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Matthias Greiff and Fabian Paetzel

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Coordination: Bernd Hayo • Philipps-University Marburg
Faculty of Business Administration and Economics • Universitätsstraße 24, D-35032 Marburg
Tel: +49-6421-2823091, Fax: +49-6421-2823088, e-mail: hayo@wiwi.uni-marburg.de

The Importance of Knowing Your Own Reputation

Matthias Greiff* and Fabian Paetzel†

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Abstract

We experimentally investigate a finitely repeated public good game with varying partners. Within each period, participants are pairwise matched and contribute simultaneously. Participants are informed about contributions and each participant evaluates her partner's contribution. At the beginning of the next period, participants are re-matched and, except for the two control treatments, receive information resulting from the previous period's evaluations. There are three information treatments: Participants receive information either about their own evaluation or about their partner's evaluation or both. Although participants condition their contributions on their partners' evaluations, this information alone is insufficient to raise contributions. Only if participants also know their own evaluation, we do find a significant increase in contributions relative to the control treatments.

JEL Codes: C72, C91, D03, D83.

Keywords: Conditional Cooperation, Evaluation, Public Good Games, Prisoner's Dilemma, Repeated games with varying partners, Reputation, Second-order beliefs.

*Corresponding author. Department of Economics, Justus Liebig University Giessen, Germany. Email: matthias.greiff@wirtschaft.uni-giessen.de, www.matthiasgreiff.net. We thank Max Albert, Andreas Hildenbrand, Benjamin Ho, Stefan Traub, the participants at the ESA International Conference 2012 at NYU, and the participants at the Brown Bag Seminar at the University of Bremen for helpful comments, discussions and encouragement. All remaining errors are our own.

†Department of Business Adminstration and Economics, Centre for Social Policy Research, University of Bremen, Germany. Email: fpaetzel@uni-bremen.de.

1 Introduction

Cooperation problems, like prisoner's dilemmas or public good games, can, in principle, be solved by a strategy of cooperating selectively with other cooperators. The problem of selective cooperation is that individuals have to recognize each other. Under certain conditions, this problem can be solved by reputations. Selective cooperators acquire a reputation for selective cooperation, which allows them to identify each other and to cooperate among themselves. With reputations, selective cooperation may work even if any two individuals interact only once. If Alice cooperates with Bob, Alice acquires a good reputation, which motivates Chris to cooperate with her.

There are two different mechanisms leading to selective cooperation. These mechanisms are often not sharply distinguished, probably because they are perfect substitutes in noise-free environments. First, there is *indirect reciprocity*: Cooperate with those who have earned a good reputation. Second, there is *conditional cooperation*: Cooperate with those whom you expect to cooperate with you, and use reputation as a predictor of cooperation. At first sight, the description of conditional cooperation looks like a more elaborated story that boils down to indirect reciprocity. However, this is not the case. Both mechanisms are quite different, and in this paper we set out to distinguish experimentally which one explains cooperation in an environment that exhibits some (but not all) important characteristics of real-world reputation systems.

Let Alice and Bob play one period of a public good game. With indirect reciprocity, Alice's cooperation can be rewarded by Chris who has received information about Alice's behavior and has the possibility to punish or reward her in the next period. In this sense, indirect reciprocity is closely linked to reputation. Bolton et al. (2005) and Seinen and Schram (2006) present results from repeated asymmetric helping games. In the helping game, two participants, a donor and a recipient, are matched and the donor has to decide whether to help the recipient (cooperate) or not (defect). If the donor chooses to help, she incurs a cost smaller than the benefit for the recipient. Bolton et al.'s and Seinen and Schram's results reveal that information about a partner's most recent action increases rates of cooperation. In the just-mentioned experiments and in theoretical contributions (e.g., Nowak and Sigmund, 1998), an individual's reputation is information about her choices in previous periods of a repeated game. In the experiments, reputations do not contain noise and an individual can infer her own reputation from her past action. For example, in Bolton et al. (2005), starting in period two, a participant's reputation consists of the information about her choice in the preceding period. Since this is common knowledge, there is no uncertainty with respect to the information contained within the reputation.[1]

Selective cooperation can also be achieved if conditional cooperators can identify each other (e.g., Sell and Wilson, 1991; Brosig et al., 2003; Bolton et al., 2005). In games with observable

[1] Although repeated games with reputations often claim to study the effect of reputations, it would be more precise to call these games repeated games with observable actions. Some theoretical models (e.g., Nowak and Sigmund, 1998) avoid the term reputation and use the term *image score*, which is the number of times an individual cooperated in the past, instead.

actions, identification of conditional cooperators is based on information about past actions, or based on reputations summarizing information about past actions.[2] Again, let Alice and Bob play one period of a public good game. Within that period, Alice's cooperation can be returned by Bob if he correctly anticipates Alice's behavior and cooperates himself. Several experiments (see, e.g., Fischbacher et al., 2001; Brosig et al., 2003) have shown that individuals are conditional cooperators who condition their behavior on the expected behavior of others.[3] Fischbacher et al. (2001) employ the strategy method to show that in a one-shot public good game without reputation building about half of the participants have a preference for conditional cooperation. Brosig et al. (2003) analyze communication taking place before a repeated public good game and find that participants express a willingness for conditional cooperation.

The difference between indirect reciprocity and conditional cooperation is, first of all, a question of motivation. Indirect reciprocators are backward-looking and want to reward those who have cooperated with others in the past. Conditional cooperators want to cooperate with people who cooperate with them now. Of course, both may use reputations in order to find out whether their partners are the kind of people they want to cooperate with. However, when reputation is a noisy signal of past behavior, information about their own reputations becomes relevant for conditional cooperators but not for indirect reciprocators.

In the case of noisy reputations, an individual cannot, with certainty, infer her own reputation from her own past actions. If she is an indirect reciprocator, this does not matter: Her only problem is to classify her current partner. If, however, she is a conditional cooperator, classifying her current partner is not enough. She would also like to know how her current partner classifies her. Knowing one's own reputation becomes important because this influences second-order beliefs: What does my partner expect me to do?[4]

Let us assume that Alice and Bob are both conditional cooperators. Alice has a good reputation, which is known to Bob. Likewise, Bob has a good reputation, which is known to Alice. This may make both quite confident that their partner is a conditional cooperator. This, however, is not sufficient for mutual cooperation: Conditional cooperators are not motivated to cooperate with other conditional cooperators; they are motivated to cooperate with those who cooperate with them. If both had a common belief that both are conditional cooperators, their cooperation problem would turn into a coordination problem, and it is not unreasonable to assume that both would coordinate on the better equilibrium, mutual cooperation. Believing that the partner is a conditional cooperator is not enough; Alice must believe that Bob believes her to be a conditional

[2]Information about past actions is not necessary for conditional cooperation. In one-shot games and repeated games without observable actions, identification of conditional cooperators can be based on pre-play communication, in which conditional cooperators signal their intentions or commitments (Brosig et al., 2003; Bicchieri and Lev-On, 2007; Bochet and Putterman, 2009). This, however, is not relevant for our experiment.

[3]Reviews of the experimental economics literature on conditional cooperation can be found in Ledyard (1995, section III.C.3.), Gächter (2007), and Chaudhuri (2011, section 2).

[4]A similar reasoning can be found in the explanation of guilt aversion (see section 4.1 in Dufwenberg et al., 2011).

cooperator, and Bob must believe that Alice believes the same of him. These are second-order beliefs. A crucial element in forming second-order beliefs (and the theoretically also relevant higher-order beliefs, which we do not discuss explicitly) is that Alice knows her own reputation, in order to infer what Bob believes about herself, and likewise for Bob.

We report the results of a public good experiment designed to distinguish between indirect reciprocity and conditional cooperation. We allow participants to evaluate the behavior of their partners by assigning them zero to ten stars, similar to the reputation mechanisms used by Amazon or EBay. Evaluations are noisy signals of past behavior because assignments are not automatic but chosen by the relevant partners.

In non-laboratory environments, reputation is the subjective belief or opinion an individual holds about someone else. A participant's reputation is not a simple label visible to all others, but each participant has a private list containing other participants' reputations. Since reputation is in the eye of the beholder, reputations are not observable, but it is reasonable to assume that reputations are influenced by the available information. Since evaluations are subjective judgments, they contain noise. Uncertainty regarding the information content of the evaluation enters because there is uncertainty about how evaluations are given, e.g., there exists the possibility that "nice" actions receive "bad" evaluations and "bad" actions receive "nice" evaluations. And even if high contributions receive good evaluations, it remains unclear whether a participant defected in order to maximize her payoff or because her partner had a bad evaluation, i.e., the underlying motive remains unclear. In non-laboratory environments as well as in our experiment, noise is due to behavioral uncertainty and not to some artificial lottery with known probabilities. We inquire which kind of information about evaluations is relevant for fostering cooperation: information about the evaluation received by one's partner, information about one's own evaluation, or both. We find that information about the partner's evaluation as well as one's own evaluation is necessary for raising cooperation above the level observed in control treatments. Our results support the hypothesis that conditional cooperation, and not indirect reciprocity, explains why reputation systems can solve problems of mutual cooperation.

In explaining mutual cooperation in repeated games with reputation, we argue that the information contained in evaluations is of crucial importance. However, it is also conceivable that evaluations are a good, i.e., a positive (negative) evaluation is a reward (punishment) in itself (see Gächter and Fehr, 1999; Greiff and Paetzel, 2012). In a similar way, image-concerns (the desire to be liked by others, see, e.g., Frey and Neckermann, 2008; Ariely et al., 2009) are a possible explanation for cooperation. These two explanations (evaluations as goods and image-concerns) are, in principle, compatible with the observed behavior but they can only explain part of the results.

2 Experimental Design

Our experiment is a finitely repeated public good game with varying partners. Participants play 15 repetitions (called periods) of a public good game. In each period, participants are randomly and anonymously paired, with no pair interacting more than once (absolute stranger matching). Participants were informed about the matching protocol. Within each period participants choose their contributions to a linear public good. At the end of each period, each participant is told her decision, her partner's decision and her own as well as her partner's earnings. Based on this information each participant is asked to evaluate the behavior of her partner.

Treatment	Evaluation	Information
T0	no	none
T1	yes	none
T2	yes	information about own most recent evaluation
T3	yes	information about partner's most recent evaluation
T4	yes	information about own and partner's most recent evaluation

Table 1: The five treatments: At the end of each period participants evaluate each other in T1 to T4 but not in T0. At the beginning of the next period they receive no information (T0 and T1) or information about the own or the partner's most recent evaluation (T2, T3, and T4).

Our experiment consists of five treatments, two of them being control treatments. Table 1 provides a summary. In the first control treatment (T0) participants play a public good game without evaluating each other. In the second control treatment (T1) participants evaluate each other but receive no information about their own or their partner's evaluation. We included T1 to check if the mere expression of evaluations, and the associated act of reflection, has any effect on contributions.

In the remaining three treatments, participants receive, at the beginning of each period, information about their own or their current partner's evaluation in the last period (i.e., information about the most recent evaluation). We consider all possible variations: information about one's own evaluation (T2), information about the partner's evaluation (T3), and both pieces of information (T4). By changing the information being passed on, we separate those pieces of information that are essential for inducing high contributions from other pieces of information.[5]

At the beginning of each period but the first, and depending on the treatment, participants receive information about the partner's reputation. Each period participants make two decisions. First, participants choose how much of their endowment to contribute to the public good. Each

[5]Image-concerns could be at work in T3 and T4. Since a participants own evaluation is not observed by a large audience but by only one anonymous partner, visibility is low and image-concerns are likely to be weak (Frey and Neckermann, 2008; Ariely et al., 2009).

the other participant chooses

you choose	A	B	C	D
A	10 | 10	13 | 9	16 | 8	19 | 7
B	9 | 13	12 | 12	15 | 11	18 | 10
C	8 | 16	11 | 15	14 | 14	17 | 13
D	7 | 19	10 | 18	13 | 17	16 | 16

Figure 1: Payoff bi-matrix; payoffs are in euros.

participant's endowment is $e = 3$, contributions are restricted to $c = 0, 1, 2, 3$, and payoffs are given by:

$$\pi_i(c_i, c_j) = 4(e_i - c_i) + 3(c_i + c_j) - 2. \tag{1}$$

Second, after participants are informed about choices and payoffs, each participant evaluates the other participant's contribution decision. Participants assess each other's decision by assigning between 0 and 10 stars. Participants are explicitly told that 0 stars corresponds to the worst and 10 stars to the best possible evaluation, i.e., the meaning of the different signals is pre-determined. Participants are re-matched and the next period begins. We decided to use 0 to 10 stars for evaluations in order to ensure that evaluations are noisy signals. With another scale, say 0-3 stars, an obvious strategy would be to evaluate a contribution of x by assigning x stars, which would make it possible to infer actions from evaluations.

In designing the experiment we avoided loaded language. More precisely, we did not use words like *team member, team*, or *partner*. To keep the experiment as simple as possible, participants were given a payoff bi-matrix (Figure 1) instead of equation 1. In addition to the payoff bi-matrix presented on the screen, participants had a hard copy of the payoff bi-matrix on which they were allowed to make notes. Payoffs were given in euros. Participants were asked to make their decisions by choosing a row from the payoff bi-matrix, which made it possible to avoid loaded terms like *give* or *take*.

The experiment took place at the University of Bremen in December 2011 and was conducted using the z-Tree software (Fischbacher, 2007). We ran one session for each of the five treatments. In each session 18 participants participated. All participants were students who were recruited using the online recruitment system ORSEE (Greiner, 2004). Students came from different fields and were randomly assigned to a treatment.

Upon arrival participants were randomly assigned to a computer terminal and received a set of written instructions (see Appendix). The experimenter read the instructions aloud. Participants had the opportunity to ask questions. Before the experiment started, participants had to answer three (T0) or six (T1 - T4) control questions, testing whether they understood the experiment correctly. The vast majority answered all questions correctly.[6] After the partipants had answered the control questions, the correct answers were shown to them on the next screen.

At the end of the experiment one period was randomly selected and this period's payoff plus a show-up fee (5 euros) determined participants' payments. Participants were paid in private. Average earnings were 15.91 euros. Each session lasted about 80 minutes.

3 Predictions, Hypotheses & Results

In our experiment, participants make two decisions within each period: the decision to contribute to the public good and the decision to evaluate the partner's behavior. In this section we present predictions, hypotheses and results for individual contributions (subsection 3.1) and evaluations (subsection 3.2). Moreover, we discuss how individual behavior is affected by partners' evaluations (3.3) and participants' own evaluations (subsection 3.4) before we look at how evaluations affect contributions (subsection 3.5).

3.1 Individual Contributions

With respect to the theoretical predictions concerning individual contributions we first derive the prediction that follows from the assumptions that (1) participants are rational and self-interested, (2) only concerned about their monetary payoffs, and that (3) participants believe that others are like them in these respects. With these assumptions being fulfilled, participants' evaluations have no effect. The game-theoretical solution is the subgame-perfect equilibrium which is obtained by backward induction. Rational, selfish participants will contribute zero in the last period of the game. Since selfishness and rationality are common knowledge, contributing zero in the last period will be anticipated and backward induction predicts that contributing zero is the dominant strategy in each period. In the subgame-perfect equilibrium all participants maximize their payoffs by contributing zero in each period of the game. Information about participants' own and their partners' evaluations are cheap talk, since participants have no incentive to choose one evaluation over another. In line with the subgame-perfect equilibrium, the theory predicts that contributions are zero in all treatments.

Tables 2 and 3 summarize the data on individual contributions. Both tables reveal that there

[6]In T0 there were only three control questions. All 18 participants answered all three questions correctly. In T1, T2, T3 and T4 there were six control questions. 62 participants (86.1%) answered all six questions correctly, 9 participants (12.5%) answered 5 questions correctly, and one participant (1.4%) answered only four questions correctly.

	T0	T1	T2	T3	T4
Mean	0.607	0.670	0.315	0.578	0.922
Std. dev.	1.145	1.188	0.800	1.024	1.181
N	270	270	270	270	270

Table 2: Mean, standard deviation and number of observations of absolute contributions, $0 \leq c \leq 3$ (pooled data for all 15 periods).

	T0	T1	T2	T3	T4
$c_i = 0$	75.93%	73.70%	82.96%	71.48%	54.44%
$c_i = 1$	4.07%	4.07%	8.89%	10.00%	18.15%
$c_i = 2$	3.33%	3.70%	1.85%	7.78%	8.15%
$c_i = 3$	16.67%	18.52%	6.30%	10.74%	19.26%

Table 3: Choice frequencies for each treatment (pooled data for all 15 periods).

is no difference in individual contributions in the control treatments T0 and T1. Means, standard deviations (see Table 2) and the distribution of individual choices (see Table 3) are very similar. A two-sided Mann-Whitney test confirms that there is no difference between the distribution of individual contributions in T0 and T1 ($z = -0.613$, $p = 0.54$). The comparison of the distribution of individual contributions shows that the mere expression of evaluation has no effect on contributions. In the remainder of this paper, we will not distinguish between T0 and T1 but pool the data and refer to T0 and T1 as control treatments. In the control treatments, contributions are similar to what is observed in other experiments (e.g., Andreoni and Miller, 1993; Ledyard, 1995): Contributions start at 52 percent in period one and decrease to 12 percent in the last period.

Compared to the control treatments, in which three-quarters of all participants contributed nothing, there is a higher fraction of free-riders (83%) in T2 ($z = -3.122$, $p = 0.00$). This shows that feedback alone (information about the own but not the partner's evaluation) is ineffective in increasing contributions. One reason for this might be the decision to give good evaluations to free-riders, which will be discussed in the next section. Regarding T3 and T4, we find that, on average and compared to the control treatments, individual contributions are not higher in T3 ($z = 0.297$, $p = 0.77$) but higher in T4 ($z = 4.765$, $p = 0.00$).

3.2 How participants evaluate

Because the decision to evaluate the other's behavior has no direct effect on own or other's payoffs, it is a form of cheap talk (see Farrell and Rabin, 1996). A payoff-maximizing participant has no incentive to choose one evaluation over another. Cheap talk is meaningless if participants evaluate randomly. There is no correlation between j's behavior and i's evaluation, and a participant's evaluation carries no information about the action she has taken. In this *babbling equilibrium* evaluations will be treated as meaningless.[7]

A very different picture emerges if higher contributions receive better evaluations. Although talk is cheap, it is informative. Because there is a correlation between j's behavior and how i evaluates j, j's received evaluation is an informative signal revealing information about the action j has taken. In this *revealing equilibrium* evaluations carry meaning.

We expect that high contributions trigger good evaluations because contributions have the same characteristics as gifts: They are voluntary given, they are costly to give, and they result in a benefit for the receiver. Gächter and Fehr (1999) and Greiff and Paetzel (2012) show that there exists a positive correlation between contributions to a public good and social approval. Moreover, Gächter and Fehr's questionnaire study reveals that participants anticipate this regularity. Experimental findings from public good games with costly rewards and punishments (Fehr and Gächter, 2000; Masclet et al., 2003; Sefton et al., 2007) reveal a similar pattern: Above-average contributions are rewarded and below-average contributions are punished. In accordance with the just-mentioned empirical findings, we hypothesize that the *revealing equilibrium* is more likely than the *babbling equilibrium*.

> **Hypothesis 1:** Higher contributions receive better evaluations in (a) T1, (b) T2, (c) T3, and (d) T4.

In the rest of this section, we look at the data to see if Hypothesis 1 is in line with the observed behavior. The first two lines in Table 4 report the correlations between participants' contributions and the corresponding evaluations (i.e., the number of stars received). We see that in T1, T3 and T4 there is a strong, positive correlation. In T2, however, the correlation is surprisingly low. The third and forth lines in Table 4 show the number of participants who gave non-decreasing, and non-increasing evaluations. Let $g_i(c)$ denote the evaluation given by i for a contribution c, and let $r_i(c)$ denote the evaluation that i receives for contributing c. Participant i's evaluations are non-decreasing if $g_i(c) \geq g_i(c-1)$ for $c \in \{1, 2, 3\}$, i.e., if higher contributions do not receive worse evaluations. Participant i's evaluations are non-increasing if $g_i(c) \leq g_i(c-1)$ for $c \in \{1, 2, 3\}$, i.e., if lower contributions do not receive worse evaluations. Since the number of participants who give non-decreasing or non-increasing evaluations is quite low in the treatments in which the partners' evaluations are provided (T3 and T4), evaluations contain noise.

To get a more detailed picture, we take a closer look at the evaluations of participants who contributed their endowment completely (maximum contributors) and participants who contributed

[7] The terms *babbling equilibrium* and *revealing equilibrium* are borrowed from Farrell and Rabin (1996). In the *babbling equilibrium* messages are uncorrelated with the sender's private information, the receiver anticipates this and ignores the messages. In the *revealing equilibrium* messages are correlated with private information and the messages will be believed by the receiver if the sender has no incentive to lie.

	T1	T2	T3	T4
ρ	0.510	0.132	0.545	0.635
p-value	0.000	0.030	0.000	0.000
non decr.	12	9	7	6
non incr.	2	3	0	0

Table 4: Spearman correlation coefficient (ρ) between partners' contributions and evaluations of partners' decisions and corresponding p-values in the first two rows. Number of participants who evaluated non-decreasing (third row) and non-increasing (forth row). In total there were 18 participants in each treatment.

	Evaluation (number of stars received)										
Treatment	0	1	2	3	4	5	6	7	8	9	10
T1	2.0%	2.0%	8.0%	4.0%	6.0%	4.0%	0.0%	0.0%	6.0%	10.0%	58.0%
T2	0.0%	5.9%	0.0%	11.8%	0.0%	11.8%	11.8%	0.0%	5.9%	11.8%	41.2%
T3	0.0%	0.0%	0.0%	0.0%	6.9%	13.8%	0.0%	13.8%	17.2%	6.9%	41.4%
T4	1.9%	3.8%	3.8%	3.8%	0.0%	1.9%	5.8%	5.8%	13.5%	7.7%	51.9%

Table 5: Evaluations of participants who contributed their endowment completely ($c = 3$).

	Evaluation (number of stars received)										
Treatment	0	1	2	3	4	5	6	7	8	9	10
T1	33.7%	26.6%	2.5%	4.5%	3.5%	3.5%	7.5%	5.0%	0.0%	0.5%	12.6%
T2	11.6%	11.2%	4.0%	9.8%	3.6%	16.1%	11.6%	2.7%	3.1%	0.4%	25.9%
T3	48.7%	16.6%	4.1%	3.1%	2.1%	10.9%	3.1%	1.6%	1.0%	0.5%	8.3%
T4	50.3%	16.3%	5.4%	6.8%	4.8%	5.4%	3.4%	0.7%	2.7%	0.7%	3.4%

Table 6: Evaluations of participants who contributed nothing ($c = 0$).

nothing (zero contributors). Table 5 depicts the distribution of evaluations received by maximum contributors. For all treatments the distribution is right skewed. The majority of maximum contributors were evaluated with 10 stars. In all treatments more than 40 percent of maximum contributors received the best possible evaluation, and less than 10 percent were evaluated with 0 or 1 star.

Table 6 depicts the evaluations received by zero contributors. Here the pattern is less clear. In T1, T3 and T4 more than 50 percent of zero contributors were evaluated by 0 or 1 star. In T2 only 22.8 percent of zero contributors were evaluated by 0 or 1 star, and 25.9 percent were evaluated by 10 stars. For T1, T3 and T4 the distribution is left skewed, meaning that contributing nothing leads to bad evaluations. For T2, there is a substantial fraction of zero contributors who received a bad evaluation, but there is also a substantial fraction of zero contributors who received a good evaluation. This results is mostly driven by three participants who played Nash in all periods, evaluated the partner with 10 stars if she played Nash, and evaluated the partner with less than 10 stars if she made positive contributions.

We find that low contributions receive bad evaluations in T1, T3 and T4, and that a sizable fraction of low contributions received the best possible evaluation in T2. Regarding high contributions we find that high contributions receive good evaluations in all treatments. The existence of a strong positive correlation between contributions and evaluations and the small number of participants who give non-decreasing evaluations in T3 and T4, the treatments in which participants know their partners' most recent evaluation, suggests that evaluations are noisy but informative signals for pro-social behavior in T3 and T4. Result 1 summarizes the evidence on evaluations and relates it to Hypothesis 2.

> **Result 1:** There is a strong positive relation between contributions and evaluations in T1, T3, and T4. In T2 zero contributions and high contributions receive positive evaluations while in T1, T3, and T4 only high contributions receive good evaluations. Hence, Hypotheses 1 (a), (c) and (d) are confirmed but Hypothesis 1 (b) has to be rejected.

3.3 How participants react to information about their partners' evaluations

In the finitely repeated public good game with varying partners and a reputation system being in place, free-riding is still the unique subgame-perfect equilibrium. This follows from assumptions (1), (2) and (3), but if one of these assumptions is replaced, we arrive at a different prediction. In the following, we show that three alternative theories – bounded rationality, rational cooperation, and conditional cooperation – predict that participants condition their behavior on their partners' evaluations.

Bounded rationality: Several experiments revealed that the subgame-perfect equilibrium is not a good prediction for repeated games with non-varying partners. Participants perform backward induction, but only for a few periods, so that behavior in early stages of the game is more cooperative (Selten and Stoecker, 1986; Bornstein and Yaniv, 1998; Bornstein et al., 2004). Taking into account participants' limited ability to do backward induction means that we have to replace assumption (1) with (1′): Participants are boundedly rational and self-interested. From (1′), (2) and (3) it follows that contributions will be zero for the last couple of periods for which participants perform backward induction. In earlier periods, participants perceive the game as an infinitely repeated game. From the Folk theorems (see Fudenberg and Tirole, 1991, section 5.1.2) we know that there is a large number of possible equilibria. In our experiment, a plausible equilibrium strategy is a variant of tit-for-tat (TFT), in which a participant conditions her own behavior on the partner's evaluation instead of conditioning her behavior on the partner's behavior in the previous period. This is a form of indirect reciprocity in which participants with good (bad) evaluations will be rewarded (punished).[8] Although participants face a different partner each period and do not directly observe their partners' choices, participants know their partners' evaluations. Provided that participants evaluate according to the *revealing equilibrium*, evaluations are noisy but informative signals about past behavior and participants can condition their own behavior on the partners' evaluations, allowing indirect reciprocity to emerge.

Rational cooperation: Another possibility is to keep assumptions (1) and (2) but replace assumption (3) with (3′): Participants believe that there is a positive fraction of conditional cooperators. With the reputation system being in place, a participant's evaluations will be indicative about a participant's type. It follows that – depending on a participant's belief about her partner's type – strategic reasoning can result in positive contributions, even if there are no conditional cooperators at all (Kreps et al., 1982).

Conditional cooperation: Finally, we can replace (2) with (2′): A positive fraction of participants are conditional cooperators. For conditional cooperators mutual cooperation is the dominant strategy, and a conditional cooperator will cooperate if she expects her partner to cooperate. Otherwise she will defect. With uncertainty with respect to participants' types (assumption 3′) evaluations will be indicative about a participants types, and conditional cooperators will condition their behavior on the partner's evaluation.

From all three theories it follows that participants condition their behavior on their partners' evaluations. In line with these predictions we derive Hypothesis 2.

Hypothesis 2: In T3 and T4, participants contribute more when their partner has more stars (except, possibly, for an end-game effect).

Table 7 provides some stylized facts about the impact of the available information on partici-

[8] The TFT strategy, in which participants cooperate in the first period and imitate the partner's previous action in later periods (see Axelrod, 1984) is an equilibrium strategy for all treatments provided that participants are boundedly rational. Since our game is a repeated game with varying partners, direct punishment is impossible. Instead, punishment would be indirect and contagious in the sense that a single defection triggers defection by all other participants (Kandori, 1992). It is important to note that we are not concerned with the just-described TFT strategy, but a variant of it, in which participants condition their behavior on their partners' evaluations.

pants' behavior. Each row shows the fraction and absolute number of zero contributors and the fraction and absolute number of maximum contributors. All numbers include only observations where the respective information was available. Looking at the numbers for T3, we see that out of all participants who had an partner with a good evaluation (8 stars or better), 55.2% contributed zero and 20.7% contributed the maximum. Out of all participants who had an partner with a bad evaluation (2 stars or less), 79.7% contributed zero and 5.7% contributed the maximum. This means that if the partner's evaluation is good as opposed to bad, participants tend to contribute more. A similar pattern can be found for T4, as the last four lines of Table 7 reveal.

	information condition	$c = 0$	N	$c = 3$	N
T0+T1	no information	74.8%	404	17.6%	95
T2	own eval. good	82.7%	62	10.7%	8
	own eval. bad	93.3%	56	1.7%	1
T3	other's eval. good	55.2%	16	20.7%	6
	other's eval. bad	79.7%	126	5.7%	9
T4	own eval. good, other's eval. good	25.0%	3	58.3%	7
	own eval. good, other's eval. bad	48.5%	16	27.3%	9
	own eval. bad other's eval. good	63.6%	21	3.0%	1
	own eval. bad, other's eval. bad	77.8%	42	3.7%	2

Table 7: Impact of available information on behavior. We say that a participant has a good evaluation if she was evaluated with 8 stars at least, we say that she has a bad evaluation if she was evaluated with 2 stars at most.

We included Table 7 in order to illustrate how participants react to the available information. It reveals some interesting patterns, but it cannot tell us if the results are significant. In order to test Hypothesis 2 we estimated the following two OLS panel regressions in which c_i denotes participant i's contribution, r_i denotes the own and r_j the partner's most recent received evaluation. α, γ and δ are coefficients, β is a vector of coefficients, and $\mathbf{x_i}$ is a vector of control variables.[9]

$$c_i = \alpha + \mathbf{x_i}\beta + \gamma r_j \qquad \text{(for T3)} \tag{2}$$

$$c_i = \alpha + \mathbf{x_i}\beta + \gamma r_j + \delta r_i \qquad \text{(for T4)} \tag{3}$$

If participants condition their contributions on the evaluation of the partner, we would expect

[9] β is a 19×1 vector of coefficients; $\mathbf{x_i}$ is a 1×19 vector containing control variables for period as well as a dummy variable for each participant. This way we control for individual effects (see Königstein, 2000). The model was estimated with the constraint that the coefficients for participants' dummy variables sum up to zero (see Suits, 1984).

γ to be positive and significant. The regressions confirm the theoretical prediction and show that the effect of the partner's evaluation is positive and significant ($\gamma = 0.071$, $p = 0.000$ in T3, $\gamma = 0.047$, $p = 0.006$ in T4). Participants' reactions to partners' evaluations together with the finding that higher contributions receive better evaluations (see section 3.2) provide evidence for indirect reciprocity.

Result 2: In T3 and T4 participants condition their contributions on their partners' evaluations. Hypothesis 2 is confirmed.

3.4 How participants react to information about their own evaluations

In this section we look at how individual contributions are influenced by information about the contributor's own evaluation. For indirect reciprocators there should be no difference in behavior between T3 and T4. However, the additional information regarding the own evaluation in T4 can translate in behavioral differences for conditional cooperators who expect their partners to be indirect reciprocators or conditional cooperators. In T3, Alice does not know her own evaluation, so there is uncertainty with respect to her second-order belief. Alice does not know what behavior Bob expects from her. The additional information about her own evaluation reduces this uncertainty. In T4, Alice does know her evaluation, so there is less uncertainty with respect to her second-order belief, and conditional cooperation becomes easier. More precisely, in T4, conditional cooperators with bad evaluations will make low contributions because they expect their partners (both indirect reciprocators and conditional cooperators) to do the same. For conditional cooperators with bad evaluations the partner's evaluation does not matter. This is different for conditional cooperators with good evaluations, who will condition their contributions on their partners' evaluations. If the partner's evaluation is good, this partner might be an indirect reciprocator or a conditional cooperator. Both types of partners will condition their contribution on the conditional cooperator's own evaluation. If the conditional cooperator's own evaluation is good, her partner will contribute, and if the conditional cooperator's own evaluation is bad, her partner will defect. This motivates Hypothesis 3.

Hypothesis 3: (a) In T4, participants will condition their behavior on their own evaluations, i.e., participants who have received a good evaluation will contribute more. (b) In T4, participants will condition their behavior on the partner's evaluation only if the participant's own evaluation is good.

From Table 7 it is apparent that participants' own evaluations affect behavior in T4. We see that participants condition their behavior on the own evaluation, i.e., on average, participants with a good evaluation tend to contribute more than participants with a bad evaluation. This is confirmed by regression (3), in which the coefficient δ is positive and significant ($\delta = 0.068$, $p = 0.000$). Hypothesis 3 (a) is confirmed.

In the following regression we check whether participants with good evaluations react differently to the partners' evaluations. We regress participant i's contributions (c_i) on the partner's most recent received evaluation (r_j), a dummy variable (H_i), and the interaction between the dummy variable and the partner's evaluation. $H_i = 1$ for participants with an own evaluation of 5 stars or better, and 0 otherwise.[10] Regression 4 was estimated separately for T3 and T4.

$$c_i = \alpha + \mathbf{x_i}\beta + \gamma r_j + \phi H_i + \mu(H_i \times r_j) \tag{4}$$

	T3	T4
H_i	0.052	0.124
	(0.139)	(0.188)
r_j	0.650***	0.009
	(0.018)	(0.022)
$H_i \times r_j$	0.037	0.082*
	(0.038)	(0.033)
N	252	252
F	7.24***	7.48***
$\bar{R}^2$	0.340	0.349

Table 8: Coefficients from eqn. 4. Panel corrected standard errors in parenthesis. $* : p < 0.05$, $** : p < 0.01$, $*** : p < 0.001$.

Table 8 shows the results. For T3, both the coefficient of the dummy variable and the coefficient of the interaction term are insignificant. The coefficient of the partner's evaluation is significant. This means that in T3, the treatment in which participants know their partners' but not their own evaluations, there is no difference in behavior between participants with good evaluations and participants with bad evaluations: Both condition their own contributions on their partner' evaluations.[11] For T4, the dummy variable's coefficient and the coefficient of the partner's evaluation are insignificant. However, the coefficient of the interaction term is significant, which implies that there is a difference in behavior between participants who received a good evaluation and participants who received a bad evaluation. Participants with bad evaluations (less than 5 stars) do

[10]As above (see equations 2 and 3), α, γ, ϕ and μ are coefficients, β is a vector of coefficients, and $\mathbf{x_i}$ is a vector of control variables. β is a 19×1 vector of coefficients; $\mathbf{x_i}$ is a 1×19 vector containing control variables for period as well as a dummy variable for each participant. The model was estimated with the constraint that the coefficients for participants' dummy variables sum up to zero.

[11]Since participants do not know their own evaluation in T3, it is not surprising that we do not find any differences in behavior between participants with good and participants with bad evaluations. However, participants might form expectations about their own evaluations, which could influence behavior.

not condition their own contributions on their partners' evaluations[12], and participants with good evaluations (5 stars or more) condition their behavior on their partners' evaluations. These results show that in T3 all participants condition their behavior on the partners' evaluations while in T4 only participants with good evaluations condition their behavior on the partners' evaluations.

> **Result 3:** Participants condition their behavior on their own evaluation. Hypothesis 3 (a) is confirmed. If participants know their own evaluations, only participants with good evaluations condition their behavior on their partners' evaluations. Hypothesis 3 (b) is confirmed.

3.5 How information about evaluations affects contributions

In section 3.1 we presented a summary about individual contributions. In this section, we take a more detailed look at contributions, which result from the combined effect of participants' decisions to evaluate (see subsection 3.2) and participants' reactions to evaluations (see subsections 3.3 and 3.4). Mean and standard deviations of individual contributions are presented in Table 2. Contributions in the control treatments are similar to results from other experiments, as already mentioned above. In T2, however, contributions are significantly lower (two-sided Mann-Whitney-U test, $z = -3.122$, $p = 0.002$). Why is this the case?

In the aggregate, it seems that in T2 participants contribute more if their own evaluation is high (see Table 7). However, the effect of the own evaluation on contributions is not significant.[13] A closer look at the data reveals the following pattern: Participants did not increase their contributions in response to good evaluations. More than 90 percent of the participants who contributed nothing in period $t-1$, contributed nothing in period t, regardless of the received evaluation. Participants who made positive contributions in period $t-1$ and received a bad evaluation decreased their contributions. About half of the participants who made positive contributions and received a positive evaluation also decreased their contributions. We think that participants reactions to evaluations – decreasing contributions in response to bad evaluations and not increasing contributions in response to good evaluations – together with the decision to give good evaluations to participants who contributed their endowment completely and to free-riders (see section 3.2) explains why contributions in T2 are lower compared to the control treatments.

Regarding contributions in T3, a look at Table 2 reveals that, compared to the control treatments, mean contributions are slightly lower in T3. However, a two-sided Mann-Whitney-U test shows that there is no difference between the distribution of contributions between T3 and the control treatments ($z = 0.297$, $p = 0.767$). Although high contributions receive good evaluations, and

[12] In T4, the vast majority (69.1 %) of participants with a bad evaluation contributed zero, 18.1 % contributed one euro, 6.7 % contributed two euros, and 6.0 % contributed three euros.

[13] We ran an OLS regression with individual contribution as dependent variable and received evaluation, period, and participant dummies as independent variables. The coefficient on received evaluation is positive but not significant at the 10 percent level.

participants condition their contributions on their partners' evaluations, the information about partners' evaluations does not increase the average level of contributions.[14]

In T4, the mean contribution is higher than in all other treatments (see Table 2) and the distribution is less right skewed (more probability mass is shifted to the left, see Table 3). A two-sided Mann-Whitney-U test ($z = 4.765$, $p = 0.000$) confirms that the distribution of contributions in T4 is significantly different from the distribution of contributions in the control treatments. As we have shown above (see Table 7 and Result 3), higher contributions are driven by participants whose own evaluation is good. We summarize our findings regarding contributions in Result 4.

> **Result 4:** The reputation system has no significant effect on contributions if participants receive information about their partners' evaluations but not about their own evaluations. The reputation system results in higher contributions if participants receive information about their own as well as their partners' evaluations, i.e., if evaluations are common knowledge.

4 Conclusion

In this paper, we investigated how reputation mechanisms lead to selective cooperation in a finitely repeated public good game with varying partners. In similar experiments (Bolton et al., 2005; Seinen and Schram, 2006), a participant's reputation is identical to information about her behavior in previous periods of the game. Those experiments found that reputation systems increase contributions because participants can choose conditional strategies, i.e., a participant can make her period-t action dependent on her partner's action in period $t - 1$. From this point of view, reputation systems are effective in increasing contributions because they provide information about previous choices of an partner with whom one has never interacted before, and thus allow indirect reciprocity to emerge.

In contrast to experiments where reputation is information about behavior in previous periods of the game, our experiment contains noisy reputations. Within each period, participants play the public good game and, after observing contributions, evaluate each other. By giving evaluations, participants assess the actions of each other, and provide information which could influence reputations. Since participants differ in how they evaluate others' actions and in how evaluations influence reputations, a participant's reputation is not a publicly observable signal but unobservable. This means that, in contrast to a noise-free environment, a participant cannot infer her own reputation from her own past actions. For indirect reciprocity this makes no difference since participants condition their behavior on what their partner did in the past. If, however, participants

[14] Although average contributions in T3 are not significantly higher than average contributions in the control treatments, a reputation system that provides information about the partner's but not the own evaluation can be effective in increasing cooperation in real world situation. In the experiment participants have no option to opt-out, so they react to bad evaluations with low contributions. In real-world markets, however, a buyer might opt-out and refuse to interact with sellers who received bad evaluations. Sellers with bad evaluations will be selected out and only sellers with good evaluations will remain in the market.

are motivated by conditional cooperation, knowing their own reputation is relevant because this influences second-order beliefs.

By varying the amount of information that is provided, we find that information about the partner's most recent evaluation does not increase contributions, although participants tend to make higher contributions when matched with an partner who received a good evaluation. However, we find that if participants have information about their own and their partners' evaluations, contributions increase significantly. Our explanation is that information about one's own evaluation facilitates conditional cooperation. If my partner knows my evaluation, it is possible that she conditions her behavior on my evaluation. Knowing my own evaluation allows me to more accurately assess what my partner expects from me. My own evaluation contains information which allows me to more accurately assess my partner's expectations about my behavior, and hence, the behavior that I can expect from my partner.

There are (at least) four mechanisms by which reputation systems can increase cooperation: (1) a good reputation might be a reward in itself, (2) individuals might have image-concerns, (3) reputation allows for indirect reciprocity (i.e., rewarding those who cooperated with others), and (4) reputation makes it possible to predict the partner and, thereby, allows for conditional cooperation (i.e., cooperating with those who cooperate with me). Only conditional cooperation is based on second-order beliefs (Alice's beliefs about what Bob thinks of her). If second-order beliefs are relevant, it becomes important to know not only the partner's reputation but also one's own.

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Appendix: Instructions

Welcome to the experiment and thank you for participating!

Please read the instructions carefully. Do not talk to your neighbors during the entire experiment. If you have any questions please raise your hand. One of the experimenters will come to you and answer your questions privately. Following this rule is very important. Otherwise the results of this experiment will be worthless.

Please take your time reading the instructions and making your decisions. You are not able to influence the duration of the experiment by rushing through your decisions, because you always have to wait until the remaining participants have reached their decisions. The experiment is completely anonymous. At no time during the experiment nor afterwards will the other participants know which role you were assigned to and how much you have earned.

You will receive a show-up fee of 5 euros for your participation. Depending on your decisions and the decisions of the other participants you can additionally earn between 7 and 19 euros. You will be paid individually, privately, and in cash after the experiment. The expected duration of the experiment is 90 minutes. The exact course of the experiment will be described in the following.

The experiment consists of 15 rounds which all follow the same course. In each round participants will be randomly and repeatedly assigned to groups of two members. Your payoff will be determined only by your own decisions and the decision of the other group member. The decisions of the other groups do not affect your payment. You will not encounter the same participant in subsequent rounds.

Within a round:

You and another participant will form a group of two in each round. Both members will be asked about their expectations regarding the decision of the other member, and make a decision. This completes a round. Your and the other member's decision determine your payoffs. [in T0]

You and another participant will form a group of two in each round. Both members will be asked about their expectations regarding the decision of the other member, make a decision and evaluate the decision of the other member. This completes a round. Your and the other member's decision determine your payoffs. [in T1, T2, T3 and T4]

The payoffs (in euros) corresponding to each combination of decisions are listed in table 1 [Table 1 refers to Table 1

Table 1 is also shown on the decision screen and contains every possible decision you can make in its row head. The possible decisions of your group member are listed in the column head. The corresponding payoffs for you and the other group member can be found in the cell in which row and column intersect. The number on the left of the vertical bar is your payment, the amount on the right of the vertical bar is the payment of the other group member.

Starting with the second round, at the beginning of each round, you will be informed about how the other group member has been evaluated in the previous round. The other group member will

be informed about how you have been evaluated in the last round. [in T3 and T4]
Before you decide, you will be asked, what decision you expect from the other group member. Afterwards you and the other group member decide at the same time. After that, both group members get informed about their payoffs.
After you have been informed about your payoff, you are able to evaluate your group members' decision. Therefore, your own decision and payoff as well as the decision and payoff of the other group member will be displayed. To evaluate, you can grant up to 10 stars, where 0 stars is the worst possible and 10 stars is the best possible evaluation. [in T1, T2, T3 and T4]
The other group member will not be informed on how you evaluated her, and you will not be informed how you have been evaluated by the other group member. The sole purpose of giving evaluations is to capture how you assess the other member's decision. [in T1]
In the next step, the other group member will be informed on how you evaluated her, and you will be informed how you have been evaluated by the other group member. [in T2 and T4]

Calculation of your final payoff:

One of the 15 rounds will be randomly chosen to determine the payoffs at the end of the experiment. The decisions that were made in the randomly chosen round determine the payoffs for all participants. This means that every round could be the payoff-relevant round. After the last round is completed there will be a brief questionnaire. Afterwards you will receive your payoff in cash.

The experiment will begin shortly.
If you have any questions please raise your hand and wait calmly until someone comes to you.
Please do not talk to the other participants during the entire experiment.
Thank you for participating.