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Less sensitive reputation spurs cooperation: An experiment on noisy reputation systems

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Less sensitive reputation spurs cooperation: An experiment on noisy reputation systems*

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Abstract

Using a repeated public good game with stranger matching, we compare how two different reputation systems with endogenous evaluations affect rates of cooperation. Contributions are public information and each participant evaluates her partner's contribution. At the beginning of each period, participants receive information about the partner's evaluation in previous periods. There are two information treatments: Each participant receives information either about her own and her partner's most recent evaluation, or about her own and her partner's average evaluation. Results show that with average evaluations reputation is less sensitive, incentives for reputation building are stronger and contributions are higher.

Keywords: Conditional cooperation; Endogenous evaluations; Noisy reputation; Informativeness

JEL: C72, C91, D03, D83

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1 Introduction

In repeated interactions among strangers, reputation systems can increase cooperation by providing information about behavior in the past (Milinski et al. 2001, Keser 2002, Bolton et al. 2005, Seinen & Schram 2006, Engelmann & Fischbacher 2009, Huck et al. 2012). In the design of reputation systems, the designer has to decide about which information to provide. Theoretically, an individual could be informed about all evaluations of every other individual. In practice, this would require lots of time and enormous cognitive effort. Hence, in most cases, it is not feasible. To avoid cognitive overload, the designer of a reputation system faces the tradeoff between providing information about a few evaluations and providing information about a simple summary statistic. Should individuals be informed only about the most recent evaluations, or should individuals be informed about a summary statistics?

Several papers (Gächter & Fehr 1999, Masclet & Pénard 2012, Abraham et al. 2016, Greiff & Paetzel 2015, 2016) have shown that there is a strong positive correlation between cooperation and evaluations, and that this is common knowledge. In line with this evidence, we assume that there is a commonly known norm of how to evaluate behavior, so that it makes sense to think of the information *A* receives about *B* as a signal of *B*'s tendency to cooperate. The informativeness of the signal, as we will argue below, depends on the specific design of the reputation system.

If everyone evaluates according to the norm, evaluations are informative and individuals will trust the information provided by the reputation system. If however, the reputation system is noisy, evaluations are less informative and individuals might not trust the information provided by the reputation system. With noisy evaluations, there exists a signal extraction problem because A cannot, with certainty, infer B's past behavior from the information about B.

Noise might come from two sources. Firstly, since evaluations are subjective judgments, there is behavioral uncertainty. Individuals might deviate from the norm of how to give evaluations (Masclet & Pénard 2012, Greiff & Paetzel 2016). Secondly, noise might come into the reputation system if information is exchanged through informal networks which can be manipulated, (e.g., through word-of-mouth, gossip, see Sommerfeld et al. 2008, Huck et al. 2010).[1]

In Greiff & Paetzel (2016), the information *A* receives about *B* is equivalent to *B*'s most recent evaluation. Hence, an individual's evaluation is a proxy for her behavior in the preceding period. Compared to a control treatment without evaluations, contributions are significantly higher when participants are informed about their partners' and their own most recent evaluations.

Providing information only about the most recent information implies that an individual has information about her partner's behavior in the preceding period, but everything that has happened more than one period ago is forgotten. Individuals have a strong incentive to cooperate because a single bad evaluation completely ruins the reputation. However, since a single bad evaluation is forgotten after one period, a good reputation can be restored faster, which increases the incentive to defect. We say that such a reputation system is very sensitive. It is

[1] Another kind of noise could arise if evaluations are completely determined by an individual's behavior. Then, an individual who defected against a partner with a bad evaluation receives the same evaluation as an individual who defected against a partner with a good evaluation. Although the evaluation is informative about the individual's behavior in the past, it might not be a good predictor about behavior in the future (Sugden 1986, Milinski et al. 2001, Bolton et al. 2005).

sensitive because *B*'s most recent evaluation completely determines the information provided to *A*.

This is different when the signal is *B*'s average evaluation because with average evaluations, forgetting takes more time. For example, if the summary statistic is the partner's average evaluation based on her last $T > 1$ evaluations, it takes T periods until a bad evaluation is forgotten. This implies that such a reputation system is less sensitive. It is not very sensitive because with increasing T, less weight is given to the most recent evaluation. Compared to reputation systems that provide information about behavior in the preceding period, *A* learns less about *B*'s behavior in the immediately preceding period because *A* is not informed about the evaluation *B* received in the immediately preceding period. The reputation system is less sensitive because noise cancels out as T increases so that the average evaluation (i.e., the signal) becomes more precise.[2]

We hypothesize that a reputation system that is less sensitive leads to more cooperation than a reputation system which is sensitive because the information provided by the sensitive reputation system is less reliable. In this paper we present results from a laboratory experiment designed to test this hypothesis. Participants play a repeated public good game with varying partners and endogenous evaluations. At the end of each period, participants evaluate each other, and, at the beginning of the next period, each participant is informed about her own and her partner's (average) evaluation. Because evaluations are not automatically assigned but chosen by the relevant participants, the reputation system contains noise which is due to behavioral uncertainty. We compare behavior across two treatments. We find that cooperation is about 50% higher if the reputation system provides information about average evaluations instead of most recent evaluations.

2 Experimental design and procedures

In both of our treatments, participants play a 15 period repeated public good game with varying partners. In each period, participants are randomly and anonymously paired and each participant makes two decisions. First, participants choose simultaneously how much of their endowment ($e = 3$) to contribute ($c \in \{0, 1, 2, 3\}$) to a public good. Assume participant i is being matched with participant j. Then, participant i's payoff is given by $\pi_i(c_i, c_j) = 4(e_i - c_i) + 3(c_i + c_j) - 2$.

Second, after participants are informed about choices and payoffs, each participant evaluates the other participant's contribution decision. Participants simultaneously 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. Participants are re-matched and the next period begins.

Our two treatments differ with respect to information. In treatment EVAL1, at the beginning of each period but the first, participants receive information about their own and their partner's evaluation from the immediately preceding period. In treatment EVAL3, participants receive information about their partner's average evaluation and their own average evaluation. Starting in period 4, average evaluations are computed based on the last three evaluations. In period 2, average evaluations are evaluations from period 1. In period 3, average evaluations are averages over evaluations in periods 1 and 2.

[2]What do we mean by more precise? Say that there is a commonly known norm of how to evaluate behavior, and that individuals deviate from the norm and evaluate randomly with probability ϵ. By the law of large numbers, a participants average evaluation converges to its true value (i.e., the evaluation according to the norm) as T increases.

For each treatment, we ran five sessions, so that we conduct the statistical analysis using session-averages as independent observations. 18 participants took part in each session and each participant participated in only one session. In total, 180 students participated in the experiment. Sessions lasted for about 80 minutes and average payments (including a 5 euros show-up fee) were 16.75 euros.[3]

3 Results

Before we analyze contributions, we check if evaluations are informative. Pooled over all participants and periods, the rank correlation between the partner's contribution and the evaluation the partner received is 0.715 ($p < 0.001$) in EVAL3 and 0.582 ($p < 0.001$) in EVAL1. Hence, evaluations are noisy but informative. Across treatments, we find that participants are more generous in assigning evaluations when their own evaluation is bad. Nonetheless, the effect is small and a partner's contribution is the most important determinant of the evaluation she receives. About 58.20% of participants with a bad average evaluation (3 stars or less) assign 9 or 10 stars to a partner, who contributed nothing. For participants with a good average evaluation (7 stars or more), the fraction is 73.00%. This can also be interpreted as mild evidence for standing. Standing is a reputation dynamic according to which a participant receives a bad evaluation only if she defected against a partner who had a good evaluation. Defection against a partner with a good evaluation does not result in a bad evaluation (see Sugden 1986, Milinski et al. 2001).

3.1 Contributions

To test our main hypothesis, we compare average contributions. Average contributions are 0.941 in EVAL1 and 1.429 in EVAL3. When observations are pooled over periods, contributions are about 50% higher in EVAL3 as compared to EVAL1 (compare Figure 1a). A Mann-Whitney-test with session averages shows that these differences are significant (5 obs. per treatment, $p = 0.0283$).

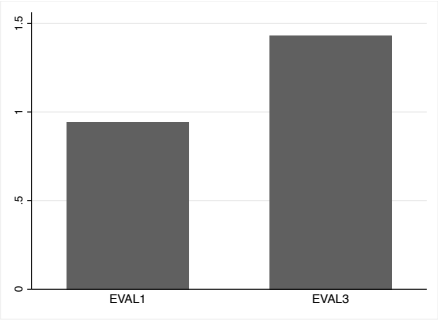
Figure 1b shows that in both treatments, contributions decrease over time. However, in EVAL3 contributions are always higher than in EVAL1.

Regressions (1) and (2) in Table 1 show how contributions are affected by the information contained in the own evaluation r_i and the partner's evaluation r_j. Both, one's own and the partner's evaluation have a significant and positive effect on contributions. In regressions (3) and (4) we added the interaction term of one's own and the partner's evaluation ($r_i \times r_j$). The interaction term captures the effect of both evaluations being high simultaneously. The corresponding coefficient is positive and significant, revealing that if both the own (r_i) and the partner's evaluation (r_j) are high, participants make higher contributions.[4]

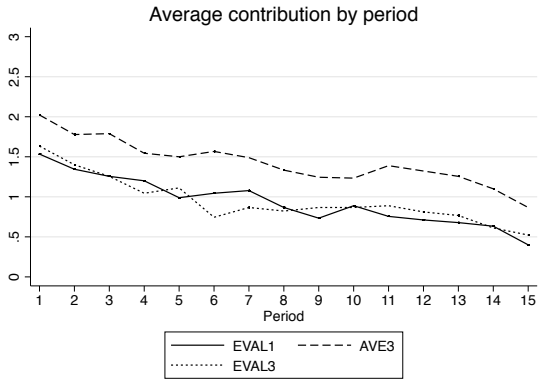
Note that in regression (2) for EVAL3, the coefficients of r_i and r_j are about twice as large as in the corresponding regression (1) for EVAL1. Also the coefficient of the interaction term in regression (4) for EVAL3 is higher than in regression (3) for EVAL1. This reveals that

[3] Observations of the treatment EVAL1 are borrowed from the treatment OTHER+OWN from Greiff & Paetzel (2016).

[4] In Greiff & Paetzel (2016) we argue that the interaction term's positive coefficient can be explained by a preference for conditional cooperation.



(a) Average contributions by treatment.



(b) Contributions over time; data points are means of absolute contributions for each period.

Figure 1: Sub-figure (a) shows average contributions pooled over periods. Sub-figure (b) present contributions over time.

	(1)	(2)	(3)	(4)
	EVAL1	EVAL3	EVAL1	EVAL3
r_i	0.060***	0.138***	0.016	0.063**
	(0.010)	(0.014)	(0.013)	(0.024)
r_j	0.071***	0.138***	0.028**	0.055**
	(0.011)	(0.014)	(0.009)	(0.021)
Period	-0.041***	-0.014	-0.043***	-0.013
	(0.008)	(0.008)	(0.007)	(0.008)
$r_i \times r_j$			0.009***	0.015***
			(0.002)	(0.003)
Constant	0.609***	0.055	0.837***	0.455**
	(0.107)	(0.122)	(0.101)	(0.140)
N	1260	1260	1260	1260
$R^2(within)$	0.132	0.176	0.151	0.191
$R^2(between)$	0.369	0.708	0.361	0.712
$R^2(overall)$	0.169	0.314	0.178	0.330

Table 1: Contributions as a function of evaluations. Regressions (1) and (3) use data from treatment EVAL1; regressions (2) and (4) use data from treatment EVAL3. Regressions are random effects regression with robust standard errors in parentheses, r_i is the own and r_j is the partner's average evaluation. $*$ for $p < 0.05$, $**$ for $p < 0.01$, $***$ for $p < 0.001$.

with average evaluations, participants react stronger to the information they receive, possibly because average evaluations are perceived as more reliable.[5]

[5]In order to test if participants react significantly stronger in EVAL3, we run the following regressions on the pooled data from both treatments: $c_i = \alpha_0 + \alpha_1 D + \alpha_2 r_i + \alpha_3 D r_i + \alpha_4 D r_j + \alpha_5 P$ and $c_i = \beta_0 + \beta_1 D + \beta_2 r_i + \beta_3 r_j + \beta_4 r_i r_j + \beta_5 D r_i r_j + \beta_6 P$. P is the variable for period; D is a dummy variable with $D = 1$ for treatment

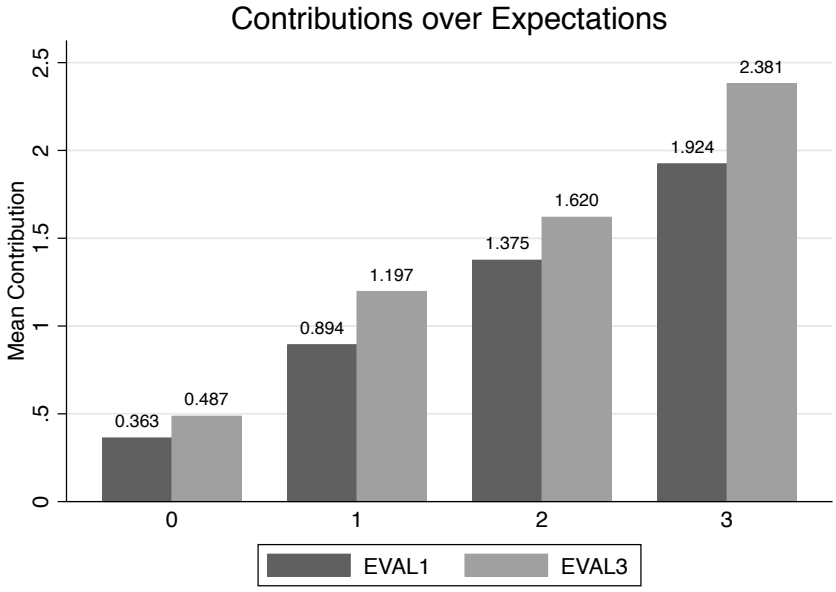


Figure 2: Contributions as a function of expectations.

Focusing on contributions in the first period, we see that in EVAL3 contributions are significantly higher in the first period (compare Figure 1b, $p = 0.007$, Mann-Whitney test with individual contributions as independent observations). This indicates that participants anticipate that the information provided by the reputation system in EVAL3 is more reliable.

Also note that in all regressions, period has significant and negative effect in EVAL1 but not in EVAL3. This means that for given evaluations (r_i and r_j), contributions do not decrease over time. This is different in EVAL1. In regressions (1) and (3) the period coefficient is negative and significant, showing that contributions decrease even if evaluations do not change.

3.2 Increased reliability strengthens conditional cooperation

In the preceding section, we saw that in EVAL3, participants react stronger to the information they receive. This can be attributed to the higher reliability of the information provided by the reputation system in EVAL3, which strengthens conditional cooperation and strategic reputation building.

In Figure 1 we saw that for given evaluations (r_i and r_j) contributions are higher in EVAL3. In Table 2 we take data from both treatments and regress contributions on expectations and some controls. In line with conditional cooperation, the coefficient on expectations is positive and significant (0.386).

Including the interaction term between expectations and a treatment dummy for EVAL3 allows us to compare the strength of conditional cooperation across treatments. The interaction term's coefficient is 0.138 and significant. This implies that if a participant's expectation increases by one unit, she increases her own contribution by 0.386 in EVAL1 but by 0.524 in EVAL3.

EVAL3. The coefficients α_3, α_4 and β_5 are all positive and significant at $p < 0.001$.

Constant	0.805***
	(0.077)
D	0.136
	(0.088)
Expect.	0.386***
	(0.040)
$D \times$ Exp.	0.138**
	(0.052)
Period	-0.037***
	(0.005)
N	2700
$R^2(within)$	0.331
$R^2(between)$	0.490
$R^2(overall)$	0.377

Table 2: Contributions as a function of expectations. Pooled data from EVAL1 and EVAL3. D is a treatment dummy. RE regression with robust standard errors in parentheses. $*$ for $p < 0.05$, $**$ for $p < 0.01$, $***$ for $p < 0.001$.

Another way to look at this is Figure 2, which plots average contributions for all possible expectations about the partner's contribution. An interesting finding is that in EVAL3, participants who expect their partners to contribute one euro, contribute more than one euro (1.197 euros). We believe that it is unlikely that this is due to altruism. Rather, we interpret this as evidence for strategic reputation building (Engelmann & Fischbacher 2009). Because of the higher reliability, evaluations are more valuable and participants are willing to contribute more in order to receive good evaluations.

4 Concluding discussion

The results from our experiment support our hypothesis that a reputation system with noisy reputation which provides information based on a simple summary statistic leads to more cooperation than a reputation system which provides precise information based on behavior in the immediately preceding period.

In EVAL3, the reputation system is less sensitive compared to the reputation system in EVAL1. A single extreme evaluation, which might be due to noise, does less damage to B's reputation. Hence, with average evaluations the reputation system is more reliable, even though the reputation system is noisy. Since contributions are higher in the first period, it seems that participants anticipate the higher reliability of the reputation system.

Conditional cooperation is a potential mechanism that can explain higher contributions in EVAL3. Conditional cooperators condition their own contributions on the partner's expected contribution. In EVAL3 the reputation system provides information that is more reliable, hence, conditional cooperation is stronger.

In all treatments, cooperation decreases over time. An explanation for the decrease in contributions is imperfect conditional cooperation (Fischbacher et al. 2001, Keser & van Winden 2000): A is willing to contribute if she expects her partner to contribute, but instead of match-

ing her partner's expected contribution, A contributes less. Consequently, A's average evaluation deteriorates and because of this, A's partners lower their contributions in the subsequent periods. Arguably, the decrease in cooperation could be slower if the game has a longer horizon.

In general, evaluations are subjective. If reputation relies on subjective evaluations, every reputation system contains some degree of noise. Using a simple summary statistic decreases the noisiness in the system because average values are by definition less sensitive. The reputation system provides information which is more reliable, and as a consequence, cooperation is increased.

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A Experimental 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 from a scientific point of view.

Please take your time reading the instructions and making your decisions. You are not able to inuence 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 23 euros. You will be payed 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 only be determined 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, make a decision on their own and evaluate the decision of the other member. This completes a round. The resulting decision combination from your and the other members decision determines your payoffs.

The associated payoffs (in euros) are listed in Figure 1. Figure 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 amount 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, you will be informed about how the other group member has been evaluated in the previous round, at the beginning of each round. The other group member will be informed about how you have been evaluated in the last round.

- At the beginning of the second round, you will be informed about how the other group member has been evaluated in the first round. The other group member will be informed about how you have been evaluated in the first round.
- At the beginning of the third round, you will be informed about how the other group member has been evaluated in the previous two rounds. The average rating of the first two rounds of the other group member will be displayed to you. The other group member will be informed about how you have been evaluated in the previous two rounds. Your average rating of the first two rounds will be displayed to her.
- Starting with the fourth round, you will be informed about how the other group member has been evaluated in the previous three rounds, at the beginning of each round. The

average rating of the first three rounds of the group member will be displayed to you. The other group member will be informed about how you have been evaluated in the previous three rounds. Your average rating of the first three rounds will be displayed to her.

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 team 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 the next step the other group member will be informed on how you evaluated herăand you will be informed how you have been evaluated by the other group member.

Calculation of your final payoff

Your final payoff consists of three parts:

(i) The show-up fee of 5 euros.

(ii) The second part of your payoff (between 7 and 19 euros) depends on your and the other group members decision in a round. One of the 15 rounds will be randomly chosen to determine the payoffs at the end of the experiment. This means that every round could be the payoff-relevant round. The decisions that were made in the randomly chosen round determine the payoffs for all participants.

(iii) The third part of your payoff depends on your expectations. One of the 15 rounds will be randomly chosen to determine the payoffs at the end of the experiment. In no case the round, which was selected for the second part of your payoff, will be selected. Except the round, which was selected for the second part of your payoff, each round could therefore be the payoff relevant. If you were right with your expectations regarding the decision of the other group member, you can earn additionally 4 euros. Otherwise, your payout is zero. Only if the other group member has actually taken the decision you expected, you earn the additional 4 euros.

After the last round is completed there will be a brief questionnaire. Afterwards you will get your payoffs by 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.

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– Latest Contributions

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