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INSTITUTIONAL CHOICE VS COMMUNICATION IN SOCIAL DILEMMAS – AN EXPERIMENTAL APPROACH

Abstract

This paper presents an experimental study that compares the ability of human groups to escape the tragedy of the commons through institutional change or communication. Teams of five players are placed in a dynamic CPR environment with inefficient institutional settings. The results clearly show the vital importance of communication. At the same time, the groups who were allowed to replace the inefficient institutional settings by other more appropriate rules performed worse than those groups who were not given this opportunity.

Key-words: social dilemmas, laboratory experiment, group behavior, institutional choice, communication

JEL: C92, D71, D62, Q20

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1. Introduction

Since Hardin (1968)'s tragedy of the commons, social dilemmas have been on the research agenda of social science. Human societies face social dilemma situations in many fields of their economic life. At the same time, they have proven to be very creative in finding ways to resolve these dilemma situations (e.g., Ostrom 1990, Heltberg 2002). Following Messick and Brewer (1983), they apply two general categories of solutions. First, the individuals can communicate and convince each other to cooperate while leaving the formal institutions for their interaction unchanged. Alternatively, they can change precisely these institutions in order to alter the individual incentives in a way that makes cooperative behavior individually rational. The applicability and effectiveness of these two options has been analysed in a large number of laboratory experiments. Depending on the options the players have in the experiment, two types of experiments can be identified. The vast majority of experiments belongs to the first type, permitting the individual player to choose between different actions within a given set of rules. The primary objective of these single-choice experiments is to find out to what extent individuals cooperate in social dilemma situations and what factors determine the degree of cooperation. Communication is found to increase the level of cooperation substantially (e.g., Isaac et al. 1984, Isaac et al. 1994, Ostrom et al. 1992). In the second group of experiments (hereafter double-choice experiments), individual players can choose between different actions. Additionally, the group of players as a whole can change the institutional restrictions on the individual choice of action (e.g., Samuelson and Messick 1986, Carpenter 2000). Though the number of double-choice experiments is still small, their results indicate that the participants are able to escape the tragedy of the commons by changing the institutional framework if they are given this opportunity. With respect to their set-up, the existing double-choice experiments differ substantially from the single-choice experiments found in the literature. Therefore it is impossible to compare the relative effectiveness of communication and institutional change as a means to resolve social dilemma situations. The current paper presents a first series of experiments that is designed to facilitate this comparison. The paper is organized as follows. Section 2 gives a short overview on previous experiments on human behaviour in social dilemma situations. Section 3 outlines the set-up of the experimental study presented in this paper, while section 4 lays out the predictive theory. The results of the experiments are presented in section 5 and discussed in section 6.

2. Previous experiments on human behavior in social dilemma situations

Social dilemma situations appear when a number of individuals have free access to a scarce common pool resource (CPR) or when they have to provide a public good on basis of voluntary contributions (e.g., Olson 1965, Ostrom 1990). The number of single-choice experiments on human behavior in social dilemma situations is large. They differ in some major characteristics of their set-up, such as group size, form and level of payoffs or the extent to which players are allowed to communicate. Most of them are so-called public good games, in which a group of individuals are given the task to provide a public good on the basis of voluntary contributions (e.g., Marwell and Ames 1979, Isaac et al. 1984, Isaac et al.1994, Palfrey and Prisbrey 1997). In addition, some CPR-experiments are reported. These assemble a number of players around a CPR, which they have to cultivate (e.g., Gardner et al. 1987, Ostrom et al. 1992, Walker et al. 2000). Regardless of their actual set-up, all single-choice experiments report an average degree of cooperation that is below the group-efficient degree but substantially above the one predicted by economic theory (e.g., Isaac et al. 1984, Ostrom et al. 1992, Palfrey and Prisbrey 1997, Walker et al. 2000). Face-to-face communication increases the degree of communication (e.g., Ostrom et al. 1992, Weimann 1994) because it allows the players to signal their willingness to cooperate (e.g., Brosig 2002) and use moral suasion and threats to induce cooperative behaviour among their co-players (Fehr and Gächter 2000).[1]

The author found only three double-choice experiments that were performed by Samuelson et al., (1984) respectively Samuelson and Messick (1986), Sato (1987) and Carpenter (2000). These experiments place a group of players in a CPR environment and let them play a number of rounds under a fixed set of rules. Thereby the players are given the chance to learn about the basic mechanisms of the game and try to resolve the social dilemma without restricting the access to the CPR. The players do not know who their co-players are and are not allowed to communicate before or during the experiment.[2] Consequently, they cannot signal a possible predisposition to cooperate, nor can they apply moral suasion or threats to induce cooperative behavior. As a result, the overall payoffs are far from efficient. In the second part of the experiment, some groups are given the opportunity, to change the rules of the game and play a number of further rounds. The institutions are enforced at zero costs. These groups made use of the new opportunity and as a result their payoffs increase considerably to reach a near efficient level. The control groups who played the second part of the experiment under the initial inefficient set of institutions continued to perform poorly.

In sum, the single- and double-choice experiments show that communication respectively institutional change helps groups to resolve social dilemma situations to an extent that they cannot reach without these possibilities. However, the existing single-choice experiments do not permit institutional change while the double-choice experiments performed so far do not allow communication. At the same time, the two

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[1] The chance to impose sanctions on defecting players has similar effects (e.g., Chen and Plott 1996, Fehr and Gächter 2000)

[2] In the experiments by Samuelson et al. (1984), the subjects are told that they are part of a group of six individuals. In reality, however, they do not play in groups; every individual participates in an isolated experiment in which the other members of the groups are simulated. In every round, the human player receives false feedback on the behavior of his co-players.

types of experiments are fundamentally different in their set-up. Therefore, it is difficult to compare communication and institutional with respect to their relative efficiency as a means to overcome social dilemma situations. The following section presents an experimental set-up which is especially designed to facilitate this comparison.

3. Experimental set-up

3.1 Rules

As in the experiment by Sato (1987), the experimental set-up is explained by using a real-life background that may cause framing effects that, in turn, lead to a higher degree of cooperation as compared to a game without real-life background (e.g., Zelmer 2003). As all groups are presented the same real-life background, it cannot explain differences in the performance of experimental and control group, on which this paper focuses. The main purpose of introducing a real-life background is to allow those groups who are allowed to communicate to exploit fully the advantage of communication. It allows the group to refer to real-life categories rather than abstract entities in their discussions. The following real-life background is presented: Five families live off the fish they catch in a nearby lake and sell at the local market. For all families, fishing is the only source of income. Every family consists of three generations. Only the second generation engages in fishing and makes all the necessary decisions. After a certain time, this formerly active generation retires and hands over the right to fish to the next generation. Provided that the lake is not depleted, the young generation will grant the retired generation a pension. Since the fish does not exist in abundance and reproduces only at a limited rate, a permanent flow of fish can only be guaranteed if each family catches less fish per period than it theoretically could. The families can organize the necessary fishing restriction by setting a quota of fish every family is allowed to catch. In order to enforce this quota, they can hire an independent patrolling service. The higher the patrolling intensity, the higher the patrolling costs each family has to incur.

The experiment is played by five players, each representing the active generation of one family. The aim of every player is to maximize his total income during the experiment. It consists of the money he can earn when selling his fish on the market (1 $ per fish) minus the patrolling costs plus the pension. The fishing will take seven rounds in total. Every player can catch as much as 2 000 fish per round. Initially, the lake contains 10 000 fish. At the beginning of every round, the teams have the possibility to install a quota that settles the number of fish that each player is allowed to fish in the current round. If three players agree on this quota, it is passed and violations will be punished, provided that the defecting players are caught. Before the fishing starts, the players can change the patrolling rule that sets the probability P of catching a player who tries to defect. Six different levels of patrolling can be chosen (see Table 1). The rule is changed if three players vote in favor of the new rule; otherwise the old rule remains active. Initially, the rule is set to rule 2.

Next, each player decides independently on the number of fish he intends to catch. His fishing plans can be in accordance with the quota or deviate from it. Once all players have made their decision they declare their fishing plans to the organizer of the game. The players do not know each others' fishing plans. If a player defects, his fishing success depends on whether he is caught or not. For each attempt to defect, a random number processor is used to determine whether it is successful or not. If a player gets caught, he will receive no fish and his attempt to defect will be publicly announced. Otherwise his fishing plans are not reduced and his defection is not made public.

Table 1: Patrolling rules, costs and probability of catching a defecting player

Patrolling rule	Patrolling costs (C) per player and round	Probability P (patrolling intensity)
1	0	0.00
2	50	0.25
3	150	0.50
4	250	0.67
5	450	0.85
6	700	0.95

The total demand for fish consists of the sum of fishing plans of the cooperative players plus the fishing plans of those defecting players who were successful in their attempts to defect. If the total demand for fish is smaller or equal to the contents of the lake, every player (except for those who are caught defecting) will get the demanded number of fish. If the total demand exceeds the number of fish in the lake, all fish will be distributed among these players proportionally to their demand. The final amount of fish left in the lake is announced. If the lake contains less than 500 fish, there will be no further fishing and thus the experiment ends here. Otherwise, the remaining number of fish is doubled to give the starting point of the next round. However, the number of fish cannot exceed 10 000. The fishing ends at the latest after seven rounds.

In the eighth round, the players retire and are granted a pension. Every player will receive a single payment amounting to one quarter of the remaining number of fish in the beginning of round 8, at most $ 2 000. In round 8, the players do not have to incur any patrolling costs. The experiment ends here. The organizer informs every player separately about his total income during the experiment. For every $ 1 000, a player is paid 1 Euro in cash.[3]

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[3] This "exchange rate" ensures that the average payoff amounts to the average wage a student can expect when spending the same amount of time on a students' job. In addition, a player

3.2 Participants

Six teams of players (MAJC-teams) played the experiments precisely according to the rules laid out in section 3.1 without any restrictions on communication. Another six teams (MAJnoC-teams) followed the same rules but were not allowed to communicate verbally or non-verbally throughout the experiment. The remaining 20 teams were neither allowed to nor informed about the possibility to change the patrolling intensity. Eight teams (FIX25C teams) played under the fixed rule 2 (P = 25 percent; C = $ 50) and were allowed to communicate freely.[4] Six FIX25noC teams faced the fixed rule 2 but were not allowed to communicate. Figure 1 gives a systematic overview of these for major groups. Hereafter, the teams in row 1 are called MAJ teams while those in row 2 are called FIX25 teams. An additional set of six experiments was performed where patrolling intensity was set to P = 10 percent at costs of C = $ 10 per round (FIX10) while communication was permitted.

Figure 1: Major groups by set-up

	Institutional change	
Communication	permitted	prohibited
permitted	MAJC	FIX25C
prohibited	MAJnoC	FIX25noC

The experiments were performed at the University of Giessen, Germany, between October 2000 and November 2004 and involved 56 female and 104 male students majoring in economics who participated on a voluntary basis.

4. Predictive theories

This section will develop predictions concerning the behavior of the groups of students in the experiment described above. Section 4.1 applies game-theoretic rea-

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who defects doubles his monetary reward earned in the corresponding round from one to two Euro. Thereby both average and marginal incentives are high enough to comply with the suggestions by Davis and Holt (1993, 24-26).

[4] The surprisingly high degree of cooperation observed in the first six FIX25C experiments led the author to perform two extra experiments.

soning to predict the individual as well as group behavior in the different set-ups. In section 4.2, these predictions are then discussed and modified or complemented by taking into account evidence from earlier experimental studies.

4.1 Game theoretic predictions

4.1.1 Quota-setting behavior

The efficient fishing strategy for the group as a whole is to extract 5 000 fish in the first six rounds and 6 000 fish in the seventh round. This leaves 8 000 fish in the lake at the beginning of round 8 and therefore ensures the maximum pension of $ 2 000 for each player. The maximum total group earning is thus $ 46 000, which equals $ 9 200 per player. Every deviation from the described strategy will reduce the total group return. If undiscovered defection leads to over-fishing, the CPR can only recover if the quota is reduced in the next round. The optimal quota Q*, that is the quota that maximizes the total possible yield, is given by the following expression:

$$Q_t^* = \max\{0; 0.2(F_t - R_t)\} \quad (1)$$

where F_t = number of fish in the lake in the beginning of round t

$R_t = 5\,000$ for $t = 1 \ldots 6$; $R_t = 4\,000$ for $t = 7$.

Assuming rational players, the teams can be expected to follow this method of quota-setting.

4.1.2 Rule-setting behavior, defection and group payoff

After the quota has been set, each player has to decide whether to comply with it or to try to extract more fish. The probability for a defecting player to be caught does not depend on the number of fish he wants to catch in addition to the quota. Hence:

Prediction 1: Defecting players will try to extract the maximum possible number of 2 000 fish.

Table 2: Simulated payoffs for different patrolling rules and levels of defection

Patrolling rule / player 1's strategy	Individual payoff of player 1 for … defecting co-players (payoff calculated using a discount rate of 0.1 per round)				
	0	1	2	3	4
1 / cooperate	9 200 (6 386)	5 731 (4 527)	2 240 (2 094)	1 571 (1 514)	1 222 (1 200)
1 / defect	15 268 (11 108)	5 400 (4 934)	3 333 (3 200)	2 500 (2 450)	2 000 (2 000)
2 / cooperate	8 850 (6 125)	6 698 (4 780)	3 352 (2 820)	2 140 (1 952)	1 789 (1 673)
2 / defect	11 682 (8 383)	7 071 (5 684)	4 029 (3 596)	3 104 (2 869)	2 514 (2 384)
3 / cooperate	8 150 (5 604)	6 245 (4 326)	5 475 (3 964)	3 813 (2 928)	3 574 (2 833)
3 / defect	7 662 (5 341)	6 856 (4 894)	5 175 (3 909)	4 302 (3 358)	3 522 (2 861)
4 / cooperate	7 450 (5 082)	5 917 (4 037)	6 376 (4 396)	5 487 (3 820)	5 779 (4 065)
4 / defect	4 750 (3 147)	4 691 (3 115)	4 384 (2 941)	4 169 (2 816)	3 966 (2 714)
5 / cooperate	6 050 (4 039)	5 196 (3 451)	5 867 (3 917)	5 653 (3 768)	5 936 (3 963)
5 / defect	858 (227)	922 (268)	892 (242)	936 (277)	976 (299)
6 / cooperate	4 300 (2 734)	3 985 (2 517)	4 279 (2 720)	4 255 (2 704)	4 297 (2 732)
6 / defect	-2 230 (-2 088)	-2 190 (-2 062)	-2 205 (-2 069)	-2 208 (-2 074)	-2 197 (-2 065)

Under the initial rule, the probability of getting caught when defecting is 0.25. Thus any player can increase his expected short-term payoff by defecting. Due to the stochastic nature of the game, the expected long-term payoff from defection cannot be calculated exactly. Table 2 contains estimates for the payoffs from cooperation and defection that an individual player can expect for different patrolling intensities and co-players' behavior. These estimates represent the average payoffs of 10 000 simulated experiments per constellation. Teams are assumed to set their quota efficiently. Two different estimates are presented. While the first figure represents the sum of all payoffs throughout the experiment, the payoffs in parenthesis are discounted using the rate of 0.1 per round. Discounting accounts for the fact that, given the danger of resource extinction, the payoffs become increasingly uncertain the later in the experiment they are expected to occur. The discount factor thus represents the rate of time preference due to uncertainty. The simulated payoffs in Table 2 show that for rule 2, defection represents the strictly dominant strategy. Hence rational players can be expected to defect under the initially installed patrolling intensity. At the same time, the simulation results clearly show that collective defection reduces the expected payoff by 71.6 percent from $ 8 850 to $ 2 513 per capita. This patrolling intensity is insufficient to ensure efficient payoffs and preserve the CPR. This is true all the more for the patrolling intensity of P = 0.1 set for the FIX10C teams. In their case, the surveillance can merely be called symbolic.

MAJ teams can destroy the incentives to defect by increasing the patrolling intensity. Rule of thumb calculations indicate that, under rule 3 (P = 0.5), a risk-neutral player cannot expect any short-term gains from defection as the expected payoff is equal to the certain payoff in the case of cooperation. Among risk-averse players, rule 3 is sufficient to induce cooperative behaviour, yet the structure of payoffs in table 2 indicates that any cooperative equilibrium under rule 3 remains fragile. Especially when assuming a positive rate of time preference, any rational player is better off if he defects as soon as he expects one or more of his co-players to defect. Merely the patrolling intensity of rules 4 to 6 is sufficient to destroy all short- and long-term incentives to defect. Among these three rules, rule 4 induces a stable cooperative equilibrium at the lowest patrolling costs. The corresponding payoff of $ 7 450 per player represents a benchmark for MAJ teams.

Prediction 2: At minimum, MAJ teams will achieve a net return of $ 7 450 per player, which equals a group payoff of $ 37 250.

For those teams who are allowed to communicate, threats are an alternative instrument to induce cooperation. First, they can threaten to set an inefficiently high quota for the rounds following defection. However, any higher quota will surely further reduce the expected income of both defecting and cooperative players. Therefore the corresponding threat lacks credibility. Second, the other players can threaten to react by changing from cooperative behavior to defection. The CPR will be depleted very quickly, destroying the prospect of future fishing income as well as the pension. As long as the cooperative players see a chance for the CPR to recover, a change from cooperation to defection is irrational. The corresponding threat is thus not credible either. Consequently, FIX teams do not have any effective instruments to destroy the incentives to defect. Hence,

Prediction 3: FIX teams will witness a higher frequency of defection than MAJ teams.

Prediction 4: FIX teams will not be able to preserve the CPR from extinction.

Other than FIX25C and FIX10C teams, MAJC teams can apply an additional third type of threat to induce cooperative behavior. They may threaten to vote for a higher patrolling intensity if one or more player defect. As the costs of this reaction are moderate and the benefits are substantial, players can credibly threaten to install a high patrolling rule once defectious behavior occurs. However, backward induction shows that this threat is not sufficient to destroy the incentives to defect.[5] Thus patrolling has to be installed in round 1.

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[5] See Appendix for a detailed description of the underlying course of argumentation.

Prediction 5: MAJ teams will introduce patrolling rule 3 or higher in round 1.

4.2 Evidence from earlier experiments

Game-theoretic reasoning systematically underestimates the level of voluntary cooperation in social dilemma games. This is especially true in those cases where players are allowed to communicate (e.g., Ostrom et al. 1992, Weimann 1994). This leads to prediction 6.

Prediction 6: FIX25C teams will have higher payoffs than FIX25noC teams.

For the relative performance of MAJC and MAJnoC teams, the conclusions are less straight forward. Given the right to communicate, MAJC teams have to rely less heavily on patrolling to ensure cooperation. Thus,

Prediction 7: MAJnoC will set a higher patrolling intensity than MAJC teams.

The resulting difference in patrolling costs may result in a minor difference in payoffs but are not large enough to expect such differences to be significant.

Previous single choice experiments have shown a termination effect, that is a substantial though not full deterioration of cooperative behavior in the last round (e.g., Weimann 1994, Ledyard 1995). This leads to prediction 8:

Prediction 8: FIX teams will witness an increase in defection in the last round.

Consequently, the CPR is in danger of extinction, giving support to prediction 4.

Finally, all experimental studies report a very wide dispersion of group behavior. In single choice experiments, some groups are found to cooperate in the vast majority of cases, while others show extensive defection (e.g., Isaac et al. 1984, Isaac et al. 1994, Gardner et al. 1997). As these teams are placed in an identical environment with identical incentives, the different degrees of cooperation observed must be caused by differences in group characteristics such as the players' attitude towards risk or their preference for fairness (e.g., Boone et al. 1999). While some teams are able to reach a cooperative solution under the given set of rules, the same rules prove inappropriate for other teams. In single-choice experiments, all teams are forced to play under the same set of rules. Those teams who find these inappropriate to reach a cooperative solution will perform poorly because they do not have a suitable instrument at hand to resolve the social dilemma. MAJ teams are given a suitable instrument as they are allowed to change the rules if this proves necessary. As a result, their average economic performance can be expected to be higher than that of FIX-teams who do not have the opportunity to change the institutions (e.g., Sato 1987, Carpenter 2000). These considerations lead to final prediction 9[6]:

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[6] This prediction is also backed by theoretical considerations following an evolutionary approach (e.g., Sethi and Samanathan 1996).

Prediction 9: MAJ teams will reach systematically higher average payoffs than FIX teams.

5. Results

5.1 Quota-setting behavior

In those experiments where communication was allowed, all teams passed quotas in all rounds. In 89.8 percent, the quota was passed unanimously. All teams set the efficient quota of 1 000 fish per capita in round 1, thereby clearly indicating that they identified the group-efficient fishing strategy. As indicated in table 3, the quota setting-behavior in the following rounds equalled the one proposed in section 4.1 in the vast majority of cases. In total, 86.6 percent of all quotas were set efficiently, indicating that the teams were able to identify the group-efficient fishing strategy. Those teams that were not allowed to communicate were substantially less efficient and unified when setting the quota. In 16.9 percent of the rounds, they did not manage to agree on a binding quota, and only once was a quota passed unanimously. Only 58.4 percent of the quotas set in round 1 were efficient. In the following rounds, this share dropped to less than 40 percent.

Table 3: Quota-setting behavior

Set-up	Share of rounds with binding quota [percent]	Share of unanimous quotas [percent]	Share of quotas set efficiently in round __ [percent]		
			1	2 – 6	7
MAJC	100	80	100	71	80
MAJnoC	88.6	2.9	66.7	10.3	25
FIX25C	100	92.9	100	95	75
FIX25noC	78.6	0	50	16.7	33.3
FIX10	100	95.1	100	96.7	40

5.2 Rule-setting behavior and defection

After setting a quota, MAJ teams have to decide about the patrolling intensity. In the beginning of the game, three of these teams abolished patrolling completely, six left the rule unchanged and only three teams introduced rule 3 (see Table 4).

Table 4: Patrolling rule and intensity in MAJ groups

Group	Patrolling rule in round							Average patrolling intensity*
	1	2	3	4	5	6	7	
MAJC_1	1	1	1	1	1	1	1	0.00
MAJC_2	3	3	3	3	3	3	3	0.50
MAJC_3	2	3	3	2	2			0.35
MAJC_4	2	3	3	1	1	3	3	0.32
MAJC_5	1	2	3	3	2	3	2	0.32
MAJC_6	1	1	1	1	1	1	1	0.00
Average patrolling intensity	0.17	0.29	0.33	0.21	0.17	0.30	0.25	0.25
MAJnoC_1	2	2	2	2	1	2	2	0.25
MAJnoC_2	3	3	3	2	4			0.54
MAJnoC_3	2	1	2	3	3	3	3	0.42
MAJnoC_4	2	3	3	3	2	3	3	0.42
MAJnoC_5	2	1	3	3	3	2	1	0.33
MAJnoC_6	2	3	2	1				0.25
Average patrolling intensity*	0.29	0.29	0.38	0.33	0.38	0.38	0.31	0.37

* Calculated only from those rounds in which a binding quota was passed.

Prediction 5, according to which MAJ teams will set rule 3 or stricter in round 1, is clearly rejected (binomial test for a probability of setting rule 3 or higher of 0.95, $\alpha = 0.05$). All 12 MAJ teams made use of this right at least once during the experiment. Three teams changed the patrolling rules in the first round and stuck to the newly introduced rule throughout the entire experiment. Two of these teams chose rule 1; one team chose rule 3. The other teams changed the rule more frequently, at most 5 times. The strictest patrolling rule implemented was rule 4. The average patrolling intensity throughout the entire game – measured by the probability of discovering defection – was 0.25 for MAJC and 0.37 for MAJnoC teams.[7] The difference in patrolling intensity is not significant (t-test, $\alpha = 0.1$) in a simple comparison but proves significant when controlling for pre-game contact (see section 5.4) in a two-way ANOVA (Student-Newman-Keuls-Test, $\alpha = 0.05$), thus giving support to prediction 7. In both set-ups the lowest average rule per round was observed in round 1. Tracing the rule-changing behavior beyond the first round reveals no systematic pattern for MAJC teams ($r_{SP} = 0.07$, conservative testing, $\alpha = 0.05$) or MAJnoC teams ($r_{SP} = 0.357$, conservative testing, $\alpha = 0.05$).

The average number of defections per round differs between the teams with a minimum value of 0.64 for FIX25C teams and a maximum of 1.52 for FIX25noC

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[7] This average is calculated for those rounds where a binding quota was passed.

teams (see Table 5). Pairwise comparisons of the average number of defections across set-ups reveal a significant difference between FIX25C and FIX25noC teams (t-test, α = 0.05), thus giving support to prediction 6. In order to account for the permission to change rules and communication at the same time, a two-way ANOVA is performed but reveals no significant effect of either of these two factors on the average number of defections. Thus prediction 3, according to which the FIX25 teams are expected to witness a higher defection rate than MAJ teams, is rejected. When tracing defection across rounds, no termination effect was observed in FIX teams. Prediction 8 is rejected (Fisher-Yates test, α = 0.05). In 44.8 percent of all attempts to defect (57.6 percent in the MAJC, 25.8 percent in the MAJnoC, 33.3 percent in the FIX25C, 18.2 percent in the FIX25noC and 40.6 percent in the FIX10C set-up), players planned to extract less than the maximum possible amount of 2 000 fish. Prediction 1 is clearly rejected (binomial test for a probability of choosing 2000 fish of 0.95, α = 0.05).

Table 5: Group characteristics and group performance

group	average patrolling intensity*	net group payoff	defec-tions per round	changes in rule	distinction after round	group pension	average number of se-mester	average number of visits	female players
MAJC_1	0	44 800	0.14	1		8 000	7	3.4	0
MAJC_2	0.5	40 750	0	1		10 000	5.4	2.8	2
MAJC_3	0.35	21 548	1.8	2	5	0	7.2	2.4	2
MAJC_4	0.32	27 900	2	4		2 400	1	2.6	1
MAJC_5	0.32	27 350	1.29	5		5 250	4.2	2	1
MAJC_6	0	46 000	0	1		10 000	11.2	0.8	2
Average	0.25	34 724.67	0.83	2.33		5 941.67	6.00	2.33	1.33
MAJnoC_1	0.25	38 930	0.6	0		10 000	6.8	0.6	1
MAJnoC_2	0.54	19 800	2	2	5	0	5.4	1.2	3
MAJnoC_3	0.42	21 050	0.5	3	7	0	3	2.6	3
MAJnoC_4	0.42	12 972.5	1	3		2 537.5	3	3.4	4
MAJnoC_5	0.33	19 050	1	3	7	0	5..2	3	2
MAJnoC_6	0.25	17 265	2	3	4	0	6.6	1	3
Average	0.37	21 511.25	1.06	2.33		2 089.58	4.96	1.97	2.67
FIX25C_1	0.25	34 650	1.29			10 000	9.4	2	0
FIX25C_2	0.25	44 250	0			10 000	2	2.8	1
FIX25C_3	0.25	40 030	2.43			6 000	7.4	1	2
FIX25C_4	0.25	43 250	0.14			10 000	7.6	2	0
FIX25C_5	0.25	42 650	0.29			10 000	10.4	0.2	3
FIX25C_6	0.25	42 150	0.29			10 000	7	3.2	0
FIX25C_7	0.25	40 090	0.71			7 900	7.6	0	1
FIX25C_8	0.25	43 250	0			10 000	1	2.4	2
Average	0.25	41 903.33	0.64			8 983.33	6.83	1.47	1.33
FIX25noC_1	0.25	18 150	1.43			1 250	3	2	2
FIX25noC_2	0.25	34 025	0.5			8 125	5	1.8	4
FIX25noC_3	0.25	26 625	1.83			3 375	5	0.4	4
FIX25noC_4	0.25	30 400	2.83			4 500	9	3.8	0
FIX25noC_5	0.25	28 931	1.5			3 230	3	3.2	0
FIX25noC_6	0.25	38 275	0.75			7 625	3	0.8	4
Average	0.25	31 057.75	1.52			4 682.5	5	2.05	2
FIX10C_1	0.1	40 550	0.86			9 000	8.8	1.6	2
FIX10C_2	0.1	32 830	1.57		7	0	4	0.2	1
FIX10C_3	0.1	30 500	1.17		6	0	8.8	2	0
FIX10C_4	0.1	40 640	0.43			4 000	9	0.4	3
FIX10C_5	0.1	42 460	0.57			10 000	10.2	0.6	3
FIX10C_6	0.1	45 200	0.14			10 000	9	2	0
Average	0.10	38 696.67	0.78			5 500	8.3	1.13	1.5

* Calculated only from those rounds in which a binding quota was passed.

5.3 Economic performance

MAJC teams achieved net payoffs ranging from \$ 21 548 to the maximum possible yield of \$ 46 000, with an average of \$ 34 725. MAJnoC teams performed worse on average (\$ 21 511), with payoffs ranging between \$ 12 973 and \$ 38 930. Three MAJC and five MAJnoC teams ended up with a group payoff that was below the one they could have expected when setting rule 4 (\$ 37 250). Prediction 2 is clearly rejected for both MAJC and MAJnoC teams (binomial test for a probability of reaching this minimum payoff of 0.95, α = 0.05). FIX25C teams reached payoffs between \$ 34 650 and \$ 44 250 and performed best on average (\$ 41 290), while FIX25noC and FIX10C teams received group payoffs in the medium range (\$ 31 057, respectively \$ 38 697). The net payoff of FIX25C teams is significantly larger than for MAJC teams (t-test, α = 0.1), for MAJnoC (Mann-Whitney-U-Test, α = 0.01), and for FIX25noC teams (t-test, α = 0.01) Prediction 6 is clearly supported. In addition, MAJC performed significantly better than MAJnoC teams (t-test, α = 0.05). Finally, FIX10C teams reached higher group payoffs than MAJnoC teams (t-test, α = 0.01) and FIX25noC teams (t-test, α = 0.05). To facilitate a direct comparison of communication versus institutional change as measures to escape the tragedy of the commons, a two-way ANOVA using FIX25 and MAJ teams is performed. It shows a significantly positive impact of communication on group payoff (F-Test, α = 0.01). At the same time, FIX25 teams are found to have reached a significantly higher group payoff than MAJ teams (F-Test, α = 0.01). Prediction 9, suggesting that MAJ teams will be economically more successful than FIX teams, is clearly rejected.

Apart from the group payoff, the ability to preserve the CPR from extinction can be taken as an alternative measure of economic success. Except for one MAJC, four MAJnoC, and two FIX10C teams, all teams managed to keep the pool of fish from extinction. The average pension for these groups remained below \$ 6 000. On the other hand, six out of eight FIX25C teams reached the full pension. The pensions of MAJC and FIX10C teams are significantly smaller than those of FIX25C teams (Mann-Whitney-U-Test, α = 0.1). The same is true for the pensions of the MAJnoC teams (Mann-Whitney-U-Test, α = 0.05) and FIX25noC teams (t-test, α = 0.01). At the same time, no difference was found between MAJC and MAJnoC teams on the one and FIX10C or FIX25noC teams on the other hand (t-test, α = 0.1). Prediction 4, according to which FIX teams cannot preserve the CPR from extinction, is clearly rejected (binomial test for a probability of extinction of 0.95, α = 0.05). The two-way ANOVA using FIX25 and MAJ teams shows that FIX25 teams achieved significantly higher pensions (F-Test, α = 0.05). Communication is found to have a significantly positive effect on pensions as well (F-Test, α = 0.01).

5.4 Group characteristics and group performance

Like previous experiments (e.g., Weimann 1994, Boone et al. 1999), this experiment produces heterogeneous results with respect to group payoff, pensions, frequency of defection or rule setting behavior. This section addresses the question of whether these differences result from differences in group characteristics. For this purpose, the sex composition of groups and average number of semesters was documented (see table 5). In most cases, the players within one team knew each other by name, yet the intensity of personal contact between them, measured by the average number of co-players who have visited each player before the game, differed substantially across teams. An average number of four visits means that each player has visited all of his co-players while zero visits indicates no private visiting at all. In a first step, it is necessary to compare the average team characteristics across set-ups to make sure that the differences in performance, in particular between MAJ and FIX25 teams, do not result from systematic differences in the teams between the two set-ups. With respect to the five different set-ups, no significant differences in the average number of semesters, number of female players, or intensity of pre-game contact among teams were observed (Kolmogorov-Smirnov-test, $\alpha = 0.05$).[8]

In a next step, the different performance of the individual teams is analysed to find a possible impact of group characteristics. The differences in group payoff, pension, and frequency of defection show no systematic relationship to the differences in the ascertained group characteristics. All corresponding Spearman's coefficients of correlation are smaller than 0.42 (conservative testing, $\alpha = 0.05$). Thus, there is no straight-forward monotonic relationship between group characteristics and performance. Given this first result, the influence of pre-game contact deserves a more thorough analysis because groups of players who know each other well communicate more fruitfully and thus may be able to induce a higher level of cooperation. In Table 6, the teams are divided into three categories with increasing intensity of pre-game contact. The table shows no monotonic relationship between the intensity of pre-game personal contact and economic performance. Teams that had the second-most intensive pre-game contact (between 1 and 3 visits) performed worst in most groups. However, in a two-way ANOVA with respect to set-up and pre-game contact, the differences in group pension, net group payoff, and rate of defection to the teams with lower respectively higher pre-game contact did not prove significant (t-test, $\alpha = 0.1$). At the same time, there is a significant difference in patrolling intensity among MAJ teams with respect to intensity of pre-game contact. Those teams with a medium intensity of contact set a significantly higher patrolling intensity than the other teams (Student-Newman-Keuls, $\alpha = 0.05$).

Table 6: Intensity of pre-game contact and group performance

Average number of visits	n	average patrolling intensity*	net group payoff	defections per round	changes in rule	group pension	average number of semesters
			MAJC teams				
up to 1 visit	1	0	46 000	0	1	10 000	11.20
between 1 and 3 visits	4	0.37	29 387	1.27	3	4 412.5	4.45
3 or more visits	1	0	44 800	0.14	1	8 000	7
			MAJnoC teams				
up to 1 visit	2	0.25	28 097.50	1.3	1.5	5 000	6.7
between 1 and 3 visits	2	0.48	20 425	1.25	2.5	0	4.2
3 or more visits	2	0.38	16 011.25	1	3	1 268.75	3
			FIX25C teams				
up to 1 visit	3		40 923.33	1.14		7 966.67	8.47
between 1 and 3 visits	4		41 350	0.36		10 000	5
3 or more visits	1		42 150	0.29		10 000	7
			FIX25noC teams				
up to 1 visit	2		32 450	1.29		5 500	4
between 1 and 3 visits	2		26 087.5	0.97		4 687.5	4
3 or more visits	2		29 665.5	2.17		3 865	6
			FIX10C teams				
up to 1 visit	3		38 643.33	0.86		4 666.67	7.73
between 1 and 3 visits	3		38 750	0.72		6 333.33	8.87
3 or more visits							
			All teams				
up to 1 visit	11	0.13	37 222.83	0.92	1.25	6 626.67	7.62
between 1 and 3 visits	15	0.43	31 199.9	0.91	2.75	5 086.67	5.3
3 or more visits	6	0.19	33 156.69	0.90	2	5 783.44	5.75

* Calculated only from those rounds in which a binding quota was passed.

6. Discussion

All groups, regardless of whether they were allowed to change the institutional settings or not, witnessed a degree of cooperation throughout the entire game that substantially exceeded the one predicted by game theory. In those cases where defection occurred, the players in more than 50 percent of the cases extracted less than the maximum possible 2 000 fish suggesting that the corresponding players wanted to defect without heavily diminishing the CPR in the case of success. This seemingly irrational behavior supports the notion put forth by Albers et al. (2000), who argue that the mere existence of chance constitutes a source of positive utility that is independent of the structure of payoffs. At the same time, warm-glow effects are likely to have prevented excessive defection (e.g. Andreoni, 1995, Palfrey and Prisbrey 1997).

With respect to the central question of the paper, the results provide strong evidence for the importance of communication to resolve social dilemma situations. This support is threefold. First, communication made it possible for the teams to reach binding quotas that found strong support among most or all group members. Those teams who were not allowed to communicate were unable to reach this level of consensus. The high degree of cooperation among FIX25C and FIX10C teams provides the second piece of evidence. Third and most important, the clear gap in both group payoff and pensions as well as in the average rate of defection between FIX25C and FIX25noC shows that communication is an efficient instrument to induce cooperation. At the same time, the performance of FIX10C teams shows that communication when combined with merely symbolic patrolling is not sufficient to ensure efficient results. The MAJnoC teams who were not allowed to communicate tried to compensate for this by increasing the patrolling intensity, thereby keeping the rate of defection at a lower level. However, they did not fully compensate for the lack of communication.

As in previous double-choice experiments, the MAJ groups made frequent use of the right to change the institutional settings. In the current experiment, all teams made use of this possibility at least once during the experiment. This gives further support to the notion that individuals regard institutional change as a method of dissolving social dilemma situations. In one central aspect, however, the results of the current experiment heavily contradict those of previous double-choice experiments. Unlike the teams in the experiments performed by Sato (1987) and Carpenter (2000), the MAJ teams in the current experiment were not able to capitalize the right to change the institutional settings. When compared to the FIX25 teams, who started with the same patrolling intensity without being allowed to change them, they were even significantly less successful economically. This result heavily contradicts the wisdom of textbooks on the economic theory of decision making that state that an additional option never reduces the payoff of an economic agent and at worst leaves the payoff unchanged. Neither a lack in self-control (e.g., Thaler 1991, p.77-90) nor problems of self-commitment (e.g., Fudenberg and Tirole 1991, p.74-77) can explain why the additional option led to losses in average payoffs.

7. Conclusion

Messick and Brewer have named two different measures, communication and institutional change, by which groups of people can resolve social dilemma situations and reach efficient results. One strand of literature reports on a number of laboratory experiments that show that communication improves efficiency. Another strand shows that groups make use of the right to change the rules in order to overcome the social dilemma. So far, however, there is no experimental study that directly compares the two measures in a unified set-up. This paper reports on a series of laboratory experiments which facilitate this comparison. As in most experiments on social dilemma situations, the degree of voluntary cooperation was substantially higher than predicted by game theory. With respect to the impact of communication, the results are in line with previous studies, showing that those groups who are allowed to communicate reach higher payoffs than those groups who are not given this opportunity. At the same time, the MAJ groups who were given the right to set efficient institutions were not able to capitalize the right but performed worse than the FIX25 teams who played under a set of fixed institutions that, according to game theoretic reasoning, were too weak to induce cooperation. This result contradicts elementary economic reasoning and casts doubt on the ability of individuals to predict correctly the impact of institutional change and thus their capability to apply institutional change to resolve social dilemma situations.

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Appendix: Backward induction to support Prediction 5

Assume that the group agreed to install rule 1. In this case, a defecting player can earn \$ 2 000 instead of \$ 1 000 by defecting. If, in the next round, a higher patrolling rule is set, his future income is reduced by the additional patrolling costs. These are higher, the more rounds are left. In addition, the increased patrolling intensity will make it less profitable for him to defect in the next rounds. If he complies to the quota, he can earn only \$ 600 instead of \$ 1 000 in the round following his defection. After that, a gross fishing income of \$ 1 000 is feasible again. Hence his net gain from defection in round t is given by the following formula:

$$\text{Net gain} = 600 - \Delta C_R \times (7 - (t+1)) \qquad (2)$$

where ΔC_R represents the change in patrolling costs per round.

For any player who expects one or more of his co-players to defect, $\Delta C_R = 0$ because the patrolling intensity will be increased regardless of his own action. Thus he faces massive incentives to defect. Now consider the case where the individual player expects all his co-players to comply to the quota. Assuming rule 3 (C = \$ 150) is set as a reaction to defection, defecting pays if there are less than 4 rounds left to play. If, however, players realize that under rule 1, defection is rational in rounds 4-6, they must introduce a higher patrolling rule in the beginning of round 4 to fight defection effectively. As a result, the net gain from defecting in round 3 equals \$ 600, as $\Delta C_R = 0$. Hence control has to be introduced in round 3. If this is again anticipated, a player can try to increase his income by defecting in round 2. In the end, this line of reasoning leads to the following prediction 5.

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