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CYCLES OF CONDITIONAL COOPERATION IN A REAL-TIME VOLUNTARY CONTRIBUTION MECHANISM

by

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Cycles of conditional cooperation in a real-time voluntary contribution mechanism

M. Vittoria Levati, Ro'i Zultan

Abstract This paper provides a new way to identify conditional cooperation in a real-time version of the standard voluntary contribution mechanism. Our approach avoids most drawbacks of the traditional procedures because it relies on endogenous cycle lengths, which are defined by the number of contributors a player waits before committing to a further contribution. Based on hypothetical distributions of randomly generated contribution sequences, we provide strong evidence for conditionally cooperative behavior. Moreover, notwithstanding a decline in contributions, conditional cooperation is found to be stable over time.

Keywords Public goods game, Real-time protocol, Information feedback, Conditional cooperation, Simulations

JEL Classification C72, C92, H41

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1 Introduction

It is a well-established stylized fact that individuals contribute voluntarily to public goods even when material self-interest would make free-riding the individually best option. One of the most widely accepted explanations for this fact is the existence of "conditional cooperators", i.e., individuals who are more willing to contribute when others also contribute or are expected to do so (Fischbacher et al. 2001; Frey and Meier 2004). Evidence of conditional cooperation has been found both in controlled laboratory experiments (see, e.g., Keser and van Winden 2000; Brandts and Schram 2001; Fischbacher et al. 2001; Levati and Neugebauer 2004; Chaudhuri and Paichayontvijit 2006; Croson 2007; Gächter 2007; Fischbacher and Gächter forthcoming) and outside the laboratory (e.g., Frey and Meier 2004; Heldt 2005).

So far the existence and extent of conditional cooperation has been investigated mainly using two paradigms. In the following we describe the paradigms and point out the weaknesses inherent in each one. We proceed to suggest a new way which enables us to study conditional cooperation in a direct and clean way.

In the first paradigm, proposed by Fischbacher et al. (2001), participants have to indicate how much they are willing to contribute for each possible value of the others' average contributions. Those who submit a 'contribution schedule' that is monotonically increasing with the others' average contribution are categorized as conditional cooperators. This method explicitly measures conditional cooperation and as such it is likely to induce an experimenter demand effect. The strategies are exogenously set as conditional strategies, and the subject must make an "active" choice in order not to use the conditional component of the strategies. Clearly, this conveys expectations for conditional strategies, which may also be construed as recommendations. In other words, if one is asked to condition her contribution on the others' average contribution, she may actually do so, although she would have chosen differently in a context in which conditional cooperation is not made salient.

The second paradigm involves eliciting beliefs about others' contributions and then testing whether beliefs vary positively with one's own contributions (Frey and Meier 2004; Heldt 2005; Croson 2007; Neugebauer et al. 2009). This method arguably presents more problems than the former as it measures conditional cooperation in an indirect way. Specifically, correlational relationships between beliefs and choices do imply causality. A simple alternative explanation for a positive relationship between beliefs and choices is the (false) consensus effect (Ross et al. 1977; Dawes 1990). In the presence of this effect, individuals are likely to use the knowledge of their own choice to predict the choices of others (Engelmann and Strobel 2000). Therefore, a correlation between beliefs and choices is to be expected regardless of conditional cooperation.

In this paper, we offer a novel way to identify conditionally cooperative behavior. Our method allows subjects to implement conditional strategies in a transparent way, using actual information about others' behavior. Contrary to most of the public goods experiments conducted so far, in which contribution decisions are private and simultaneous, we rely on a real-time version of the voluntary contribution mechanism.[1] Specifically, players are given a fixed time interval (the "round") in which to update their decisions. Within a round, players can increase their contribution from 0 to anything up to their whole endowment in single-unit increments by clicking an apposite button. The player's allocation to the public good at the end of the allotted time interval, if any, is taken to be her contribution for that round. Our analysis is twofold. First, we establish the overall effect of allowing for conditional cooperation on contribution levels. Then we define a new measure which enables us to study the dynamics within a round. We use randomly generated hypothetical distributions together with the new measure in order to classify behavior in different

[1] The real-time protocol of play has been introduced by Dorsey (1992) and subsequently employed by Kurzban et al. (2001) Güth et al. (2002), Goren et al. (2003), and Goren et al. (2004). None of these studies, however, used the dynamics of contributions during the round to directly ascertain conditional cooperation.

rounds.

To provide evidence for conditional cooperation and the effects thereof, we distinguish between two treatments that differ in the information supplied to players. In the *instantaneous feedback treatment* (henceforth, IF-treatment), feedback information is in real time in the sense that players' contribution decisions are instantaneously transmitted to their partners. In the *standard feedback treatment* (henceforth, SF-treatment), information regarding the other group members is provided only at the end of the round. Thus, conditional cooperation within the round is only possible in the IF-treatment, whereas the SF-treatment serves as a control for our analysis.

The IF-treatment allows potential contributors to wait, observe what the others do, and then determine whether to "commit" to a further contribution. Hence, under this treatment, conditionally cooperative individuals would start contributing and then hold off their contribution until they see the others' response.[2] The number of contributors a player waits before making a further contribution during the round defines the player's *cycle length*. If conditional cooperation is an important behavioral drive, the IF-treatment should engender, on average, higher cycle lengths than expected by chance and higher cycle lengths than the SF-treatment − where observing the others' contributions before incrementing one's own is not possible and thus waiting for others is meaningless. Testing conditional cooperation by computing cycle lengths has at least two clear advantages as compared to previous studies. First, it avoids the possibility of an implicit experimenter demand effect because it uses the spontaneous dynamics generated within the round. Second, it reduces all problems associated with the formation and interpretation of expectations about the others' contributions.

To compute cycle lengths, and therefore assess the relevance of conditionally cooperative strategies, we consider the case, most common in practice, in which

[2] Ostrom (2000) suggests that conditional cooperators are willing not only to cooperate if others do so, but to initiate cooperative actions when no cooperation norm has been set up.

players are heterogeneously endowed. To the best of our knowledge, there have been only two studies investigating how inequality in wealth affects voluntary contributions under the real-time protocol of play (Güth et al. 2002, and Goren et al. 2003). Both these studies report different contribution proportions of players with different endowments, with low endowed participants contributing earlier and relatively more than high endowed participants.

The remainder of the paper is organized as follows. The next section describes the experimental design. Section 3 presents the results and provides details on the "cycle length" and its use for the detection of conditional cooperation. Section 4 concludes.

2 Experimental design

The basic game is the standard repeated linear voluntary contribution mechanism introduced by Isaac et al. (1984) with the real-time protocol of play developed by Dorsey (1992). Groups of size 4 interact for 4 periods in a partners design. In each period, each group member $i = 1, \ldots, 4$ is endowed with income e_i, which can be either privately consumed or invested in a public good. Individual endowments are asymmetric: in each four-person group, two "rich" members are endowed with 15 ECU and two "poor" members with 5 ECU.[3] The type of each participant (either rich or poor) is randomly assigned at the beginning of the experiment and kept constant over an entire experimental session. The distribution of endowments is common knowledge, i.e., subjects know the others' individual endowment.

Denoting by c_i individual i's contribution to the public good (with $c_i \leq e_i$), the monetary payoff of each i is given by

$$\pi_i = e_i - c_i + 0.5 \sum_{j=1}^{4} c_j. \tag{1}$$

[3]ECU is the experimental currency unit, which is converted to euro at the end of the experiment with a conversion rate of 1 ECU = 5 euro-cents.

Hence, the dominant strategy for a selfish, payoff-maximizer player is to contribute nothing, while the socially efficient outcome (maximizing the sum of π_i over $i = 1, \ldots, 4$) is to contribute everything.

The duration of each round is set to 180 seconds. Subjects are informed that, during this time interval, they can incrementally increase their contribution to the public good from 0 to anything up to their whole endowment by clicking on a small button provided for this purpose. Each time a subject clicks the button, she increases her contribution by 1 ECU. During each round, subjects receive on-screen information about the time (in seconds) elapsed in the round. The same screen informs each subject about her type, her initial endowment, her current level of contribution and her remaining endowment. In the IF-treatment, participants can observe the current contribution of the other group members, each of whom is identified by her type (rich vs. poor). Subjects are aware that their contribution level at the end of each round represents their period contribution decision. At the end of the round, participants in both treatments get feedback on their own period-earnings in ECU. In the SF-treatment they are also informed about the individual contributions in their group, identified by type.

Under the assumption of identical selfish players who maximize their own monetary payoff as formulated in (1), the prediction in the IF-treatment coincides with that in the SF-treatment: i.e., each agent will free-ride. Since the marginal benefit from the public good is 0.5 (< 1), player i can gain by increasing her own contribution only if she induces another player to increase her contribution in turn. But then no contribution sequence with positive contributions can be in equilibrium because the player who makes the last contribution in the sequence is better off by withholding this last increment.[4] Thus, the only remaining equilibrium outcome is zero contributions.

[4]Note that if we allow for simultaneous moves, this statement would hold for each group of possible last movers.

The computerized experiment was conducted at the laboratory of the Max Planck Institute in Jena in July 2003. The experiment was programmed via z-Tree (Fischbacher 2007). Participants were undergraduate students from different disciplines at the University of Jena. After being seated at a computer terminal, they received written instructions (see the Appendix for an English translation), which were also read aloud to establish common knowledge. Understanding of the payoff procedure was assured by a control questionnaire that subjects had to answer before the experiment started.

In total, we ran six sessions (three per treatment). Each session involved twenty-four participants. Because of the partner design, this yields 18 independent observations for each treatment. Sessions lasted, on average, an hour. Subjects received their accumulated round payoffs (plus a show up fee of €2.50) at the end of the experiment. Excluding the show-up payment, the average earnings per subject were €8.11.

3 Experimental results

The results are presented in two subsections. The first subsection focuses on contribution behavior and investigates whether allowing for conditional cooperation (as in the IF-treatment) affects contribution levels. The second subsection provides a clear definition of "cycle length" and uses this concept to identify conditional cooperation.

3.1 Analysis of contribution behavior

Table 1 summarizes the experimental results under the two treatments. Both the mean and the median contributions differ between treatments: as compared to a situation where observing the contributions of the other group members before committing to a further contribution is not possible, providing real-time information about the others' behavior significantly raises average contributions

Table 1: Summary statistics on contributions in the two treatments

	IF-treatment	SF-treatment
Mean	24.94	19.76
Median	24.88	18.12
Std. dev.	8.49	6.83
% of $c_i = 0$	3.13	14.93

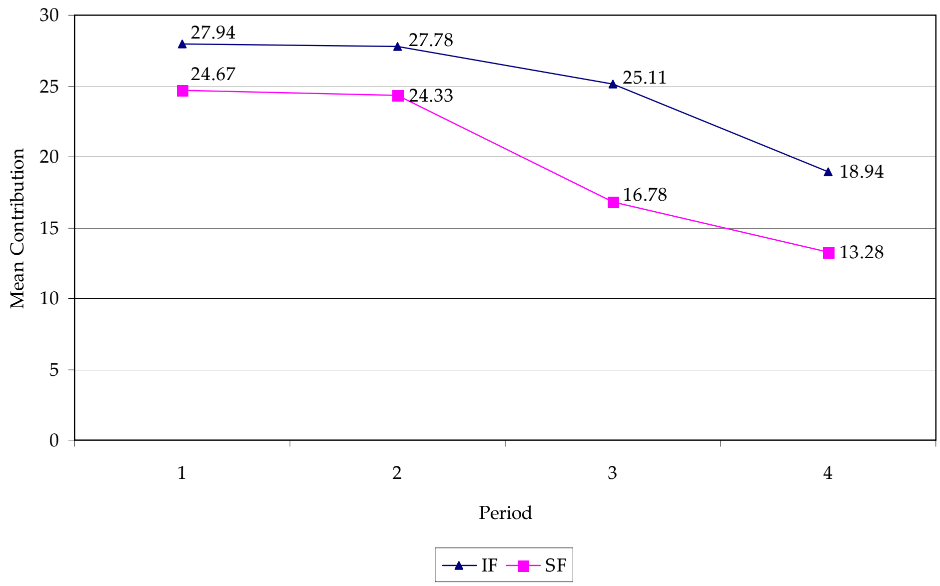


Figure 1: Total average contributions per period separately for the IF- and the SF-treatment

($p = 0.028$; one-sided Wilcoxon rank sum test with continuity correction).[5] Thus, the possibility of naturally implementing conditional strategies fosters contribution. There is also more full free-riding (contributions of zero) in the SF-treatment than in the IF-treatment (14.93% versus 3.13% overall).

Figure 1 displays the time path of average contributions in the two treatments. In each single period, average contributions are higher in the IF-treatment than in the SF-treatment. Furthermore, contributions in both treatments decline, on average, over time. The difference in contributions between the first and the last period is statistically significant for both treatments

[5]All statistical tests rely on independent group observations.

($p = 0.013$ for the IF-treatment; $p < 0.001$ for the SF-treatment; two-sided Wilcoxon signed rank test with continuity correction).

These findings are corroborated by a linear mixed regression with individual contribution decisions as the dependent variable, and *Period* (taking values 1 to 4) and the dummy *Info* (which equals 0 for SF and 1 for IF) as independent variables. The model has random effects at two levels: the 18 independent matching groups and the 144 individuals.[6] The results of the regression are reported in Table 2.

Table 2: Linear mixed-effects regression − Individual contributions on time and dummy treatment

Independent variable	Coefficient	Std. error	t-value	p-value
Constant	6.991	0.518	13.496	0.000
Period	−0.857	0.126	−6.809	0.000
Info	1.313	0.573	2.292	0.024

Table 3 presents the average absolute contributions of rich and poor group members as well as their average relative contributions (a participant's own contribution divided by her endowment), separately for the two treatments. In line with previous experiments allowing for asymmetric endowments under the real-time protocol of play (Güth et al. 2002; Goren et al. 2003), we find that, in both treatments, poor group members contribute a larger share of their endowment as compared to rich members. Moreover, while rich participants contribute significantly more in the IF-treatment than in the SF-treatment ($p = 0.020$; one-sided Wilcoxon rank sum test with continuity correction), poor participants' contributions are not significantly different across treatments ($p = 0.233$). This suggests that rich group members drive the differences in total average contribution between treatments.

We conclude this section by considering the *order* and *time* of contribu-

[6] The estimation method accounts for first-order autocorrelation in the within-(matching) group residuals.

Table 3: Average absolute and relative contributions of rich and poor group members in the two treatments

	IF-treatment		SF-treatment	
	Rich	Poor	Rich	Poor
Absolute contr.	8.60 (3.67)	3.87 (1.03)	6.17 (3.15)	3.71 (0.79)
Relative contr.	0.57 (0.24)	0.77 (0.21)	0.41 (0.21)	0.74 (0.16)

Note: Standard deviations are in parentheses.

tions within a round, i.e., if there is a subject who is more likely to contribute first thereby acting as a "leader", and how long a participant waits, on average, before deciding to increment her contribution by one unit given that a contribution decision has been made.

The sequential-contribution structure of the IF-treatment naturally poses the question of whether a player voluntarily becomes the first mover and attempts to elicit contributions from others by setting a good example.[7] Examining, separately for the two treatments, who contributes first in each group and each period, we find that the rich group members make the first contribution in their group and take the lead in 50 out of the 72 cases in IF and in only 29 cases in SF. Thus, in the treatment with real-time feedback information, the poor group members tend to wait for the rich to start contributing. Moreover, it is not the same subject who acts as a "leader" over the 4 periods, suggesting that an intrinsic leadership motive is not the main reason for the higher contribution levels observed in the IF-treatment.

Figure 2 describes the average waiting time between two consecutive contributions in each of the four periods (the averages are over players for each independent group). Before increasing their contribution by one unit, subjects wait, on average, more in the IF- than in the SF-treatment. Furthermore, while in SF the average waiting time between consecutive contributions tends

[7] Previous papers dealing with endogenous leadership in voluntary contribution experiments include, among others, Potters et al. (2005), Güth et al. (2007), and Levati et al. (2007). In these studies leadership is implemented as a sequential public goods game where one group member contributes first and all the others follow.

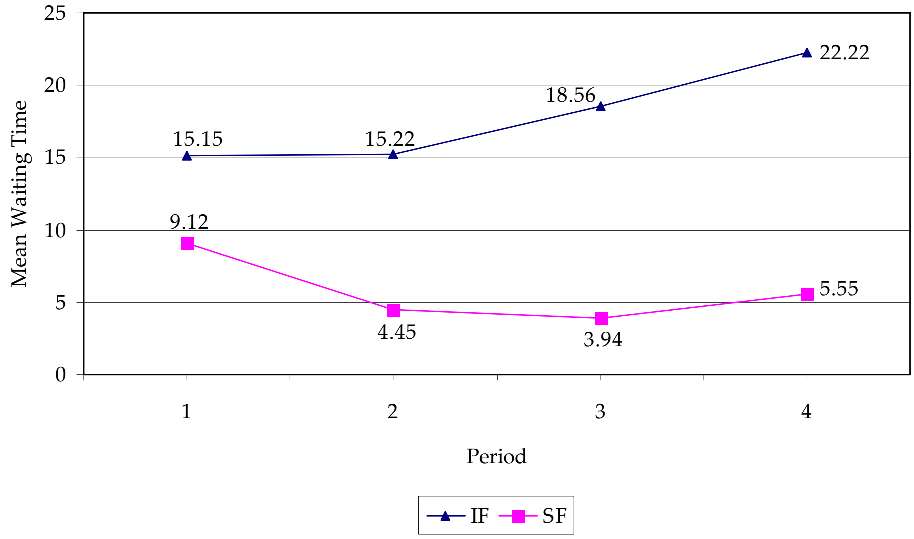


Figure 2: Average waiting time between two consecutive contributions separately for the IF- and the SF-treatment

to decrease after period 1, the opposite tendency can be observed in IF, where participants take longer to commit to a further contribution in later periods. These results are consistent with our main finding regarding the dynamics of conditional cooperation, which we present in the next subsection.

3.2 Cycles and conditional cooperation

We define a *cycle* as the history between two consecutive contributions of a player *within a round*. Denote the kth cycle of player i ($i = 1, \ldots, 4$) by γ_{ik}. If $c_i < 2$, the cycle is not defined. Otherwise, since players can vary their contributions by single-unit increments, the number of cycles of player i is $c_i - 1$. The *length* of each cycle γ_{ik} (with $k \in [1, c_i - 1]$) is given by the number of players, including i, who contribute within γ_{ik}. Therefore the minimal cycle length is 1 (meaning that no other group member contributes within the cycle), and the maximal cycle length is 4 (meaning that all three other group members contribute within the cycle). Since the cycle length of the four members of a group within a round are interdependent and constrained differently for the two

Table 4: Summary statistics on observed cycle lengths in the two treatments ($N_{IF} = N_{SF} = 18$ for both rich and poor members)

	IF-treatment		SF-treatment	
	Rich	Poor	Rich	Poor
Mean	1.887	2.314	1.523	1.591
Median	1.903	2.146	1.466	1.530
Std. dev.	0.313	0.735	0.316	0.372

player types (rich vs. poor),[8] in the following analysis we differentiate between the two types.

Table 4 provides descriptive statistics on the observed cycle lengths. The data analysis relies on the independent group observations, i.e., $N = 18$ for both treatments and both player types. In line with the hypothesis that providing real-time information about the others induces conditionally cooperative behavior and thus longer cycles, cycle lengths in the IF-treatment exceed significantly those in the SF-treatment for both the poor and the rich group members ($p < 0.001$ for both comparisons; Wilcoxon rank sum test).

Albeit significantly different between treatments, the raw cycle lengths are only partially informative on the relevance of conditionally cooperative strategies because they are constrained to the actual contribution profiles. In the IF-treatment, the observed cycle lengths do not reflect only the degree to which a subject waits for the others before committing to a further contribution, but also the sum of individual contributions within each round. For example, if three members of a group tolerate free-riding by the fourth member and still wait for one another before making a further contribution (therefore behaving as conditional cooperators), the maximum cycle length they can reach is 3 rather than 4.

In order to abstract from such considerations, we aim to use cycle lengths to

[8] For example, if the four group members contribute their whole endowment and always wait for each other before contributing a further ECU, the poor group members are expected to have four cycles of length 4 each, whereas the rich group members should have five cycles of length 4 and nine cycles of length 2 where the poor members do not appear.

measure the degree to which subjects behave as conditional cooperators *given* the contribution profile in their group. The question we pose is the following: assuming that the players contribute in a given round the observed amounts, does the *sequence* of contributions over that round reflect conditional cooperation? To answer this question we generate, for each round, a new sequence of contributions corresponding to the observed contribution profile. In each step of the simulation, we randomly choose (with equal probability) one of the players to make the next increment in contributions. This is repeated until all players have contributed their observed final amounts. Thus, each contribution sequence obtained in such a way reflects one possible outcome, which is in line with the observed contribution levels as well as with the null hypothesis of randomness.[9] This simulation is performed independently for each of the 18 groups and each of the 4 rounds to produce 72 different random sequences. Once the random sequences have been thus generated, we can compute, separately for each treatment, the hypothetical *mean* cycle length of each player type.[10]

The simulation is repeated 30,000 times to generate a distribution under the null hypothesis of random contribution sequences, and a p-value is determined based on the rank of the observed mean cycle length within this distribution. A low rank implies that the observed mean cycle length occupies a significantly high position in the generated "theoretical" distribution. This not only means that the null hypothesis of randomness in the observed cycle lengths can be rejected, but also reflects conditional cooperation. On the other hand, a high rank corresponds to an observed mean cycle length that occupies a significantly low position in the generated distribution, reflecting not only non-randomness but also separation of the contributions over the round, which we refer to as

[9] Note that this method corresponds better to the game structure than taking random permutations of the observed sequence.

[10] Since the analysis is done at the group and round levels and some players contributed less than 2 ECU within a round, there are some missing values in the cycle lengths. In particular, the mean cycle length is not defined in 3 out of 72 cases for the poor members in IF and in 6 out of 72 cases for the rich members in SF.

Table 5: Hypothetical distributions, based on 30,000 random contribution sequences, and rank of the observed mean cycle length within the corresponding distribution

	IF-treatment		SF-treatment	
	Rich	Poor	Rich	Poor
Mean	1.800	2.081	1.729	1.923
Std. dev.	0.028	0.038	0.039	0.045
Min	1.696	1.944	1.553	1.763
Max	1.896	2.208	1.865	2.092
Observed mean	1.887	2.314	1.523	1.591
Rank	54	1	30001	30001

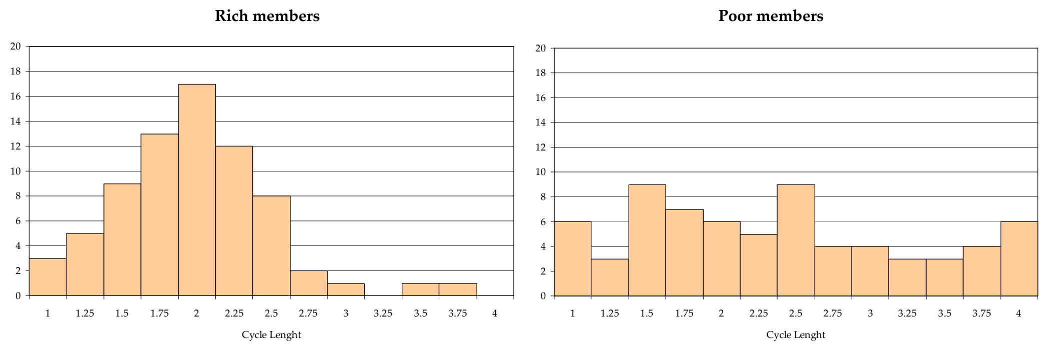
time separation.

The results of the simulations are reported in Table 5. In the IF-treatment, the observed mean cycle length of the poor players is higher than all 30,000 randomly generated mean cycle lengths ($p < 0.001$), and the observed mean cycle length of the rich players is higher than all but 53 of the 30,000 randomly generated mean cycle lengths ($p = 0.004$).[11] These results provide strong evidence for conditional cooperation in the IF-treatment. Conversely, in the SF-treatment, the observed mean cycle length of both player types is lower than all randomly generated cycle lengths, providing strong evidence for time separation due to differences in speed or patience across subjects.

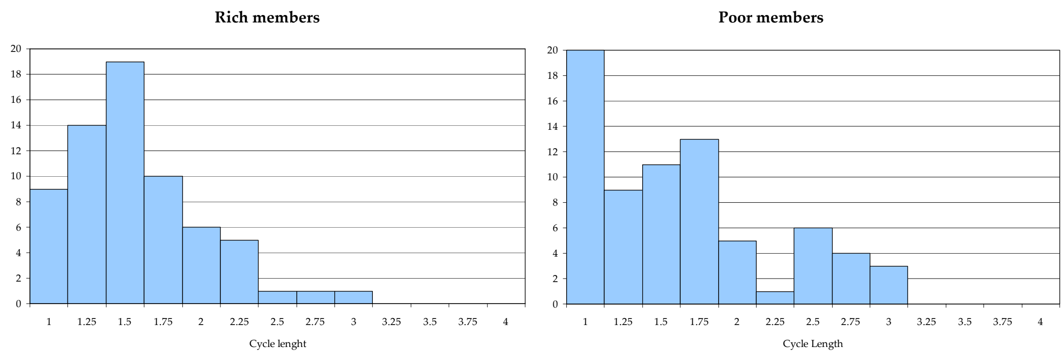
The analysis so far has been based on the observed mean cycle length for each treatment and each player type. We turn now to analyze the cycle lengths observed in all 72 rounds. This will allow us to classify conditionally cooperative groups separately for the two poor members and the two rich members.[12] Figure 3 presents histograms of the observed cycle lengths over all rounds separately for each treatment and each player type. Rounds where groups behave conditionally cooperative should lie in the right tail of the various distributions. They

[11] Each of these p-values is two-sided and represents the rank of the observed mean cycle length within the corresponding theoretical distribution (i.e., $p = \frac{Rank}{30,000} \times 2$).

[12] Differently from Fischbacher et al. (2001), this classification is not done at the individual level, but considering the two players of the same type within each group.



(a) *IF*-treatment



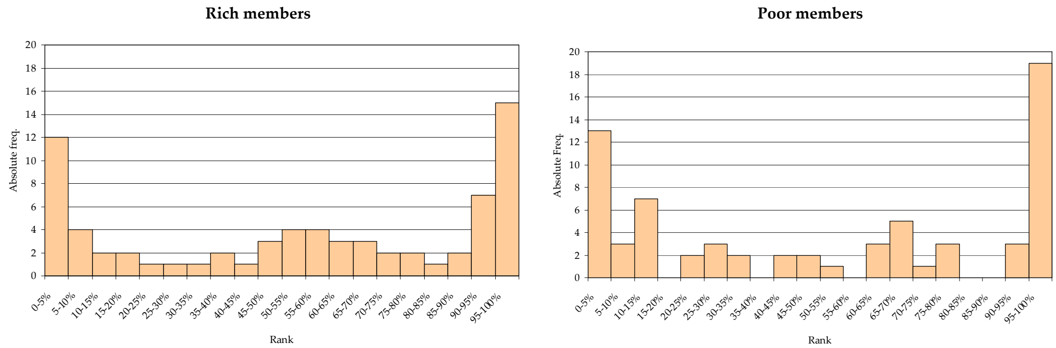
(b) *SF*-treatment

Figure 3: Distribution of observed cycle lengths over all rounds, separately for the IF- and the SF-treatment and for rich and poor group members

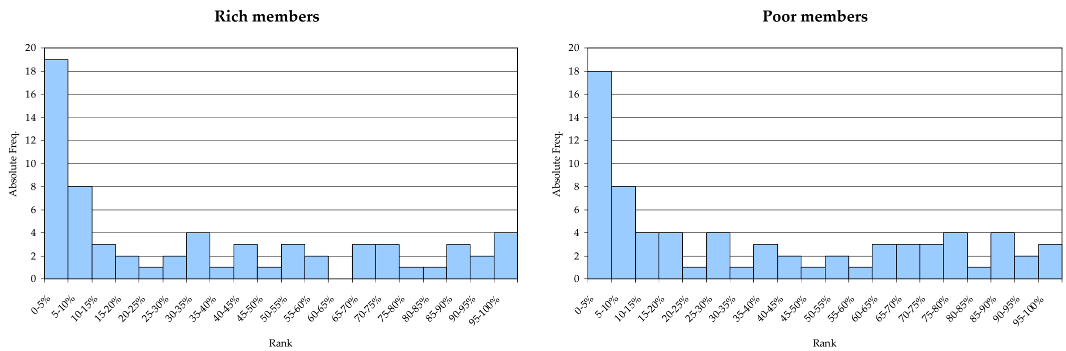
are hardly detectable in the IF-treatment and absent in the SF-treatment.

As discussed above, the variance in cycle lengths mainly reflects differences in the group contribution levels. To take this into account, we run additional simulations, following the procedure described above, so as to identify conditional cooperation in specific rounds. More specifically, based on the observed contributions, we generate 10,000 random sequences and compute, for each sequence, the mean cycle lengths of the poor and rich group members.[13] For each round and each player type we obtain the rank of the observed cycle length within this randomly generated distribution. The obtained ranks are expressed as percentiles in Figure 4. Like for the analysis of the observed mean cycle

[13]We re-run the simulations in order to avoid dependencies between the two analyses.



(a) *IF*-treatment



(b) *SF*-treatment

Figure 4: Rank of observed cycle lengths within the corresponding hypothetical distribution

length, high percentiles, corresponding to low ranks, reflect conditional cooperation in the round, whereas low percentiles, corresponding to high ranks, reflect time separation. The results are summarized in Table 6.

The difference between Figure 3 and Figure 4 is striking: the simulation analysis makes the evidence for conditional cooperation jump out of the raw cycle lengths data. Without conditional cooperation or time separation, the distribution of percentiles is expected to be uniform. The two distributions in the SF-treatment reflect a tendency for time separation in around 25-30% of all rounds (see bottom graphs in Figure 4). The two distributions in the IF-treatment reflect a tendency for both conditional cooperation and time separation (see top graphs in Figure 4). Specifically, 15 out of 72 rich member-

Table 6: Relative frequencies of cycle lengths lying at the extremes of the corresponding randomly generated distribution

	IF-treatment		*SF*-treatment	
	Rich ($N = 72$)	Poor ($N = 69$)	Rich ($N = 66$)	Poor ($N = 72$)
Top 10% (Cond. Cooperation)	30.6%	31.9%	9.1%	6.9%
Bottom 10% (Time Separation)	22.2%	23.9%	40.1%	36.1%
Top 5% (Cond. Cooperation)	20.8%	27.5%	6.1%	4.2%
Bottom 5% (Time Separation)	16.7%	18.8%	28.8%	25.0%

Note: N denotes the number of observations.

observations and 19 out of 69 poor member-observations (20.8% and 27.5%, respectively) are in the top 5% of their corresponding randomly generated distribution; 12 rich member-observations and 13 poor member-observations (16.7% and 18.8%, respectively) are in the bottom 5% (see also Table 6). All four distributions differ significantly from the uniform distribution ($p < 0.005$ in all cases, one-sample Kolmogorov-Smirnov test).

Finally, we look at the development of cycle lengths over time. A comparison of the mean cycle lengths in the first and last rounds shows a significant decrease only for the poor group members in the IF-treatment ($p = 0.022$ according to a Wilcoxon signed rank test; $p > 0.05$ for the rich members in IF and for both types in SF). To investigate whether this decline indicates less conditional cooperation or changes in the upper limit of the cycle lengths due to changes in the contribution levels, we turn again to the randomly generated distributions and perform a Wilcoxon signed rank test on the ranks of the observed cycle lengths therein. Controlling for the effect of the different contribution levels in such a way causes the decline to disappear ($p = 0.246$). Specifically, 6 out of 18 groups are in the top 5% of their corresponding randomly generated distribution in both the first and the last period.[14]

[14] Of less interest is a significant increase for the poor group members in the SF-treatment, which suggests diminished time separation. This may be due to the fact that in the first period some subjects take longer than others to decide on their contribution. More specifically, the ranks of 9 out of 18 groups in the first period are in the bottom 5% whereas no group lies

4 Conclusions

In this paper we have provided a new way of detecting conditional cooperation in a standard linear voluntary contribution mechanism. In order to allow subjects to endogenously implement conditional strategies, we relied on the real-time protocol of play. Within this context, we have studied contribution strategies by introducing the new concept of "cycle length", which is derived from the sequence of contributions within a round. We have compared behavior in a treatment where individual decisions were instantaneously transmitted to all partners (the so-called IF-treatment) to behavior in a standard control treatment where conditional strategies within a round were ruled out. The flexibility of the contribution patterns is a crucial feature of our design, leading to some lack of control when one wants to estimate the extent of conditional cooperation. To compensate for this relaxation, we supplemented the experimental data with simulation analyses and generated hypothetical data based on the endogenous contribution decisions.

In line with the results of Kurzban et al. (2001), our experimental data indicate that allowing subjects to observe their partners' actual contributions before committing to a further contribution − namely, allowing for conditional cooperation − significantly increases average contributions. The sequences of contributions within a round enable us to determine how this occurs. We observe that compared to the control, the IF-treatment engenders not only higher contribution levels, but also significantly higher cycle lengths. This suggests that, throughout the round, subjects tend to increase their contribution in small increments, waiting for others to contribute as well before making an additional contribution.

Although the IF-treatment yields higher contributions than the control, contributions in both treatments significantly decline over as a few as four pe-

in the lowest percentile in the last period. This interpretation is in line with the decline in average waiting time between two consecutive contributions observed in the SF-treatment.

riods, therefore resembling the typical pattern of standard public goods experiments. It would be tempting to conclude that, in the IF-treatment, this is due to a breakdown in conditional cooperation. Yet, our data reveal that subjects continue to behave in a conditionally cooperative way within the bounds of the diminished contributions. This may be a result of some subjects attempting (mostly unsuccessfully) to reestablish conditional cooperation.

Due to the lack of a benchmark, the observed mean cycle lengths are not sufficient *per se* to establish the degree to which conditional cooperation is at play. We solved this problem by generating a benchmark distribution under the null hypothesis that each contribution in the sequence is as likely to come from one player as from any other. Comparing the actually observed cycle lengths of the two player types in the IF-treatment to the corresponding hypothetical benchmark distribution reveals that over 20% of round plays lie at the top 5% of the corresponding distribution, therefore exhibiting conditional cooperation.

To sum up, by introducing the analysis of cycles in the sequence of contributions and using round-specific randomly generated counterfactual data, we were able to support the prevalence of conditional cooperation in public goods settings in a clean way, which avoids the drawbacks of the procedures employed so far. In particular, the approach we used here avoids not only the possibility of an experimenter demand effect, but also all problems associated with the formation of expectations about the others' contributions. Our results show that, when possible, conditional cooperation emerges in significant proportion. Despite the downward trend in contribution levels, conditional cooperation appears to be stable.

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Appendix: Experimental instructions (originally in German)

Welcome and thanks for participating in this experiment. You receive €2.5 for having shown up on time. If you read these instructions carefully and follow all the rules, you can earn more. The €2.5 and all additional amount of money will be paid to you in cash immediately after the experiment.

During the experiment, we shall not speak of euros but rather of ECU (Experimental Currency Unit). ECU are converted to euros at the following exchange rate: 1 ECU = €0.05.

It is prohibited to communicate with the other participants during the experiment. If you have any questions, please ask us. We will gladly answer your questions individually. It is very important that you follow this rule, otherwise we shall have to exclude you from the experiment and from all payments.

The instructions are identical for all participants.

Detailed information on the experiment

The experiment is divided into four periods. In every period, you will be interacting in groups of four persons. The composition of your group will be randomly determined at the beginning and kept constant for the entire experiment. That is, your three group members will be the same in all periods of the experiment. The identity of your group members will not be revealed to you at any time.

In your group there will be 2 members of type A and 2 members of type B. You will learn your type at the beginning of the experiment. Types do not change, i.e., you will keep your type over the entire experiment.

At the beginning of each period, each participant receives a number of ECU. In the following we refer to this as "your endowment".

- If you are an A-participant, you will receive an endowment of 5 ECU per period.
- If you are a B-participant, your endowment will be 15 ECU per period.

Your task in each period

In each period, you as well as the other three participants in your group have to decide how much of your endowment (5 or 15 ECU) you want to contribute to a project. Whatever you do not contribute, you keep for yourself ("*ECU you keep*").

You will have 3 minutes (i.e., 180 seconds) for deciding about the amount of ECU that you want to contribute to the project. During this time you can either gradually increase your contribution from 0 (which is the starting point) or leave it unchanged. Once you have decided to give a certain amount, you can raise it again but you can never lower it.

[*Participants in the IF-treatment read:* While the 3 minutes go by, you will be continuously informed about the actual level of contributions of each of your partners. You will also know which type (A or B) decides to contribute.]

Your contribution level at the end of the three minutes will represent your period contribution decision.

Your contribution decision as well as the contribution decisions of your three group members will determine the "income from the project". This is:

$$\textbf{Income from the project} =$$
$$= \frac{2}{4} \times \textit{Sum of the 4 group members' contributions to the project}$$

In words, to determine the "income from the project" we will sum up the contributions of the four group members, multiply this sum by 2, and then divide the resulting amount equally among the 4 group members independently of how much each of them has contributed.

Your "period income" will be calculated by adding the "ECU you keep" to the "income from the project". That is:

$$\textbf{Period Income = ECU you keep + Income from the project}$$

[*Participants in the IF-treatment read:* You will learn about your period income at the end of each period.]

[*Participants in the SF-treatment read:* You will learn about the contributions of each of your partners as well as about your period income at the end of each period.]

The sum of your period income in all four periods will determine the payment that you will receive from the experiment.

Before the experiment starts, you will have to answer some control questions to verify your understanding of the rules of the experiment.

Please remain seated quietly until the experiment starts. If you have any questions please raise your hand now.