

Fairness versus Efficiency

How Procedural Fairness Concerns Affect Coordination

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Abstract What happens if a mechanism that aims at improving coordination between individuals treats selected individuals unfairly? We investigate in a laboratory experiment whether procedural fairness concerns affect how well individuals are able to solve a coordination problem in a two-player Volunteer's Dilemma. Subjects receive external action recommendations that can help them avoid miscoordination if followed by both players. One of the players receives a disadvantageous recommendation to volunteer while the other player receives a recommendation not to volunteer that gives her a payoff advantage if both players follow the recommendations they have received. We manipulate the fairness of the recommendation procedure by varying the probabilities of receiving a disadvantageous recommendation between players. We find that the recommendations improve overall efficiency regardless of their consequences for payoff division. However, there are behavioral asymmetries depending on the recommendation received by a player: advantageous recommendations are followed less frequently than disadvantageous recommendations in case of actions that guarantee a low payoff. While there is no difference in acceptance of different recommendation procedures, beliefs about others' actions are more pessimistic in the treatment with a procedure inducing unequal expected payoffs. Our data shows that beliefs about others' behavior are correlated with one's own behavior, however this is the case only when following recommendations is a strategy that involves payoff-uncertainty.

Keywords Coordination · Correlated equilibrium · Recommendations · Procedural fairness · Volunteer's Dilemma · Experiment

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1 Introduction

Coordination problems are frequent in everyday interactions. Consider a situation at work in which exactly one volunteer is needed for serving on a workplace committee or writing the report from a meeting. If one person volunteers, everyone will benefit from the report being written or from a well-functioning committee. However, volunteering is time-consuming and hence costly to the individual, so everyone prefers someone else doing it. In order to avoid a situation where no one volunteers (or too many sign up), the employees have to solve a coordination problem. Where no formal rules are established, such problems can be solved with the help of some mechanism - for example, by a social norm determining who should do the task (the youngest team member or the oldest, etc.), via a coin toss, or by a third party (e.g. the boss) picking the one who should do the job. However, such a mechanism might lead to some individuals contributing more often, while others frequently escape from investing time. External mechanisms that imply different likelihoods of being picked as a volunteer across individuals might be perceived as unfair - not only by the one who is picked by the procedure, but also by those who avoid contributing. In the following study, procedural fairness is defined as sensitivity to differences in expected payoffs for the players.

In this paper, we examine whether procedural fairness plays a role in how well individuals are able to solve a coordination problem. In a laboratory experiment, we provide subjects with action recommendations as an external mechanism to improve coordination in a Volunteer's Dilemma game (Diekmann 1985). In this game, it is sufficient that one member of a group volunteers in order to make everyone better off. However, volunteering induces costs that are specific to the provider. As it does not matter who volunteers, two pure-strategy efficient Nash equilibria but no dominant strategies exist.¹ Without any additional mechanism, coordination on one of the equilibria can be difficult to achieve. Both underprovision (no one volunteers) and overprovision (too many people volunteer) constitute inefficient outcomes resulting from coordination failure.² To overcome the coordination problem, we give participants action recommendations - either to play the costly action or to abstain from it. Both players know their own recommendation and also which recommendation the other player receives. By allowing individuals to condition their action on the recommendation they receive, coordination on an efficient outcome can be achieved even without direct communication. Correlated equilibria become attainable, which can raise expected payoffs above Nash Equilibrium payoffs (Aumann 1974, 1987).

We manipulate the fairness of the recommendation procedure by varying the probabilities with which subjects receive a recommendation to volunteer. By doing so, we alter the expected payoffs of following recommendations between subjects. We evaluate the behavior of advantaged and disadvantaged individuals, the resulting coordination rates, and earnings both in comparison to situations without any recommendations and compared to a fair mechanism.

Previous experimental studies show that fair action recommendations often are efficiency-enhancing. Van Huyck et al (1992) find that subjects follow public, non-binding announcements if they do not conflict with payoff-dominance. Furthermore, subjects are more likely to follow the announcements if they induce equal average payoffs compared to unequal average payoffs during the whole treatment. Similarly, Croson and Marks (2001) study a threshold public good game and find that individual recommendations about each subject's contribution increase efficiency in contrast to a situation without recommendations. Duffy and Fisher (2005) show that potentially irrelevant announcements about market conditions can help subjects coordinate on "sunspot equilibria" in a laboratory financial market. Cason and Sharma (2007) study private action recommendations and show that private recommendations are followed if players believe that their counterparts will follow the recommendations as well. Duffy and Feltovich (2010) find that subjects follow private recommendations if they are payoff-enhancing compared to the Nash equilibrium, but do not follow the recommendations if they make them worse off than playing Nash equilibrium strategies would.

All those experiments use mechanisms that treat players symmetrically, such that all players can expect the same payoffs before the recommendation is realized. We will examine if a coordination mechanism that systematically puts one party at an advantage implies efficiency losses compared to such fair mechanisms. Our work is closely related to Anbarci et al (2015), who investigate the impact of payoff

¹ For more theoretical and experimental results on the Volunteer's Dilemma, see Darley and Latane (1968); Latane and Rodin (1969); Diekmann (1993); Weesie (1993, 1994) and Myatt and Wallace (2008).

² For an overview on coordination failures in laboratory experiments, see Camerer (2003) and Devetag and Ortmann (2007).

asymmetry on following recommendations in Battle of the Sexes games. By varying payoff asymmetry and the availability of recommendations between treatments, they study whether recommendations that point at both Nash equilibria with equal probability improve coordination. They find, as predicted, that subjects are less likely to follow recommendations with higher payoff asymmetry. While Anbarci et al vary the payoff matrix of the underlying game and keep the probabilities for the two equilibria equal, we keep the payoffs constant and use the probabilities with which we recommend each of the two Nash equilibria to manipulate procedural fairness across treatments.

In our treatment with asymmetric probabilities, expected payoffs of following a recommendation before the recommendation is realized vary between players. Previous experimental work suggests that people do not only care about ex-post, realized inequality, but also about ex-ante inequality in expected payoffs as an important aspect of procedural fairness (Bolton et al 2005; Krawczyk and Le Lec 2010; Brock et al 2013; Linde and Sonnemans 2015). Bolton et al (2005) study sequential games where first moves are decided by lotteries. Via the calibration of the lottery, the authors manipulate the expected value of the ultimatum game proposal. They find that low proposals are more acceptable if the lottery is judged as fair compared to a lottery that is biased towards the disadvantageous outcome. Theoretical models such as by Trautmann (2009), Krawczyk (2011) or Saito (2013) account for the importance of procedural fairness by incorporating expected payoffs into the utility function.

Building on this literature, we investigate whether inequality in expected payoffs also affects the efficiency of action recommendations as a coordination mechanism.³ The experimental design consists of three treatments: subjects play a Volunteer's Dilemma and receive either (i) no recommendations, (ii) efficient recommendations that induce *equal* expected payoffs as long as both subjects follow the recommendations, and (iii) efficient recommendations that induce *unequal* expected payoffs as long as both subjects follow the recommendations. This allows us to answer the following questions: Does inequality in expected payoffs matter for individuals' decision to follow action recommendations? Do differences in expected payoffs reduce the efficiency gains in a coordination game? And does the behavior of advantaged and disadvantaged individuals differ with regard to following the recommendations? We analyze the frequency of coordination on efficient outcomes, players' earnings and rates of following recommendations in order to answer these questions.

Our results show that most of the subjects are more concerned about efficiency and potential gains from coordination rather than differences in expected payoffs. Even a biased procedure was accepted by the subjects and the introduction of recommendations as a coordination mechanism increased efficiency in comparison with a treatment without any mechanism. We find that subjects are more likely to follow recommendations that give secure payoffs, even if they are disadvantageous, i.e. induce the equilibrium with a lower payoff for the player. While there were no significant differences in following recommendations between treatments, we find differences in individuals' beliefs about others' actions between treatments with different recommendation procedures.

The paper is structured as follows: section 2 introduces the coordination game used in the experiment and outlines the potential relevance of procedural fairness when using recommendations to improve coordination. Section 3 describes the experimental design. Hypotheses are outlined in section 4, while section 5 discusses the results, followed by section 6 with conclusions and discussion.

2 Analytical framework

2.1 Action recommendations in the Volunteer's Dilemma

Table 1 presents the basic setup of the two-player Volunteer's Dilemma. A public good is provided if at least one player volunteers. Each player has to decide between X (volunteer) and Y (not volunteer).⁴ Decisions are made simultaneously. Both players receive a if at least one of them volunteers and 0 if no one volunteers. A volunteer bears the cost c , $c > 0$. Both players are better off when volunteering compared to a situation in which no one volunteers: $a > a - c > 0$.

³ Our study hence uses a definition of fairness different from that of, for example, Kahneman et al (1986), who define fairness in terms of reference points and framing or, Konow (2001), who finds context-dependence of fairness. We limit our study to investigating procedural fairness as defined in the articles and models cited above.

⁴ In the experiment, names of actions were framed in a neutral way (X, Y) in order to avoid framing effects. For ease of exposition, we will use the neutral labels in the remainder of the article.

Table 1: Payoff matrix of the Volunteer's Dilemma.

		Player 2	
		X (volunteer)	Y (not volunteer)
Player 1	X (volunteer)	$a - c, a - c$	$a - c, a$
	Y (not volunteer)	$a, a - c$	$0, 0$

The game has no dominant strategy. There are two pure strategy Pareto-efficient Nash equilibria $((X, Y)$ and (Y, X)), in each of which one of the players volunteers and the other does not, granting the payoff $a - c$ to the volunteer who plays X and a to the player playing Y . However, this equilibrium requires Nash conjectures, i.e., players having correct beliefs about other players' actions, which is a quite strong assumption that is often not fulfilled (Camerer 2003).

Furthermore, the game has a mixed strategy Nash equilibrium, in which each of the players volunteers with probability $1 - \frac{c}{a}$ and takes no action with probability $\frac{c}{a}$. The expected payoff for each player in the mixed strategy Nash equilibrium is

$$\pi_{Nash}^e = a - c. \quad (1)$$

Action recommendations can improve coordination by helping to avoid over- and underprovision. Given that both players know which recommendation the other one received, they can correlate their strategies via the recommendation so that the inefficient outcomes are avoided. If both players follow the recommendation, new equilibria become attainable. Such equilibria are called correlated equilibria (Aumann 1974, 1987).

Direct action recommendations to both players are used to induce correlated play. The given recommendations aim at achieving coordination on the efficient outcomes (X, Y) and (Y, X) : it is either recommended to player 1 to play X and at the same time to player 2 to play Y , or player 1 receives the recommendation Y and simultaneously player 2 receives X . If both players follow the recommendation they receive, the inefficient outcomes (X, X) and (Y, Y) are avoided, and the correlated equilibria that become attainable have the highest potential efficiency gains compared to the Nash equilibria (Aumann 1974, 1987).

The distribution of recommendations to both players is common knowledge. Both players know which recommendation the other player receives when their own recommendation is realized, and they know the probabilities with which they receive a specific recommendation.

Let the probability that player 1 receives the recommendation Y and player 2 receives recommendation X be denoted with p , $p > 0$. Given our set of possible recommendations, the probability of player 1 to get recommendation X and player 2 to get recommendation Y equals $1 - p$. Under the assumption that both players believe that the other one follows the recommendation, no one has an incentive to deviate after the recommendation is realized, since a unilateral deviation would decrease their payoffs: from a to $a - c$ in case a player receives the recommendation "play Y " or from $a - c$ to 0 if he receives the recommendation "play X ". Hence, any convex combination of equilibria suggestions (X, Y) and (Y, X) constitutes a correlated equilibrium, independent of the value of p .

If both players follow their recommendations, expected payoffs from following the recommendation for player 1 are:

$$\pi_1^e = pa + (1 - p)(a - c) = a - (1 - p)c, \quad (2)$$

and for player 2:

$$\pi_2^e = p(a - c) + (1 - p)a = a - pc. \quad (3)$$

Equations 2 and 3 show that expected payoffs from a strategy to always follow the recommendation are higher than the expected payoff from playing the mixed strategy Nash equilibrium, $\pi_{Nash}^e = a - c$ (for each player). Hence, correlating their strategies via following the action recommendations is individually rational for both players. Moreover, it increases the sum of expected payoffs above the sum of Nash equilibrium payoffs.

2.2 Procedural fairness

Expected payoffs from a correlated equilibrium vary with the probability the action recommendations are given. As can be seen from equations 2 and 3, expected payoffs depend on the value of p . If $p = 0.5$, both players can expect

$$\pi_{1,2}^e = a - 0.5c \quad (4)$$

as equilibrium payoffs. However, for any value of p different from 0.5, expected payoffs from following recommendations will differ between player 1 and player 2.

Differences in expected payoffs have been identified as one important aspect of procedural fairness. In contrast to outcome fairness models such as models developed by Fehr and Schmidt (1999) or by Bolton and Ockenfels (2000), where the difference in payoffs to be received matters for decision-making, individuals who care about procedural fairness take additional factors into account, such as the likelihood of different outcomes or the feasibility of an equal split. For example, Trautmann (2009) develops a procedural fairness model based on the outcome fairness Fehr-Schmidt model where both absolute payoffs and differences in expected payoffs enter the utility function and matter for decision-making. The differences in realized payoffs are replaced by the differences in expected payoffs. In this model, individuals care both about advantageous and disadvantageous inequalities in expected payoffs, but are more sensitive to disadvantageous inequality than to advantageous inequality.

In our study, we adopt the definition of procedural fairness as differences in expected payoffs, as in Trautmann (2009). The model does not incorporate outcome fairness considerations. However, as we keep the payoff structure constant across treatments, the inequality in outcomes in Nash equilibria is kept the same, hence it does not affect the between-treatment comparison.

If inequality in expected payoffs matters for decision-making in a coordination game like ours, behavior could be sensitive to the value of p , with which an advantageous recommendation for player 1 (“Y”, to not volunteer) and a disadvantageous one for player 2 (“X”, to volunteer) is given. For example, for $p > 0.5$, player 1’s expected earnings will be greater than player 2’s. If people exhibit sensitivity to procedural fairness, following the recommendations as described in the previous section does not necessarily constitute the equilibrium strategies for all players. If disutility from inequality in expected payoffs outweighs utility gains from the increase in expected payoffs, players might prefer not to follow the recommendations. This might be especially true for disadvantaged players according to the Trautmann model, which predicts that players who are disadvantaged by a procedure are more sensitive to procedural fairness.

3 Experimental design

In each treatment, subjects play a Volunteer’s Dilemma game with the following calibration: $a = 10$ and $c = 5$. The normal form of the game is shown in Table 2. This payoff structure captures situations with high gains to both parties from volunteering, high costs for the volunteer and zero payoffs to both parties when no one volunteers, and is in line with previous experimental work on the Volunteer’s Dilemma (Rapoport 1988; Diekmann 1993).

Table 2: The experimental calibration of the Volunteer’s Dilemma.

		Player 2	
		X	Y
Player 1	X	5, 5	5, 10
	Y	10, 5	0, 0

The game is repeated for 30 rounds without feedback between the rounds. One half of the subjects are randomly assigned to the role of player 1; the rest of the subjects take the role of player 2. The role does not change during the experiment. In each round, the subjects in the role of player 1 are randomly matched into pairs with the subjects in the role of player 2. This matching procedure keeps the number of independent observations high and prevents subjects from developing strategies depending on past

behaviour, such as alternation, that might emerge when being matched with the same partner repeatedly (as in Duffy et al 2015). We use points as our experimental currency, with an exchange rate of 0.75 euros per point.

The experiment has a between-subject design and consists of three treatments. The first treatment serves as a baseline to evaluate behavior and coordination rates without action recommendations (we will refer to this treatment as *Baseline*). In this treatment, subjects play a standard Volunteer’s Dilemma game 30 times, as shown in table 2. It serves as a benchmark to evaluate the effectiveness of the coordination mechanisms in other treatments.

Action recommendations that serve as a coordination mechanism are introduced in the remaining two treatments. We recommend only actions that lead to one of the two Nash equilibria in the Volunteer’s Dilemma presented in Table 2, provided that the recommendations are followed. Hence, if one of the players is advised to volunteer (X), the other player is advised not to volunteer (Y). Because not volunteering when the other person volunteers gives the highest achievable payoff, we will call strategy Y advantageous, while volunteering is disadvantageous. Subjects have full information about the recommendations: through all 30 rounds, they are shown on the screen the probabilities of receiving each recommendation and what recommendation their counterparts will simultaneously receive, as well as the recommended play for a given round. In the second treatment, equal probabilities are assigned to the two pure Nash equilibria (*CD50*). This treatment’s primary purpose is to measure the changes in coordination in comparison to the *Baseline* treatment. In the third treatment, the different probabilities are assigned to action recommendations leading to the two pure Nash equilibria. The desired NE for player 1, (Y, X), is recommended with probability 0.9 and the NE that puts player 2 at an advantage (X, Y) is recommended with probability 0.1 (*CD90*). This treatment allows us to study the effects of inequality in expected payoffs on coordination rates and efficiency. The summary of the experimental design with probabilities of all possible recommendations with respect to the treatment are presented in Table 3.

Table 3: Summary of the experimental design

Treatment	Recommendation	Expected payoff player 1	Expected payoff player 2
<i>Baseline</i>	None	5	5
<i>CD50</i>	$P(X, Y)=0.5,$ $P(Y, X)=0.5$	7.5	7.5
<i>CD90</i>	$P(X, Y)=0.1,$ $P(Y, X)=0.9$	9.5	5.5

The expected payoff for both players is 5 points if mixed strategy Nash equilibrium is played. When the action recommendations are followed in the *CD50* treatment, expected payoffs for both players increase to 7.5 points. Expected payoffs are very uneven in the *CD90* treatment. If both players follow the recommendations, player 1 receives an expected payoff of 9.5 points and player 2 of 5.5 points. Hence, if perfect coordination is reached, player 1 receives 63% and player 2 37% of the total expected payoff. Compared to the expected payoffs from mixed strategy Nash equilibrium, even the disadvantaged player is better off by following the recommendation, though the expected gains are relatively small.

The series of recommendations subjects receive were randomly generated before the experiment and are the same across the sessions of a particular treatment. In *CD50*, the number of recommendations to volunteer is the same for both parties, in *CD90*; the disadvantaged player (player 2) receives three favorable recommendations (Y) and 27 recommendations to play X , while player 1 receives 27 recommendations to play Y and 3 recommendations to play X . The series of recommendations for player 1 in both treatments is displayed in Figure 5 in the appendix.

Each round has the same structure. In all treatments, we present both players with the normal form of the game. In the treatments with a coordination mechanism, *CD50* and *CD90*, subjects are also shown the probabilities with which each of the two Nash equilibria is recommended, as well as the actual

recommendation for the round. Subjects do not receive any feedback about outcomes or past behavior of other players until the very end of the experiment.

The experiment has a neutral framing. In the on-screen and printed instructions, we avoid words like partner or opponent and call subjects in the other role “the participant you are matched with”. Player 1 is called “Red participant”, player 2 “Blue participant”. The possible actions of the players are called X and Y . The coordination mechanism is called “recommendation” and we explain its working and consequences extensively in the instructions. It is displayed on the screen with the sentence “The recommendation is: ...”, directly above the field where subjects enter their decision.⁵ Full instructions for the *CD50* treatment, control questions and screen-shots can be found in the appendix.

After the experiment, we elicited risk preferences with an investment task proposed by Gneezy and Potters (1997). Subjects were endowed with 10 points (each point worth 10 euro cents) and had to decide about an investment in a risky asset. The asset had a probability of 0.5 of being successful: in this case it paid 2.5-fold the invested amount. With a probability of 0.5, the asset was not successful and the invested amount was lost.⁶ Subjects could invest any integer between 0 and 10 into the asset.

Furthermore, socio-demographic information was collected in a questionnaire after the experiment (age, gender, field of study, number of semesters in university). We also conducted two tests to account for possible effects of personality on behavior, the Big Five personality traits (the BFI-S by Gerlitz and Schupp 2005) and Locus of Control (the IEC itinerary by Rotter 1966 in a German translation by Rost-Schaude et al 1978). In the *CD50* and *CD90* treatments, two questions about the recommendations were included. Firstly, we elicited the beliefs about following behavior of the participants in the other role. The answer could be given on a scale with four items: all participants followed the recommendation, most participants followed it, most did not follow the recommendation, nobody followed the recommendation.⁷ Then subjects were also asked whether or not they felt disadvantaged by the recommendations.

Only after filling out the questionnaire, subjects were presented with the actions chosen by themselves and by the participant they were matched with in each round, the two randomly chosen rounds for the payment⁸, and the payoffs from the risk elicitation task. The rounds chosen for payoff were the same for all subjects within a session. Average total earnings were 13.87 euros (including a show-up fee of 4 euros), with a minimum of 4.50 euros and a maximum of 21.50 euros.

Each experimental session had 24 participants. We conducted three sessions of each treatment, and in all nine sessions, 216 subjects participated. The experiments were conducted in MELESSA, the Munich Experimental Laboratory for Economic and Social Sciences, in January 2015. Each session lasted between 60 and 75 minutes. Instructions were read out loud and were available on paper throughout the experiment. To make sure that subjects understood the instructions, a computer-based quiz was conducted and the experiment only started after all subjects answered all control questions correctly. The experiment was programmed in z-Tree (Fischbacher 2007) and participants were recruited via the ORSEE recruitment software (Greiner 2004).

4 Hypotheses

To test whether procedural fairness concerns affect coordination and the efficiency gains of correlated equilibria, we formulate hypotheses with respect to the frequency of recommendations followed, the frequency of successful coordination on one of Nash equilibria, and earnings. First of all, we compare the use of action recommendations to a situation without recommendations. We hypothesize that the existence of a coordination mechanism increases coordination and hence the earnings of players.

⁵ Before running the experiments, we conducted two pilot sessions of *CD50* and *CD90*. Subjects in these pilots had problems understanding the part of the instructions dedicated to the recommendations. As this part is central, we clarified it and supplied more information; for example, we explicitly stated that the probability that both matched participants at the same time get recommendations X or Y is zero.

⁶ The calibration used in the risk task has been introduced by Charness and Gneezy (2010).

⁷ The belief-elicitation was conducted after the experiment rather than before or after every decision and was not incentivized as we wanted to avoid the experimenter effect, in which subjects would behave in a socially desirable way rather than act according to their preferences. The scale of four items with verbal descriptions of the others' following behavior was chosen for the belief elicitation to avoid potential problems with correct expression of probabilities among subjects; see Erev et al (1993).

⁸ Players were paid for two rounds in order to increase the marginal incentives of every decision as compared to being paid for one round. We did not pay subjects for all rounds in order to avoid portfolio effects.

Results from multiple studies show that conditioning the strategies on an external signal improves the overall efficiency (for example, Cason and Sharma 2007; Duffy and Feltovich 2010). However, it is unclear how procedural fairness concerns might affect coordination rates and the efficiency of strategy recommendations as a coordination mechanism. Trautmann (2009) notes that an individual's utility depends on the realized payoff and her sensitivity towards procedural fairness (differences in expected payoffs). If the preference for payoff maximization is stronger than procedural fairness concerns, we would observe that an unfair coordination mechanism leads to higher coordination rates than coordination rates that are reached without recommendations. On the other hand, if procedural fairness concerns are stronger than efficiency concerns, individuals would disregard the coordination mechanism and we would observe no significant differences between the treatment with unfair coordination mechanism and the treatment without any coordination mechanism. This leads us to following hypotheses:

Hypothesis 1: Coordination rates (and earnings) in treatments with recommendations that induce *equal* expected payoffs (*CD50*) are higher than in treatments without recommendations (*Baseline*).

Hypothesis 2a: Coordination rates (and earnings) in treatments with recommendations that induce *unequal* expected payoffs (*CD90*) are higher than in treatments without recommendations (*Baseline*) if payoff maximization concerns are stronger than procedural fairness.

Alternatively:

Hypothesis 2b: Coordination rates (and earnings) in treatments with recommendations that induce *unequal* expected payoffs (*CD90*) are not higher than in treatments without recommendations (*Baseline*) if procedural fairness concerns are stronger than payoff maximization.

Findings from experimental studies on procedural fairness show that individuals are less likely to accept biased procedures, even if this is connected with forgoing monetary payments (for example, Bolton et al 2005). Hence, we predict that people are less likely to follow recommendations if they induce inequality in expected payoffs, in contrast to the case when they induce equality in expected payoffs.

Hypothesis 3: Coordination rates (and earnings) in treatments with recommendations that induce *equal* expected payoffs (*CD50*) are higher than in treatments with recommendations that induce *unequal* expected payoffs (*CD90*).

The frequency of coordination on one of the Nash equilibria in the treatments with coordination mechanism stems from individuals' propensity to follow recommendations. As discussed above, people dislike being treated unfairly and hence are less willing to coordinate in situations in which coordination induces unequal expected payoffs, compared to situations in which coordination induces equal expected payoffs. We predict that individuals are less likely to accept recommendation procedures (i.e. follow recommendations) that systematically favor one of the players and put the other one at a disadvantage, compared to procedures that leave players equal in terms of expected payoffs.

Hypothesis 4a: Subjects follow the recommendations in treatments with a coordination mechanism that induces *unequal* expected payoffs (*CD90*) less frequently than in treatments with a coordination mechanism that induces *equal* expected payoffs (*CD50*).

More specifically, we expect that disadvantaged players are more sensitive to procedural unfairness than advantaged players. Following Bolton et al (2005) and Trautmann (2009), we assume that individuals dislike being put at a disadvantage more than being in an advantaged position.

Hypothesis 4b: Subjects in the role of the *disadvantaged* player follow the recommendations less frequently than the subjects in the role of the *advantaged* player in treatments with a coordination mechanism that induces unequal expected payoffs (*CD90*).

5 Results

5.1 Coordination rates and earnings

Table 4 presents mean values of key variables across all subjects and rounds for each of the three treatments. The rows present the average point earnings, the average coordination rates (whether one of the

two pure Nash equilibria (X, Y) or (Y, X) was achieved in a round) and average rates of following recommendations. As can be seen in Table 4, subjects follow the recommendations more frequently in *CD50* compared to *CD90*, which results in slightly higher coordination rates. Coordination rates are lowest in the *Baseline* treatment without any recommendation procedure and, in that case, are close to what is predicted by a mixed strategy Nash equilibrium (0.5). The differences in coordination rates have an impact on the efficiency in terms of earnings, which are lowest in *Baseline*, followed by earnings in *CD90*, and are highest in *CD50*.

Table 4: Mean values of coordination rates, following rates and earnings across treatments. The last 3 columns present p-values from pairwise comparisons between treatments using Wilcoxon rank-sum tests.

	Means			p-values of pairwise comparisons		
	<i>Baseline</i>	<i>CD50</i>	<i>CD90</i>	<i>Baseline</i> - <i>CD50</i>	<i>Baseline</i> - <i>CD90</i>	<i>CD50</i> - <i>CD90</i>
Coordination rate	0.45	0.66	0.62	<0.0001	0.0001	0.5532
Following rate	-	0.79	0.75	-	-	0.5325
Earnings	5.31	6.17	5.99	<0.0001	0.0048	0.1344

Note: For tests on following rates and earnings, data from all rounds was collapsed at the subject level ($n = 72$ in each treatment). Since coordination rates are the same for both types of players, $n = 36$ in each treatment.

In the following, Wilcoxon signed-rank tests have been used for testing single samples or matched samples and Wilcoxon rank-sum tests for testing unmatched samples, unless otherwise stated. We test for significance using the 0.05 significance level unless otherwise specified.⁹

Players in *Baseline* coordinate on one of the efficient outcomes significantly differently than predicted by the mixed-strategy Nash equilibrium (MNE), 0.5 ($p < 0.02$). Both in *CD50* and *CD90*, coordination rates are significantly different than 0.5: 0.66 and 0.62 respectively ($p < 0.01$ for each treatment). The pairwise comparison of coordination rates between the treatments with recommendations shows no significant differences (see Table 4).

Figure 1 gives a more detailed overview of play across treatments, comparing the observed frequencies of the four possible outcomes with the predictions of MNE and correlated equilibria (CE) in the treatments *CD50* and *CD90*. The figure shows that players in most of the cases did not play according to either CE or MNE predictions¹⁰, despite the increase in coordination rates when recommendations are implemented.

The predicted outcome frequencies of the two equilibria (X, Y) and (Y, X) were not reached in any of the treatments with recommendations, except for the outcome (X, Y) in *CD90*, which was supposed to be reached 10% of the time. Although the observed frequencies of the efficient outcomes in treatments *CD50* and *CD90* move towards the frequencies predicted by CE compared to the baseline treatment, subjects did not follow the recommendations all the time ($p < 0.0001$ for both treatments).

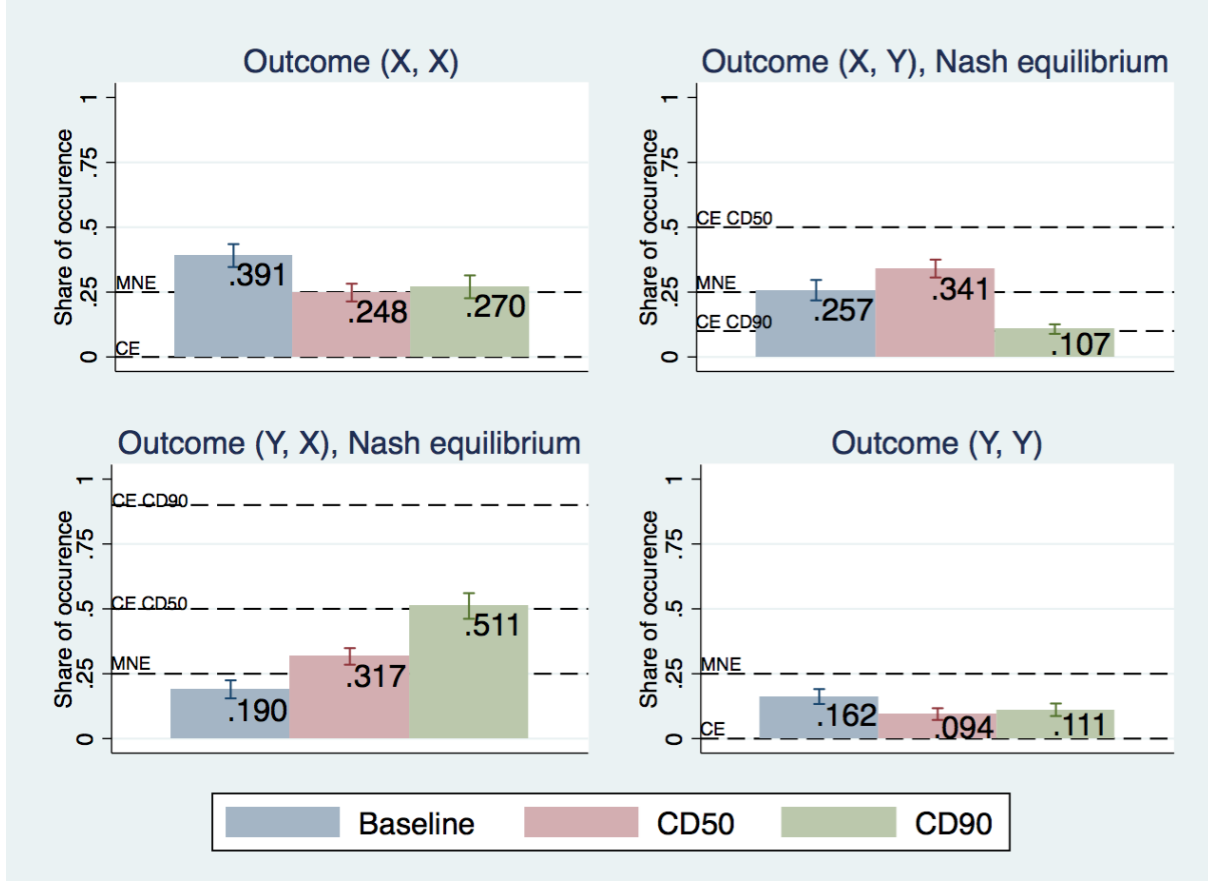
The introduction of recommendations substantially reduced the frequency of the occurrence of outcome (Y, Y) (underprovision) in treatments with a recommendation device, compared to *Baseline*. Observed frequencies of outcome (X, X) (over-provision) were significantly reduced when recommendations were given, compared to the baseline treatment, however were still on a high level compared to 0% predicted by CE. This can be explained by the fact that players chose the strategy X that guaranteed a low payoff more frequently than the payoff-uncertain strategy Y that could result in higher payoff if both players followed their recommendations, even when they received a recommendation to play Y .¹¹ A more detailed analysis of how players react to the different recommendations will follow in the next section.

⁹ In all aggregate tests, we have collapsed the data at the subject level across periods to achieve independent observations. Furthermore, since coordination rates are the same for both types of players (a successful coordination by definition requires two players of different type matched with each other), we have run the tests only on the data from one type of player.

¹⁰ In *Baseline*, we do not reject the hypothesis that outcome (X, Y) was achieved 25% of time, but we can reject this hypothesis for outcome (Y, X) . This result is surprising, since outcomes (X, Y) and (Y, X) are perfectly symmetric. Even though it seems that type 1 players chose strategy X more frequently than type 2 players, we cannot reject the hypothesis that both types of players played X with equal proportions. One possible explanation is a relatively low number of observations; another possible reason might be the emergence of conventions that can differ between populations and is facilitated by labels (Van Huyck et al 1997).

¹¹ The hypothesis of equal frequencies of choosing X and Y is supported only for type 2 players in treatment *CD50*.

Fig. 1: Outcomes played across treatments with MNE and CE predictions and 95% confidence intervals



With respect to following recommendations, Figure 2 illustrates the following rates by player type and the comparison to predictions of CE. Subjects followed the recommendations less frequently than 100%. 79% of all recommendations were followed in *CD50*, while 75% were followed in *CD90*. This difference is not statistically significant. Further decomposition of recommendations into disadvantageous (*X*) and advantageous ones (*Y*) shows that there are no significant differences in following rates between treatments or types of players, except for the case of following disadvantageous recommendations by advantaged and disadvantaged players (following rates are: 0.85 and 0.83 respectively ($p=0.028$); data available upon request).

Detailed results of pairwise comparisons of individual earnings between treatments are provided in the last row of Table 4. As earnings depend on the subjects' ability to coordinate, the results reflect the findings on coordination. We find significant differences in average earnings between *Baseline* and *CD50* and in average earnings between *Baseline* and *CD90*, but no significant differences in earnings between the treatments with recommendations. Moreover, average earnings across players in the treatments with recommendations are significantly lower than predicted by CE; while predicted expected point earnings in *CD50* were 7.5, subjects earned only 6.17 ($p<0.0001$). However this was still significantly more than predicted by MNE (5 points, $p<0.0001$). The same results hold with respect to *CD90*, in which average point earnings predicted by CE were 7.5 points and observed 5.99 ($p<0.0001$ for both one-sided tests).

Figure 3 presents point earnings by player type and the comparison with predicted earnings of MNE and CE. In the baseline treatment, average earnings of type 1 players were 5.14 points, in line with MNE predictions, while they were significantly different from the MNE prediction for type 2 players (5.48 points). That difference stems from the fact that type 2 players volunteered slightly less and those players reached their preferred Nash equilibrium (*X, Y*) more often than (*Y, X*). However, the comparison of earnings between players shows no significant difference in payoffs between type 1 and type 2 players. In Treatment *CD50*, earnings of both players are not significantly different, and lie in the interval between the earnings predicted by MNE (5 points) and CE (7.5 points). In *CD90*, (disadvantaged) type 2 players'

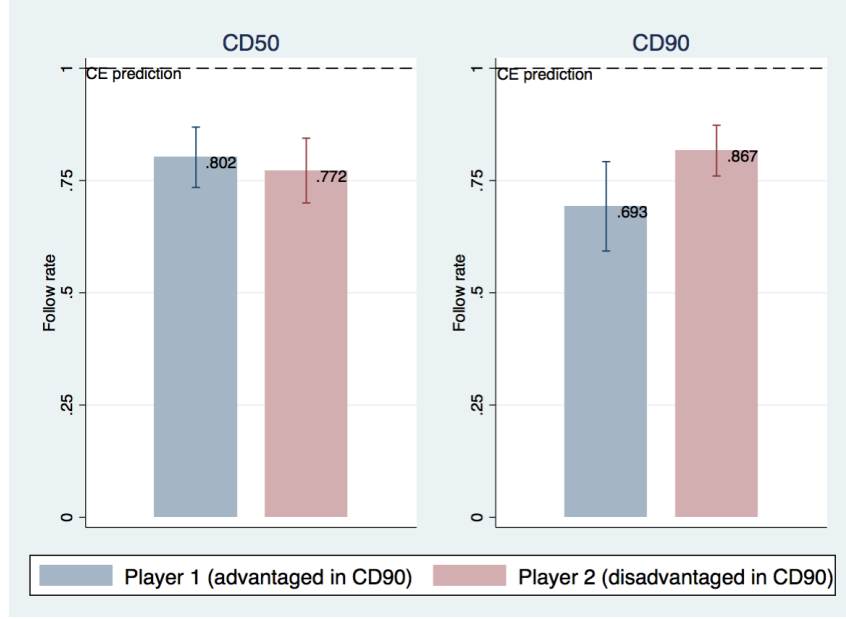
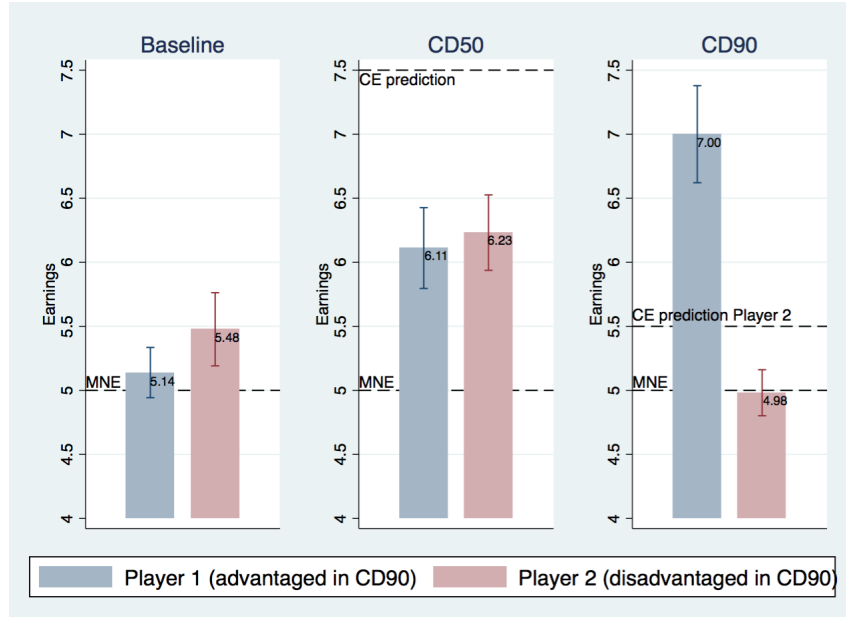
Fig. 2: The frequency of following recommendations by player type in treatments *CD50* and *CD90*

Fig. 3: Earnings by player type in all treatments



earnings are not significantly different from MNE prediction (5) but are significantly different from CE prediction (5.5). Advantaged type 1 players' earnings are different than predicted by MNE or CE and lie between these predictions: 5 and 9.5. Hence, we can conclude that, in the treatment with unfair recommendations, disadvantaged subjects were not worse off than without recommendations, but also did not benefit compared to the baseline treatment. Subjects put at an advantage were significantly better off. Thus, introducing an unfair procedure still constitutes a Pareto improvement compared to a situation without any coordination procedure.

These findings lead us to the first two results: we fail to reject hypothesis 1 and 2a, but we reject hypothesis 2b and 3:

Result 1: Action recommendations that induce equal expected payoffs for both players improve coordination rates and earnings compared to the situation without recommendations.

Result 2: Action recommendations that favor one of the players while putting the other one at a disadvantage improve coordination rates and earnings compared to the situation without recommendations.

Result 3: There are no significant differences in coordination rates and average earnings between treatments with fair and unfair recommendations. Hence, in aggregate terms, procedural fairness concerns seem to play a less important role than efficiency concerns.

5.2 Following recommendations

Before we start the analysis, we will briefly check how successful the randomization of subjects was and whether we observe time trends. Descriptive statistics on the subjects' characteristics across treatments can be found in the appendix (Table 7). There are significant differences in the share of females and economics students between the treatments. Thus, we will control for these variables in our main regression specifications. Subjects were randomly matched in every period and no feedback was supplied; hence we do not expect any learning process across time. Based on the results from Mann-Kendall tests, we find no significant monotonic time trends in the following and coordination rates on any of NE. The averages of key variables over the course of the 30 rounds are presented in figures 6-10 in the appendix.

Next, we will look at individual determinants of the decision to follow recommendations in our treatments *CD90* and *CD50*. Since we are mainly interested in interaction effects between treatment and type of player, we use a linear probability model (LPM) to analyze the data, as resulting interaction terms cannot be interpreted in the same way in non-linear models as in linear models (for contributions to this discussion, see e.g. Ai and Norton (2003), Greene (2010), Puhani (2012), and Karaca-Mandic et al (2012)).¹²

Table 5 shows the results of LPM regressions with the dependent variable taking the value 1 if a player followed the recommendation and 0 otherwise. In Model 1, individuals' behavior is explained by treatment and type of player (Player 1 or Player 2), as well as the interaction between the two. If we account for the type of player, the results indicate that type 1 players in *CD90* are less likely to follow the recommendation than type 1 players in *CD50*, although this effect is only marginally significant. There are no significant differences in following recommendations between type 2 players in *CD50* and *CD90* ($p=0.321$). A simple test for linear combination of parameters indicates the surprising result that disadvantaged players in *CD90* follow recommendations more often than advantaged players in *CD90* ($p=0.028$).

The specification of Model 2 includes a dummy variable indicating a subject received a favorable recommendation not to volunteer (i.e., to play *Y*). This is the recommendation that, given both players follow it, results in a payoff of 10 for an individual. However, if the other player does not follow the recommendation to volunteer (i.e., to play *X*), both players will earn zero points. Following a *Y*-recommendation thus always comes at an uncertainty of receiving a payoff of zero. On the other hand, playing strategy *X* guarantees a payoff of 5 regardless of the other player's behavior, hence is safe. Players are significantly less likely to follow recommendation *Y* compared to a recommendation to play *X*. Once the additional variable is included, the coefficient of the interaction term between treatment and player type becomes insignificant. It means that the difference in the behavior of type 1 players between treatments stems mainly from the fact that type 1 players in *CD90* receive an advantageous recommendation more frequently than type 1 players in *CD50*. There are no significant differences between players within the same treatment *CD50* and *CD90* or between treatments.¹³ One of the possible interpretations might be that it is not the unfair procedure per se that decreases the likelihood of following, but the uncertainty of the outcome. Individuals are willing to reject the favorable procedure to secure a lower payment, instead of facing the uncertainty about whether the other player will follow a procedure that puts her at a disadvantage. Our results stay in line with study by Van Huyck et al (1990), who studied how individuals behave when facing strategic uncertainty in coordination games with multiple equilibria and found support for individuals choosing actions that maximize minimum payoffs. In our study, strategy *X* is a maximin strategy, as volunteering ensures that the public good is provided and hence grants payoff of 5

¹² As robustness checks, we ran panel regressions, probit regressions and logistic regressions with odds ratios. Results are consistent with our LPM results and are available upon request.

¹³ We have also run a regression as specified in Model 2 with additional interaction effects between treatment and advantageous recommendation and the results show that there are no differences between treatments in following the same types of recommendations (results available upon request).

to the provider. On the other hand, choosing strategy *Y* is connected with strategic uncertainty that the other player will also not volunteer, hence the public good will not be provided and both players receive a payoff of 0.

The advantaged individuals might hesitate whether the other players follow the disadvantageous recommendation and might ignore their own recommendations more often. On the other hand, disadvantaged individuals might find no reason for their opponents not to follow the recommendations; hence, in this situation, their best response is to follow the recommendations as well. To explore whether beliefs affect the decision to follow recommendations across treatments and player types, we include a variable that captures subjects' beliefs about how others react to recommendations (Model 3). This variable was elicited via the non-incentivized post-experimental questionnaire.¹⁴

In line with previous research (Cason and Sharma 2007), beliefs matter for individual behavior. Those who believe that the other individuals follow recommendations are more likely to follow them as well. It is also a sign that subjects understood that it is best for them to follow the recommendations if others do so. Furthermore, one can observe the importance of beliefs by noticing a nontrivial increase in goodness of fit measure once the variable *OthersFollow* is added in the model: adjusted R-square increases from 0.036 to 0.128.¹⁵

In the specification of Model 4, we control for the following variables: gender, period effects, session effects, and subjects of studies, as well as risk aversion and personality traits (measured by Locus of Control and Big Five tests), which seem not to be correlated with following the recommendations¹⁶ and have a very small effect on the coefficients of the other variables as well as on the goodness of fit. It might seem surprising that elicited risk preferences are not significant in explaining the variation in decisions to follow recommendations, which entails strategic uncertainty, but similar results have been found in previous studies. For example, Kocher et al (2015) show that there is no relation between risk preferences and cooperation in a public good game. The authors argue that preferences towards risk stemming from nature might differ from the preferences towards uncertainty resulting from actions of another person.

We also checked whether there are significant gender differences between treatments. While women follow recommendations significantly more frequently than men in treatment *CD50*, the relation is insignificant in *CD90* and has the opposite sign. Furthermore there are no differences between women in *CD50* and *CD90*, nor between men in these conditions.¹⁷ To conclude, while women do follow recommendations more frequently than men if the procedure is fair, these differences between genders disappear in an unfair environment.

The analysis of individual-level behavior in response to recommendations leads to results 4a and 4b, in which we reject hypotheses 4a and 4b:

Result 4a: In the treatment with the coordination mechanism that induces unequal expected payoffs, subjects do not follow the recommendations less than in the treatment with a coordination mechanism that induces equal expected payoffs.

Result 4b: Disadvantaged players do not follow recommendations significantly less often than advantaged players or players in the fair treatment. However, there are differences in how players react to advantageous recommendations: these are followed less often than disadvantageous recommendations.

We have also conducted OLS regressions with individual point earnings as a dependent variable (detailed results are available upon request). Results corroborate the findings as follows: following the recommendations is a payoff-enhancing strategy for all players. Furthermore, they are the consequence of subjects' behavior and experimental design: advantaged players in *CD90* earn significantly more than disadvantaged players in *CD90* and type 1 players in *CD50*, who in turn earn more than type 1 players in *Baseline*; type 2 players in *CD50* earn more than type 2 players in *Baseline* or disadvantaged players in *CD90*. Moreover, there were no significant differences in payoffs between disadvantaged players in *CD90* and type 2 players in *Baseline* treatment. A more in-depth analysis reveals that, although coordination on average was higher in *CD90* than in *Baseline* and coordination on player 2's favorable Nash Equilibrium

¹⁴ The original variable was a variable indicating the belief about how many of the other subjects in the opposite role follow the recommendations, ranging from 1 indicating "everyone follows" to 4 "no one follows". We summarized the data into a binary variable that takes the value 1 if the subject's answer was 1 or 2 in the original variable. In *CD90*, this variable is higher among type 2 players (mean=0.67) compared to type 1 players (mean=0.61), but it is not significantly different.

¹⁵ A more detailed analysis of the relevance of beliefs is explored in the next subsection.

¹⁶ Only individuals with a more pronounced trait Neuroticism follow recommendations significantly less often ($p=0.012$).

¹⁷ The results are available from the authors upon request.

Table 5: Linear probability model on following the recommendations.

	Model 1 Coef./SE	Model 2 Coef./SE	Model 3 Coef./SE	Model 4 Coef./SE
Treatment CD90	-0.109* (0.06)	-0.046 (0.06)	0.018 (0.04)	-0.011 (0.07)
Type of Player Player 2	-0.030 (0.05)	-0.030 (0.05)	-0.006 (0.04)	-0.037 (0.04)
Treatment*Type of Player CD90×Player 2	0.154** (0.07)	0.028 (0.07)	-0.012 (0.06)	0.014 (0.06)
Advantageous Recomm. Yes		-0.157*** (0.04)	-0.157*** (0.04)	-0.157*** (0.04)
Others follow Yes			0.288*** (0.03)	0.275*** (0.03)
Control variables Constant	no 0.802*** (0.03)	no 0.880*** (0.03)	no 0.640*** (0.04)	yes 0.765*** (0.16)
Adj. R-Square	0.012	0.036	0.128	0.142
Number of Cases	4320	4320	4320	4320

Significance levels : * : 10% ** : 5% *** : 1%. Standard errors clustered at the subject level.

Control variables include: period, session dummies, economics/business student dummy, below-average risk aversion dummy, Locus of Control, Big Five.

was around 10% as predicted, the relatively high rate of underprovision in *CD90* (11%) erased gains for player 2 compared to the treatment without action recommendations.

In summary, the results demonstrate that the existence of coordination mechanisms increases efficiency, even if one party is strongly favored by the mechanism. We find that the beliefs about other players behaviour is an important explanatory variable of following the recommendations or not.

5.3 The role of beliefs

Based on the results from linear probability models, beliefs play an important role in individuals' behavior in the strategic situations modeled in our experiment. To further explore their relevance, we have conducted tests to check whether there is a relationship between beliefs and treatments. Because beliefs about others following the recommendations were elicited only in the treatments with recommendations, in the following tests we run comparisons for these two treatments.

We have conducted tests using the binary variable describing beliefs, which takes value 1 if a subject believes that everyone or most of the players in the other role follow recommendations. There is a significant relationship between treatment and beliefs (chi-square test $p=0.042$). The results from a Wilcoxon rank-sum test corroborate these results ($p=0.043$). A further decomposition of data by type of player (player 1/player 2) shows that these differences in beliefs are driven by type 1 players (chi-square test $p=0.035$). Hence, the advantaged players, knowing that others are put at a disadvantage, expect them to follow the procedure less frequently. This may indicate that subjects believe that other players are concerned about the fairness of the procedure.

Interestingly, all players in *CD50* and disadvantaged players in *CD90* hold correct beliefs. Only advantaged players in *CD90* have incorrect beliefs: disadvantaged players in *CD90* follow recommendations significantly more frequently than advantaged players believe that they do (one-sided test of proportions $p=0.0268$).

To investigate whether these differences in beliefs are related with individuals' behavior, we have compared how the following rates differ across different beliefs. There are no differences in following rates between treatments contingent on individual beliefs. However, beliefs are positively correlated with

following rates ($p < 0.0001$ for each treatment). The left panel of Table 6 displays following rates in treatment *CD50*, contingent on type of player and beliefs. In this treatment, both players were treated fairly by the coordination mechanism and their expected payoffs were the same; hence, we do not expect any differences between players and Wilcoxon rank-sum tests show that there are none. However, there is still a significant difference in following with respect to beliefs. Last but not least, the right panel of Table 6 represents following rates in treatment *CD90* contingent on beliefs and type of player. As can be seen, there is a significant difference in following between advantaged and disadvantaged players who think that other subjects mainly do not follow recommendations. Regardless of their beliefs, disadvantaged players follow their recommendations most of the time. Furthermore, there is a significant difference in following rates with respect to beliefs.

Table 6: Left panel: following rates contingent on beliefs and type of player in treatment *CD50*; Right panel: following rates contingent on beliefs and type of player in treatment *CD90*

	CD50			CD90		
	Type of player			Type of player		
Others follow	Player 1	Player 2	Wilcoxon rank-sum p	Player 1 (advantaged)	Player 2 (disadvantaged)	Wilcoxon rank-sum p
No	0.606 n=6	0.537 n=9	0.106	0.410 n=14	0.742 n=12	0.001
Yes	0.841 n=30	0.851 n=27	0.636	0.873 n=22	0.854 n=24	0.495
Wilcoxon rank-sum p	0.008	<0.0001		<0.0001	0.0499	

Next, we look at following rates as a response to a particular (advantageous/disadvantageous) recommendation. Figure 4 provides following rates of different types of recommendations contingent on beliefs. The data was pooled for both treatments, *CD50* and *CD90*, as there were no significant differences between treatments.¹⁸ Following rates of recommendation to volunteer, “X”, are presented in the left panel. Surprisingly, following rates of the disadvantageous recommendation do not differ with respect to beliefs. Regardless of beliefs, individuals follow recommendations to volunteer relatively frequently (more than 80% of the time). Theoretically, if a person receives a disadvantageous recommendation and believes that her counterpart does not follow the received recommendation, it is payoff-enhancing to not follow it either. However, strategy “X” has an advantage of being secure and playing it guarantees a safe payoff of 5 regardless of the other player’s strategy. Following rates of recommendations not to volunteer, “Y”, are presented in the right panel. As can be seen in the figure, the following rates of receiving an advantageous recommendation differ significantly contingent on individuals’ beliefs. Even though strategy “Y” can lead to higher equilibrium payoff if the other player follows his recommended action, it is also uncertain. Hence, we can conclude that beliefs are correlated with the decision to follow only when individuals receive advantageous recommendations that involve payoff uncertainty.

These findings lead us to the following result:

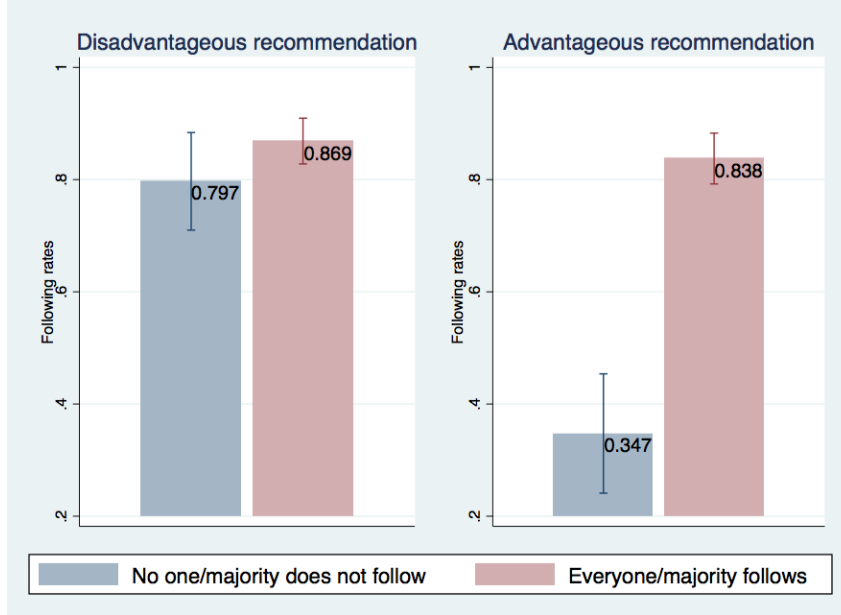
Result 5: Advantaged individuals in the treatment with a coordination mechanism inducing unequal expected payoffs predict less frequently that everyone or most of their counterparts follow recommendations than individuals in the treatment with a coordination mechanism inducing equal expected payoffs. Furthermore, beliefs are correlated with following rates only when following the recommendation does not guarantee a safe payoff.

6 Discussion and conclusion

Our study highlights the benefits of external action recommendations in improving coordination. We demonstrate that the existence of coordination mechanisms increases efficiency, even if one party is

¹⁸ The same results are found if we run tests for each treatment separately and contingent on type of player. There are no differences between different types of players.

Fig. 4: Following rates contingent on beliefs with respect to advantageous and disadvantageous recommendations



strongly favored by the mechanism. When individuals are confronted with a situation in which they face uncertainty about the behavior of the other party, recommendations play an important role for coordination, even if it induces inequality in expected payoffs.

The findings from the study can be applied in coordination mechanisms where fairness might play a role, for example, informal rules governing the exploitation of common pool resources. While there might be many outcome allocations that guarantee sustainability, inequality in the expected harvest can lead to destabilization of the governing institutions (Klain et al 2014; Cox et al 2010). On a larger scale, preventing the catastrophic consequences of climate change can be modeled as a coordination game with multiple equilibria (Tavoni et al 2011; DeCanio and Fremstad 2013; Madani 2013). In this context, action recommendations can be understood as the suggestion of an equilibrium profile by a ‘global planner’ (Forgó et al 2005). This suggestion does not necessarily have to imply equal expected payoffs (Beg et al 2002; Thomas and Twyman 2005). A negotiation process that is perceived as fair by all parties has been identified as an important prerequisite to reach an agreement (Winkler and Beaumont 2010; Lange et al 2010; Rübbecke 2011).

Our results are in line with a study by Eckel and Wilson (2007), who show that signals of actions that aim at implementing a risk-dominant equilibrium are more likely to be followed in a coordination game, compared to signals aimed at implementing payoff-enhancing (Pareto-superior) but risk-dominated equilibrium. In their study, signals were sent either by commonly-observed players or simulated players. They do not frame the signal as a “recommendation”, but rather as an observed move of a chosen player. They find that, while signals to play a less risky but inefficient strategy are readily followed, signals to play risky but efficient strategies (that constitute Pareto-superior Nash equilibrium) significantly increase the play of that action, although not to the same degree as the safe actions. Similarly, Brandts and Macleod (1995) find in a coordination game with recommended play that the choice of strategy is affected by the minimum payoff that one can gain by playing it. In other words, less risky strategies are more likely to be followed even if they constitute Pareto-inferior equilibria.

Our results corroborate findings of Hong et al (2015). In their experiment, subjects had to trade off a fair distribution of payoffs against an increasing sum of payoffs. Authors estimate social welfare preferences and find that the majority of the individuals weakly prefers efficiency over equality.

However, our findings differ from Anbarci et al (2015). In their experiments, subjects rejected external recommendations that implied ex-ante equality but ex-post inequality in Battle of the Sexes games. A potential reason for the discrepancy in the results can be the experimental design. While Anbarci et al change the payoff matrix, we keep it constant across treatments and measure the impact of the fairness of

the recommendation procedure. The subjects in Anbarci et al (2015) reject the recommendations because of the inequality of the outcomes of the game, not based on the perceived fairness of the coordination procedure. Our experiments also differ with respect to the underlying coordination game. This might explain why Anbarci et al report higher following rates than we do.

Furthermore, the study by Bolton et al (2005) can help explain the high acceptance of our unfair recommendation procedure. The authors show that a biased procedure is more likely to be accepted if an unbiased procedure is not feasible. In our study, subjects can either follow recommendations that put one of them in a disadvantaged position or reject it; however rejection implies a substantial loss of efficiency. There is no fair coordination procedure available in treatment *CD90*. Potentially, if an unfair recommendation procedure was chosen by one of subjects over the fair one and implemented, we could observe higher rejection rates of the procedure.

Moreover, it is possible that subjects would reject unfair action recommendations to a larger extent if they were picked by other subjects, in a similar fashion as they reject unfair ultimatum proposals more often if they are chosen by a subject using a ‘monocratic’ rule compared to a ‘democratic’ rule, as for example in Grimalda et al (2008). In our experiment, the procedure was chosen by the experimenter and subjects were randomized into the roles of player 1 and player 2. Randomization into roles could be seen as a fair procedure, reducing potential concerns about the lottery determining expected earnings. However, Bolton et al (2005) observe rejections of unfair procedures even if they are implemented by an experimental lottery similar to our study. Furthermore, in a post-experimental questionnaire, we asked subjects if they feel disadvantaged and learned that significantly more type 2 players in *CD90* feel disadvantaged than type 1 players in the same treatment (Wilcoxon rank-sum $p < 0.0001$). More research is needed to identify the characteristics of situations in which unfair procedures are rejected versus situations in which such procedures are accepted. This is also crucial for policy-makers to understand when policy suggestions, for example on public good provision, will face resistance and when they will be accepted by the general public.

Our study is limited to cases that can be represented as one-shot situations, as subjects had only a low probability of encountering their current “partner” repeatedly in our experiments. It would be of interest to investigate in future research how outcomes change when subjects learn the outcomes after every encounter. It might well be the case that procedural fairness considerations become more salient when individuals are allowed to learn over time. This would mean that our results should be interpreted as a lower bound.

In general, the role of beliefs that are formed when individuals face different procedures deserves further explanation. In our study, beliefs were elicited only after the whole experiment in a non-incentivized task. Additional research is necessary to explore their role in driving people’s behavior in situations in which concerns about procedural fairness and efficiency, as well as strategic uncertainty, are involved. Our results indicate that subjects might hold wrong beliefs about how others react to recommendations when facing coordination procedure that makes individuals unequal. Naturally, the incorrect beliefs lead to further inefficiencies if subjects act in accordance with them.

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Appendix

Tables

Table 7: Balancing test on observables

	Means			Differences		
	Baseline	CD50	CD90	CD50-Baseline	CD90-Baseline	CD50-CD90
female	0.514	0.653	0.569	-0.139*	-0.055	0.083
age	24.46	23.96	23.54	0.500	0.917	0.417
semesters	4.028	4.403	4.028	-0.375	0	0.375
econ	0.472	0.278	0.431	0.194**	0.042	-0.153*
Risk aversion task	6.403	6.625	6.944	-0.222	-0.542	-0.319
Personality traits						
Locus of Control ^a	11.72	12.17	12.64	-0.444	-0.917	-0.472
Neuroticism ^b	12.17	13.03	12.31	-0.861	-0.139	0.722
Extraversion ^b	14.79	15.04	15.21	-0.250	-0.417	-0.167
Openness ^b	15.04	15.85	15.49	-0.806	-0.444	0.361
Agreeableness ^b	15.29	16.03	15.29	-0.736	0	0.736
Conscientiousness ^b	15.43	15.15	15.60	0.278	-0.167	-0.444
N	72	72	72			

Significance levels : * : 10% ** : 5% *** : 1%. Two-sided t-tests.

^a Locus of Control (LoC) can range from 0 to 23. We added up the external answers to the questions, hence a higher LoC means that a subject is more external and believes that his life and decisions are rather controlled by environmental factors rather than by himself. ^b Each of the Big Five traits can range between 3 and 21. We added up the answers given on seven-item Likert scales to the three questions for each trait. A higher score means that the trait is more pronounced.

Figures

Fig. 5: The series of recommendations in *CD50* and *CD90* for Player 1

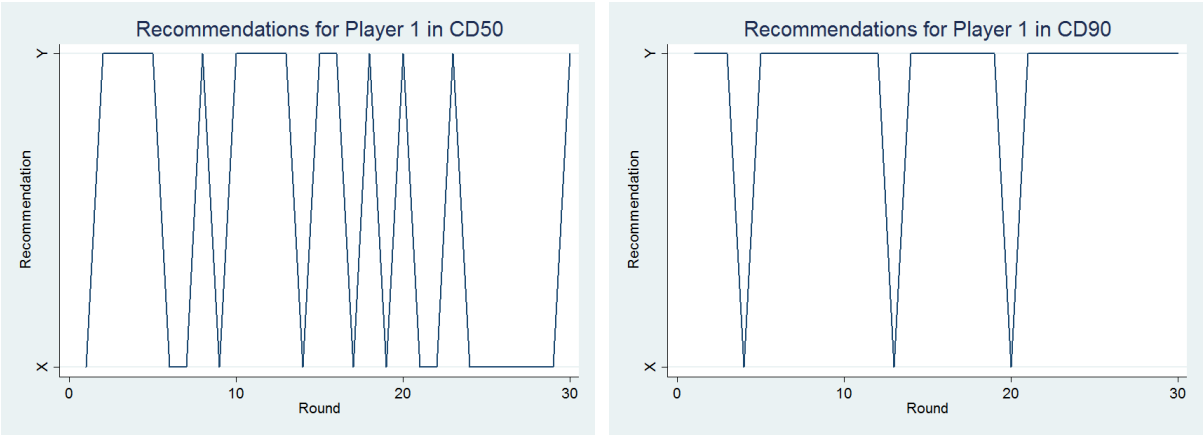


Fig. 6: Average coordination rates over time in all three treatments

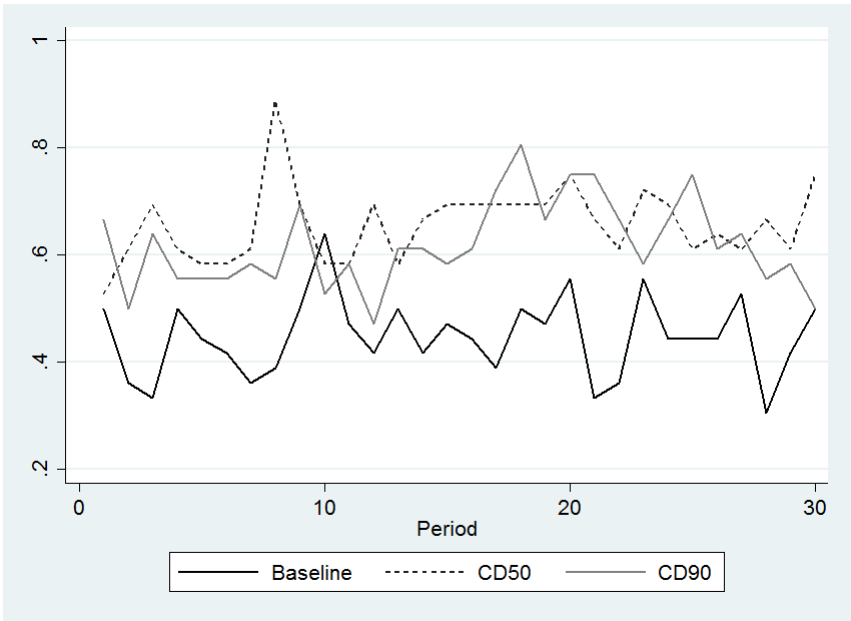


Fig. 7: Average rates of individuals who follow the recommendation over time in CD50 and CD90

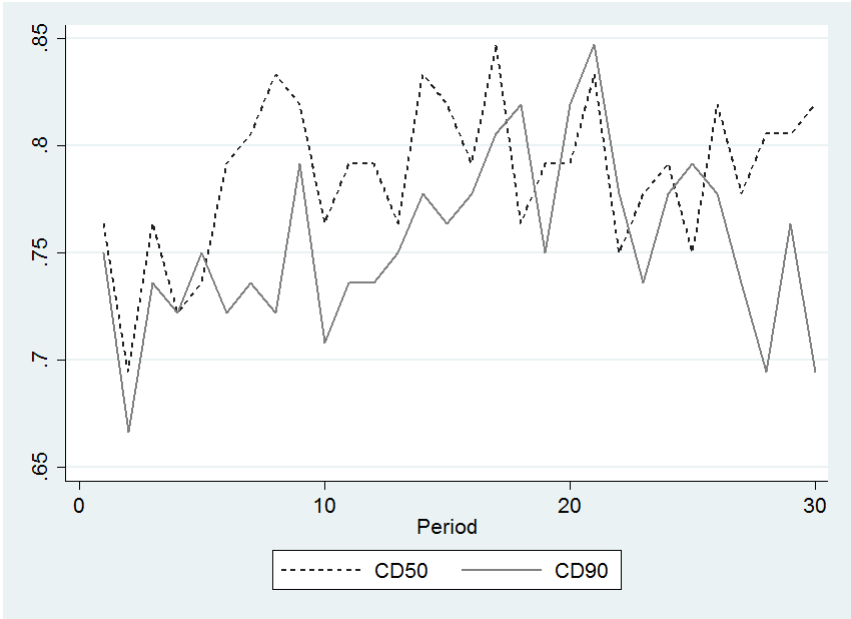


Fig. 8: Average earnings over time in all three treatments

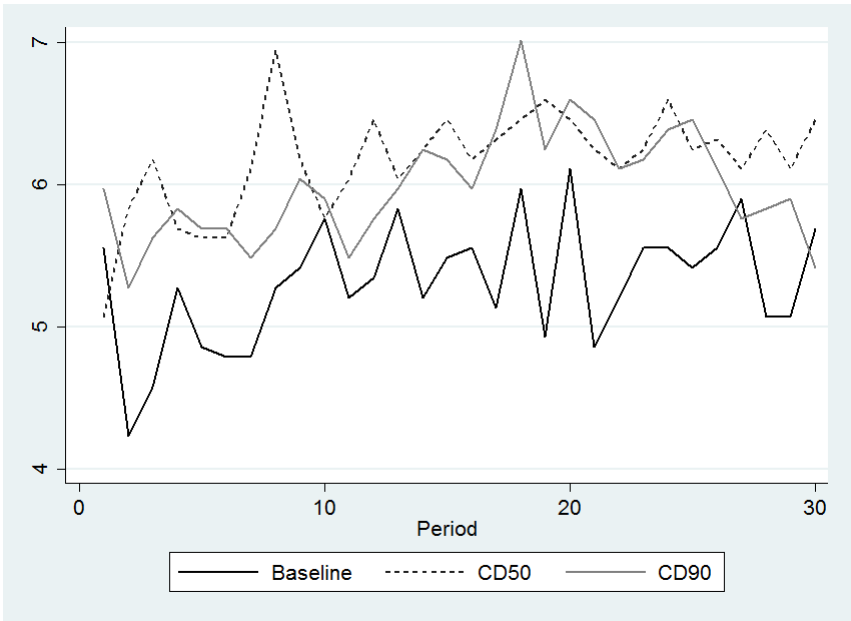


Fig. 9: Average rates of individuals who follow the recommendation over time in CD50, separately for Player 1 and Player 2

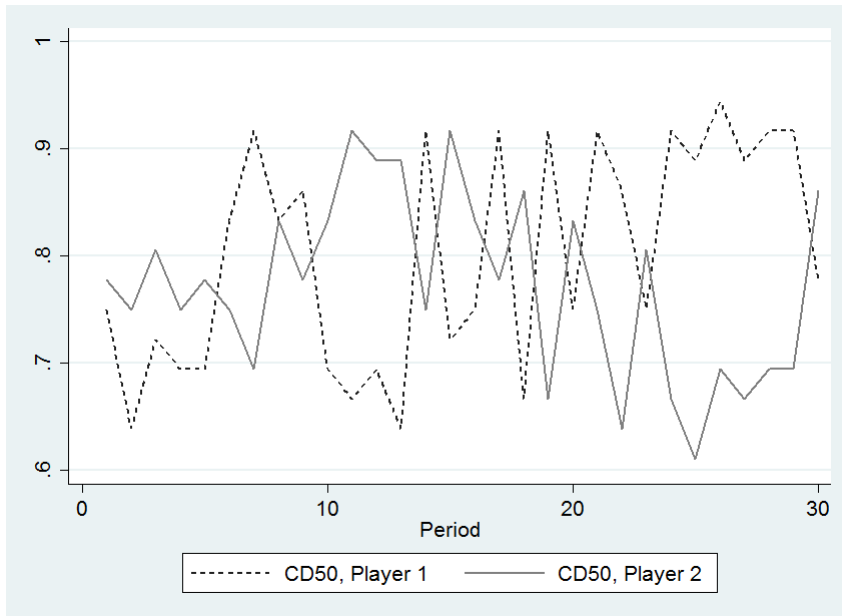
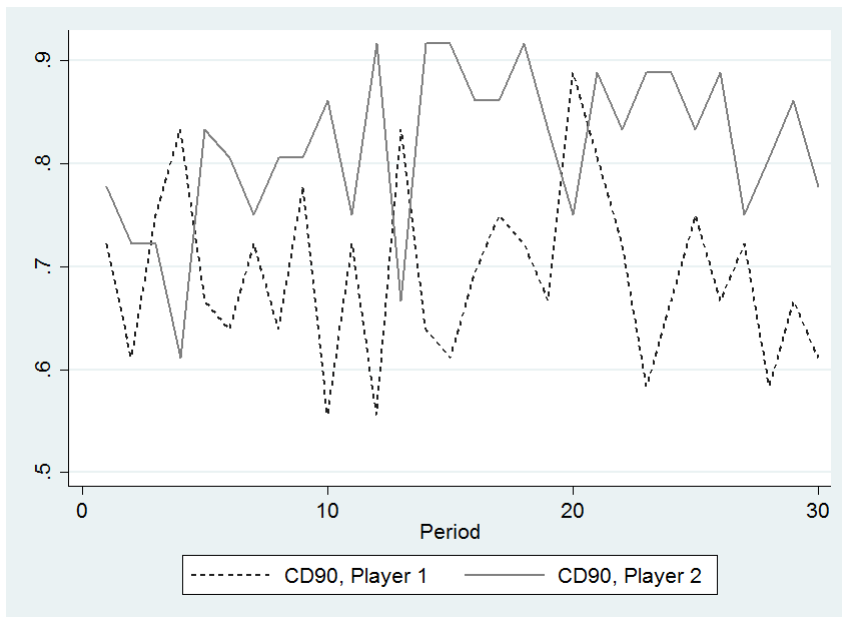


Fig. 10: Average rates of individuals who follow the recommendation over time in CD90, separately for Player 1 and Player 2



Translation of the Experimental Instructions for the *CD50* Treatment**General Instructions**

Welcome to this experiment! Please read the instructions carefully. They are identical for all participants. During the experiment, you and the other participants are asked to make decisions. All money you earn will be paid to you privately in cash at the end of the experiment. In addition, you will receive a show-up fee of 4 euros.

During the experiment, it is forbidden to talk with the other participants, to use mobile phones, or to start other programs at the computer. Please also turn off all electronic devices. If you do not follow these rules, you will be excluded from the experiment and all payments.

If you have a question, please raise your hand. An experimenter will then come and answer your question quietly. If the question is relevant for all participants, we will repeat it publicly and answer it.

Part I of the experiment

Roles and the number of rounds

In this part of the experiment, you will be asked to make a decision in each of 30 rounds, which will be described below. 24 people participate in today's experiment. Before the first round begins, all participants will be randomly divided for today's experiment into two equal-sized groups. One group is called the Red Participants, and the other is called the Blue Participants. The group you are in will stay the same throughout the experiment.

In each round, you will be randomly matched to a person in the other group. You have an equal chance of 1-to-12 of being matched to any particular person in the other group. You will never interact with participants belonging to the same group as you. You will not be told the identity of the person you are matched with, nor will that person be told your identity, even after the end of the session. All the decisions you make, and the other information you provide us, will remain confidential.

The structure of the experiment in each round

All rounds are identically structured. Both you and the person you are matched with have two choices available: *X* and *Y*. The choices that you and your matched participant make jointly determine your point earnings for the round. The following table shows how the amount of points depending on your and your matched participant's decisions is determined:

Payment table

		Blue Participant	
		<i>X</i>	<i>Y</i>
Red Participant	<i>X</i>	Red earns: 5 Blue earns: 5	Red earns: 5 Blue earns: 10
	<i>Y</i>	Red earns: 10 Blue earns: 5	Red earns: 0 Blue earns: 0

In each round, one of the four cells in the above table will be relevant to your point earnings.

If you are a Red Participant, your choice of *X* or *Y* will determine which row of the table the relevant cell belongs to. Your matched participant's choice of *X* or *Y* will determine the column.

If you are a Blue Participant, the situation is reversed: your choice of *X* or *Y* will determine which column of the table the relevant cell belongs to, and your matched Red Participant's choice of *X* or *Y* will determine which row the relevant cell belongs to.

In both cases, your choices, as well as the choices of the participant you are matched with, determine the relevant cell. The first number in the relevant cell represents the Red Participant's point earning for the round and the second number represents the Blue Participant's point earning for the round.

- If the Red Participant chooses X and the blue participant chooses Y , Red earns 5 points and Blue earns 10 points.
- If both participants choose X , both each receive 5 points.
- If both participants choose Y , both each receive 0 points.
- If the Red Participant chooses Y and the blue participant chooses X , Red earns 10 points and Blue earns 5 points.

Recommendations

Before you choose your action for each round, both you and the participant you are matched with will be given recommendations on the screen. In any round, there are two possible recommendations. Those are generated according to the following rules:

- There is a 50% chance (on average 5 out of 10 times) in each round that it will be recommended that the Red Participant choose X and the Blue Participant choose Y .
- There is a 50% chance (on average 5 out of 10 times) in each round that it will be recommended that the Red Participant choose Y and the Blue Participant choose X .

It will never happen that you are recommended to both choose X or both choose Y . These recommendations are optional; it is up to you whether or not to follow them. Notice that your recommendation also gives you information about the recommendation that was given to the person matched to you. The recommendations themselves have no direct effect on the points you can earn. The following table summarizes these recommendations and their likelihoods.

		Blue Participant	
		X	Y
Red Participant	X	never recommended Red earns=5, Blue earns=5	recommended with 50% probability (5 out of 10 times) Red earns=5, Blue earns=10
	Y	recommended with 50% probability (5 out of 10 times) Red earns=10, Blue earns=5	never recommended Red earns=0, Blue earns=0

Your decision

Each participant makes his or her decision without knowing the decision of the other participant. The following figure shows the example of a screen-shot where you enter your decision:

Periode

1 von 30

Verbleibende Zeit [sec]: 28

Sie sind der Teilnehmer.

Die Wahrscheinlichkeit, dass der Computer Ihnen X empfiehlt und dem anderen Teilnehmer Y, beträgt 50%.
 Die Wahrscheinlichkeit, dass der Computer Ihnen Y empfiehlt und dem anderen Teilnehmer X, beträgt 50%.

		Blauer Teilnehmer	
		X	Y
Roter Teilnehmer	X	Rot verdient: 5 Blau verdient: 5	Rot verdient: 5 Blau verdient: 10
	Y	Rot verdient: 10 Blau verdient: 5	Rot verdient: 0 Blau verdient: 0

Die Empfehlung lautet:

Bitte geben Sie Ihre Entscheidung ein:
 ☐ X
 ☐ Y

OK

You should make your decision within the proposed 30 seconds. The computer program gives you as much time as you need, even though this takes more than the 30 seconds. After that time, you will be shown the request “Please make your decision now”.

After all participants have made their decisions and clicked the red OK button, the next round will start immediately. You will not receive any information on the decision of the other participant or the point earnings. This information will be provided to you after the end of the experiment.

As a reminder: You will be re-matched with a participant in the other role before each round.

Earnings from part I of the experiment

After round 30, the computer program will randomly select two rounds. The total number of points you earn in these two rounds will be converted into cash at an exchange rate of 75 euro cents per point. The two rounds chosen for the payments hold for all the participants. You will be informed at the end of the experiment which two rounds were chosen for payment.

Part II of the experiment

The second part of the experiment is independent from the first part. Both the instructions and the exchange rate from points to euros for part II will be different from part I. All necessary information and the exchange rate will be shown on the computer screen after the end of the first part. If you have questions concerning part II, raise your hand. An experimenter will then come to your place to answer your questions quietly.

After part II of the experiment

After the second part of the experiment, the computer will show a questionnaire. After you have filled in the questionnaire completely, you will see a summary of all your decisions and the decisions of the participants you were matched with. It will also show you your earnings. The earnings are calculated from the points you received in both parts of the experiment and the respective exchange rates. Your cash payment is this amount plus the 4 euros show-up fee.

If you have any questions, please raise your hand now. If there are no further questions, the experiment will start with a short quiz at the computer. This quiz is solely conducted to test your understanding of these instructions and has no influence on your payment.

Screenshot of the Quiz in the Baseline Treatment (German)

Bevor das Experiment startet, nehmen Sie bitte an einem kurzen Quiz teil. Das Quiz ist nur dafür vorgesehen, Ihr Verständnis der schriftlichen Anleitung zu überprüfen und hat keine Auswirkungen auf Ihren Verdienst.

Richtig oder falsch: Ich bleibe in allen 30 Entscheidungsrunden ein roter oder blauer Teilnehmer. ☐ richtig
☐ falsch

Richtig oder falsch: Ich werde in allen 30 Runden mit dem selben Teilnehmer in der anderen Rolle zusammentreffen. ☐ richtig
☐ falsch

Richtig oder falsch: Ich kann die Wahl von X oder Y des anderen Teilnehmer sehen, bevor ich meine eigene Entscheidung über X oder Y treffe. ☐ richtig
☐ falsch

Nehmen Sie an, Sie seien der Rote Teilnehmer. Wenn Sie X wählen und der andere Teilnehmer Y, wie hoch ist Ihr Verdienst in Punkten?

Nehmen Sie an, Sie seien der Blaue Teilnehmer. Wenn Sie Y wählen und der andere Teilnehmer X, wie hoch ist Ihr Verdienst in Punkten?

Nehmen Sie an, dass Sie und der andere Teilnehmer X wählen. Wie viele Punkte bekommt jeder von Ihnen?

Nehmen Sie an, dass Sie und der andere Teilnehmer Y wählen. Wie viele Punkte verdient jeder von Ihnen?

Richtig oder falsch: Am Ende des Experiments bekomme ich meinen Verdienst von zwei zufällig ausgewählten Runden aus Teil I des Experiments zum Umtauschkurs von 0.75 Euro je Punkt ausbezahlt. ☐ richtig
☐ falsch

Screenshot of the Quiz in the *CD50* Treatment (German)

Bevor das Experiment startet, nehmen Sie bitte an einem kurzen Quiz teil. Dieses Quiz ist nur dafür vorgesehen, Ihr Verständnis der schriftlichen Anleitung zu überprüfen und hat keine Auswirkungen auf Ihren Verdienst.

Richtig oder falsch: Ich bleibe in allen 30 Entscheidungsrunden ein roter oder blauer Teilnehmer. ☐ richtig
☐ falsch

Richtig oder falsch: Ich werde in allen 30 Runden mit dem selben Teilnehmer in der anderen Rolle zusammentreffen. ☐ richtig
☐ falsch

Richtig oder falsch: Wenn der Vorschlag meines Computers X lautet, dann ist der Vorschlag des anderen Teilnehmers ebenfalls X. ☐ richtig
☐ falsch

Wie hoch ist die Wahrscheinlichkeit für einen Vorschlag von Y für Rote Teilnehmer? (Eingabe als Zahl ohne %-Zeichen).

Wie hoch ist die Wahrscheinlichkeit für einen Vorschlag von X für Rote Teilnehmer? (Eingabe als Zahl ohne %-Zeichen).

Von 10 Vorschlägen, wie oft sieht ein Roter Teilnehmer durchschnittlich den Vorschlag X?

Von 10 Vorschlägen, wie oft sieht ein Roter Teilnehmer durchschnittlich die Ankündigung Y?

Wie hoch ist die Wahrscheinlichkeit für einen Vorschlag von Y für Blaue Teilnehmer? (Eingabe als Zahl ohne %-Zeichen).

Wie hoch ist die Wahrscheinlichkeit für einen Vorschlag von X für Blaue Teilnehmer? (Eingabe als Zahl ohne %-Zeichen).

Von 10 Vorschlägen, wie oft sieht ein Blauer Teilnehmer durchschnittlich den Vorschlag X?

Von 10 Vorschlägen, wie oft sieht ein Blauer Teilnehmer durchschnittlich den Vorschlag Y?

Richtig oder falsch: Ich kann die Wahl von X oder Y des anderen Teilnehmer sehen, bevor ich meine eigene Entscheidung über X oder Y treffe. ☐ richtig
☐ falsch

Nehmen Sie an, Sie seien der Rote Teilnehmer. Wenn Sie X wählen und der andere Teilnehmer Y, wie hoch ist Ihr Verdienst in Punkten?

Nehmen Sie an, Sie seien der Blaue Teilnehmer. Wenn Sie Y wählen und der andere Teilnehmer X, wie hoch ist Ihr Verdienst in Punkten?

Nehmen Sie an, dass Sie und der andere Teilnehmer X wählen. Wie viele Punkte bekommt jeder von Ihnen?

Nehmen Sie an, dass Sie und der andere Teilnehmer Y wählen. Wie viele Punkte verdient jeder von Ihnen?

Richtig oder falsch: Am Ende des Experiments bekomme ich meinen Verdienst von zwei zufällig ausgewählten Runden aus Teil I des Experiments zum Umtauschkurs von 0.75 Euro je Punkt ausbezahlt. ☐ richtig
☐ falsch

OK

Screenshot of the Quiz in the *CD90* Treatment (German)

Bevor das Experiment startet, nehmen Sie bitte an einem kurzen Quiz teil. Dieses Quiz ist nur dafür vorgesehen, Ihr Verständnis der schriftlichen Anleitung zu überprüfen und hat keine Auswirkungen auf Ihren Verdienst.

Richtig oder falsch: Ich bleibe in allen 30 Entscheidungsrunden ein roter oder blauer Teilnehmer. ☐ richtig
☐ falsch

Richtig oder falsch: Ich werde in allen 30 Runden mit dem selben Teilnehmer in der anderen Rolle zusammentreffen. ☐ richtig
☐ falsch

Richtig oder falsch: Wenn der Vorschlag meines Computers X lautet, dann ist der Vorschlag des anderen Teilnehmers ebenfalls X. ☐ richtig
☐ falsch

Wie hoch ist die Wahrscheinlichkeit für einen Vorschlag von Y für Rote Teilnehmer? (Eingabe als Zahl ohne %-Zeichen).

Wie hoch ist die Wahrscheinlichkeit für einen Vorschlag von X für Rote Teilnehmer? (Eingabe als Zahl ohne %-Zeichen).

Von 10 Vorschlägen, wie oft sieht ein Roter Teilnehmer durchschnittlich den Vorschlag X?

Von 10 Vorschlägen, wie oft sieht ein Roter Teilnehmer durchschnittlich den Vorschlag Y?

Wie hoch ist die Wahrscheinlichkeit für einen Vorschlag von Y für Blaue Teilnehmer? (Eingabe als Zahl ohne %-Zeichen).

Wie hoch ist die Wahrscheinlichkeit für einen Vorschlag von X für Blaue Teilnehmer? (Eingabe als Zahl ohne %-Zeichen).

Von 10 Vorschlägen, wie oft sieht ein Blauer Teilnehmer durchschnittlich den Vorschlag X?

Von 10 Vorschlägen, wie oft sieht ein Blauer Teilnehmer durchschnittlich den Vorschlag Y?

Richtig oder falsch: Ich kann die Wahl von X oder Y des anderen Teilnehmer sehen, bevor ich meine eigene Entscheidung über X oder Y treffe. ☐ richtig
☐ falsch

Nehmen Sie an, Sie seien der Rote Teilnehmer. Wenn Sie X wählen und der andere Teilnehmer Y, wie hoch ist Ihr Verdienst in Punkten?

Nehmen Sie an, Sie seien der Blaue Teilnehmer. Wenn Sie Y wählen und der andere Teilnehmer X, wie hoch ist Ihr Verdienst in Punkten?

Nehmen Sie an, dass Sie und der andere Teilnehmer X wählen. Wie viele Punkte bekommt jeder von ihnen?

Nehmen Sie an, dass Sie und der andere Teilnehmer Y wählen. Wie viele Punkte verdient jeder von ihnen?

Richtig oder falsch: Am Ende des Experiments bekomme ich meinen Verdienst von zwei zufällig ausgewählten Runden aus Teil I des Experiments zum Umtauschkurs von 0.75 Euro je Punkt ausbezahlt. ☐ richtig
☐ falsch

OK