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Experimental Evidence on Learning in Ultimatum Bargaining

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Abstract
This paper reports experimental evidence on behaviour in an Ultimatum Game where responders have low structural information and feedback so that they have to learn the nature of the game during repeated play. The results lend support to the view that certain learning conditions are less favourable in terms of individual outcomes than others as suggested by the contingent learning approach (Slembeck, 1998a). Furthermore, there is evidence that proposers behave "less fair" when responders lack structural information, which contrasts with common notions of fairness or "manners" in ultimatum bargaining (Camerer and Thaler 1995).

JEL Classification: C72, C78, C92
Keywords: bargaining, game theory, contingent learning, asymmetric information, fairness, experiments

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1. Introduction

In economics, subjects have traditionally been assumed to act in environments that provide ideal conditions for decision making and learning. This paper reports experimental evidence on how people behave in less than ideal conditions for the case of the well-known Ultimatum Game. In the standard version of the game, two players bargain over a fixed amount called the pie. The first player (the proposer) proposes how to split the pie between him and a second player (the responder) who then has the opportunity to accept or reject the proposed split. If it is accepted, both players get their agreed share. If it is rejected, both players receive nothing. Under the assumption that players aim to maximize their own incomes, the unique subgame-perfect equilibrium is that the proposer offers the smallest possible amount and responders accept every positive offer. A great number of experiments, however, has demonstrated that most experimental subjects do not accept offers of less than about 40% of the pie (see ROTH, 1995a, for an overview of the experimental literature). This result has been interpreted by the players' concern for "fairness" with regard to the split of the pie (see CAMERER AND THALER, 1995, for a discussion). In order to make the game more realistic and to study whether "fairness" is sensitive to the information provided, the game has been investigated experimentally for the case where players have asymmetric information about the size of the pie.[2] However, it is a common feature of this literature that players know the structure of the game. Also, the players usually have common knowledge about the informational asymmetry.[3]

The present paper looks at a more drastic, but sometimes more realistic case where players do not know the structure of the game, but have to learn optimal play under two feedback conditions, one of which allows to learn the structure of the game, while the other condition prevents from doing so. It is the aim of this study to explore how people learn to play the Ultimatum Game under low information conditions. The main interest is on learning behaviour and the role of learning determinants as described in the *contingent learning approach* by SLEMBECK (1998a). In addition, the study sheds new light on the role of fairness in ultimatum bargaining in that there is experimental evidence that proposers behave "less fair" when responders lack structural information. The idea and motivation for studying games of low information is outlined next in Section 2. Section 3 describes design, hypotheses, and procedures of the experiment. The results are presented in Section 4 and discussed in Section 5. Section 6 concludes.

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[2]See eg., ROTH AND MURNIGHAN (1982), MITZKEWITZ AND NAGEL (1993), CROSON (1996), RAPOPORT AND SUNDALI (1996), KAGEL, KIM AND MOSER (1996). An overview of ultimatum bargaining with complete and incomplete information can be found in SLEMBECK (1998b).

[3]The experiment by ROTH AND MURNIGHAN (1982) is an exception. They find that the frequency of agreement in their bargaining game depends on whether it is common knowledge what information the bargainers possess (see ROTH (1995b) for details and discussion).

2. Low Information Games

There are several reasons to study games where the model of the situation is incompletely known to the players. As KALAI AND LEHRER (1995) have pointed out, the assumption of a "complete model" may be unrealistic and too demanding even for highly rational players engaged in moderate size problems for many applications.[4] Hence, in real life situations, players are usually not endowed with payoff matrices or game trees so that they have to learn the structure that links behaviours to outcomes. Sometimes real-life players may even be unaware that they are actually playing a game.

This extreme case has been studied in psychology where a *minimal social situation* is defined as a situation where the payoffs of two persons are determined by each other's behaviour, but both are oblivious of their interdependence (SIDOWSKI ET AL., 1956). When only two behavioural options (*a* and *b*) are available, the outcomes are determined by a simple payoff matrix – called "mutual fate control" by THIBAUT AND KELLEY (1959) – as shown in Figure 1.

	a	*b*
a	1 , 1	0 , 1
b	1 , 0	0 , 0

Figure **1**: The "Mutual Fate Control" Payoff Matrix of the Minimal Social Situation

In this situation a person can only influence the payoff for the other person, but not for herself. Psychologists were interested whether people are able to coordinate on (*a* , *a*) for the case that they do not know the payoff matrix, and given that they do not even know that they are in an interdependent situation.[5] To this end, the minimal social situation has been studied in a large number of experiments. The results show that subjects are able to coordinate on (*a* , *a*), provided that they play repeatedly against the same opponent many times. That is, people eventually learn

[4]See MATSUSHIMA (1997) for a similar critique. – KALAI AND LEHRER (1995, 124) define a *complete model* as each player having complete detailed information about the identity of his opponent, their feasible sets, information structures, utilities, and so forth.

[5]The casual story for this game is that two commuters travel on the same train every day. They always sit in adjacent compartments, both of which are uncomfortably cold. Each compartment has a lever marked "heater", but there is no indication at to whether it should be turned to the left or to the right to increase the temperature. What the commuters do not know is that there is a fault in the electrical wiring of the train: moving either lever to the left increases the temperature (option *a*) and moving either lever to the right decreases the temperature (option *b*) in the *adjacent* compartment. Although the commuters cannot influence their own comfort directly, they would both benefit, if they turned their levers to the left at the beginning of each journey (COLEMAN ET AL., 1990). – With regard to an economic application, one may think of some activity that can be done in two different ways, both of which leave the payoffs for the actor unaffected, but one of which has positive external effects on others that are not know to the actor herself.

to play strategy *a*, given favourable learning conditions. In the psychology literature, this observation is explained by *reinforcement learning* which simply assumes that players adopt the strategy that yielded high payoffs in the past and avoid strategies that yielded low payoffs (see COLEMAN ET AL., 1990, who provide a multiperson generalization of the minimal social situation and references to empirical work).[6]

In the view of traditional game theory, the minimal social situation is not really a game, since a game is defined as a situation of *strategic* interdependence. Because the involved individuals are not aware of their factual interdependence, the situation is not strategic to them, and, hence, there is no reason for them to think about their own behaviour in terms the behaviour of others, i.e., they have no incentive to behave strategically. Therefore, the minimal social situation lacks the element of strategy that is fundamental to the traditional game theoretic definition.

Informing individuals that outcomes are not only determined by their own behaviour, but also by the behaviour of others – however, withholding information about the actual structure that links actions to outcomes – turns the situation into what may be called a *game of low information*. In such a game, players may aim to take the behaviour of others into account in their own choices, but since they suffer from deficient structural information, players not only have to learn about the behaviour of other players, but also about the underlying structure. Hence, players must form beliefs about the structure of the game *and* about the behaviour of others from experience.

From the viewpoint of a single decision maker this situation is know as a *multi-armed bandit problem* in the economic literature (see e.g., ROTHSCHILD, 1974). More recently, GILBOA AND SCHMEIDLER (1996) have proposed a *case-based optimisation model* where a decision maker is unaware of the payoff distributions corresponding to the available options, but learns to optimise from past experience. In the context of games, KALAI AND LEHRER (1995) have outlined a theory of *subjective games and equilibria*, where players do not know the payoff structure, but face a multi-person, multi-armed bandit game. Players are modelled to use an “environment response function” that compresses all payoff relevant uncertainties of the game into a one person decision problem, and allows them to assign a probability distribution for all arms of the bandit based on the history of play (see also MATSUSHIMA, 1997).

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[6] Simple reinforcement learning (see BUSH AND MOSTELLER (1955) for a formal model) is merely an application of THORNDIKE’S (1911) *law of effect* that can be interpreted as a “win-stay, lose-change” strategy for repeated play. Applying this strategy to the minimal social situation yields one of the following sequences: (i) if both players start by playing *a*: (*a* , *a*), (*a* , *a*), (*a* , *a*), (*a* , *a*)....; (ii) if both players start by playing *b*: (*b*, *b*), (*a* , *a*), (*a* , *a*), (*a* , *a*)...; (iii) if one player starts by playing *a* and the other by playing *b*: (*a* , *b*), (*b*, *b*), (*a* , *a*), (*a* , *a*).... or (*b* , *a*), (*b* , *b*), (*a* , *a*), (*a* , *a*).... – ROTH AND EREV (1995), EREV AND ROTH (1998) have adopted a modified version of reinforcement learning in the context of game theory (see also BÖRGERS AND SARIN, 1997).

Based on evidence from individual decision making, SLEMBECK (1998a) has outlined a general theory of learning determinants where the influence of situational restrictions on learning is analysed qualitatively. This *contingent learning approach* focuses on the role of such restrictions in situations that provide imperfect conditions for learning, especially with respect to the available information. Among other learning determinants, the approach stresses the importance of quality, quantity and content of feedback when information about the structure of the game, e.g., the payoff structure, is missing or deficient. The example of the minimal social situation illustrates this importance nicely.

In sum, there are several reasons for studying situations or games of low information. First, such situations may be more realistic and, therefore, be more relevant for actual economic behaviour for many applications. Explorative studies can be useful especially when there is no sound theory available, and understanding how people behave when they have little information may enrich economic theory in important ways. Second, as the example of the minimal social situation demonstrates, people are able to cope with such situations given appropriate conditions for learning. Thus, it may be worthwhile to study such situations with respect to human learning (see e.g. NORTH, 1996), especially since economics has traditionally assumed ideal conditions for learning that are unlikely to be met in real life situations.[7] When interested in learning or adaption processes, a natural research strategy, therefore, is to study situations of less-than-ideal learning conditions.

With respect to the Ultimatum Game, a situation of low information has been studied experimentally, e.g., in SLEMBECK (1998b). While the proposers had complete information about the game, the responders did not exactly know what kind of situation they were involved in (low information condition). The situation was labelled as an experiment in decision making. Responders were presented amounts they could either accept or reject, and were told that these amounts were the results of decisions made by other participants in other rooms. They also knew that they would receive the amount, if they accepted and get nothing if they rejected. – For this case, theory predicts that every positive amount is accepted, and the same holds for fairness theories since "fairness" is not an issue for low information responders who do not know that they are playing an Ultimatum Game. Evidence from this experiment is, however, that many responders under low information did not accept all positive amounts; in fact, they rejected offers more frequently than an other group of responders that had complete information. To

[7]The most obvious case are theories based on *rational expectations* where economic actors are assumed to already have learned everything relevant. The view that economics traditionally has focused on steady states of some unspecified adaptive process is defended in LUCAS (1987) and has been criticized, among others, by WINTER (1987). The importance of appropriate conditions for learning has been stressed, e.g., by TVERSKY AND KAHNEMAN (1987).

explore this finding more deeply, the present paper looks at a somewhat less extreme case as explained in the next Section.

3. Experiment

Hypotheses and Design

The present experiment is designed to test two simple hypothesis of the contingent learning approach (CLA, henceforth). The first hypothesis simply claims that lacking information about the structure of the situation or game impedes players from optimal play. Hence, for the case of *low structural information*, players are hypothesized to be worse off compared to the case of complete information. In the experiment this idea is implemented by having responders face a two-armed bandit problem where one arm represents accepting the offer, while the other means rejecting it. Furthermore, information for responders is also "low" in the sense that they do not see any amount before choosing an arm.

The second hypothesis in question claims that learning is influenced by quality, quantity and content of feedback. More specifically, learning is fostered the more the content of feedback reveals about the underlying structure of the game. Hence, lacking structural information can, to some extent, be substituted by feedback. In the experiment this idea was implemented by giving one group of responders (under low structural information) only feedback concerning the outcomes of their own choices, while responders of an other group (also under low structural information) received also feedback about the outcome for the other player. The behaviour of both groups was compared to a control group that played under standard conditions with complete information and feedback. The information conditions of *responders* are summarized in Table 1.

	structural information	feedback	
		player's own payoff	opponent's payoff
Treatment 1	low: 2-armed bandit	yes	no
Treatment 2	low: 2-armed bandit	yes	yes
Control Group	complete	yes	yes

Table 1: Information Conditions of Responders

Responders in T1 and T2 knew that they were involved in a two-person game that would be repeated twenty times. They also knew (i) that there were two types of players, (ii) that they themselves were player 2, and (iii) that they would be matched with a new player each round.[8] In all three groups *proposers* had complete information about the game, and, therefore, knew the information conditions of their opponents. The instructions to the subjects are shown in the Appendix.

As for play under complete information, theory predicts that proposers make minimal offers and responders accept every offer. This prediction may hold even more for responders under low information since they face a two-armed bandit where one arm always yields some positive payoff, while the other always returns a payoff of zero. Since responders do not know that they are actually playing an Ultimatum Game, they may be assumed not to reject offers out of fairness considerations,[9] especially because they do not see any amount before choosing an arm. Of course, since the arms are not connected to any meaning *ex ante*, players first have to learn the consequences that the two arms yield, so that rejections are likely to occur in the beginning. But after having learned these consequences rational players are assumed to choose exclusively one arm, namely the one which yields a positive payoff so that rejection rates converge to zero.

This type of reasoning clearly holds for responders in Treatment 1 (low feedback condition). However, responders in Treatment 2 may learn about the structure of the game, because they receive also feedback about the consequences of their own decision for player 1 (high feedback condition). Hence, not much reasoning is required for responders under this condition to learn that any positive amount they receive and any positive amount their opponent receives sums up to a constant. With regard to the content of feedback CLA predicts that play under high feedback (T2) is more in accordance with standard play (control group) than under low feedback (T1), while standard theory does not predict any behavioural differences between the three conditions after low information responders have learned the functions of the two options available to them.

The present design also allows to gain evidence on the role of fairness in ultimatum bargaining from responder behaviour. Note that if proposers care about fairness regardless of the information of the responders as the hypothesis of *fairness as altruistic impulse* suggests ("trying to be fair", KAGEL ET AL., 1996), proposer behaviour should not differ between the three conditions (control group, T1 and T2). Furthermore, if players care about equitable outcomes in the context of a particular interaction, as CAMERER AND THALER (1995) have

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[8]Although playing repeatedly against the same opponent may have made learning more efficient for responders – as the results from experiments on the minimal social situation suggest –, the traditional rotation matching scheme was maintained in order to make the results comparable to previous work. Repeated ultimatum bargaining with fixed opponents has been investigated in SLEMBECK (1999) where reputation effects are shown to be behaviourally relevant.

[9]Recall that consideration of fairness are often assumed to be the source of rejections in the literature on ultimatum bargaining under complete information (see CAMERER AND THALER, 1995).

suggested, it is unclear why proposers should ask for a significantly larger share of the pie for themselves when facing uninformed responders, as the results of the present experiment indicate. This would seem at odds with the notion of “manners” that has been stressed by Camerer and Thaler, as will be discussed in Section 4.

Experimental Procedures

A total of 100 students from a large university in the United Kingdom took part in the treatments reported in this paper. 20 experimental subjects were randomly allocated to the control group and 40 more subjects were randomly assigned to each of the two treatment groups. Each subject played 20 rounds of the Ultimatum Game on networked computers, always in the role of a responder or proposer as assigned at the beginning of a session at random. Instructions were given on computer screens (see Appendix) and participants were allowed to ask questions after reading the instructions. During the sessions, participants could not see each other and the only communication was via computers according to the following rules.

Each round a pie of £10 was to be divided in that proposers had to decide the share (called *offer*) they wanted to allocate to responder. Offers were allowed to range between £0.10 and £9.90 in increments of £0.10.

•In the *control group*, offers were displayed on the screens of responders *before* they could choose to accept or reject the offer by pressing the appropriate key on the keyboard. Feedback concerning the responders’ choice was given to proposers and the payoffs for each round were displayed on the screens of both players. This is a standard procedure in ultimatum bargaining (see player screens in the Appendix).

•In *Treatments 1 and 2* responders were presented two neurally labelled options to choose from, i.e. a “left” and a “right” key on the keyboard. After choosing and confirming the choice, a feedback screen displayed the choice again together with the payoff for the responder in that round. In addition to this information the responders’ feedback screen *in T2 also showed the amount the proposer received*. This was the only difference between T1 and T2 (see player screens in the Appendix).

In both treatments, for exactly half of the responders, the “left” key corresponded to accepting an offer, while the “right” key had the function of rejecting the offer. For the other half the function of the keys was reversed in order to control for a potential bias with respect to choosing left or right keys. Of course, this information was not given to the subjects. However, they knew that they were matched with a new player each round. At the end of the session, two rounds were randomly chosen by the computer, and participants were paid in cash according to the actual outcome in those rounds. A show-up fee of £5 was added to the final payments. This procedure was described in the instructions (see Appendix).

4. Experimental Results

The results for the *control group* are similar to those from other studies under complete information (see SLONIM AND ROTH (1998) for a recent overview of typical results). The mean offer is £4.21, with a mode of £5.00 and a median of £4.00. In contrast, Treatments 1 and 2 show distinctly different proposer behaviour in that offers are much lower in terms of means, modes, and medians (see Table 2).

	control group	treatment 1 (low feedback)	treatment 2 (high feedback)
mean offer	4.21£	2.25£	2.59£
modal offer	5.00£	0.10£	0.10£
median offer	4.00£	2.00£	2.05£
rejection rate	26.5%	19.3%	34.8%
proposer advantage	5.1%	45.7%	31.7%

Table 2: Overview of Main Results

With regard to responder behaviour, Table 2 shows that rejections are less frequent in T1 (19.3%), but much more frequent in T2 (34.8%), compared to the control group (26.5%). The most striking difference, however, is found in the so-called *proposers' first-mover advantage*.[10] In the literature, this term is used to describe the finding that responders in ultimatum experiments under complete information accept splits that are somewhat less than fifty-fifty so that proposers earn more income than responders on average. The idea is that while proposers are allowed to announce a split, the role of the responders is restricted to accepting or rejecting offers without having the opportunity to make counter-offers (GÜTH ET AL. (1982), KAGEL ET AL. (1996)). Thus, the first-mover advantage may simply be measured by the difference in incomes between proposers and responders in percent of the pie. Table 2 shows that this advantage is dramatically increased in T1 and T2 (45.7% and 31.8% of the pie respectively) compared to the control group with only 5.1%. The differences between treatments are analysed in more detail next.

[10]The proposers‘ first mover advantage (*fma*) as shown in Table 2 was calculated in the following way:

$$fma = \frac{e(p) - e(r)}{\Pi}$$

with e(p), e(r) being the total earnings over all rounds of proposers and responders respectively; Π is the total size of the pie. – Put differently, in T1 and T2 *proposers* earned £126 and £97 respectively while proposers in the control group earned only £78 on average per subject over all rounds. *Responders* earned £35 in T1, and £34 in T2, but £68 in the control group. Thus, proposers earned 3.6 times the income of proposers in T1, and 2.9 times in T2, but only about 1.1 times in the control group.

4.1. Proposer Behaviour

Proposer behaviour can be analysed with respect to offer sizes and across rounds. When offers are grouped in ranges, Figure 1a shows that in the control group the distribution is single-peaked, and most offers (72%) fall in the two middle ranges of £3.1–4 and £4.1–5. In contrast, in Treatments 1 and 2 most offers are in the lowest range of £0.1–1. Hence, there is a strong tendency to make low offers in the two treatments. Both treatments, however, have a bimodal distribution of offers across ranges in that there is a second peak in the range of „fair“ offers (£4.1–5), which is stronger in T2 (see Fig. 1a).

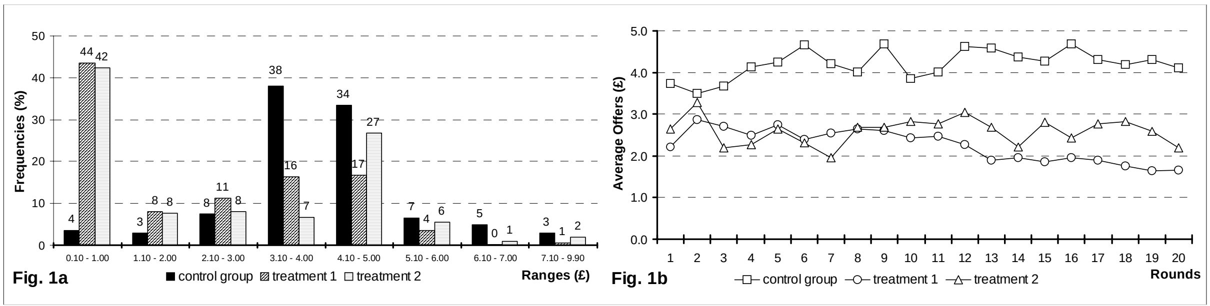

Figure 1: Proposer Behaviour a) relative frequencies of offers across ranges of offers
b) mean offers (in £) across rounds

The differences in offers across ranges are statistically significant between the control group and the treatments ($p < .01$), and between treatments ($p < .05$) in the χ^2 test. The tendency to make lower offers in the treatments, but somewhat “fairer” offers in T2 than in T1 can also be found when looking at the frequencies at which *focal offers* are made. Focal offers involve values that are interpreted as behaviourally relevant in the literature. £5 is a focal offer because it represents an equal split of the pie, and £0.1 represents the minimal feasible offer. £4 may be a focal value because previous studies have shown that offers below 40% of the pie are often rejected.

Table 3 gives the frequencies for these focal offers. In the control group offers of £4 and £5 are by far the most frequently offered values, while £0.1 is rarely offered. In contrast, the modal offer in both treatments is £0.1, but in T2 £5 is offered almost equally often (see Tab. 3). Hence, proposers in T2 tend to make either “fair” or “low” offers. Overall, proposers make much lower offers to uninformed responders than to informed ones, even more so the less informed they are, i.e. the less feedback responders receive.

	control group	treatment 1	treatment 2
£ 5	13.0%	7.5%	19.0%
£ 4	11.5%	9.0%	3.75%
£ 0.1	1.0%	26.0%	21.0%

Table 3: Frequencies of Focal Offers

The finding that the proposers' first mover advantage is strongly increased in the two treatments (see Tab. 2) is largely a result of the much lower offers proposers make when facing low information responders. This difference in proposer behaviour is also found when comparing *mean offers across rounds* (see Fig. 1b). For the control group mean offers are significantly higher across rounds than in the treatments (with an overall median of £4 compared to a median of £2 in T1 and T2; see Tab. 2). Furthermore, in the treatments there is a tendency to reduce offers over time that is not found for the control group. Again, this tendency is somewhat stronger for T1, which indicates that proposers are ready to take advantage of the ignorance of responders the less informed these are. The reported differences in offers across rounds (see Fig. 1b) between the control group and the treatments, as well as between the two treatments are highly significant in the Kruskal-Wallis Test ($p < .01$)[11].

4.2. Responder Behaviour

For the control group, responder behaviour in terms of the rejection rate of 26.5% corresponds to what has been found in previous studies (see eg., ROTH ET AL., 1991, who report a mean rate of 26.75% for four different countries). As for the offers, that remained almost constant across rounds, there is no apparent trend in rejection rates over time (see Figure 2a).

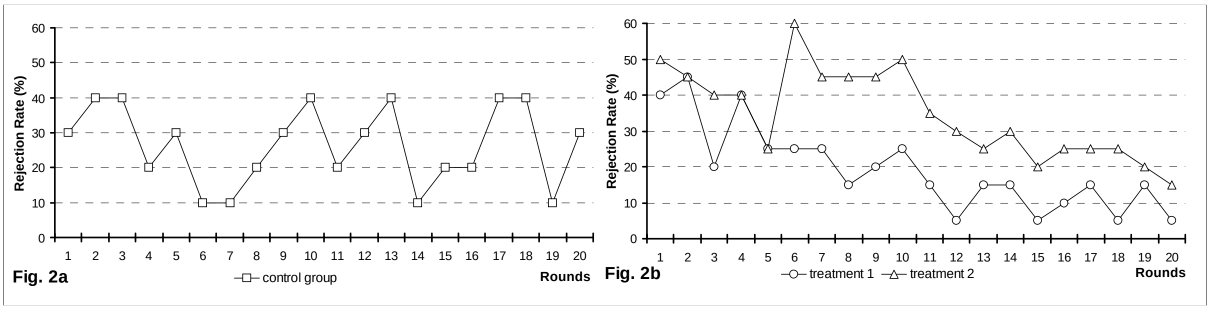

Figure 2: Responder Behaviour Across Rounds

In contrast, rejection rates decrease in the second half of the session in both treatments (see Fig. 2b). Hence, after several rounds low information responders seem to have learned to choose the option that yields positive payoffs. However, there is a systematic difference between the two treatments in that responders with high feedback (T2) reject offers more often than those under the low feedback condition (T1) after round 5.[12] While rejection rates in T1 are 10.5% on average over the second 10 rounds, they are more than twice as high (25%) in T2 for this

[11]Note that the Kruskal-Wallis one-way analysis of variance is the generalization of the well-known Mann-Whitney Test (for two independent samples) to *k* independent samples (see SIEGEL AND CASTELLAN, 1988).

[12]This difference is statistically significant at $p < .01$ in the Mann-Whitney Test. Also, differences in rejections are significant at this level between the control group and T2 (but not between the control group and T1).

period.[13] This indicates that the content of feedback strongly influences responder behaviour, even though responders know how much they receive only after making their choice in each round. These observations will be discussed in the next section.

5. Discussion

The results presented in the previous section will now be discussed with respect to the hypotheses presented in Section 3 according to three observations that summarise the main evidence from this experiment.

OBSERVATION 1: *Offers are systematically lower and the proposers' first-mover advantage is strongly increased when proposers face uninformed responders (T1, T2) compared to responders under complete information (control group). However, offers are not minimal.*

The evidence that proposers make much lower offers to uninformed responders than to informed ones (see Fig. 1) – thereby increasing their income surplus towards the responders from 5% of the pie in the control group to 46% in T1 and 32% in T2 (see Tab. 2) – demonstrates that the average proposer is prepared to take advantage of his or her superior information. Hence, in the present experiment there is not only a first-mover advantage, but also an information advantage on the side of the proposers. Observation 1 clearly supports the CLA hypothesis that a lack of structural information prevents from optimal play in terms of payoffs compared to complete information.

More importantly, the observation is at odds not only with standard theory (that predicts minimal offers), but also with the interpretation of fairness as an altruistic impulse, since the latter would mean making similar offers to informed and uninformed responders. This is clearly not the case so that this version of the fairness hypothesis is not supported by the data.

The notion of "manners", as CAMERER AND THALER (1995) have suggested, does not seem to be convincing in the context of the present experiment either, because it is not obvious why offering less to badly informed opponents should be in accordance with any "manners". An alternative interpretation that seems more in accordance with the present data would be that proposers seek to maximise their own incomes, but strategically account for the veto power of responders as a restriction to maximising. This interpretation, that may also explain why mean offers stay well above the minimum, is discussed in more detail with regard to observation 2 next.

[13]Note that even in the last 5 rounds the average rejection rate is much higher in T2 (22%) than in T1 (10%).

OBSERVATION 2: *Proposers make lower offers to responders under low feedback (T1) than to responders under high feedback (T2).* – see Fig. 1.

Similar to observation 1, this observation supports a CLA hypothesis, namely that higher feedback – that reveals more about the structure of the game or situation – fosters learning and yields better outcomes (i.e., higher incomes) compared to lower feedback. This effect, however, seems mainly due to the proposers' anticipation of the responders' situation. In the interpretation given above – that proposers aim to maximise their incomes, but respect the responders' veto power – proposers strategically make one of the responders' options, i.e., one arm of the bandit, considerably more attractive than the other by offering clearly more than the minimal. Hence, offering £0.1 makes the "accept" option not significantly more attractive than the "reject" option, but mean offers above £2 may do so.

With regard to observation 2, this interpretation may also hold for responders with high feedback (T2), since they learn each round how much the proposer received. Therefore, proposers may feel that they must make the "accept" option even somewhat more attractive for these responders. However, since responders learn the size of the amount they receive only after choosing an option, offers do not have to be as high as under complete structural information in the control group.

This type of reasoning may explain the differences in offers between the two feedback conditions (observation 2), and between the treatments and the control group (observation 1) in terms of strategic behaviour.[14] In contrast, the interpretation of proposer behaviour in terms of "manners" is not easy to sustain with regard to observation 2, since "unfairness" can be detected in the high feedback condition (T2), but proposers nevertheless do not make substantially higher offers in T2 than in T1 (however, much lower offers than in the control group). Furthermore, observation 2 contrasts with standard theory, and with the interpretation of fairness as an altruistic impulse.

OBSERVATION 3: *Although rejection rates decrease as responders under low structural information learn to play the two-armed bandit, a) rejection rates stay positive, and b) under high feedback (T2) rejection rates are persistently higher than under low feedback conditions (T1).*

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[14]The term "strategic" refers to behaviour that involves then anticipation of opponents' behaviour. Of course, in the context of the present experiment, strategical behaviour in this sense involves some degree of identification with the role as a proposer, since opponents are newly matched each round, and behaving strategically, thus, contributes to a public good. However, it is known in the literature that subjects do – often unconsciously – identify with their role and with fellow subjects in the same role (see HERTWIG AND ORTMANN, 1998), and subjects do contribute to public goods in many experiments (see LEDYARD, 1995).

This observation first shows that low information responders are indeed able to learn the two-armed bandit, since one arm always yields some positive payoff, while the other always returns zero. Any sensible learning theory would predict this finding. What remains to be explained, however, is why rejection rates never go to zero even after responders may have learned the functions of the arms (after 10 rounds, say), and why there is a difference between the two feedback conditions. The answer is not straightforward, especially not for the low feedback condition (T1). The following interpretations seem possible.

1) After having learned the functions of the options (i.e., the arms of the bandit), low information responders may have been hoping for higher payoffs from the "accept" option by sometimes choosing the "reject" option. Hence, although they did not know the exact structure of the game, responders knew that they were in an interdependent situation, and, therefore, may have tried to behave "strategically".

2) Low information responders may not have believed that they were acting in a stable environment. That is, responders may believe that the "reject" option not always returns zero, and, therefore, sometimes tried this option (e.g., hoping to get some large payoff). This interpretation seems appealing particularly with regard to T1 where responders could learn only about the two options they faced, but not about the underlying structure of the game. Evidence from psychological experiments on so-called *probability matching tasks* shows that people tend to sometimes choose an option that has performed poorly in the past even after they have learned that a better performing option exists (see VULKAN, 1996 for a survey). One interpretation is that subjects choose the low performing option in order to gather information about the current status of that option, because they believe that the structure of the situation or game may not be stable and, therefore, change over time.[15]

3) Payoffs from the "accept" option were, at least sometimes, so low that responders did not sytematically distinguish between the two options, therefore sometimes choosing the "reject" option. This hypothesis has been investigated by looking at the probability of choosing the "reject" option after a "low" amount (of £1 or less) was experienced. A binominal test shows that there is no statistically significant relationship between rejection behaviour in a given round

[15]In probability matching tasks the outcomes of two (or more) options depend on stochastic processes that are not influenced by the subjects' behaviour. However, the probabilities for the two options to yield a rewarding payoff are different (but fixed). For example, the option "left" returns a payoff x with probability 0.7 while "right" pays x with probability 0.3. Experiments have shown that many subjects approximately match these probabilities in that they choose "left" 70% of the time and "right" 30% of the time, instead of maximising their payoffs by always choosing the better performing option. Possible interpretations are (i) that subjects do not believe that they are facing truly random processes (therefore trying to find some pattern), (ii) that they believe that they can influence probabilities, and/or (iii) that probabilities are not fixed because the environment is not stable.

and the amount observed in the previous round so that this interpretation is not supported by the data.[16]

4) Considerations of fairness may have played a role for the rejections. This interpretation cannot be ruled out completely, but seems less plausible for responders with low feedback (T1) than those with high feedback (T2). Hence, since responders in the latter condition were allowed to learn the effect of their behaviour on responders, they may have tried to “punish” low offers. This interpretation, however, may seem less compelling than interpretation 1 („strategic“ behaviour), because the design of the experiment did not allow responders to see offers before choosing an option. Therefore, responders could not discriminate between “fair” and low offers before “punishing”. Also, since they were matched with a new player each round, they could not “punish” certain opponents in later rounds. The possibility for some sort of “blind punishment”, however, cannot be excluded.

Overall, the first two interpretations discussed above may seem most convincing. They are not mutually exclusive and both involve evolutionary arguments. Hence, trying to behave strategically in a situation that is framed as a “game” is likely to be a heuristic learnt outside the laboratory in game-like situations where strategic behaviour pays off. The heuristic may say something like “*try something else and see how the opponents react*”. This may explain why the rejection rates were higher for those responders with high feedback (T2) who knew more about the structure of the game, i.e. who knew that there was a fixed amount to be split, and may have tried to influence that split. The second argument is also of evolutionary nature since checking occasionally on the actual state of an option that performed poorly in the past may be a strategy or heuristic shaped by evolution in a world that is not stable (“*check again later*”). This may well explain why the rejection rates are not zero even under low feedback (T1) after 20 rounds.

6. Conclusions

In sum, the present study allows for several conclusions. First, with respect to learning behaviour the results show that people are able to adopt to situations of low structural information. In the present design, however, this lack of information cannot be overcome completely so that low information players suffer from the informational deficiency in terms of payoffs. The extent to which this is the case, however, crucially depends on the learning conditions, namely on the content of feedback. Hence, this study nicely demonstrates the importance of this content and presents a case where missing structural information can, to some extent, be replaced by feedback. – Furthermore, it has been argued from a more psychological

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[16]The test included both T1 and T2 for the last 10 rounds. The null hypothesis that rejections occurred with equal probability after observing a small amount (≤ £1) and after observing another amount could not be rejected. The test is also not significant for all rounds and amounts ≤ £2.

perspective that individuals may use general heuristics like "*try something else and see what the opponent does*" or "*check again later*" when learning to cope with a situation of low (structural) information. Both heuristics may be interpreted as part of an ongoing information gathering processes, that has been shaped by everyday experience or evolution.

Second, with respect to fairness behaviour this study presents evidence that subjects (proposers) are willing to exploit their informational advantage. This seems at odds with common notions of fairness or "manners". In addition, the lower the information of their opponents, the more are subjects willing to take their advantage. This finding has been interpreted to be supportive for the view that responders may be less concerned with fairness, but more with strategy in the sense discussed above. Therefore, evidence form the present study seems to suggest that at least part of the "fairness" usually observed in ultimatum bargaining may well result from strategic considerations (that account for the veto power of the responders).

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Appendix: Instructions and Player Screens

- **Control Group**

  Note: Instructions are identical for both types of players to ensure that all subjects understand both roles equally well. Only after the instructions, the computer randomly assigned the subjects to their respective roles as proposers and responders (see screen 3). Thereafter, these roles were fixed throughout the session.

- **Treatment 1 and 2**

  Note: Instructions and player screens are identical for both treatments except for differences indicated in the boxed text.

Bold and <u>underlined</u> text appeared in special colours on screens.

Options are shown in <brackets>.

Screen 1 for all players

Welcome!

Today you will have the opportunity to participate in a decision making experiment. If you follow the instructions carefully and make good decisions, there will be an opportunity for you to earn money during the session.

The Rules of the Game

•The session consists of <u>20 rounds</u>.
•In each round <u>two players</u> are matched randomly, i.e. you will play with a new player in each round.

In each round the two players face the following task:

First, <u>player 1</u> decides how to split the amount of £10 between him or her and player 2.

- •The amount player 1 wants to give to player 2 is called an <u>offer</u>.
- •The offer can be any amount between £9.90 (highest possible offer) and £0.10 (lowest possible offer), in increments of £0.10.
- •That is, player 1's offer can be £9.90, £9.80, £9.70......£0.30, £0.20, or £0.10.
- •In each round player 1 can choose a new offer that may be identical to or different from previous offer(s).
- •The offer is transmitted to player 2 via the computer, and player 1 will see how player 2 reacted before the next round begins (see next).

Second, <u>player 2</u> has to decide whether to accept or reject player 1's offer.

- •<u>If player 2 accepts</u> the offer, player 2 receives the amount offered, and player 1 receives £10 minus the offer.

  Example: If the offer is £X.XX, and player 2 accepts it, player 2 receives £X.XX and player 1 receives £10 – £X.XX.
- •<u>If player 2 rejects</u> the offer, <u>both players</u> receive £0 (zero) in this round.

Third, both players are informed about how much they and the other player earned in that round.

These three steps are identical in all 20 rounds.

These instructions can be accessed any time during the session by clicking on the <Help> button.

<OK, I understand. Please continue with the instructions>

Screen 2 for all players

Please note

•Each round is new and independent of other rounds.
That is,
-you are matched with a new player in each round.
-in each round there is a new £10 to be split.
•You will be assigned randomly to be either in the role of player 1 or player 2.
•You will keep that role throughout the session, i.e. in all 20 rounds.

Method of Payments

•At the end of this session 2 rounds from the 20 rounds played by each player will randomly be selected.
•The cash value earned in these two rounds will be paid to each player in addition to the £5 for participating.

Final Comment

•You play completely anonymously. Neither the experimenter nor the other participants in this experiment will know your identity, or how you behaved in this experiment.
•What you earn is your own business.

<scroll back to previous screen> <continue>

Screen 3 for all players

The computer will now decide randomly if you are player 1 or player 2.

You are player "1 / 2" throughout this session, i.e. in all 20 rounds.

<continue>

Player Screen for Player 1

Round # (1-20)

You are payer 1.
Please choose the amount you want to offer to player 2 out of £10.

Please recall that you will receive £10 minus your offer if the offer is accepted, and player 2 will receive your offer. If your offer is rejected both of you will receive £0.
Your offer must be in increments of £0.10.

I want to offer " __x.y0___ " £ to player 2.
<Confirm> <Change>

Player Screen for Player 2

Round # (1-20)

You are player 2.
The amount player 1 offers to you is " ___ "£ out of £10.

<I accept> <I reject>
<Confirm> <Change>

Feedback Screen for Player 1

Round # (1-20)

Player has decided to "accept"/"reject" your offer of "__" £.

You earned "___"£ in this round.
Player 2 earned "___"£ in this round.

Please prepare for the next round.

<continue> <help>

Feedback Screen for Player 2

Round # (1-20)

You have decided to "accept"/"reject" the offer of "__" £.

You earned "____"£ in this round.
Player 1 earned "____"£ in this round

Please prepare for the next round.

<continue> <help>

Screen 1 for players 1

Welcome!

Today you will have the opportunity to participate in a decision making experiment. If you follow the instructions carefully and make good decisions, there will be an opportunity for you to earn money during the session.

The Rules of the Game

•The session consists of 20 rounds, each of which is played by two players.
•You are player 1 throughout the session, and you will be matched each round with a new player 2.

In each round the two players face the following task:
First, you (player 1) decide how to split the amount of £10 between you and player 2.

- •The amount you want to give to player 2 is called an offer.
- •The offer can be any amount between £9.90 (highest possible offer) and £0.10 (lowest possible offer), in increments of £0.10.
- •That is, your offer can be £9.90, £9.80, £9.70......£0.30, £0.20, or £0.10.
- •In each round you can choose a new offer that may be identical to or different from previous offer(s).
- •The offer is transmitted to player 2 via the computer, and you will see how player 2 reacted to your offer before the next round begins (see next).

Second, player 2 reacts to your offer by pressing one of two buttons labeled “left” and “right”.

- •Player 2 sees only these two buttons on his screen, and has no information about you making an offer, nor about the size of your offer.
- •By pressing one of buttons, player 2 accepts your offer, i.e. he receives the amount you offered, and you receive £10 minus your offer in that round.

  Example: If the offer is £X.XX, and player 2 accepts it, player 2 receives £X.XX and you receive £10 – £X.XX.
- •By pressing the other button, player 2 rejects your offer, and both of you receive £0 (zero) in this round.

Text for Treatment 1

Third, you are informed about player 2’s choice, and how much you earned in this round.
Player 2 is ONLY informed about how much he earned in this round, but NOT how much YOU earned.

Text for Treatment 2

Third, you are informed about player 2’s choice, and how much you earned in this round.
Player 2 is informed about how much he earned this round, and ALSO how much YOU earned.

These three steps are identical in all 20 rounds.

These instructions can be accessed any time during the session by clicking on the <Help> button.
<OK, I understand. Please continue with the instructions>

Please note
•Each round is new and independent of other rounds.
That is,
-you are matched with a new player in each round.
-in each round there is a new £10 to be split.

Method of Payments
•At the end of this session 2 rounds from the 20 rounds played by each player will randomly be selected.
•The cash value earned in these two rounds will be paid to each player in addition to the £5 for participating.

Final Comment
•You play completely anonymously. Neither the experimenter nor the other participants in this experiment will know your identity, or how you behaved in this experiment.
•What you earn is your own business.

<scroll back to previous screen> <continue>

Screen 1 for players 2

Welcome!

Today you will have the opportunity to participate in a decision making experiment. If you follow the instructions carefully and make good decisions, there will be an opportunity for you to earn money during the session.

The Rules of the Game

•The session consists of 20 rounds, each of which is played by two players.
•You are player 2 throughout the session, and you will be matched each round with a new player 1.

In each round you will see two buttons on your screen.

- •The left button is labeled “left”.
- •The right button is labeled “right”.
- •You may choose to push either one of these buttons, and then confirm your choice by pushing the “confirm” button at the bottom of the screen.

Text for Treatment 1

> •The next screen will then show you the amount you earned in this round.

Text for Treatment 2

> •The next screen will then show you the amount you earned in this round, and also how much player 1 earned.

Please note

•All 20 rounds are identical as described above.
•However, each round is independent of other rounds.
That is, you may freely choose to push the “left” or “right” button.

Method of Payments

•At the end of this session 2 rounds from the 20 rounds played by each player will randomly be selected.
•The cash value earned in these two rounds will be paid to each player in addition to the £5 for participating.

Final Comment

•You play completely anonymously. Neither the experimenter nor the other participants in this experiment will know your identity, or how you behaved in this experiment.
•What you earn is your own business.

These instructions can be accessed any time during the session by clicking on the <Help> button.

<OK, I understand> <Help>

Player Screen for Player 1

Round # (1-20)

You are payer 1.
Please choose the amount you want to offer to player 2 out of £10.

Please recall that you will receive £10 minus your offer if the offer is accepted, and player 2 will receive your offer. If your offer is rejected both of you will receive £0.
Your offer must be in increments of £0.10.

I want to offer “ __x.y0___ ” £ to player 2.

<Confirm> <Help>

Player Screen for Player 2

Round # (1-20)

You are player 2.
Please choose “left” or “right” by clicking on the respective button.

<left> <right>

<confirm your choice> <help>

Feedback Screen for Player 1

Round # (1-20)

Player has decided to “accept”/”reject” your offer of “___” £.

You earned “___”£ in this round.
Player 2 earned “___”£ in this round.

Please prepare for the next round.

<continue> <help>

Feedback Screen for Player 2

Round # (1-20)

You have chosen the “left” / “right” key.

Text for Treatment 1	*Text for Treatment 2*
You earned “____”£ in this round.	**You earned “____”£ in this round.** **Player 1 earned “___”£ in this round.**

Please prepare for the next round.
<continue> <help>