A tale of two carrots: The effectiveness of multiple reward stages in a Common Pool Resource game*

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Abstract

Economic efficiency in social dilemma experiments can be increased by allowing for one-shot peer-to-peer sanctions or rewards. In case of sanctions the efficiency gain disappears if the experiment design allows for retaliation, or 'reciprocity in punishment'. We examine whether efficiency increases or decreases when allowing for reciprocity in rewarding. We find that allowing for reciprocity in rewards increases the number of reward tokens exchanged but at the cost of reduced efficiency in the social dilemma situation.

Key words: Social dilemma situations, economic experiments, classification of behavioral types;
JEL Classification: C72, C92, D74.

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1 Introduction

Nowadays, the world is confronted with a variety of pressing environmental problems, including depletion of fisheries, tropical deforestation, and biodiversity loss. At the heart of these problems is the lack of sufficiently well-defined and/or enforced property rights which tend to result in overexploitation of the resource under consideration. The benefits of extracting an extra unit of the resource are private, whereas its costs (for example the increased scarcity because of lower levels of regeneration) are borne by all. Absent cooperation, each individual resource user ignores the costs she imposes on other resource users, and hence, from a social welfare point of view, puts too much effort into resource harvesting. And this is observed to occur even if access to resources is limited to a specific group of individuals (such as a community).

The combination of appropriation externalities and lack of individualized and sufficiently well-defined property rights provides a classic case for government intervention, but socially optimal resource management may also be achieved by means of cooperation among resource users. Over the past two decades, many economic experiments have been conducted to assess the relative effectiveness of so-called self-regulatory instruments in sustaining cooperation in social dilemma situations, such as public goods games or common pool resource games. Instruments include ostracism (Masclet, 2003), peer-to-peer rewards (Sefton et al. (2007), Vyrastekova and van Soest (2008)), and verbal expressions of approval or disapproval (Masclet et al. (2003)), but most attention has been paid to the effectiveness of peer-to-peer punishments.

Ostrom et al. (1992) and Fehr and Gächter (2000) were the first to use economic experiments to analyze whether efficiency in multi-agent social dilemma situations increases if subjects are given the opportunity to impose sanctions on their peers. Both studies find that the threat of sanctions is indeed very effective as the resulting level of efficiency in the social dilemma situation is very close to the socially optimal level. This is surprising as game theory predicts that rational self-interested agents would never engage in punishing their peers. The reason is that these experiments are set up such that imposing punishments is not only costly to the subject receiving the sanction, but also to the subject imposing it. That means that punishing is tantamount to providing a second-order public good. If the punishment is effective in changing the recipient's behavior, the benefits accrue to all group members whereas the costs are borne by the punisher. And if, on top of that, the game is finitely repeated, backward induction makes it even less likely that punishments will be imposed. Punishing non-cooperative behavior in the last period is a costly investment with zero future payoffs, and hence punishing is not rational in any of the preceding periods either.

So, contrary to these game-theoretic predictions both Ostrom et al. (1992) and Fehr and Gächter (2000) observe that subjects frequently impose sanctions on those fellow group members that act non-cooperatively in the social dilemma situation.[1] But in real life there may be yet another reason not to impose punishments on one's peers, and that is that one makes oneself vulnerable to counterpunishment (or retaliation). This has been explored by Nikiforakis (2008), who added a second punishment stage to Fehr and Gächter's (2000) experiment. Those who get punished in the first punishment stage are given the opportunity to counterpunish in the second. The result is that the efficiency gains of punishments vanish: the threat of counterpunishment takes away the willingness to impose punishments in the first stage, and hence cooperation unravels (see also Denant-Boemont et al. (2007)).

Peer-to-peer sanctioning is the most well-studied decentralized enforcement instrument in social dilemma experiments, but it is not the only one. Peer-to-peer rewards have been analyzed too; see for example Sefton et al. (2007) and Vyrastekova and van Soest (2008). These two studies use different impact ratios of rewards, and come to opposite conclusions regarding

[1]Note that in these experiments subjects are free to impose sanctions on any of their peers. Conditional on being willing to impose sanctions it seems most logical to punish those who free-ride on the cooperative efforts of the others. That this is not necessarily the case is shown by Hermann et al. (2008) who find that in some countries and cultures not only free-riders are sanctioned, but also sometimes those who contribute most to the public good.

the efficiency consequences of rewards. Whereas Sefton et al. impose that it costs 1 experimental currency unit (ECU) to increase the payoffs by the reward recipient by 1 ECU (i.e., a 1:1 ratio), Vyrastekova and van Soest use a ratio of costs of 1 unit to increase the recipient's payoffs by 3 (i.e., a 1:3 ratio). The difference between 1:1 and 1:3 is crucial as an exchange of reward tokens between two subjects makes both better off in the 1:3 parameterization (as each subject's net gains are 2 points) whereas their payoffs remain unchanged in case of the 1:1 parameterization.[2]

Indeed, when using the 1:3 impact ratio, Vyrastekova and van Soest observe that efficiency in the social dilemma situation increases if subjects are given the opportunity to give rewards to their peers (whereas Sefton et al. do not observe any efficiency gain).[3] But even with a 1:3 impact ratio the improvement is less substantial than is typically the case with the single stage punishment mechanism. The natural question is then whether adding a second reward stage would result in efficiency being even closer to the social optimum, or not. At first sight, it seems that efficiency can only be improved taking as given that subjects are willing to incur costs to reward their peers, the benefits of acting cooperatively are increased.

In this paper we examine whether the opportunity to 'counterreward' one's peers indeed increases efficiency in the social dilemma situation. We take the experiment by Vyrastekova and van Soest (2008) as a starting point and add a second reward stage. We follow the literature by using a Partner treatment where the subjects' identities are reshuffled between periods, so that rewarding cannot become a game in itself (cf. Fehr and Gächter (2000), Nikiforakis (2008), Denant-Boemont et al. (2007), and Vyrastekova and van

[2]Note that transfer rewards (1:1) are not necessarily more realistic or common than 'net-positive' rewards (1:3). A ratio higher than 1:1 can be defended by noting that in case of financial rewards marginal utility of income may differ between agents. But rewards may also take the form of helping each other (e.g., helping with the harvest, minding each others' children, etc.), and the opportunity cost of time may differ well between agents as well as over time (cf. Vyrastekova and van Soest (2008)).

[3]This finding that rewards are effective too is not only interesting from a scientific point of view. In most societies the right of coercion is restricted to the government, and hence peer-to-peer rewards may well be more relevant in real-world situations than peer-to-peer sanctioning.

Soest (2008)).

Note that by adding a reward stage to the experiment of Vyrastekova and van Soest (2008), we actually introduce two changes even though the second reward stage is identical to the single reward stage in that earlier study. One change is that adding a second reward stage doubles the maximum number of rewards that can be given. That means that potential free-riders in the social dilemma situation face a larger carrot to act cooperatively. And from earlier work by van Soest and Vyrastekova (2004) we know that larger rewards tend to improve cooperation. But there is also a second change, which is relevant if subjects seek to establish mutually profitable bilateral exchange relationships. In treatments with just one reward stage, the only way in which subjects can signal their intention to cooperate is by behaving cooperatively in the social dilemma situation. With two reward stages, the first reward stage can be also used to signal one's willingness to engage in a bilateral exchange of reward tokens. That means that the relationship between behavior in the social dilemma and the rewarding activity becomes less important, or is even severed.

This chapter's contribution is twofold. The first is of direct relevance from an environmental policy point of view. Whereas Vyrastekova and van Soest (2008) find that efficiency in the social dilemma situation is higher than Nash with a single stage of rewards, we find that adding a second reward stage results in efficiency falling back to its Nash level. And this in spite of the fact that we also find that the opportunity for reciprocity in rewarding increases the subjects' propensity to exchange rewards. That means that taking into account the two changes adding a second reward stage gives rise to, the second dominates the first.

The second contribution is methodological in nature. We find that adding a second reward stage substantially increases insight into the social orientation of our subjects, allowing the experimenter to classify subjects into individuals holding pro-social preferences, strategic money maximizers, and 'homo economicus'. Identifying behavioral patterns is important if the literature takes experimental play seriously, and tries to come up with utility functions that better capture actual behavior in the lab. Several methods are available, including Fischbacher et al. (2001)'s strategy method and the decomposed games approach as developed by social scientists (Liebrand, 1984). Problem with these approaches is that (i) they do not capture reciprocal preferences in an interactive setting, (ii) play in these games may contaminate play in the actual experiment, and (iii) their predictive power is not always very strong. For example, van Soest and Vyrastekova (2006) use the decomposed game approach to analyze subjects' behavior in two treatments, one with 1:3 sanctions and one with 1:1 rewards. Whereas they find that the observed differences in behavior of the various behavioral types are in concordance with the theoretical predictions, they are in many instances not significantly different.

Indeed, we find that adding a second rewarding stage induces pro-social individuals reveal to themselves by behaving very differently from the subjects whose behavior is best described as strategic money maximizers or purely self-interested individuals. Indeed, we find that the extra reward stage induces subjects to behave much more consistently than in Vyrastekova and van Soest (2008). It is an interesting avenue for future research to consider whether adding extra stages to other games also allows researchers to classify their subject pool into the various behavioral types, thus enabling theoretists to come up with models that better capture actual behavior.

The set-up of this paper is as follows. Section 2 presents the game, the game theoretical predictions, and the experimental design. The impact of the second reward stage is analyzed in Section 3. In Section 4 we take a closer look at the impact of having a second reward stage on individual behavior, on the basis of which we can classify our subject pool into cooperative individuals, strategic money maximizers and 'homo economicus'. Finally, Section 5 concludes.

2 The game and its experimental design

The social dilemma game that is studied in this paper is the common pool resource (CPR) game. In the following subsection we present the game as well as our game theoretic predictions, and in the second subsection we introduce our experimental design.

2.1 The game

In the CPR game, each of the N agents is endowed with a fixed amount of effort e which she can allocate to common pool resource extraction, or to an alternative economic activity. The amount of effort agent i allocates to extraction is denoted by x_i, and hence $e - x_i$ is the amount of effort she allocates to the alternative activity. The game is finitely repeated over T periods. Using $s1$ to denote stage 1, agent i's total payoffs in period t are given by the following equation:

$$\pi_{i,t}^{s1} = w(e - x_{i,t}) + \frac{x_{i,t}}{X_t} \left[AX_t - BX_t^2 \right], \tag{1}$$

where X_t denotes the aggregate amount of effort put in by the N agents ($X_t = \sum_{i=1}^{N} x_{i,t}$). The marginal returns from the alternative activity are constant and equal to w, and hence, the profits generated by that activity are equal to $w(e - x_i)$. The returns from the extraction activity depend on the amount of effort subject i allocates to this activity ($x_{i,t}$), but also on the total amount of effort put in by the $N - 1$ other agents ($X_{-i,t} = \sum_{j \neq i} x_{j,t}$). The total yield of the resource is equal to $AX_t - BX_t^2$, and agent i receives a share of the resource's yield equal to her share in aggregate extraction effort ($x_{i,t}/X_t$). The symmetric individual Nash equilibrium extraction effort level is $x_{i,t}^{NE} = (A - w)/B(N + 1)$, while the socially optimal individual extraction effort level is equal to $x_{i,t}^{SO} = (A - w)/2BN$. Since $x_{i,t}^{NE} > x_{i,t}^{SO}$ if $N > 1$, there is a social dilemma. Given that this game is finitely repeated, the standard game-theoretic prediction is that all agents choose the Nash equilibrium extraction effort, because of backward induction.

The above game is the baseline treatment, and will be referred to as game 0SR (i.e., the zero reward stage treatment). We implement two additional treatments, the one stage reward treatment (1SR) and the two stage reward treatment (2SR). The first stage ($s1$) in these two treatments is identical to the (first) stage of 0SR, but is then followed by either one or two reward stages (in 1SR and 2SR, respectively). Each reward stage is set up as follows.

Each of the N agents receive z reward tokens which she can keep herself, or give to one or more of the other agents. Every token that the agent keeps, is worth 1 point. Every token that is sent to a fellow group member is worth 3 points to that group member. Agent i's payoffs in stage $s = \{s2, s3\}$ in period t are therefore given by:

$$\pi_{i,t}^{s} = z - \sum_{j \neq i} p_{ij,t}^{s} + 3 \sum_{j \neq i} p_{ji,t}^{s}, \tag{2}$$

where $p_{ij,t}^{s}$ is the number of reward tokens that agent i sends to agent j ($j \neq i$) in stage $s = \{s2, s3\}$ in period t. The total individual payoffs in one period of the 0SR, 1SR and 2SR treatments are therefore $\pi_{i,t}^{0SR} = \pi_{i,t}^{s1}$, $\pi_{i,t}^{1SR} = \pi_{i,t}^{s1} + \pi_{i,t}^{s2}$ and $\pi_{i,t}^{2SR} = \pi_{i,t}^{s1} + \pi_{i,t}^{s2} + \pi_{i,t}^{s3}$, respectively.

Assuming that subjects only care about their own payoffs and are able to apply backward induction, the game theoretic predictions regarding play in the 1SR and 2SR treatments are straightforward. Given that the game is played for a finite number of periods, giving a reward in the (last) reward stage of period T does not affect future behavior anymore. That means that rational, self-interested agents do not send reward tokens in the last reward stage ($s2$ in 1SR, and $s3$ in 2SR). That means that in 2SR there is also no reason to send any reward tokens in the first reward stage ($s2$) because the recipients have no incentives to reciprocate in the second reward stage ($s3$). And given that no rewards will be given in the last period, agents choose the Nash equilibrium amount of effort in the CPR stage ($s1$) in both 1SR or 2SR. In turn this implies that positive rewarding in the (last) reward stage of period $T-1$ (i.e., $s2$ in 1SR, and $s3$ in 2SR) does not influence behavior in stage 1 of period T. Continuing reasoning backward we deduce that no rewards are given in any of the T periods in either 1SR or 2SR, and cooperation unravels. So, in our finitely repeated game the standard game theoretic prediction is that no rewards are being sent in any period, and also that the amount of effort allocated to CPR extraction is always equal to the Nash equilibrium level.

The game theoretic predictions change when the standard assumptions of rational, self-interested agents are relaxed. In case other-regarding preferences play a role, reward tokens may be used. For example, individuals with reciprocal preferences may be present in the subject pool. And these reciprocal individuals are willing to incur costs to reward some group members for their cooperative behavior in $s1$ and $s2$, and to punish others for their noncooperative behavior by refusing to send them reward tokens. The effectiveness of rewards in improving efficiency in the CPR stage is likely to be higher in the 2SR treatment than in the 1SR treatment, as the benefits of cooperation are unambiguously larger in the latter treatment.

2.2 Experiment design

The experiments were conducted at Tilburg University. The sessions for the one reward stage institution (1SR) were held during the Spring semester of 2005. Here 40 subjects participated, forming 8 groups of 5 participants, that is, $N = 5$. The sessions for the two reward stages institution (2SR) took place during the Spring and Fall semester of 2007. In total 55 subjects participated, resulting in 11 groups. Each session lasted about two hours. All 95 participants were students at Tilburg University with different nationalities and different academic backgrounds (economics, law, management, social sciences), and were recruited via e-mail. Interaction between subjects was mediated via computers, and the games were programmed in z-Tree (Fischbacher, 1999). In each session, 15 or 20 subjects participated who were randomly assigned to computer terminals. The experimental parameterization is shown in Table 1, and the resulting Nash equilibrium and socially optimal levels of extraction effort and rewarding are shown in Table 2.

Every session started with the experimenter reading out aloud the instructions of the 0SR treatment (and students were invited to read along), next there were test questions, and then the 0SR treatment was implemented.[4] To facilitate the calculations of the profits in the common pool resource activity, all subjects were given a payoff table. No information was given about either the socially optimal or Nash equilibrium extraction effort levels.

[4]The instructions are available upon request.

Variable	Description	Value
N	number of individuals per group	5
T	number of periods of the stage game	15
w	return on investments in the alternative activity	0.5
A	parameter of the CPR's revenue function	11.5
B	parameter of the CPR's revenue function	0.15
e	individual endowment of effort	13
z	individual endowment of 'reward' tokens	12
r	value of reward tokens received	3

Table 1 Experiment parameterization.

Variable	Description	Value
x^*	symmetric individual socially optimal effort level	6
X^*	aggregate socially optimal effort level	30
x^{NE}	individual Nash equilibrium extraction effort	10
X^{NE}	aggregate Nash equilibrium extraction effort	50
$p_{ij}^{NE,s}$	Nash equilibrium number of reward tokens given in stage s	0

Table 2 Socially optimal and Nash equilibrium levels of all variables of the stage game.

At the beginning of the experiment subjects were randomly matched into groups of 5 participants. The group composition remained constant for the rest of the experiment. At the beginning of every new period an identity label was assigned to each group member, and this label remained constant throughout the three stages of that period. To prevent rewarding becoming a game in itself, we follow the literature (e.g. Fehr and Gächter (2000), Nikiforakis (2008), Denant-Boemont et al. (2007), and Vyrastekova and van Soest (2008)) by randomly reshuffling the subjects' identity labels between periods.

Upon completion of 0SR, the instructions for the session's second (and last) treatment were distributed and read out. This second treatment was either 1SR or 2SR. In the 1SR treatment each subject received information about the stage 1 extraction effort decisions of all other group members (and their payoffs), the number of reward tokens he/she received from each other group member, and the number of reward tokens that group members did not distribute. Because of screen size limitations, the subjects in 2SR received the same information except for the information on how many tokens each group member kept for him or herself.

In the sessions implementing the one reward stage institution participants earned on average €15.90 (including a showup fee of €5.–), whereas the subjects in the two reward stage sessions earned, on average, €18.11.

3 The efficiency consequences of allowing for reciprocity in rewarding

Let us first have a look at the aggregate amount of effort put into CPR extraction, averaged over all groups; see Figure 1. The average aggregate extraction effort levels in the 0SR treatments of all sessions are shown in periods 1 to 15, whereas the average aggregate extraction effort levels in the two reward treatments are shown in periods 16-30.

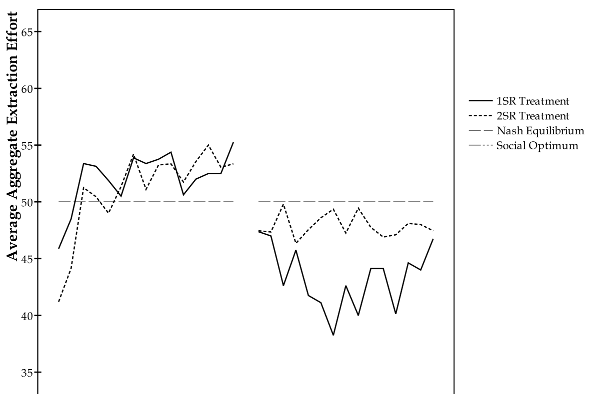


Figure 1 Average aggregate extraction effort levels in the first stage.

In the 0SR treatment –presented in periods 1 to 15– group extraction effort starts on average at a level in between the socially optimal level (30) and the Nash equilibrium level (50), but increases rapidly in the early periods. There is no difference between the two subject pools with respect to their play in 0SR as the relevant two-sided Mann-Whitney U test (with 8 and 11 groups in the 1SR and 2SR treatments, respectively) yields a p-value of 0.395.

The impact of introducing either one or two reward stages are markedly different, though; see periods 16-30. Whereas the instantaneous reduction in average aggregate extraction effort levels in the CPR stage is identical in 1SR and 2SR, play evolves very differently in the two treatments. Indeed, the single reward stage reduces average aggregate extraction effort levels significantly as compared to the 0SR treatment (as the two-sided Wilcoxon matched pairs test with 8 groups yields a p-value of 0.01), but the two stage reward treatment does not (11 groups, $p = 0.21$).

Result 1 Compared with 0SR, adding one reward stage significantly reduces the aggregate amount of effort put into CPR extraction, but adding two reward stages does not.

Next, we turn to analyzing rewarding behavior. The average individual rewarding effort is presented in Figure 2.

The first observation is that, on average, the number of reward tokens sent (and received) is lower in the 1SR treatment than in either of the two stages in 2SR. Whereas this difference is not significant for the last stage of the two treatments ($s2$ in 1SR and $s3$ in 2SR; $p = 0.35$), it is significantly higher in $s2$ in 2SR than in either $s3$ in 2SR or $s2$ in 1SR (with p-values of 0.01 and 0.02, respectively).

Result 2 On average, the total number of reward tokens sent is higher in 2SR than in 1SR.

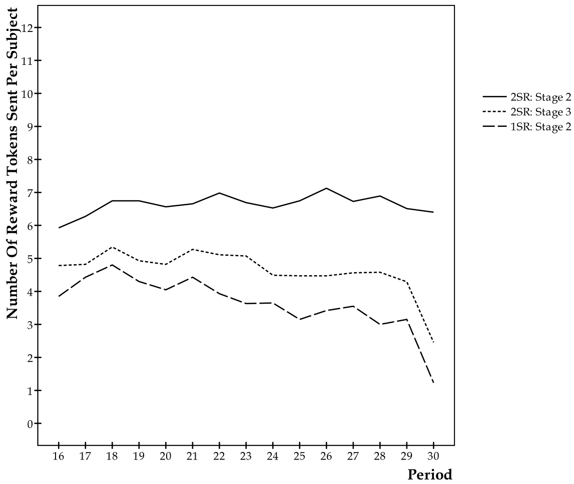


Figure 2 Average individual number of reward tokens sent in stage 2 and stage 3 in 1SR and 2SR.

As stated in the introduction, adding a second reward stage implies that the 2SR treatment differs from the 1SR treatment in two respects. In the first place the maximum number of reward tokens that can be exchanged is twice as high in 2SR, and hence subjects can offer their peers a larger carrot to sustain cooperative behavior in the CPR stage. A payoff-equivalent treatment would be one with a single reward stage, but with an impact ratio of 2:6. And from earlier work by van Soest and Vyrastekova (2004) we know that increasing the net profitability of rewards results in behavior in the social dilemma situation becoming more cooperative.

The second change is that the presence of a second reward stage allows subjects to signal their trustworthiness not only in their behavior in the CPR stage, but also in the first reward stage. In both the 1SR and 2SR there are two motivations for choosing lower extraction effort levels in the first stage. By putting relatively little effort into extraction one is more eligible for receiving rewards, but one also signals one's willingness to act cooperatively – and hence the odds for other subjects sending a reward to receive reward tokens in return, is also larger. Clearly in the 1SR treatment the only way one can signal one's willingness to engage in a bilateral exchange of reward tokens is by acting cooperatively in the extraction stage ($s1$). But in the 2SR treatment one can signal one's trustworthiness in the CPR stage, but also by one's behavior in the first reward stage. That means that the link between acting cooperatively and the reward activity is weaker in 2SR than in 1SR.

Given that we find that efficiency in the social dilemma situation is at the Nash level in the 2SR treatment, clearly the second effect dominates the first. This is evidenced by the fact that the number of rewards exchanged is identical in the last reward stage in both treatments ($s3$ in 2SR and in $s2$ in 1SR), whereas it is much higher in the 2SR's first reward stage ($s2$). Hence, the link between behavior in the CPR stage and the last reward stage becomes less strong, and cooperation in the social dilemma situation unravels.

Comparing the effectiveness of rewards and sanctions in one or two stage settings, the verdict on the effectiveness of sanctions versus rewards in sustaining cooperation seems to lean towards sanctions. The two instruments are completely symmetric in the sense that just having one decentralized enforcement stage (sanctions, or rewards) proves to be efficiency increasing, but adding a second enforcement stage makes this efficiency gain disappear.

As argued in the introduction, in principle rewards are likely to occur more often in real life situations than sanctions, if only because the right of coercion usually lies with the government. Rewards can always be given,[5] but that also means that reciprocity in rewarding cannot be ruled out either. There is no natural mechanism that prevents people to engage in 'rewarding' and 'counterrewarding'. It may be less likely that an individual will seek out another individual who acts non-cooperatively in social dilemma situations to establish a mutually beneficial exchange of good and services with, but if the other makes the first gesture, the exchange relationship is established after all.

Whereas peer-to-peer sanctions may not occur very frequently in the

[5]Keeping in mind the crucial differences between rewards and bribes, as the latter always imply a violation of property rights whereas the former does not.

real world (although there is quite a few case studies showing that they are being used in practice), they may prove to be effective if they do . Individuals who are punished in a community may sometimes have the opportunity to retaliate, but clearly there are many situations in which this is not really possible, if only because it is natural for punishers to form a collective to prevent retaliation in these matters, whereas it is less likely that the punished – at least if the punishment was justified – are able to do so too.

That means that peer-to-peer sanctions may occur in the real world in the form of 'one-stage' and 'two-stage' situations, but peer-to-peer rewards are likely appear in the form of 'two-stage' rewards only. As such, the prospects for peer-to-peer rewarding being an effective decentralized enforcement mechanism are bleak.

4 Measuring social preferences

One of the most important challenges economists are nowadays confronted with is to improve the predictive power of their models. The assumption of humans being exclusively interested in maximizing their own material welfare predicts well when analyzing behavior in the market place, but not in situations where cooperation is called for – as is the case in social dilemma situations. Experimental economics can help create data about human behavior from which better specifications of utility functions for various behavioral types (conditional cooperators, inequity averse individuals, strategic money maximizers, etc) can be derived. Various methods have been developed including the strategy method of Fischbacher et al. (2001) and the decomposed game technique developed by social psychologists (Liebrand (1984), see also Offerman et al. (1996)).

The attempt by van Soest and Vyrastekova (2006) to predict behavior in a social dilemma situation using the Decomposed Game approach is of particular interest here, as the actual experiment used is the 1SR treatment (albeit with impact factor 1:1; i.e., where rewards are effectively transfers). The Decomposed Game approach consists of 24 independent decision situations, which have actual financial consequences for the subject who makes the decision, as well as for one other (anonymous) participant the subject is matched with in the experimental session. The decision situations present dilemmas because they consist of choices between a payoff combination with large benefits for the decision maker and small benefits to the other participant, and a payoff combination where the sum of benefits is larger but with smaller private benefits to the decision maker. By choosing between the two payoff allocations in each decision situation, the decision maker has to weigh his/her own payoff gains/losses against those of the other, anonymous, participant. This approach allows the experimenter to label subjects individualistic (if they maximize their own final payoff), competitive (if they end up with a positive number of points for themselves and a negative one for the other participant), or cooperative (if they end up with both a positive number of points for themselves as well as for the other participant).

The predictive power of this test turned out to be very low in the experiment under consideration. When using the classifications thus derived to explain behavior in the CPR stage, van Soest and Vyrastekova find that the differences in behavior have the expected signs, but are generally not significant. Clearly, behavior in the 1SR treatment is too complex to be captured by a simple classification obtained via a game like the Decomposed Game approach. One of the main reasons is of course that the approach does not allow for reciprocity as all subjects make their decisions simultaneously, and – to avoid contamination – only learn the payoff consequences after the main experiment has been implemented. The strategy method of Fischbacher et al. (2001) is less susceptible to this criticism, but the fact that subjects have to answer multiple 'what if' questions tends to make them act more strategic then they would do in a situation with 'hot' interaction.

Interestingly enough, we find that our 2SR treatment may provide an alternative method for eliciting social preferences. When comparing behavior in 2SR with that in 1SR, we find that whereas it is really difficult to classify our subject pool into various behavioral types (cf. van Soest and Vyrastekova (2006)), behavior in the 2SR treatments allows for a very simple and straightforward classification of subjects. Let us first take a closer look at the aggregate CPR date.

When comparing CPR extraction behavior in 1SR and 2SR in Figure 1, the first thing to note is that behavior is much more variable in the former than in the latter. On average, the standard deviation in a group in the 1SR treatment is 1.35. The average standard deviation in the 2SR treatment is 0.64. This observation is supported by the relevant two-sided Mann-Whitney U test on differences in the standard deviations between the two treatments ($N_1 = 8, N_2 = 11$), which yields a p-value of less than 0.01.

Result 3 The variance in extraction behavior is significantly higher in treatment 1SR than in treatment 2SR.

One hypothesis explaining why behavior is much more constant in 2SR than in 1SR is that subjects try to overcome the fact that reshuffling identities between periods prevents them building a reputation as being trustworthy in exchanging reward tokens. By choosing the same extraction effort levels in a series of periods, subjects signal their identity to their fellow group members.

Let us check whether indeed subjects behave in such a way. We do so in two steps. First we check subjects' persistency in the amount of effort put into CPR extraction in the three treatments (0SR, 1SR, and 2SR). And then we check whether the difference in persistency between 1SR and 2SR give rise to differences in rewarding behavior.

Figure 3 presents the share of subjects who choose a specific level of extraction effort for eight periods, or more. The figure shows a striking difference between the three treatments. In the 0SR treatment, about 27% of the subjects put in the same amount of effort into CPR extraction in eight periods or more, whereas these percentages are 55% in the 1SR treatment and 64% in the 2SR treatment. The differences between the treatments become even more transparent when the cut-off point is set at twelve periods or more. In the 0SR treatment, 7% of the subjects choose a specific level of extraction effort for twelve periods or more. In the 1SR treatment, the percentage of subjects is 13% but it is 49% in the 2SR treatment. Result 4 re-states this finding:

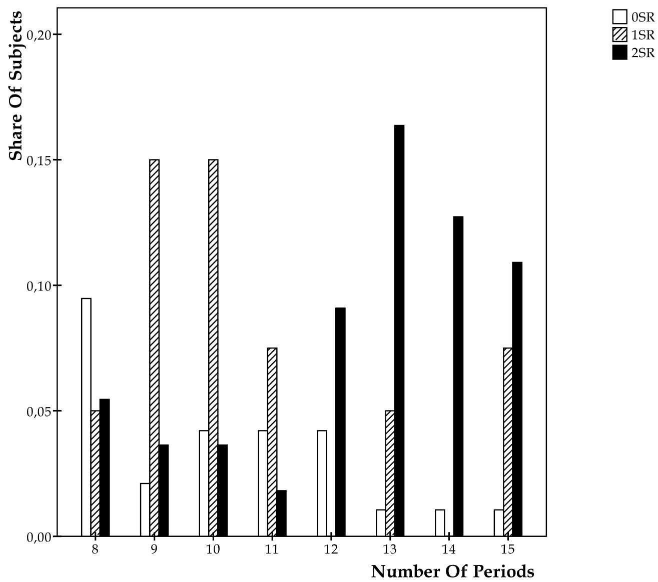


Figure 3 Share of subjects who keep their stage 1 extraction effort levels constant in the three treatments for 8-15 periods.

Result 4 Almost 50% of the subjects in the 2SR treatment extract the same number of stage 1 tokens for twelve periods or more. In contrast, less than 15% display such persistency in extraction effort in the 0SR or 1SR treatment.

So, we find that subjects are more persistent in their choice of the amount of extraction effort chosen in stage 1 in the 2SR treatment than in the 1SR treatment. Let us now have a look at whether this difference in persistency gives rise to differences in rewarding behavior.

Here we have to distinguish between the two motivations for sending reward tokens. The first is that subjects use rewards as 'intended', that is to induce fellow group members to choose lower levels of extraction effort in the social dilemma situation. The second is that subjects try to establish a mutually beneficial exchange of reward tokens with fellow group members.

In Figures 4(a) and 4(b) we plot the number of reward tokens given by sender i to recipient j as a function of the difference in extraction effort put in by sender i and recipient j $(x_i - x_j)$. If rewards would be used predominantly to mitigate payoff inequalities resulting from differences in stage 1 behavior, one would expect the lines both panels of Figure 4 to be upward-sloping. If the main aim is to establish a mutually beneficial exchange of reward tokens, one would expect the number of tokens exchanged to be an increasing function of $x_i - x_j$ in the range where $x_i < x_j$, and a decreasing function of $x_i - x_j$ for all levels where $x_i > x_j$.

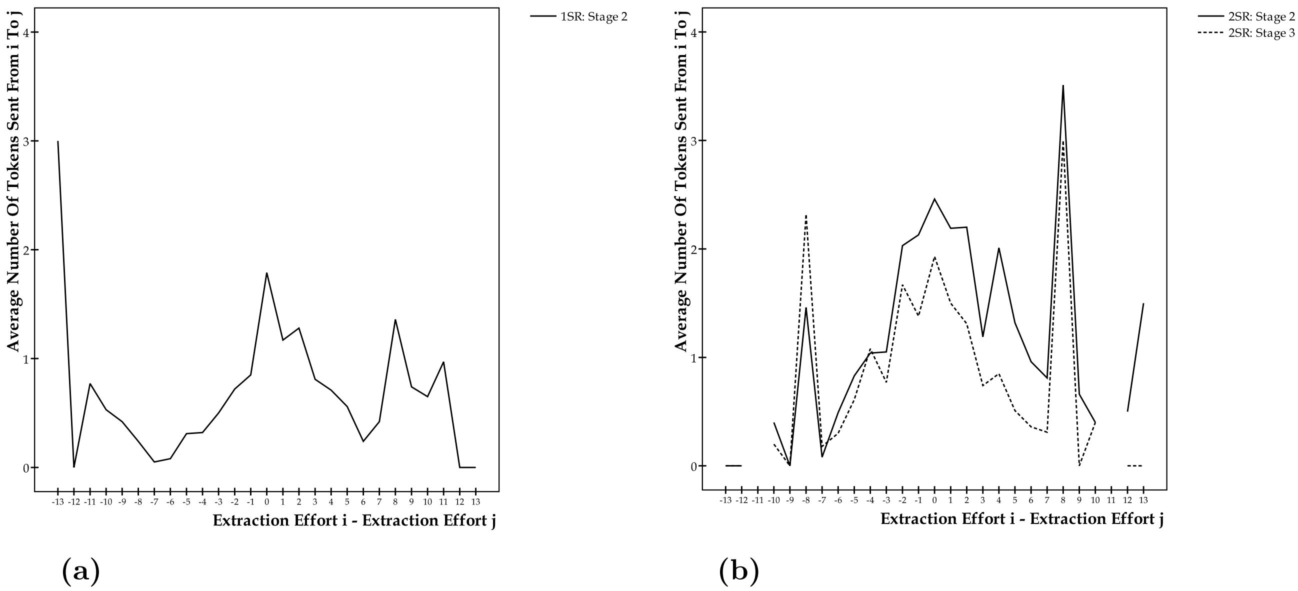


Figure 4 Average number of reward tokens sent by subject i to subject j, as a function of the difference in extraction effort $(x_i - x_j)$, for (a) the 1SR treatment, and (b) the 2SR treatment.

Clearly, straightforward rewarding cooperative extraction behavior is not the most important motivation behind sending reward tokens in either 1SR or 2SR. Subjects tend to send more reward tokens to those subjects who choose the same extraction effort level in the first stage as they do themselves. Although both treatments show peaks at differences other than zero too, these are the result of just a few decisions in case of 1SR but are much more persistent in case of 2SR. For example, the peak at -13 in 1SR is the result of one subject's decision to choose effort level 0 and send 3 reward tokens to a fellow group member who chose effort level 13. Obviously, this was just a one-time decision. But in 2SR it happens fairly frequently that subjects choosing different levels of extraction effort establish an exchange relationship. For instance, the peaks at $+8$ and -8 are the result of two subjects, one choosing effort level 13 and the other choosing level 5, sending reward tokens to each other for 12 periods. Obviously, this is one reason why efficiency in 2SR is essentially Nash – the link between CPR extraction and the exchange of reward tokens is driven more by the desire to establish mutually profitable bilateral exchange relationships than to influence CPR extraction behavior itself.

So we find that a substantial share of our subjects choose the same level of extraction effort in 12 periods, or more, and also that there is some evidence that the persistence in extraction behavior facilitates the exchange of reward tokens.

having established that a substantial share of our subjects tries to signal their identity, the next question is to whether these 'signalers' behave more cooperatively than 'non-signalers', or not. In the current setting cooperative behavior consists of three actions: (i) choosing lower levels of extraction effort than average, (ii) being willing to forego profitable exchange relationships with subjects that free-ride in the CPR stage (even though it may be privately profitable to do so), and (iii) positively reciprocate to the number of reward tokens received in stage 2 by sending back rewards in stage 3 (even though identity labels are re-shuffled upon completion of stage 3).

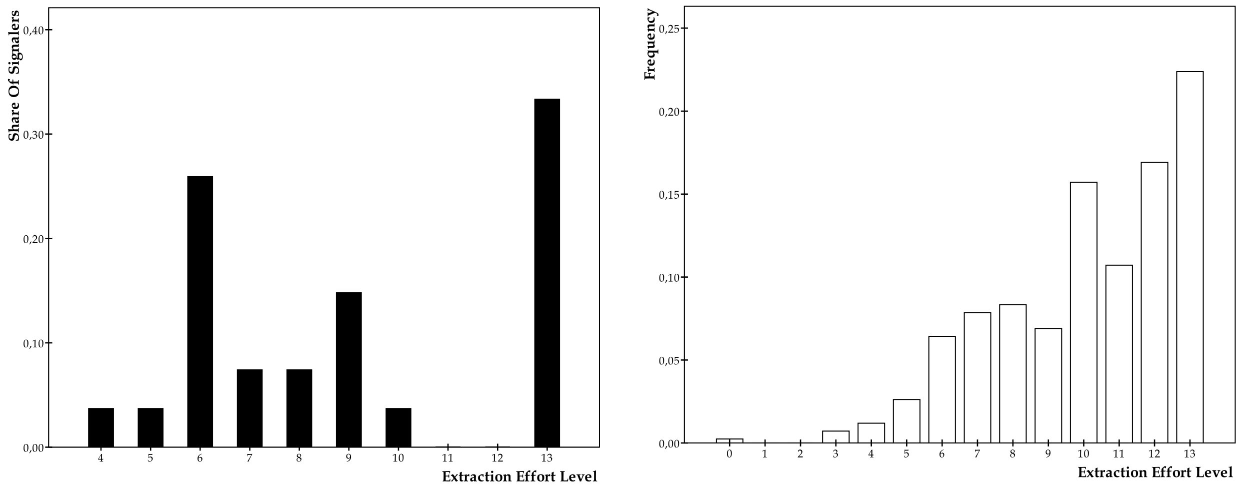
To test whether this is the case, let us first define 'signalers' as follows:

Definition 1 A 'signaler' is a subject who chooses the same stage 1 extraction effort level for twelve periods or more.[6]

This definition results in 27 subjects (of the 55 in the subject pool) to be classified as a signaler, and hence 28 as being non-signalers. Now let us have a look at the first aspect of cooperative behavior: what extraction

[6]The cut-off point of twelve periods is arbitrary. However, the results that follow are more or less the same as when a cut-off point of eleven or thirteen periods is chosen.

effort levels signalers and non-signalers tend to choose. We do so in Figure 5(a) and 5(b) respectively.



(a) **(b)**

Figure 5 (a) The distribution of signalers over the various extraction effort levels. (b) Frequency with which the extraction effert levels are chosen by the non-signalers.

In Figure 5(a) we see that of the signalers nine subjects choose extraction effort 13 for twelve periods or more, whereas the other 18 subjects choose levels of 10 and lower. That means that two-thirds of the signalers tend to behave cooperatively in the CPR stage, but one-third does not.

Comparing 5(a) and 5(b), it is evident that signalers, on average, tend to behave more cooperatively in the social dilemma situation than non-signalers. On average, the extraction effort level chosen by signalers is below Nash (even when including the nine subjects choosing 13), and hence the average effort level chosen by non-signalers is higher. So, they tend to behave more cooperatively in the CPR stage.

Result 5 On average, the extraction effort level chosen by signalers is below Nash, and the average effort level chosen by non-signalers is higher.

Next, let us have a look at the second aspect of 'cooperative behavior', and that is whether subjects are willing to forego a profitable exchange of reward tokens with subjects who free-ride in the social dilemma stage. We make a distinction between the number of reward tokens sent by signalers and non-signalers; see Figure 6.

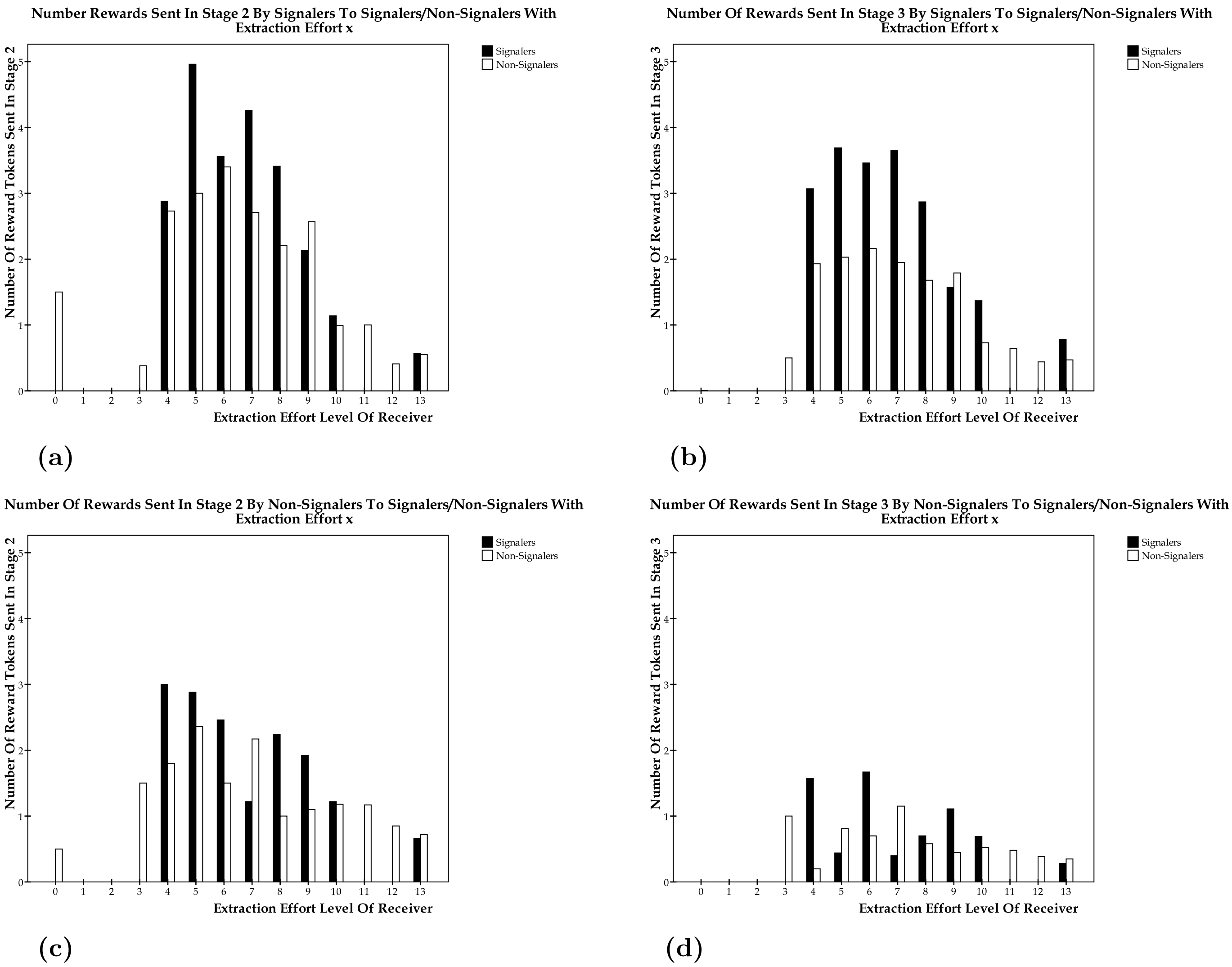


Figure 6 Number of rewards sent by signalers in: **(a)** stage 2 **(b)** stage 3. Number of rewards sent by non-signalers in: **(c)** stage 2 **(d)** stage 3.

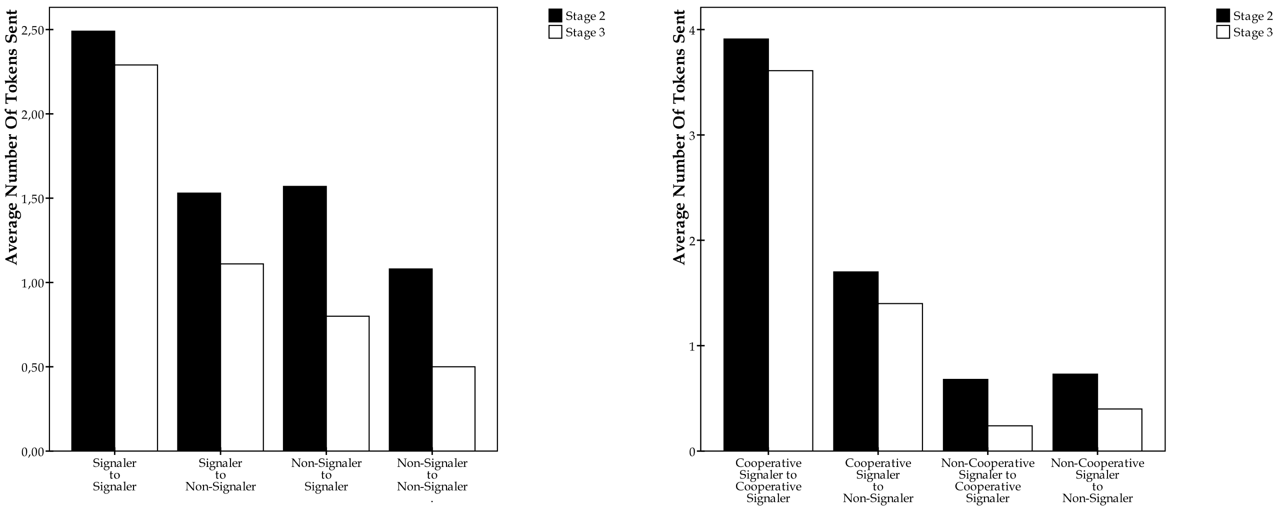
These four panels are revealing. First, there is a clear downward sloping pattern in the number of reward tokens signalers send to other signalers and non-signalers in stage 2 as well as in stage 3, with the number of tokens falling the more effort the recipient puts into CPR extraction. Non-signalers, however, display such behavior in stage 2 when sending reward tokens to signalers, but less so when sending rewards to non-signalers (remember that the bulk of the extraction effort chosen by non-signalers is 10 or higher). And in stage 3 there is hardly any detectable pattern. Therefore, signalers tend to be more willing to provide 'the second-order public good', i.e. to forego private mutually beneficial exchange of reward tokens with free-riders in the CPR stage. And these conclusions are largely confirmed when calculating the Spearman correlation coefficients between rewarding and stage 1 extraction effort of the receiver; see Table 3.[7]

	Stage 2	Stage 3	Stage 2	Stage 3
	Signalers to:		Non-Signalers to:	
Signalers	−0.46	−0.37	−0.47	−0.21
Non-Signalers	−0.48	−0.31	−0.20	−0.10

Table 3 Spearman's correlation coefficient of relation between sending rewards and stage 1 extraction effort levels of the receiver. All coefficients are significant at the 1% level.

Finally, let us have a look at the third element of cooperation, and that is how 'trustworthy' signalers and non-signalers are in positively reciprocating in stage 3 to the number of rewards received in stage 2. Figure 7 shows information on trustworthiness.

[7]To compute the correlation coefficients, each rewarding decision is taken as independent, yielding 3,300 observations in total.



(a) **(b)**

Figure 7 **(a)** The average amount of stage 2 and stage 3 tokens that are sent between subjects of the two types, averaged over all subjects and all periods. **(b)** The average amount of stage 2 and stage 3 tokens that are sent by cooperative signalers (with $x_i \leq 10$) and non-cooperative signalers (with $x_i = 13$) to cooperative signalers and non-signalers.

Again, these panels are revealing. Figure 7(a) shows the average number of reward tokens sent by signalers and non-signalers, distinguishing between the recipients being signalers and non-signalers, in the two stages. Both signalers and non-signalers send more tokens to signalers than to non-signalers, albeit that signalers tend to send more. More interesting though is the drop in the number of tokens sent from stage 3 as compared to stage 2. Whereas the number sent in stage 3 is about half of the number sent in stage 2 in case of non-signalers, the drop is much less pronounced in case for signalers. Here it is important to remember too that our definition of signalers includes not only those subjects that persistently chose a relatively low extraction effort level (18 of the 27 signalers), but also those subjects that chose effort level 13 for twelve periods or more (the other 9 signalers). We find a crucial difference between the two types as the majority of the non-cooperative signalers send, on average, no tokens. When taking out these 9 subjects, the first four columns of Figure 7(a) change dramatically; see Figure 7(b).[8] If we only focus on those signalers that put in 10 tokens or less, we find that they act very cooperatively in the reward stage too. They tend to send an equal number of reward tokens to both signalers and non-signalers in stage 2 and stage 3.

Combined, Figures 5-7 suggest that indeed just adding the second reward stage allows for a full classification of our subject pool into pro-social individuals, strategic money maximizers, and individuals who behave in line with the assumption of 'homo economicus'.

The 18 subjects (= 1/3 of the pool) who are signalers and put in maximally 10 units of effort into CPR extraction are pro-social individuals. They put in less extraction effort than the average subject, they tend to send fewer reward tokens to fellow group members who put more effort into extraction, and they tend to give about the same number of tokens in stage 3 as they did in stage 2.

The 28 subjects (= 1/2 of the pool) who were labeled as non-signalers are strategic money maximizers. They adjust their extraction effort level in stage 1 to maximize their profits, they tend to send their reward tokens to the more cooperative signalers (that is, the ones with the lower extraction effort levels) because they bank on receiving reward tokens in stage 3, while they themselves tend not to send any reward tokens in stage 3.

And the remaining 9 signalers consistently choosing extraction effort level 13 (= 1/6 of our subject pool) are best labeled as 'homo economicus'. Given the lower extraction effort levels chosen by the other signalers level 13 is often the best-response level, and they do not really engage in exchanging reward tokens at all.

Having seen the evidence that some subjects try act pro-socially, the question arises what signals their trustworthiness best; is it their behavior in stage 1, stage 2, or stage 3?. For the remainder of the analysis, the following definition of a successful bilateral relationship is used:

[8] From the non-cooperative signalers, one signaler does exchange reward tokens with another signaler (a finding we have already reported in Figure 4(b)). This subject is omitted from Figure 7(b).

Definition 2 A 'connection' is a bilateral relationship between two subjects, such that both subjects reward each other in both stage 2 and stage 3 for eleven periods or more.[9]

To find out what determines the creation of a connection, a natural candidate seems to be extraction and rewarding effort in the first period. Table 4 gives the average number of reward tokens that a subject has sent and received in period 1 and period 2 to 15. The table divides subjects who are in a connection and subjects who are not.

	Period 16				Period 17–30			
	p_{ij}^2	p_{ij}^3	p_{ji}^2	p_{ji}^3	p_{ij}^2	p_{ij}^3	p_{ji}^2	p_{ji}^3
Connection	8.4	7.7	8.1	7.4	10.0	8.5	9.8	7.7
Non-Connection	3.9	2.3	4.1	2.6	3.9	1.4	4.1	2.0

Table 4 Average rewards sent and received for subjects in a connection and for subjects not in a connection.

The table shows that subjects who are in a connection give and receive substantially more reward tokens than subjects who are not in a connection. This finding is not very surprising, since the purpose of establish a connection is to exchange reward tokens. What is more surprising is that the differences in the number of reward tokens exchanged within connections and outside connections are already visible in the first period. This finding suggests that the first period is crucial for the development of connections.

So what is the key signal on the basis of which subjects decide that they are trustworthy, so that they decide to form a connection? Is it extraction effort, is it stage 2 rewarding behavior or stage 3 rewarding behavior? We test this by estimating the following Probit model:

$$\begin{aligned} y_{ij}^* &= \beta_0 + \beta_1 I(i \text{ and } j \text{ are signalers}) + \beta_2 \left(\frac{x_{i,t=16} + x_{j,t=16}}{2} \right) + \\ &\quad \beta_3 (p_{ij,t=16}^2 + p_{ji,t=16}^2) + \beta_4 (p_{ij,t=16}^3 + p_{ji,t=16}^3) + \varepsilon_{ij}, \end{aligned} \tag{3}$$

[9] Again, the cut-off point of eleven periods seems rather arbitrary. However, robustness checks are performed which have indicated that the main results do not change much.

where

$$y_{ij} = \begin{cases} 1, & \text{if } y^*_{ij} > 0; \\ 0, & \text{otherwise.} \end{cases}$$

In the model, y_{ij} is a dummy variable indicating whether a connection starts in period 2, or not. That means, it has a value of 1 when the connection is established in period 2 and zero otherwise (with the two subjects giving each other tokens in both stage 2 and stage 3 for ten periods or more). The variable $I(i$ and j are signalers) is a dummy variable which has value 1 if the subjects in the connection are signalers, and 0 otherwise. All the other variables are self-expalantory except for the variable $0.5(x_{i,t=16} + x_{j,t=16})$. It is expected that the initial choice of stage 1 extraction effort levels heavily influences the rewarding effort in stage 2 and 3 of period 16, and hence affects the dependent variable directly, or indirectly by affecting stage 2 and stage 3 rewarding. An indirect effect of stage 1 on the dependent variable is however not a problem. This will become a problem when stage 1 simultaneously has a direct effect on the dependent variable. In order to test for this, a measure of the level of stage 1 extraction effort levels is included in the model. The average stage 1 extraction effort level of subject i and j is taken as a proxy.[10]. Table 5 gives the estimation results of the model.

The regression results show that when two subjects are signalers in period 16 to 30, they have a higher probability of forming a connection. This result is intuitive, and supports the idea that subjects signal in order to bilaterally exchange reward tokens. Furthermore, the results indicate that the number of rewards sent in stage 2 of period 16 has no direct significant impact on the development of a connection in future periods. The effects of stage 3 rewarding in period 1 are however significantly positive. The more reward tokens a subject sends to another subject in this stage, the higher the probability that the two subjects will give each other tokens in future periods.

[10]In addition, a number of other measures for the impact of stage 1 are tested as robustness checks (results are not reported). For example, including the maximum and minimum of stage 1 of i and j, or adding the extraction effort levels of both subjects. More or less all the results are qualitatively the same.

Dependent variable: y_{ij}	
$I(i$ and j are signalers)	2.105^{***}
	(0.524)
$(p^2_{ij,t=16} + p^2_{ji,t=16})$	0.090
	(0.141)
$(p^3_{ij,t=16} + p^3_{ji,t=16})$	0.515^{***}
	(0.175)
$(x_{i,t=16} + x_{j,t=16})/2$	0.111
	(0.122)
Intercept	-4.075^{***}
	(1.439)
Pseudo-R^2	0.4887

Table 5 Probit regression results for the existence of a connection between subject i and subject j. In total, there are 11×10 possible connections, which creates 110 observations.

These findings can be interpreted as supporting the following mechanism. Two subjects, who reward each other heavily in stage 3 of the first period, have shown each other that they are trustworthy. Both subjects have an interest in maintaining each other's mutual trust, since receiving reward tokens is lucrative. The only way to recognize the group member with whom it is relatively safe to exchange reward tokens is by his or her stage 1 extraction effort levels, but the true test of his/her trustworthiness is whether he/she defaults in stage 3, yes or no.

5 Conclusion

In the experimental economics literature, a substantial amount of research has been dedicated to exploring the effectiveness of so-called 'decentralized' regulation mechanisms in sustaining cooperation in social dilemma situations. Decentralized mechanisms are those mechanisms where the agents involved try to solve the social dilemma situation themselves rather than by relying on some sort of centralized intervention from, say, a governmental regulatory body. Any situation where there are positive or negative externalities qualifies as a social dilemma, and hence this literature is very relevant to the environmental economics profession. And if self-regulatory instruments are found to be effective in sustaining cooperation, their presence obviates the need for (expensive and sometimes cumbersome) government intervention.

In this chapter we address the issue whether peer-to-peer rewards can reduce aggregate extraction effort in a common pool resource game towards the socially optimal level. Past research has shown that peer-to-peer rewards can indeed improve efficiency in the social dilemma situation if the benefits of receiving a reward are larger than the costs of giving it; see Vyrastekova and van Soest (2008). However, the experiment in their paper was set up such that rewarding cannot become a game in itself; subject identifiers were reshuffled between periods, and there was just one opportunity to simultaneously exchange reward tokens in every period.

When thinking about it, this set-up is artificial at best. While the reshuffling of identities can well be defended on the basis of experimental practice, there are not many instances in the real world in which there is no opportunity for direct reciprocity in rewarding. This can be remedied in the lab by adding a second reward stage to the experiment by Vyrastekova and van Soest (2008). This chapter reports the efficiency consequences of adding such a second reward stage, and the results are not very encouraging. Despite the fact that more rewards are being exchanged in the two-stage setup than in the one-stage setup, efficiency in the social dilemma situation is lower (and about equal to Nash).

That means that rewards may not be effective in sustaining cooperation in social dilemma situations after all. Unless the institutional setting is such that agents cannot positively reciprocate to rewards received from their peers, the possibility to engaging in a privately beneficial exchange of reward activities severs the link between the social dilemma situation and the rewarding activity, and cooperation in the social dilemma situation unravels.

However, the prospect for rewards may not be as bleak as the above analysis suggests. In this chapter we also tried to see to what extent adding this second reward stage facilitates classification of our subject pool into the various behavioral types, such as pro-social individuals, 'homo economicus', and strategic money maximizers. Whereas behavior in the one-stage reward setup is very spurious, there is much more consistency in our subjects' behavior in the two-stage reward setup. Indeed, we find that we can classify one-third of our subjects as pro-social, one half as strategic money maximizers, and one sixth as 'homo economicus'. From an experimental economics point of view this is interesting because it suggests that adding a stage that allows for direct reciprocity helps identify the participants' social orientation, thus facilitating the use of this experimental data in the development of new models that better capture behavior in social dilemma situations than those based on the assumption of all agents being rational and interested exclusively in their own material payoff.

But it also suggests that the extent to which rewards can sustain cooperation in the social dilemma situation crucially depends on the behavioral composition of the group. If a large share of the agents involved in the social dilemma situation have pro-social preferences – and if the amount of effort the non-pro-social agents can put into the social dilemma situation is limited, as is the case in our experiment – efficiency in the social dilemma situation can be higher than Nash. Indeed, the group that achieved the highest efficiency level in the common pool resource stage consisted of 4 subjects that were labeled as pro-social, 1 as strategic money maximizer and 0 were labeled as homo economicus. Whereas the Nash efficiency level is at 66% of the social optimum, the efficiency level achieved by this group was equal to 98% of the social optimum. In contrast, a group with one of the lowest levels of efficiency (42% of the social optimum) consisted of 0 subjects that were labeled as pro-social, 3 as strategic money maximizers and 2 were labeled as homo economicus.

That means that rewards may be able to sustain cooperation in a social dilemma situation after all, but only if the share of pro-social individuals is sufficiently high indeed.

Appendix A: Instructions for the two stages of reward treatment (for referees only)

Introduction:

You will now participate in an experiment on economic decision-making. The experiment will last approximately 1.5 hours. You will be paid after the experiment. No other experiment participant will learn how much you earned. You will be paid 5 Euros for your participation PLUS any additional earnings you will make in the experiment. How much you earn crucially depends on your decisions in the experiment.

During the whole experiment, you are not allowed to talk to other participants. Disobeying this rule results in your exclusion from the experiment. In the experiment, you will participate in three Tasks. You will earn points in each of them. At the end of the experiment, you will be paid for all the points you earned.

The exchange rate is: 100 points = 1 Euro, 1 point = 1 Euro-cent.

Experiment description:

The experiment consists of 15 rounds. In each round, you will be in a group with four other participants; a group therefore consists of five participants in total. Note that you will interact with the same four subjects in all rounds. The other members of your group will be identified by means of identity labels, 'x', 'xx', 'xxx' and 'xxxx'. These labels will remain the same within each round, but they will change between rounds. To give an example, if another group member is labeled 'x' in some round, he/she may be labeled 'xxxx' in the next round. That means that nobody is able to make a connection between another participant's decisions in different rounds.

At the beginning of every round, you receive 13 tokens. You have to decide how to divide these 13 tokens between two options: option 1 and option 2. Observe that you have to divide all your 13 tokens. Therefore if you put X tokens into option 1, you put automatically 13 - X tokens into option 2. In this task, therefore, you will be asked to make one choice: how many tokens you put in option 1. It is then automatic that you put 13 - X tokens in option 2.

Now, we will explain how you earn points for the tokens you put in option 1 and option 2.

Earnings for tokens in option 1: The number of points you earn for the tokens in option 1 depends on how many tokens you put in option 1 and how many tokens the other four group members put in option 1. You receive 9.5 points for every token you put in option 1. You also have to pay costs when using option 1. The costs depend on how many tokens in total all group members (including you) put into option 1: for every token you put into option 1 you have to pay a cost of 0.15 points MULTIPLIED BY the total number of tokens in option 1.

Earnings for tokens in option 2: The number of points you earn for the tokens in option 2 depends only on how many tokens you put in option 2. For every token in option 2 you receive 0.5 points. There are no costs.

Your total earnings in this round are the sum of points you earn in option 1 and 2, that means

9.5*X - 0.15*Y*X +0.5*(13 - X),

where X is the number of tokens you put into option 1, and Y is the total number of tokens that are put into option 1 (that is, by you and the four other group members).

When making your decisions, you can use the above formula, but you van also make use of the table below. The Table contains the number of points you can earn for different combinations of the number of tokens you put in option 1 and the total number of tokens the other four group members put in option 1. Please, have a look at the Table now.

	POINTS EARNED FOR TOKENS IN OPTION I AND OPTION II													
	Total number of tokens put in option 1 by the other FOUR group members													
	0	**4**	**8**	**12**	**16**	**20**	**24**	**28**	**32**	**36**	**40**	**44**	**48**	**52**
0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
1	15.3	14.7	14.1	13.5	12.9	12.3	11.7	11.1	10.5	9.9	9.3	8.7	8.1	7.5
2	23.9	22.7	21.5	20.3	19.1	17.9	16.7	15.5	14.3	13.1	11.9	10.7	9.5	8.3
3	32.1	30.3	28.5	26.7	24.9	23.1	21.3	19.5	17.7	15.9	14.1	12.3	10.5	8.7
4	40.1	37.7	35.3	32.9	30.5	28.1	25.7	23.3	20.9	18.5	16.1	13.7	11.3	8.9
5	47.7	44.7	41.7	38.7	35.7	32.7	29.7	26.7	23.7	20.7	17.7	14.7	11.7	8.7
6	55.1	51.5	47.9	44.3	40.7	37.1	33.5	29.9	26.3	22.7	19.1	15.5	11.9	8.3
7	62.1	57.9	53.7	49.5	45.3	41.1	36.9	32.7	28.5	24.3	20.1	15.9	11.7	7.5
8	68.9	64.1	59.3	54.5	49.7	44.9	40.1	35.3	30.5	25.7	20.9	16.1	11.3	6.5
9	75.3	69.9	64.5	59.1	53.7	48.3	42.9	37.5	32.1	26.7	21.3	15.9	10.5	5.1
10	81.5	75.5	69.5	63.5	57.5	51.5	45.5	39.5	33.5	27.5	21.5	15.5	9.5	3.5
11	87.3	80.7	74.1	67.5	60.9	54.3	47.7	41.1	34.5	27.9	21.3	14.7	8.1	1.5
12	92.9	85.7	78.5	71.3	64.1	56.9	49.7	42.5	35.3	28.1	20.9	13.7	6.5	-0.7
13	98.1	90.3	82.5	74.7	66.9	59.1	51.3	43.5	35.7	27.9	20.1	12.3	4.5	-3.3

In the first column (in grey print), you find all possible numbers of tokens you may put in option 1. You can choose any integer number from 0 to 13, that means numbers 0, 1, ..., 12, 13. In the first row (in grey print), you find the number of tokens the other four participants may (together) put in option 1. Your total payoff in one round depends on the combination of the number of tokens you put in option 1 and the number of tokens the other four participants (in total) put in option 1.

Example: Suppose you put 4 tokens in option 1. In the grey column, find the row that begins with 4 (tokens). And, suppose you think that the other four group members will put in total 12 tokens in option 1. In the grey row, find the column that begins with 12 (tokens). Look in the table for the intersection of the chosen row (4 tokens) and column (12 tokens). You find that if you put 4 tokens in option 1 and the other four members put in total

12 tokens in option 1, your total earnings in this round are 32.9 points.

In the table, observe the following. You can always make sure to earn 6.5 points in any round by putting zero tokens in option 1. You can, however, possibly earn more points if you put some tokens in option 1. How many points you earn, depends crucially on the choices of the other members of your group. If, for example, you put all 13 tokens in option 1, you can earn 98.1 points, if the other group members do not put any tokens in option 1. On the other hand, you can lose 3.3 points, if the other group members do the same as you, and put all their tokens in option 1.

Other group members affect how many points you earn, and you affect how many points the others earn.

Note that in the experiment, you and the other four members of your group will decide on the division of the tokens at the same time. Therefore, at the moment of your decision you do not know how many tokens the other members of your group will put in option 1. You can only guess.

After all group members made their decisions, you will receive information on how many tokens each group member has put in option 1 in this round, and how many points each group member earned.

We will now explain how the computer screens look like.

SCREEN 1

Have a look at Figure "Screen 1". Here you decide how many tokens you put into option 1. Use the keyboard to type in one of the numbers 0, 1, . . . , 12, 13 in the active field, and confirm your choice by pressing OK.

Warning: Before pressing OK, make sure your choice is correct. You cannot change your decision after you have pressed OK.

After having pressed OK, you will be asked to wait until all experiment participants have done the same. The experiment continues only after all experiment participants pressed OK. We therefore kindly ask you not to delay your decision too much. For every decision, a time indication of one minute is shown in the header. After this time expires, you are repeatedly asked to submit your decision, or press the OK button.

After pressing OK, a waiting screen will appear. After all experiment participants have pressed OK, Screen 2 will appear.

Figure 8 Screen 1

SCREEN 2

In the upper part of this screen you find a table with information on how many tokens each group member has put in option 1 in this round, and how many points he/she earned in this round.

Note that information about you is always given in the column denoted "me". Information in the columns denoted "x", "xx", "xxx", and "xxxx" is about the other four group members. In each round, the labels of these four subjects will change. Therefore, for example, subject denoted "x" in some period may be denoted "xxx" or "xx" or "xxxx" in the next period.

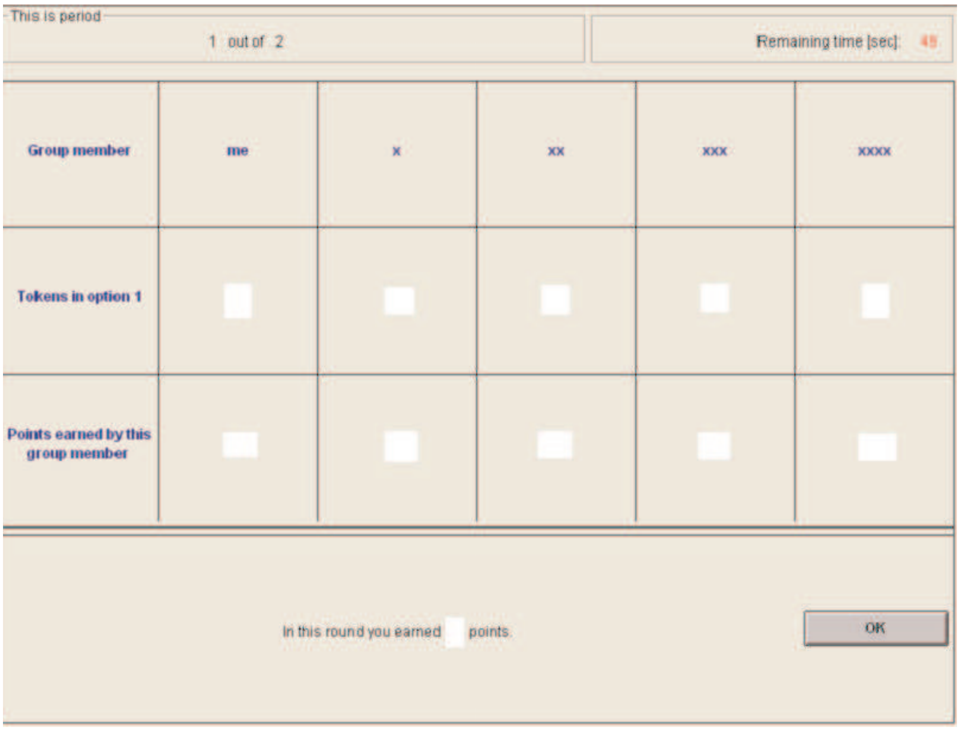


Figure 9 Screen 1

The experiment now starts with a short test to make sure that everybody understands how points are earned. Use your tables to answer the following questions. After all experiment participants answered all questions correctly, the experiment will begin.

TEST QUESTIONS:

Q1. I will be in a group with four other subjects. These will remain the same four subjects for all 15 rounds. [YES/NO]

Q2. When I choose 5 and the other four group members choose 1, 2, 9 and 0, then my payoff will be:… (use table to answer)

Q3. When a group member is denoted "xx" in round 5, then it is certain that this is the same subject as the subject denoted "xx" in round 6. [YES / NO]

Second part of the experiment:

You will now participate in the second and last part of the experiment. It also has 15 rounds. You will be matched with the same four group members as you were before. Again, these other participants remain member of your group in all 15 rounds. In this part of the experiment, however, every round consists of three stages, Stage I, Stage II and Stage III. Stage I of every round is the same as before. That means that you will receive 13 tokens and have to divide them between option 1 and option 2. The payoff table and payments are the same as before. Let us explain Stage II and Stage III.

Stage II:

In Stage II of a round (following immediately Stage I in each round), you will again receive a number of tokens – this time it is 12 tokens. Every token is worth 1 point to you. That means that you basically receive 12 points. You can now choose how many of these tokens to send to each of the other four members of your group. For every token you send to another subject in your group, your earnings will be reduced by 1 point. Every token you send to another subject in your group is worth 3 points to that subject. So, for every token you send to another subject in your group, the earnings of that subject will be increased by 3 points. You can decide to send any number of tokens (from 0,1, 2,..., 11, 12) to any number of other group members (that is, 0, 1, 2, 3, or 4 other group members). The sum of the tokens you send must not exceed 12. Also, you are not allowed to send any tokens to yourself. All five group members make this decision at the same time.

Earning points in Stage II:

The number of points you earn in Stage II of every round is calculated as follows. It is equal to:

- 12 points (for 12 tokens you received at the beginning of the round),
- MINUS as many points as the number of tokens you sent to the other four members of your group,
- PLUS three times the total number of tokens you received from the other four members in your group.

Stage III:

In Stage III of a round (following immediately Stage II in each round), you will again receive 12 tokens. Every token is again worth 1 point to you. You can now choose how many of these tokens to send to each of the other four members of your group. So, for every token you send to another subject in your group, his/her earnings increase by 3 points and your earnings will be reduced by 1 point. You can decide to send any number of tokens (from 0,1, 2,..., 11, 12) to any number of other group members (that is, 0, 1, 2, 3, or 4 other group members). The sum of the tokens you send must not exceed 12. Also, you are not allowed to send any tokens to yourself. All five group members make this decision at the same time.

Earning points in Stage III:

The number of points you earn in Stage III of every round is calculated in the same way as in Stage II. It is equal to:

- 12 points (for 12 tokens you received at the beginning of the round),
- MINUS as many points as the number of tokens you sent to the other four members of your group,
- PLUS three times the total number of tokens you received from the other four members in your group.

Your total earnings in one round of the experiment are:

- The number of points you earned in Stage I, PLUS
- The number of points you earned in Stage II, PLUS
- The number of points you earned in Stage III.

We will now explain how the computer screens look like.

SCREEN 1

This is very similar to the decision screen as in the first part of the experiment:

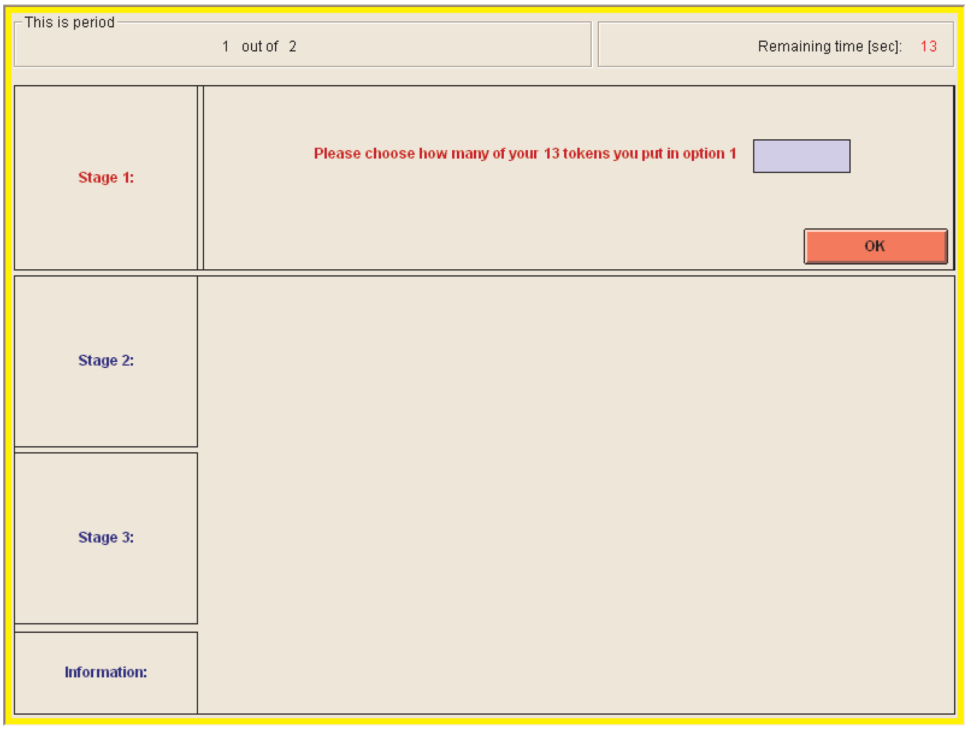


Figure 10 Screen 1a

SCREEN 2

In the upper part of this screen you find a table with information on how many tokens each group member has put in option 1 in this round, and how many points he/she earned in Stage I. Your decision is in the column "me". Decisions of the other four group members are in the columns "x", "xx", "xxx" and xxxx". Remember that these labels remain constant within each round, but that they change between rounds. So 'x' is the same subject in all three stages (Stage I, II and III) of the current round, but label of subject labeled "x" in this round may be different in another round.

In the lower part of the screen, you are asked to make a decision how many tokens from your 12 tokens to send to each of the other four members of your group. For each group member, you have to put in a number; if you do not wish to send tokens to a particular group member, you type in "0". The sum of these four numbers of tokens must not exceed the 12 tokens you received. Press OK, when you are ready to continue. A waiting screen will appear. The experiment continues only after all experiment participants have pressed OK, and therefore we kindly ask you not to delay your decision too much.

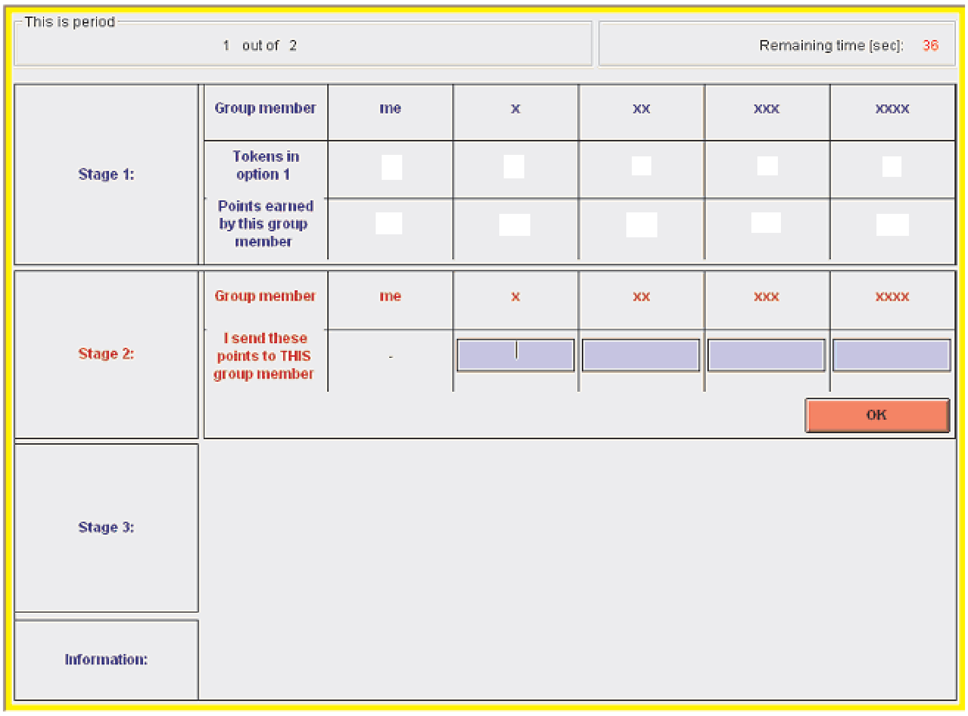


Figure 11 Screen 2a

SCREEN 3

In this screen you find all information about how many tokens each of the other group members sent to you in Stage II. In the lower part of the screen, you are asked to make a decision in Stage III : how many tokens from your 12 tokens in Stage III you want to send to each of the other four group members. For each group member, you have to put in a number; if you do not wish to send tokens to a particular group member, you type in ”0”. The sum of these four numbers of tokens must not exceed the 12 tokens you received. Note that (for example) subject denoted ”x” in Stage I is the same as subject denoted ”x” in Stage II and the same subject in Stage III.

Press OK, when you are ready to continue. A waiting screen will appear. The experiment continues only after all experiment participants have pressed OK, and therefore we kindly ask you not to delay your decision too much.

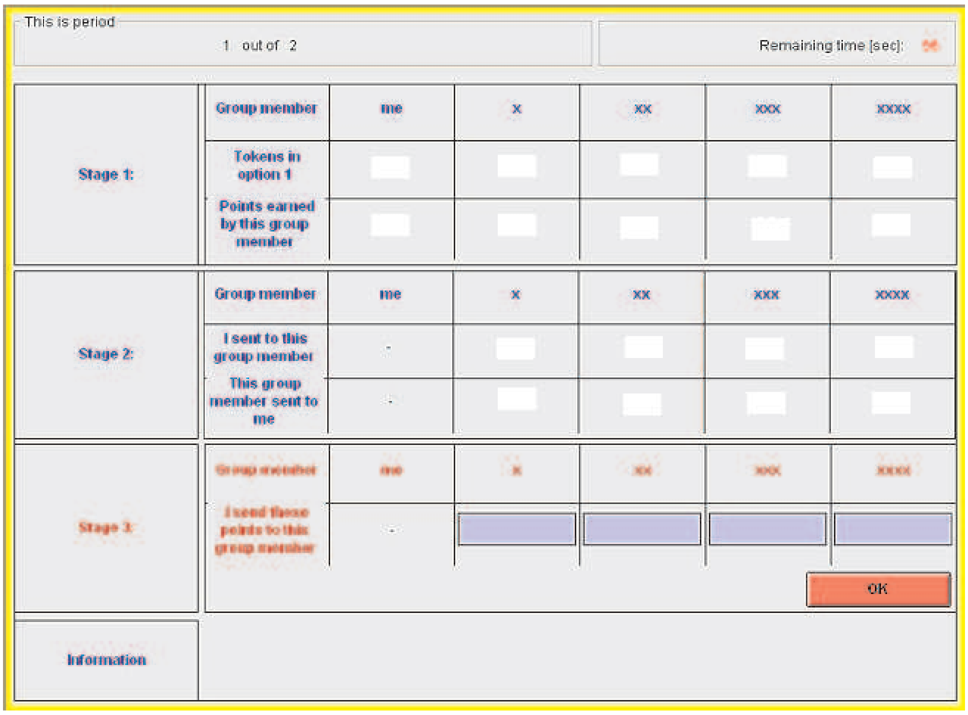


Figure 12 Screen 3a

SCREEN 4

In this screen you find the information about all three stages, and you will also learn your final payoff for this round.

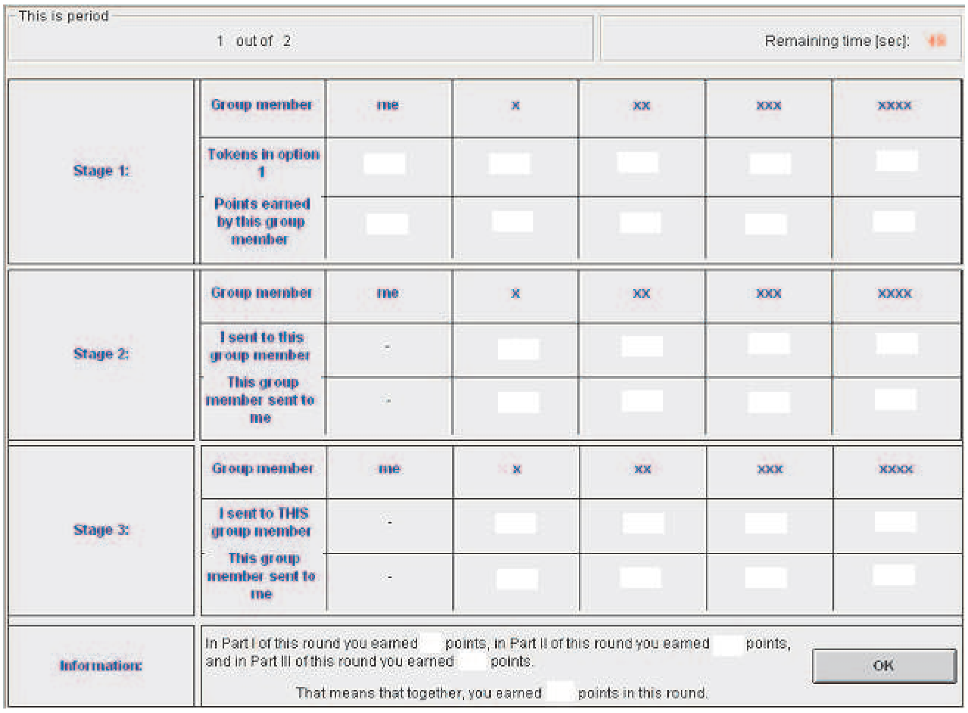


Figure 13 Screen 4a

Please, raise your hand if you have questions at this moment.

The experiment now starts with a short test to make sure that everybody understands how points are earned. Use your tables to answer the following questions. After all experiment participants answered all questions correctly, the experiment will begin.

TEST QUESTIONS:

Q1. I will be in a group with four other subjects. These are the same subjects as in the first part of the experiment. [YES / NO]

Q2. I will be in a group with four other subjects. These subjects will remain the same four subjects for all 15 rounds. [YES / NO]

Q3. Have a look at screen 3. The subject denoted "xxx" in Stage I and in Stage II and in Stage III is the same subject. [YES / NO]

Q4. When a subject is labeled "x" in Stage I of round 3, then it is certain that this is the same subject as the subject labeled "x" in Stage I of round 4. [YES / NO]

References

Denant-Boemont, L., Masclet, D., and Noussair, C. (2007). Punishment, counterpunishment and sanctions in a social dilemma experiment. *Economic Theory*, *33*, 145–167.

Fehr, E. and Gächter, S. (2000). Cooperation and punishment in public goods experiments. *The American Economic Review*, *90*(4), 980–994.

Fischbacher, U. (1999). *z-Tree: Zurich Toolbox for readymade Economic Experiments - Experimenter's Manual.* Institute for Empirical Research in Economics, University of Zurich.

Fischbacher, U., Gächter, S., and Fehr, E. (2001). Are people conditionally cooperative? evidence from a public goods experiment. *Economics Letters*, *71*(3), 397–404.

Hermann, B., Thöni, C., and Gächter, S. (2008). Antisocial punishment across societies. *Science*, *319*, 1362–1367.

Liebrand, W. (1984). The effect of social motives, communication and group size on behaviour in an n-person multi stage mixed motive game. *European Journal of Social Psychology*, *14*, 239–264.

Masclet, D. (2003). Ostracism in work teams: A public good experiment. *International Journal of Manpower*, *24*(7), 867–887.

Masclet, D., Noussair, C., Tucker, S., and Villeval, M. (2003). Monetary and nonmonetary punishment in the voluntary contributions mechanism. *The American Economic Review, Vol. 93, No. 1. (Mar., 2003), pp. 366-380.*, *93*(1), 366–380.

Nikiforakis, N. (2008). Punishment and counterpunishment in public goods games: Can we govern ourselves? *Journal of Public Economics*, *92*, 91–112.

Offerman, T., Sonnemans, J., and Schram, A. (1996). Value orientations, expectations and voluntary contributions in public goods. *The Economic Journal*, *106*(437), 817–845.

Ostrom, E., Walker, J., and Gardner, R. (1992). Covenants with and without a sword: Self governance is possible. *American Political Science Review*, *86*(2), 404–417.

Sefton, M., Shupp, R., and Walker, J. (2007). The effects of rewards and sanctions in provision of public goods. *Economic Inquiry*, *45*(4), 671–690.

van Soest, D. and Vyrastekova, J. (2004). Economic ties and social dilemmas. *CentER Discussion Paper 2004–55, Tilburg.*

van Soest, D. and Vyrastekova, J. (2006). *Peer Enforcement in CPR Experiments: The Relative Effectiveness of Sanctions and Transfer Rewards, and the Role of Behavioral Types*, chapter 6, (pp. 113–136). Cheltenham: Edward Elgar.

Vyrastekova, J. and van Soest, D. (2008). On the (in)effectiveness of rewards in sustaining cooperation. *Experimental Economics*, *Forthcoming.*