.0

Table 3: Predicted first offers ($\mathcal{O}_1$) for games from Table 1 according to different cognitive styles

5 Analysis of Negotiation Data

Table 4 summarizes medians MD, means M, and standard deviation SD of the first-period offers for all four games (see Table 13 in Appendix A for matching group averages). When comparing these values to our predictions in Table 3, we see that neither

	T_2		T_3		T_4		T_5	
MD	41.0		45.0		43.0		45.0	
M (SD)	44.2	(14.4)	45.0	(11.8)	43.3	(8.7)	44.8	(9.9)

Table 4: Average offers per experiment

of the values is close to any benchmark solution. "Equal Split" and "Offer $p_2\Pi_2$" come closest but are still far away. Similar to Johnson et al. (2002), we assume heterogeneity of cognitive styles, which is confirmed when investigating the distribution of offers (see Table 5). About 30% of all participants play exactly the equal split solution, another 30% make an offer between 40 and 45. Offers in other value ranges are less frequent.

Result 2: Median and mean offers are rather fair and normally deviate considerably from $\mathcal{O}_1^*$, what is partly justified by the response behavior in the first period with first-period responders often rejecting $\mathcal{O}_1 \leq 40$.

Offer	T_2		T_3		T_4		T_5	
	#	Accepted	#	Accepted	#	Accepted	#	Accepted
[0; 20[	5	0.0%	3	0.0%	1	0.0%	-	-
[20; 25[	3	0.0%	1	0.0%	1	0.0%	3	0.0%
[25; 30[	2	50.0%	2	0.0%	2	50.0%	-	-
[30; 35[	11	54.5%	5	60.0%	9	33.3%	7	28.6%
[35; 40[	4	50.0%	11	36.4%	13	53.8%	9	66.7%
[40; 45[	39	71.8%	30	70.0%	40	72.5%	33	78.8%
[45; 50[	10	100.0%	19	89.5%	21	95.2%	30	90.0%
[50]	38	100.0%	43	100.0%	31	100.0%	35	100.0%
]50; 100]	12	100.0%	10	100.0%	6	100.0%	7	100.0%
All		*78.2%*		*79.0%*		*78.2%*		*83.1%*

Table 5: Frequency of acceptance of offers in first period

In the first period, 50% of the offers in the interval $35 \leq \mathcal{O}_1 < 40$ are rejected, and there is a 25% rejection rate for offers between 40 and 45, illustrating that participants are pursuing fairness. For games T_3, T_4, and T_5 "Backward Induction" would therefore have led to no agreement in the first period with 50% probability. Most of the forward-looking cognitive styles would also confront the first proposer with a high risk of rejection. Although due to p_2 between 0.4 and 0.6 termination of the game after period 1 is likely, participants risk conflict when they deem first offers unacceptable.

Period	T_2		T_3		T_4		T_5	
	#	"Irrational"	#	"Irrational"	#	"Irrational"	#	"Irrational"
2	12	33.3%	11	0.0%	17	47.1%	10	30.0%
3	-	-	0	-	4	75.0%	3	33.3%
4	-	-	-	-	1	0.0%	0	-
5	-	-	-	-			0	-
All	12	33.3%	11	0.0%	22	50.0%	13	30.8%

Table 6: Numbers of counteroffers and fractions of "Irrational" counteroffers which would yield less than earlier acceptance, given their acceptance.

Across all games about a third of all counteroffers (see Table 6) assign to the second proposer less than what he would have received by accepting, i.e., a third of all counteroffers are "irrational," a fact especially observed and discussed by Ochs and Roth (1989). This is in line with the evidence of costly punishment (e.g., Fehr and Gächter (2000)), showing that when observing unfair and therefore unacceptable outcomes, participants do not mind to sacrifice own payoff in order to discipline others.

5.1 Information acquisition

Let us now focus on voluntary information retrieval before the first period. The information acquired by player 1 and player 2 is quite similar (see Table 7).[10] A test comparing the number of informations requests by player 1 and player 2 reveals significant differences.[11] About 32% of all participants do not buy any information and about 10% of all participants show unusual information requests by restricting interest to pie sizes or continuation probabilities of intermediate periods.[12] Since these retrieval patterns are infrequent and not in line with any of the cognitive syles discussed above, we neglect them.

Result 3: First-period proposers and responders reveal similar patterns of information retrieval; about one third of all participants does not invest at all in information, whereas those investing in information vary in what they retrieve.

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[10]This table can be read as follows: The columns represent experiments and players, while each row stands for a certain information pattern. Line $t = 2$, e.g., stands for participants gathering information about period 2 (only), lines $t \in [2, 3]$ stand for participants gathering information about periods 2 and 3, ... Π_t indicates that participants are only interested in pie sizes, p_t stands for participants interested in probabilities only, ... To give an example, the value 3.2% in column "T_4, Pl. 2" and row "$t \in [2,3]$, Π_t, p_t" implies that 3.2% of all players 2 in game T_4 retrieved information about all pie sizes and continuation probabilities of periods 2 and 3 and no other information, meaning they informed themselves about Π_2, Π_3, p_2, and p_3.

[11]Comparison of the fraction of proposers vs. the fraction of responders buying no information per group (31 independent observations, Wilcoxon Test): $T = 2$: Z=-0.628, p=0.530; $T = 3$: Z=-1.404, p=0.160; $T = 4$: Z=-1.386, p=0.166; $T = 5$: Z=-0.951, p=0.342.

[12]Such patterns occurred at most five times or less often. The only exception is the pattern in which participants bought information concerning the pie size in periods 2 and 3 plus the continuation probability in period 2 ($T = 3$: 13 cases, $T = 4$: 10 cases, and $T = 5$: 14 cases).

		T_2		T_3		T_4		T_5	
		Pl. 1	Pl. 2	Pl. 1	Pl. 2	Pl. 1	Pl. 2	Pl. 1	Pl. 2
$t = 2$	Π_t	24.2%	18.5%	8.9%	14.5%	19.4%	16.1%	12.9%	17.7%
	p_t	16.9%	18.5%	9.7%	8.9%	7.3%	10.5%	10.5%	10.5%
	Π_t, p_t	21.0%	29.8%	15.3%	8.9%	14.5%	11.3%	14.5%	9.7%
	Sum	62.1%	66.9%	33.9%	32.3%	41.1%	37.9%	37.9%	37.9%
$t \in$ [2, 3]	Π_t	-	-	14.5%	16.1%	5.6%	8.9%	5.6%	4.8%
	p_t	-	-	4.8%	4.0%	1.6%	1.6%	0.0%	0.8%
	Π_t, p_t	-	-	12.1%	2.4%	1.6%	3.2%	4.0%	3.2%
	Sum	-	-	31.5%	22.6%	8.9%	13.7%	9.7%	8.9%
$t \in$ [2..4]	Π_t	-	-	-	-	4.8%	5.6%	0.8%	0.0%
	p_t	-	-	-	-	2.4%	0.8%	0.0%	0.0%
	Π_t, p_t	-	-	-	-	0.0%	3.2%	0.8%	0.0%
	Sum	-	-	-	-	7.3%	9.7%	1.6%	0.0%
$t \in$ [2..5]	Π_t	-	-	-	-	-	-	1.6%	0.0%
	p_t	-	-	-	-	-	-	0.0%	0.0%
	Π_t, p_t	-	-	-	-	-	-	0.8%	0.0%
	Sum	-	-	-	-	-	-	2.4%	0.0%
No info.		37.9%	33.1%	24.2%	33.1%	29.8%	22.6%	33.9%	37.9%
Other		-	-	10.5%	12.1%	12.9%	16.1%	14.5%	15.3%

Table 7: Frequency of information acquisition per experiment

Other information acquisition patterns allow for backward induction by acquiring information for period 2 ($t = 2$), for periods 2 and 3 ($t \in [2, 3]$), for periods 2 to 4 ($t \in [2, 3, 4]$) or for periods 2 to 5 ($t \in [2, 3, 4, 5]$). Participants are interested in both, pie sizes and continuation probabilities (Π_t, p_t, about 20%), or in pie sizes only (Π_t: about 25%). About 14% of all participants are interested in the continuation probabilities only (p_t: 14%) and thus reveal a surprising curiosity.

While in game T_3 equally many participants are interested in all periods, interest in later periods decreases for the longer games (T_4, T_5). In game T_5, only 2.4% are interested in the last period ($t = T = 5$). Hence, we conclude that participants rely on forward reasoning and neglect later periods.

Result 4: When the horizon is long as, for example, in game T_5, information retrieval, as required by backward induction, is rare.

	T_2		T_3		T_4		T_5	
	Pl. 1	Pl. 2	Pl. 1	Pl. 2	Pl. 1	Pl. 2	Pl. 1	Pl. 2
Π_t	1.00	1.00	1.62	1.53	1.51	1.66	1.58	1.21
p_t	1.00	1.00	1.33	1.31	1.57	1.25	1.00	1.07
Π_t, p_t	2.00	2.00	2.88	2.43	2.20	3.09	2.80	2.50
No info.	-	-	-	-	-	-	-	-
Other	-	-	2.46	2.40	2.63	2.70	2.44	2.89
All	1.34	1.45	2.14	1.80	1.88	2.14	2.05	1.87

Table 8: Information costs per participant

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Table 8 gives an overview of average information costs. While in games T_2 and T_3 no significant difference between information costs per participant exists, in games T_4 (T_5) information costs of player 1 are significantly lower (higher) than the costs of player 2.[13]

6   Reasoning Styles

Are the offers in line with the cognitive styles discussed above? We focus on the offers in the first period (see Table 9) and first refer to the participants with an "Equal Split" strategy who should not be interested in any information and offer 50% of the initial pie (Π_1). In all four games about 40 participants bought no information, i.e., were potential equal splitters and made offers with a median of 50 (only game T_5 deviates with a median of 48). The individual offers of participants buying no information also show that more than 50% of them offered around 50 in the first period (see Tables 10-15). The "equal split" mode of reasoning is the reasoning style of about 34% of all participants.

Result 5: Equal splitters are quite frequent and develop this tendency without any attempt to explore what they could gain by behaving strategically.

Participants playing backward induction have to buy information concerning the pie size Π_t and the continuation probability p_t for all periods of the game. In games T_4 and T_5, less than 1% of all players 1 buy this information (see Table 7). In games T_2 and T_3, more than 20% and 10%, respectively, buy this information. When comparing first-period offers of participants buying and not buying all information, those not buying resort to equal split offers significantly more frequently in game T_2.[14] In addition, the average first-period offer of player 1 participants in T_2 buying Π_2, p_2-information is, with 38.81, (see Table 9) close to the theoretical prediction by backward induction. For game T_3 we do not find a significant difference in offers[15] between those participants retrieving no information and those retrieving all information for backward induction. We conclude that about 20% of participants in game T_2 resort to backward induction, while we do not find such behavior in any longer game.

Result 6: In line with earlier results (e.g., of Binmore et al. (1985)), in game T_2 only a significant share of participants behaves according to backward induction by both information retrieval and first-period offer close to its prediction.

Even so, participants interested in both continuation probabilities p_t and pie sizes Π_t of games T_4 and T_3 often choose the equal split in the first period.[16]

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[13]Comparison of information costs of first proposers vs responders per group (31 independent observations, Wilcoxon Test): $T = 2$: Z=-1.427, p=0.154; $T = 3$: Z=-2.529, p=0.011; $T = 4$: Z=-2.028, p=0.043; $T = 5$: Z=-1.320, p=0.187.

[14]Wilcoxon Test: Obs. 18, Z=-2.588, p=0.010.

[15]Wilcoxon Test: Obs. 10, Z=-1.612, p=0.107.

[16]Wilcoxon Test: T_4: Obs. 11, Z=-1.782, p=0.075; T_5: Obs. 17, Z=-1.301, p=0.193.

		T_2		T_3		T_4		T_5	
Π	MD (#)	40.00	(30)	46.00	(29)	40.00	(37)	40.50	(26)
	M (SD)	42.33	(19.3)	47.45	(18.1)	40.13	(6.7)	42.04	(7.7)
p	MD (#)	40.00	(21)	45.00	(13)	42.00	(14)	45.00	(13)
	M (SD)	42.52	(8.5)	46.28	(9.6)	44.29	(4.8)	44.08	(5.6)
Π, p	MD (#)	40.00	(26)	40.00	(25)	41.00	(20)	44.00	(25)
	M (SD)	38.81	(13.6)	41.56	(11.0)	41.55	(5.6)	42.36	(7.3)
No info.	MD (#)	50.00	(47)	50.00	(42)	50.00	(37)	48.00	(42)
	M (SD)	48.21	(12.2)	46.27	(5.4)	49.62	(9.0)	47.33	(10.8)
Other	MD (#)	-	(-)	45.00	(18)	40.00	(16)	45.00	(18)
	M (SD)	-	(-)	44.00	(8.1)	37.13	(9.8)	46.81	(14.5)

Table 9: Offers per information pattern

Hence, we attribute their interest in information to curiosity and not to cognitive styles such as "Offer $p_2\Pi_2$" and "Offer $p_2\Pi_2/2$."

Finally, we investigate cognitive styles based on pie sizes only, namely "Offer Π_2" and "Offer $\Pi_2/2$" by player 1. As expected (see the evidence of Neelin et al. (1988) and Güth and Tietz (1986)), "Offer Π_2" has little chance when suggesting $\mathcal{O}_1 > \Pi_1/2$ (see Tables 10-15: T_2: 13.3%, T_3: 13.3%, T_4: 0.0%, and T_2: 3.8%). Cognitive style "Offer $\Pi_2/2$," on the other hand, seems to occur frequently in our experiments. In games T_4 and T_5, the offers by players 1 with information about pie sizes are significantly lower than offers of participants retrieving no information.[17] In games T_2 and T_3, we find no such effect, and the offers of these participants (see Tables 10-15) are in line with the theoretical prediction: about 20% of participants in game T_2 and T_3 resort to "Offer $\Pi_2/2$" in a forward reasoning style based on pie information only.

6.1 Discussion

To summarize our results and relate them to the cognitive styles, we crosstable for each game in Table 3 the first-period offers and the information patterns (see Tables 10 to 15).

In game T_2 (see Table 10), 38% of all participants (compared to 32% in all games) buy no information, with the majority of them (30 out 47) offering 45 or more. We classify these participants as **equal splitters**. Another group of 13 participants buys no information and offers 40 to 45, apparently entertaining the idea of a **"first mover advantage."** Information of only Π_t or p_t leads to no clear deviation from the behavior of those without any information. Participants knowing both Π_t and p_t seem to rely on "Offer $p_2\Pi_2$" (offer $\mathcal{O}_\infty = 36.0$), whereas offers below 35 support neither "Offer $p_2\Pi_2/2$" nor "Offer $\Pi_2/2$".

Behavioral patterns remain similar in games lasting for three periods (T_3, see Table 11). Although fewer participants buy no information, i.e., 30 compared to 47 in game T_2, first-period offers reveal the same peaks (around 50 and in the

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[17]Wilcoxon-Test: T_2: Obs. 17, Z=-0.853, p=0.394; T_3: Obs. 12, Z=-1.479, p=0.139; T_4: Obs. 16, Z=-2.735, p=0.006; T_5: Obs. 16, Z=-2.324, p=0.020.

	No Info.	Π_t	p_t	Π_t, p_t	Other	All
$[0; 20[$	-	2	1	2	-	5
$[20; 25[$	-	2	-	1	-	3
$[25; 30[$	1	1	-	-	-	2
$[30; 35[$	2	4	1	4	-	11
$[35; 40[$	1	1	1	1	-	4
$[40; 45[$	13	7	8	11	-	39
$[45; 50[$	2	4	2	2	-	10
$[50]$	21	5	8	4	-	38
$]50; 100]$	7	4	-	1	-	12
All	47	30	21	26	0	

Table 10: Information patterns vs. first-period offers for T_2

	No Info.	Π_t	p_t	Π_t, p_t	Other	All
$[0; 20[$	-	2	-	1	-	3
$[20; 25[$	-	-	-	1	-	1
$[25; 30[$	-	-	-	1	1	2
$[30; 35[$	1	-	1	2	1	5
$[35; 40[$	1	2	1	7	-	11
$[40; 45[$	7	9	5	7	2	30
$[45; 50[$	4	4	4	4	3	19
$[50]$	16	8	5	8	6	43
$]50; 100]$	1	4	2	3	-	10
All	30	29	18	34	13	

Table 11: Information patterns vs. first-period offers for T_3

range of 40 to 45) and a similar distribution, supporting equal split strategies. For all other information patterns, i.e., Π_t, p_t or (Π_t, p_t), the distribution of the first-period offers is similar to those participants without any information. Altogether in game T_3 no cognitive style other than equal splitting is observable: only 9% of offers are below 35 suggesting that neither backward induction nor "Offer $p_2\Pi_2/2$" play a major role.

In games T_4 and T_5 (see Tables 14 and 15 in Appendix A), participants buying no information have a stronger tendency to split equally than in shorter games.

Depending on the game, median offers were either close to a fair distribution or supported the backward induction solution (see Table 12 for an overview). Nevertheless, for both the fair or the rational benchmark contradicting evidence exists. Furthermore, information retrieval allows us to distinguish different cognitive styles.

Fairness, backward induction, and forward reasoning all occur, but their influence depends on the time horizon. Some participants are fair, i.e., they offer about half of the initial pie, and are not interested in later periods of the bargaining process. Their overall share is about a third and does not change across games. The remaining two thirds of participants resort to other cognitive styles, variants of forward-looking cognitive styles, or backward induction.

We found evidence for changes in cognitive styles being related to the com-

	M of $\mathcal{O}_1$	Amnt.	Π_2	Π_3	Π_4	Π_5
Binmore et al. (1985)*	50.0% (25.0%)	£1.00	25.0	-	-	-
Neelin et al. (1988)	25.0%-30.0%	$5.00	25.0	-	-	-
	50.0%	$5.00	50.0	25.0	-	-
	34.0%	$5.00	34.0	11.6	4.0	1.4
	34.3%-36.6%	$15.00	25.0	-	-	-
	34.0%	$15.00	50.0	25.0	-	-
	34.0%	$15.00	34.0	11.6	4.0	1.4
Ochs and Roth (1989)**	40.0%	$30.00	40.0	-	-	-
	41.0%-45.0%	$30.00	40.0	16.0	-	-
	46.0%-49.0%	$30.00	60.0	-	-	-
	41.0%-45.0%	$30.00	60.0	36.0	-	-
Johnson et al. (2002)	40.0%-44.0%	$5.00	50.0	25.0	-	-
Our results	41.0%	€5.00	60.0	-	-	-
	45.0%	€5.00	84.0	40.0	-	-
	43.0%	€5.00	61.0	36.0	20.0	-
	45.0%	€5.00	72.0	42.5	29.0	20.0

* The game was played twice. In the second play only player 2 from the first
repetition made an offer. The median of the second repetition is shown in brackets.
** The games vary only with respect to Π_t. Here, we focus on the symmetric
version only.

Table 12: Median first-period offers in experiments (Π_1 normalized to 100)

plexity of the game (in game T_3 twice as many offers are near the backward
induction solution compared to game T_5 (T_4)). Some form of level-n bounded
rationality (Stahl and Haruvy (2003)), as observed by Johnson et al. (2002), is
not supported (all offers are just too high).

On the other hand, the conclusion of Ochs and Roth (1989) that participants
perceive offers below a certain threshold as "insultingly low" and reject them
is justified. In our experiments, participants rejected about 20% of all offers,[18]
which is comparable to related experiments (Johnson et al. (2002)); especially
low offers face a high risk of being rejected, which participants seem to antici-
pate. When backward reasoning based on the retrieved information suggests an
unfair offer, participants seem to stop using such information and rather resort
to a fair offer. Offers differ between participants retrieving no information and
all other participants[19] (with the exception of T_3, suggesting that allowing and
monitoring voluntary information retrieval is a promising research method).

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[18]T_2: 21.8%; T_3: 21.0%; T_4: 21.8%; T_5: 16.9%.

[19]Wilcoxon Test: T_2: Obs. 26, Z=-2.707, p=0.007; T_3: Obs. 20, Z=-1.457, p=0.145; T_4:
Obs. 24, Z=-3.687, p=0.000; T_5: Obs. 27, Z=-2.596, p=0.009.

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A Supplementary data

This appendix gathers supplementary data which might be of interest to the reader but is to extensive for the main paper.

Table 13 summarizes aggregates for all matching groups, i.e., all independent observations. Column 'MD' is the median first-period offer in the matching group, 'M' the mean, and 'SD' the standard deviation.

Gr.	T_2		T_3		T_4		T_5	
	MD	M (SD)	MD	M (SD)	MD	M (SD)	MD	M(SD)
1	40.0	38.0 (14.2)	75.0	71.5 (33.4)	41.5	43.0 (5.0)	75.0	70.5 (34.9)
2	44.5	42.3 (9.3)	40.0	42.5 (5.0)	42.5	41.0 (5.2)	45.0	44.5 (3.3)
3	40.0	38.8 (6.3)	40.0	38.8 (6.3)	37.5	37.5 (2.9)	37.5	38.5 (4.4)
4	45.0	45.0 (20.4)	46.5	39.5 (16.7)	41.0	44.5 (10.6)	33.5	34.3 (15.5)
5	40.0	42.5 (5.0)	42.5	42.8 (4.6)	44.5	44.8 (5.5)	45.0	45.0 (4.1)
6	50.0	48.0 (5.4)	47.5	46.3 (4.8)	50.0	47.8 (5.2)	47.5	46.3 (4.8)
7	45.0	43.8 (7.5)	47.5	44.3 (8.5)	33.0	35.3 (12.0)	47.5	41.8 (13.4)
8	45.0	42.5 (9.6)	44.0	44.5 (5.3)	40.0	40.0 (9.5)	44.0	44.5 (5.3)
9	45.0	42.5 (9.6)	37.5	38.8 (8.5)	45.0	41.3 (7.5)	40.5	40.0 (8.6)
10	42.5	37.5 (15.6)	50.0	48.8 (2.5)	44.0	44.5 (4.2)	47.5	46.3 (4.8)
11	42.5	37.5 (19.4)	50.0	50.3 (2.1)	46.0	46.8 (6.2)	46.0	45.8 (4.0)
12	45.0	46.3 (11.1)	45.0	43.8 (7.5)	42.5	43.0 (3.6)	45.0	42.8 (9.8)
13	41.0	48.0 (14.7)	52.5	53.0 (12.6)	38.5	38.0 (6.3)	41.5	39.5 (6.7)
14	45.0	50.0 (17.8)	50.0	46.3 (7.5)	50.0	47.0 (6.0)	50.0	47.5 (5.0)
15	40.0	38.8 (6.3)	45.0	46.3 (2.5)	45.0	44.5 (4.9)	45.0	45.5 (3.3)
16	46.0	50.5 (13.7)	42.5	41.3 (8.5)	38.0	42.8 (15.4)	44.5	43.5 (2.4)
17	50.0	47.5 (5.0)	50.0	47.5 (5.0)	45.0	45.0 (5.8)	47.5	47.6 (10.2)
18	40.0	39.5 (7.4)	43.0	46.5 (13.1)	33.5	35.3 (6.7)	41.5	41.3 (6.4)
19	40.0	37.5 (12.6)	35.0	35.0 (9.1)	50.0	47.5 (5.0)	40.0	39.3 (7.0)
20	47.5	55.0 (16.8)	50.0	50.0 (0.0)	49.5	51.0 (6.4)	50.0	51.3 (2.5)
21	40.0	33.8 (19.7)	44.0	37.0 (18.9)	50.0	46.3 (7.5)	47.5	45.0 (7.1)
22	50.0	47.5 (5.0)	50.0	50.5 (7.4)	50.0	48.0 (4.0)	50.0	47.5 (5.0)
23	50.0	47.0 (6.0)	50.0	51.3 (10.3)	46.5	45.8 (5.1)	50.0	48.0 (4.0)
24	32.5	33.8 (13.8)	42.5	35.0 (16.8)	38.5	38.0 (6.2)	44.5	44.5 (3.7)
25	40.0	40.0 (8.2)	40.0	38.8 (10.3)	42.5	43.8 (4.8)	42.5	43.8 (4.8)
26	47.5	46.3 (4.8)	39.5	41.0 (6.4)	44.5	44.8 (4.1)	44.0	43.3 (7.0)
27	47.5	58.8 (27.8)	45.0	44.3 (6.8)	41.0	42.8 (5.0)	45.5	44.3 (7.0)
28	40.0	47.5 (37.8)	45.0	46.3 (7.5)	40.0	32.3 (15.5)	42.5	44.0 (5.2)
29	50.0	55.0 (25.2)	49.5	49.3 (1.0)	46.5	52.0 (27.5)	49.0	48.3 (2.4)
30	35.0	33.8 (14.9)	38.0	34.0 (9.5)	42.5	43.8 (4.8)	40.0	37.5 (5.0)
31	45.0	45.0 (5.8)	47.0	51.0 (13.3)	43.0	44.0 (4.3)	47.0	47.5 (10.1)
All	41.0	44.2 (14.4)	45.0	45.0 (11.8)	43.0	43.3 (8.7)	45.0	44.8 (9.9)

Table 13: Offers in first period

Tables 14 and 15 offer the same analyses for game T_4, and T_5, respectively, as Tables 10 and 11 in the main paper do for the games T_2 and T_3.

	No Info.	Π_t	p_t	Π_t, p_t	Other	All
$[0;20[$	-	-	-	-	1	1
$[20;25[$	-	1	-	-	-	1
$[25;30[$	-	1	-	-	1	2
$[30;35[$	-	5	-	2	2	9
$[35;40[$	2	3	-	5	3	13
$[40;45[$	5	17	8	5	5	40
$[45;50[$	6	6	1	5	3	21
$[50]$	19	4	4	3	1	31
$]50;100]$	5	-	1	-	-	6
All	37	37	14	20	16	

Table 14: Information patterns vs. first-period offers for T_4

	No Info.	Π_t	p_t	Π_t, p_t	Other	All
$[0;20[$	-	-	-	-	-	0
$[20;25[$	1	1	-	1	-	3
$[25;30[$	-	-	-	-	-	0
$[30;35[$	1	3	-	2	1	7
$[35;40[$	1	3	2	1	2	9
$[40;45[$	8	7	4	9	5	33
$[45;50[$	14	4	2	6	4	30
$[50]$	14	7	5	4	5	35
$]50;100]$	3	1	-	2	1	7
All	42	26	13	25	18	

Table 15: Information patterns vs. first-period offers for game T_5

B Methodology

B.1 Recruiting

We recruited all participants for our experiments using ORSEE (Greiner (2004)). In addition to the 32 participants we needed for a session, we recruited 5 additional persons to ensure we could fill all matching groups. We ensured that all recruited persons had never participated in ultimatum or bargaining games before. We made no additional restrictions on the subject pool, i.e., participants came from different fields of study at the Friedrich Schiller University Jena.

B.2 Used software during sessions

We conducted our experiments in a computerized mode, i.e., we implemented all games using zTree (Fischbacher (2007)). The zTree files are available upon request.

Although we handed out instructions[20] concerning the game in written form, we displayed the changes before games T_3, T_4 and T_5 on the participants computer terminals in a one-page PDF using E-nstructions (Schmelz (2011)).

B.3 Structure of one session

Preparation: Before participants entered the laboratory, we started both zTree on the experimenters' PC and zLeaf on all client PCs. Afterwards we placed the instructions for the first game on the seats of each participant.

Admission: In order of arrival, the participants drew 1 out of 32 numbers from a box. The seats in the laboratory were also numbered from 1 to 32, and each participant took the seat with the number drawn. After each participant was assigned a seat, a student assistant sent the remaining persons (who arrived at the laboratory) home, handing them €2.50 to each.

T_2: After admission, the student assistant welcomed all participants to the laboratory and asked them to read the instructions:[21]

- "We welcome you to this experiment." (Orig.: "Herzlich willkommen zu diesem Experiment.")

- "Please read the instructions carefully." (Orig.: "Bitte lesen Sie die Anleitung gründlich durch.")

- "If you have any questions, please raise your hand." (Orig.: "Sollten Sie Fragen haben, heben Sie bitte Ihre Hand.")

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[20]See Appendix B.5 for the instructions in German and a translated version

[21]Instructions and communication were in German. We provide both an English translation and the original text.

After all participants had read the instructions, the student assistant summarized them aloud to make them common knowledge.

- "You have all read the instructions for this experiment." (Orig.: "Sie haben jetzt alle die Anleitung für dieses Experiment gelesen.")

- "I will now briefly summarize the instructions again:" (Orig.: "Ich fasse die Anleitung noch einmal kurz zusammen:")

- "The instructions are the same for all of you." (Orig.: "Die Anleitung ist für alle gleich.")

- "The experiment consists of two periods." (Orig.: "Das Experiment besteht aus zwei Runden.")

- "During each period you are either proposer or responder in alternating order." (Orig.: "In jeder Runde sind sie abwechselnd entweder Anbietender oder Nachfrager.")

- "In each period, the proposer commands an amount he can distribute between himself and his partner." (Orig.: "In jeder Runde verfügt der Anbietende über einen Betrag, den er zwischen sich und seinem Mitspieler aufteilen kann.")

- "The proposer decides how much of this amount he will offer to his partner." (Orig.: "Der Anbietende entscheidet dann, wie viel er von diesem Betrag seinem Mitspieler anbietet.")

- "Then the responder decides whether he accepts the offer." (Orig.: "Darauf entscheidet der Annehmer, ob er das Angebot annimmt.")

- "If the responder accepts the offer, the experiment ends and all receive the amount according to the agreed distribution." (Orig.: "Nimmt der Annehmer das Angebot an, endet das Experiment und alle erhalten den Betrag gemäß der abgestimmten Aufteilung.")

- "If the offer is not accepted, a random draw decides whether the experiment continues. In case of continuation, the next period begins. The responder from the preceding period is now the proposer and vice versa. If the experiment ends due to a random draw, both participants receive a payoff of 0." (Orig.: "Wird das Angebot nicht angenommen entscheidet ein Zufallszug, ob das Experiment fortgeführt wird. Im Fall der Fortführung beginnt die nächste Runde. Der Anbieter aus der Vorrunde ist jetzt der Annehmende und umgekehrt. Endet das Experiment durch den Zufallszug, so erhalten beide Spieler eine Auszahlung von 0.")

- "If both participants reach no agreement within two periods, the experiment ends and both participants receive a payoff of 0." (Orig.: "Kommt es innerhalb von zwei Runden zu keiner Einigung, so endet das Experiment auch und beide Teilnehmer erhalten eine Auszahlung von 0.")

- "The first period is special: In this period you can ex ante buy information concerning the probability that the experiment continues and the amount to distribute for every period. Every information costs you one point." (Orig.: "Die erste Runde hat eine Besonderheit: In dieser Runde können Sie Informationen bzgl. der Wahrscheinlichkeit, dass das Experiment fortgeführt wird, und den aufteilenden Betrag für jede Runde im voraus erfahren. Jede dieser Informationen kostet Sie einen Punkt.")

If, after we summarized the instructions, a participant had further questions, we answered them. Afterwards we started game T_3.

T_3: After game T_2, we displayed the instructions for game T_3 on the computer terminal. After all participants had read the instructions, the student assistant gave a short summary:

- "You have all read the instructions for the second experiment." (Orig.: "Sie haben jetzt alle die Anleitung für dieses zweite Experiment gelesen.")

- "I will now briefly summarize the instructions again": (Orig.: "Ich fasse die Anleitung noch einmal kurz zusammen:")

- "Other than the preceding experiment, this experiment ends after a maximum of 3 periods." (Orig.: "Anders als das vorhergehende Experiment endet dieses Experiment nach maximal 3 Perioden.")

- "You play with a participant you have not interacted with before. In addition, the amounts to be distributed and the probabilites for a subsequent period may change compared to the preceding experiments." (Orig.: "Sie spielen dieses Experiment mit einem Teilnehmer mit dem Sie vorher noch nicht interagiert haben. Zusätzlich können sich die aufzuteilenden Beträge und die Wahrscheinlichkeit für eine Folgeperiode gegenüber den vorangegangenen Experimenten ändern.")

If, after summarizing the instructions, a participant had further questions, we answered them. Afterwards, we started game T_4.

T_4 **and** T_5: The procedure for games T_4 and T_5 was identical to the procedure of T_3, except that we instructed participants they were now playing the third (last) experiment and that the experiment lasted up to 4 (5) periods. When summarizing the instructions of game T_5, we also informed participants that they would receive their payoffs afterwards.

- "After this experiment, you will receive your payoff." (Orig.: "Nach diesem Experiment werden Sie ihre Auszahlung erhalten.")

Payment: After game T_5 we paid all participants. After the payment the participants left the laboratory.

B.4 Matching

In the beginning of each session, we assigned all participants to one matching group for the whole session. Each matching group consisted of 8 participants, and all participants were internally numbered from 1 to 8. This internal numbering did not change throughout the session and was used to build (proposer,responder)- pairs. Table 16 summarizes the matching. For example, the participant internally numbered 1 played with participant 8 in game T_2, with participant 6 in game T_3, ...

| | T_2 | | T_3 | | T_4 | | T_5 | |
	Prop.	Resp.	Prop.	Resp.	Prop.	Resp.	Prop.	Resp.
Pair 1	1	8	6	1	1	4	2	1
Pair 2	7	2	2	5	3	2	4	3
Pair 3	3	6	8	3	5	8	6	5
Pair 4	5	4	4	7	7	6	8	7

Table 16: Matching of participants in one matching group

All participants having odd internal numbers were proposer in games T_2 and T_4, all participants having even internal numbers were proposer in games T_3 and T_5. In this way, we ensured that no participants had the same role in the first period of two subsequent experiments.

B.5 Instructions

In this subsection, we print our instructions. We only provide an English translation to stay within the space limitation. We send the German original to the interested reader upon request.

B.5.1 English Instructions - First Experiment

Welcome to this experiment and thank you very much for your participation. You receive €2.50 for showing up in time. During the experiment you can earn additional money. Please stay quiet and switch off your mobile phones and carefully read the instructions - which are the same for all. Communication between participants is not allowed. If you do not follow these rules, we have to exclude you from the experiment and any payment. If you have a question, please raise your hand, an experimenter will then come to you and answer your question in private.

The amount of €2.50 for showing up in time as well as every additional amount you earn during the experiment will be paid to you in cash at the end of the experiment. The payment will be made in private. No other participant will know the amount of your payment. Your payment depends on your own decisions and the decisions of other participants. The payment in the experiment is measured in points. The points you earn during the experiment will be converted into euro at the end of the experiment and paid to you. The conversion rate is given at the end of this document. You and all other participants make their decisions independent of others using a computer terminal.

Course of the experiment

During each of the total of four experiments you interact with another participant which we call your partner. Your partner changes from experiment to experiment but not during one experiment. With your partner you bargain during several (at least two) periods over an amount in points. To do so, you are assigned to one role in the beginning of each period: the proposer or the responder. If you are proposer in one period, your partner is responder and vice versa. Depending on your role, you will see different screens.

Course of one period
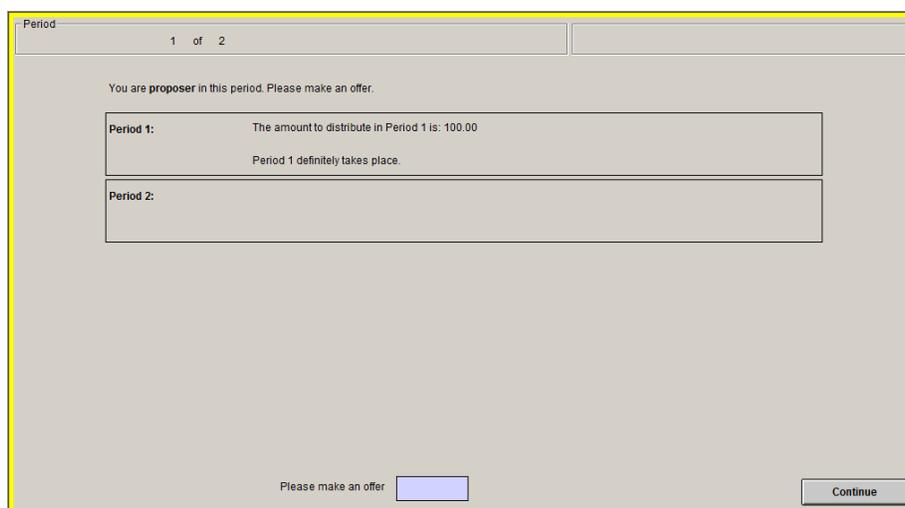
Figure 2: Offer dialog

In the beginning of one period, the proposer is the first to decide. As proposer your screen is similar to the screen in Figure 2. On this screen you see the current period in the upper left area. Below you see all information you know. In the lower area of the screen, you see a box. Into this box you enter the amount you want to offer your partner. If your partner accepts the offer, you receive the amount distributable in this period minus the offer you entered here. After you entered an amount click "Continue". You now have to wait for your partner to decide about acceptance or rejection of your claim.

As responder you have to wait until your partner makes his offer. Then you see a screen similar to the screen in Figure 3. At the top to the left, you see the current period. Below you see all the information, you know. In the lower area of the screen, you see the offer of your partner. You can decide whether you accept the offer or reject it. If you accept the offer, the experiment ends, and the proposer is informed of the acceptance.
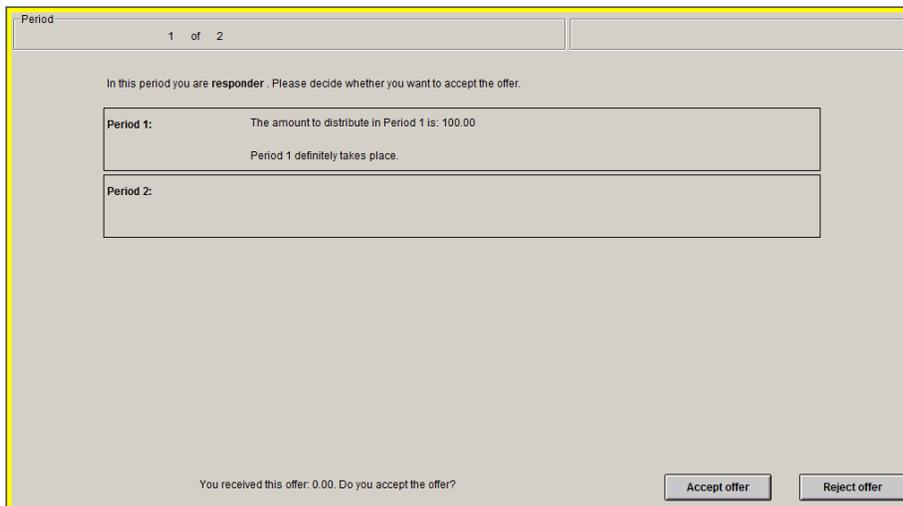
Figure 3: Response dialog

If you reject the offer, the experiment continues with a fixed probability p. In particular, we generate a random number between 0 and 1. If this number is above p, the experiment ends; otherwise, it continues.

If the experiment continues, you and your partner switch roles, and the next period of the experiment begins. Except for the changed roles, the rules for this period are identical to those of the just finished period.

If you and your partner do not reach an agreement until the end of the last period, both of you receive 0 points.

Specifics of the first period

The first period is different compared to all following periods. In the beginning of the first period, you see an information screen before the normal screens are shown (see Fig. 4).

This screen consists of one box for every potential period. In the box for period 1, you see the amount which is distributed in the first period. For all subsequent periods this box consists of two buttons. By clicking the upper button, you are informed of the amount to distribute in this period. By clicking the lower button, you get to know the probability p, with which the experiment continues in this period if you have not reached an agreement with your partner before. For each click on a button you face costs of 1 point. You can click as many buttons as you like. For example, you can click no button, click one button, ... or click all buttons. As soon as you click one button, you see the corresponding information. This information is accessible for you in this period and all subsequent periods. As soon as you have all the information you are interested in, please click "Continue" to begin bargaining.

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Please click the button containing information you are interested in. Every click on one button costs 1 point.

| Period 1: | The amount to distribute in Period 1 is: 100.00 |
| | Period 1 definitely takes place. |

| Period 2: | Amount to distribute in period 2 |
| | Probability that period 2 follows after period 1 |

Please click on the button "Continue", when you have bought all information you are interested in.   Continue

Figure 4: Information at the beginning of the first period

As you need to know the amount to distribute in each period, you are informed of this amount as soon as the corresponding period begins. This also results in costs of 1 point, as long as you have not bought this information before. But costs only arise if the corresponding period is reached. In addition, the amount you and your partner distribute declines from period to period, i.e., early agreements are beneficial.

Type and number of experiments

You will participate in four experiments, which all follow the description above. The experiments only differ in the maximum number of periods, the amounts to distribute, and the probabilities for one period. The first experiment lasts for up to 2 periods.

Payment

After the fourth experiment, you are paid. Your payoff is as follows:

+ €2.50 for showing up in time
+ €0.50 to compensate potential losses after buying information
+ Allotment of the distributed amount in the first experiment
− Costs for information in the first experiment
+ Allotment of the distributed amount in the second experiment
− Costs for information in the second experiment
+ Allotment of the distributed amount in the third experiment
− Costs for information in the third experiment

+ Allotment of the distributed amount in the forth experiment

− Costs for information in the forth experiment

During the experiments costs for information and the distributed amount are shown in points. For your payoff the points are converted into euro. The conversion rule is:

1 Point = 0.05 euro

Please consider that it is possible that you and your partner do not reach an agreement during the experiment. In this case, you may incur a loss by buying information. To compensate this potential loss, you receive another €0.50.

We round your payoff to the closest amount divisable by €0.10.

B.5.2   English Instructions - Later Experiments

The instructions for game T_3 are as follows:

The first experiment is now over. You will start the second experiment in an instant. It differs from the preceding experiment in the following points:

- The experiment lasts for a maximum of 3 periods.

- The amounts to distribute may change compared to the preceding experiment.

- The probabilities that one period follows another, may change compared to the preceding experiment.

- For this experiment you are assigned a random new partner you have not yet interacted with.

The instructions of game T_4 (T_5) were equivalent to these instructions (except for the information that the experiment lasted for 4 (5) periods and that the participant started the third (forth) experiment. In addition, the instructions of game T_5 were extended by the following hint:

After this experiment you are paid off. Please remain seated until we call you up for your payment.

References of Appendix

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