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**Working Paper**

## The effect of signalling and beliefs on the voluntary provision of public goods

Dresden Discussion Paper Series in Economics, No. 10/03

**Provided in Cooperation with:**

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*Suggested Citation:* Berlemann, Michael (2003) : The effect of signalling and beliefs on the voluntary provision of public goods, Dresden Discussion Paper Series in Economics, No. 10/03, Technische Universität Dresden, Fakultät Wirtschaftswissenschaften, Dresden

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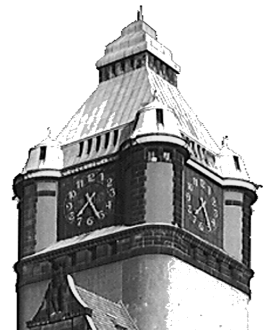
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*Dresden Discussion Paper Series  
in Economics*



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**The Effect of Signalling and Beliefs  
on the Voluntary Provision of Public Goods**  
**Some Experimental Evidence**

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*Dresden Discussion Paper in Economics No. 10/03*

ISSN 0945-4829

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An electronic version of the paper may be downloaded from the homepage:

<http://rcswww.urz.tu-dresden.de/wpeconomics/index.htm>

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# The Effect of Signalling and Beliefs on the Voluntary Provision of Public Goods Some Experimental Evidence

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Abstract:

We report and analyze the results of a series of classroom experiments on the voluntary provision of public goods. Using fixed effect panel regression models we find that cooperation significantly increases when participants are forced to guess the degree of overall cooperation. We also find that the possibility to make announcements during the experiment enhances cooperation significantly although these commitments are not binding and heavily used for cheating purposes. We suggest that this effect is due to attempts at restoring the announcements' reputation in the aftermath of heavy cheating.

JEL-Classification: C91, D74, D84

Keywords: Experimental Economics, Public Goods, Cheap Talk, Signalling, Communication, Expectations

The experiments reported in this paper were planned, organized and conducted with the help of the participants of an undergraduate class on experimental economics at Dresden University of Technology. I am grateful to the participants of this class Peter Benes, Matthias Ehnert, Markus Fucik, Ronald Herzberg, Christian Kölbl, Hartmut Kunz, Anne Mehnert, James Pustejovski, Kirstin Schoelzel, Jörg Thomä, and Lars Weinhold for their great enthusiasm in conducting the experiments.

# 1 Introduction

A pure public good is characterized by non-rivalry in consumption and the impossibility or inefficiency of excluding others from its consumption, once it has been supplied. Standard public finance theory suggests that, due to the non-excludability property, a pure public good will not be privately supplied since it is rational to make use of the free-rider option. The correction of this sort of market failure is one of the basic normative justifications for government activity. However, some doubts have been raised in how far the supply of public goods by the government is an optimal solution. It is well known that bureaucracies are subject to x-inefficiencies. Besides, it is far from being easy to uncover the public's preferences on the optimal supply of public goods. Even if various methods of revealing the public's preferences have been proposed and discussed, most of them are quite complicated to implement in practice.

When experimental economics started to evolve in the early 1980's the standard theory of public goods got subject to experimental studies, soon. Early studies on public good experiments found that people exhibit significant patterns of cooperative behaviour thereby contradicting standard theory. This initiated extensive research on the determinants of cooperation in public good experiments, which is partly theoretical and partly experimental in nature. Several motives for cooperation have been proposed and discussed.<sup>1</sup>

In the light of the experimental results the question is raised in how far the pessimistic view of standard theory according to which public goods will not be supplied on a private basis, holds true. Considerable attempts have been made to investigate by which means cooperation can

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<sup>1</sup> Among the motives that have been discussed are different forms of altruism (Andreoni (1993), Andreoni and Miller (1995)), the relative payoff position of individuals (Fehr and Schmidt (1999), Bolton and Ockenfels (2000)), cooperative gain seeking (Brandts and Schram (1996)) and different forms of reciprocity (Rabin (1993), Falk and Fischbacher (2000)).

be enhanced (for a survey see Ledyard (1995)). This paper aims at contributing to these efforts.

We report the results of a series of classroom experiments on public goods run at Dresden University of Technology in spring 2002. On the one hand we analyze in how far individual expectations of cooperative behaviour of other participants determine individual and collective cooperative behaviour. Our results indicate that one motive guiding individual behaviour is reciprocity and that the advice to make guesses at others' behaviour itself increases cooperation. On the other hand we study cooperative behaviour under a strictly limited form of communication during the experiment. Our results indicate that cooperative behaviour can be increased by introducing a non-binding signalling mechanism. Interestingly enough this holds true although the signalling mechanism is often used for cheating purposes.

## **2 Basic design of the experiments**

As indicated earlier, we report results from 6 classroom experiments run at Dresden University of Technology in spring 2002. The total number of participants was 30, most of which were undergraduate students of economics. None of the participants had taken part in an economic experiment before. Participants were randomly assigned to 6 groups of 5. In each single session 5 participants played a public good game over 10 rounds. Altogether we ran 3 different treatments with one repetition per treatment.

Upon arrival, the participants were placed at different desks in one room without the possibility to observe the others' actions. Any form of communication during the experimental session was made impossible. At the beginning of the session each participant obtained a written instruction. All participants were asked to read through the instructions carefully. Afterwards, each participant had the possibility to ask questions. These were

answered privately by the experimenter. During the experiment no additional questions were answered.

The experiment was not computerized. Whenever the participants had to act, for instance when reveal their strategies for a certain round, they had to fill out prepared forms which were collected by the experimenter after completion. The participants also had the possibility of writing down the history of the game for their own information. The participants were paid directly after the sessions in cash. The average payoff was 6.08 Euro (more detailed information on the payoffs are given in table 1). No session lasted longer than 30 minutes.

	Treatment 1	Treatment 2	Treatment 3	All treatments
Average payoff	5.39	5.86	6.98	6.08
Minimum payoff	3.66	4.98	5.50	3.66
Maximum payoff	6.26	7.26	9.64	9.64
Standard deviation	0.77	0.73	1,23	1.13

**Table 1: Payoffs**

The basic setup of all treatments was as follows: in each of the ten rounds the participants obtained an endowment of 10 tokens that could be either invested in a private or a public good. Each token invested in the private good yielded a private payoff of 4 Cent. Each token invested in the public good led to a payoff of 2 Cent for all 5 participants involved in the session. Thus, the individual payoff of participant  $i$  in round  $r$  was

$$P_{i,r} = x_{i,r}^{\text{priv}} \cdot 0.04 + \sum_{j=1}^5 x_{j,r}^{\text{pub}} \cdot 0.02, \quad x_{i,r}^{\text{priv}} + x_{i,r}^{\text{pub}} = 10$$

with  $x_{i,r}^{\text{priv}}$  and  $x_{i,r}^{\text{pub}}$  being the tokens participant  $i$  invested in the private respectively the public good. This payoff structure ensures that free-riding, i.e.  $x_{i,r}^{\text{pub}} = 0$  for all  $r$ , is the

unique subgame perfect Nash equilibrium of the game. However, the Nash equilibrium leads to a Pareto-inferior payoff structure<sup>2</sup> since all participants would be better off when investing all tokens in the public good in every single round.<sup>3</sup>

### **3 The standard experiment as reference scenario**

In his survey of the evidence of standard public goods experiments Ledyard (1995:121) reports some stylized facts on players' behaviour. Two of the most important findings are that:

- In one-shot as well as in the first rounds of finitely repeated public good experiments participants tend to invest more than the individually optimal but less than Pareto-efficient in the public good.
- Contributions to the public good decline in the course of repeated games. Often the investments into the public good decline sharply in the last round of the experiment ("last round effect"). Even in the last round the investments in the public good are significantly different from zero.

Treatment 1, which reproduces the standard public good experiment, is intended to serve as a reference scenario. In order to be suitable in this respect the two sessions of treatment 1 should coincide with these stylized facts.

Figure 1 illustrates the development of aggregate investments in the public good in the two sessions of treatment 1. In both sessions there is a significant amount of cooperation. However, the degree of cooperation varies: participants in session 1 turned out to be more cooperative than those in session 2. Moreover, contributions to the public good seem to

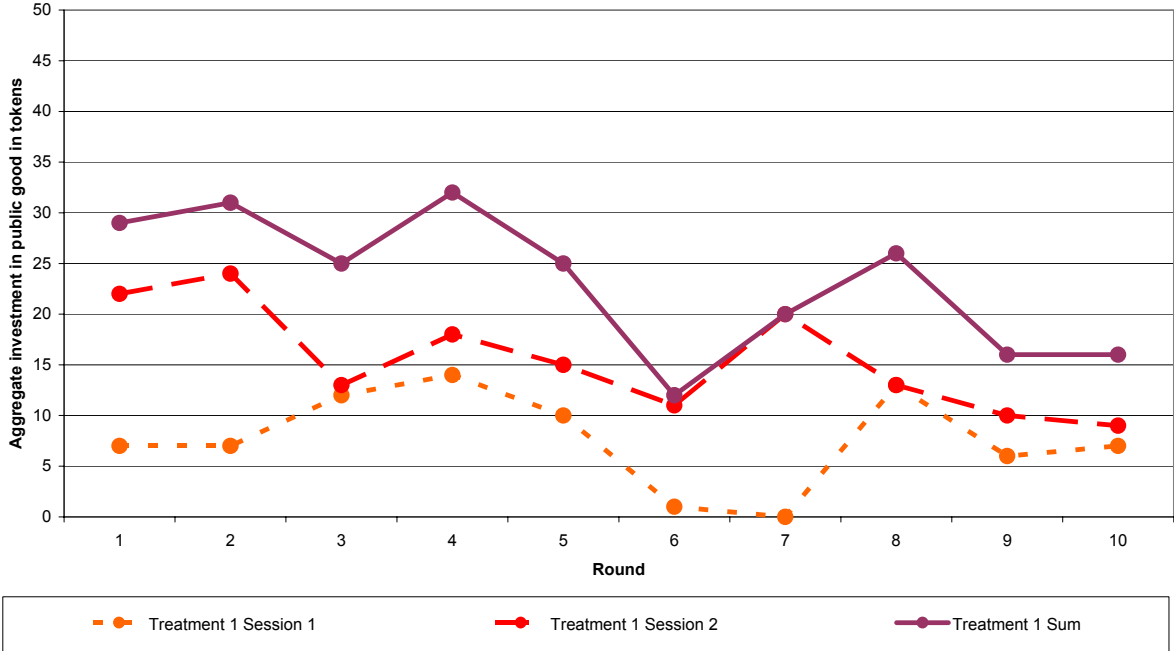
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<sup>2</sup> Given that all players behaved like free-riders during the experiment the individual payoff for every participant would have been 4 Euro.

<sup>3</sup> In that case the individual payoffs would have been 10 Euros.



decrease over time, even if this effect is again much more pronounced in session 1 than in session 2.



**Figure 1: Aggregate investments in public good in treatment 1**

However, in order to detect regularities in the data and study individual investment behaviour we have to apply appropriate empirical methods. Aggregating individual behaviour like in figure 1 has the advantage that common trends are easier to detect when not applying formal econometric or statistical methods. However, aggregation of individual behaviour is obviously inappropriate when studying individual investment behaviour. Since we focus on individual investment behaviour in this paper we use panel regression methods to evaluate the data from our experiments. Most theories trying to explain cooperative behaviour postulate the existence of different types of individuals (Brosig (2002): 276). It is thus highly questionable whether panel regressions with common intercepts are appropriate to make inferences on individual behaviour. These regressions typically have low explanatory power.<sup>4</sup>

<sup>4</sup> See e.g. the study by Wilson and Sell (1997).

We therefore apply fixed effects models to the data allowing for an individual intercept for every single player rather than a common intercept.<sup>5</sup>

In order to test for a round trend in the data we run the following fixed effects panel regression (OLS method):

$$x_{i,r}^{\text{pub}} = \alpha_i + \beta \cdot r + \varepsilon_{i,r}.$$

The results, which are reported in table 2, indicate a significant round trend in treatment 1. Thus, the participants in treatment 1 significantly decreased their investment in the public good in the course of the game.

B	-0.16
T-value	-2.05
Significance	p < 0.05
r <sup>2</sup>	0.38

**Table 2: Round trend in treatment 1**

We also tested for a last round effect by comparing the investments in round 10 with the investments in the rounds before. Since investments in treatment 1 turned out to be not normally distributed<sup>6</sup> non-parametric methods have to be applied to test for a last round effect. While the average investment in round 10 was 0.8 smaller than the average investments in rounds 1-9 (1.6 and 2.4) a Mann-Whitney rank-sum-test reveals that this difference is insignificant at the 90-percent-confidence level.<sup>7</sup>

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<sup>5</sup> Due to our relatively scarce number of observations per treatment we do not run random effects models like it is done e.g. in Neugebauer and Perote (2002).

<sup>6</sup> A Kolmogorov-Smirnov-test reveals that the hypothesis of normally distributed individual investments has to be rejected for all three treatments. Compare table A2 in the appendix for test-details.

<sup>7</sup> The statistics for tests on last round effects are provided in table A1 in the appendix.

All in all, we think that treatment 1 reproduces the stylized facts of standard public good experiments mentioned earlier quite well. Thus, usage of the results of treatment 1 as reference scenario seems to be appropriate.

### 4 Expectations on cooperative behaviour

In treatment 2 we changed the design of the standard experiment (treatment 1) only slightly. All participants were asked in every single round to guess how many tokens the group would invest into the public good before they had to decide on their own investment. However, the results of the individual guesses were neither communicated among the participants nor had it an influence on the participants' payoffs.<sup>8</sup> We should therefore expect that the incentives and behaviour of the participants were not influenced by the slightly different institutional design.

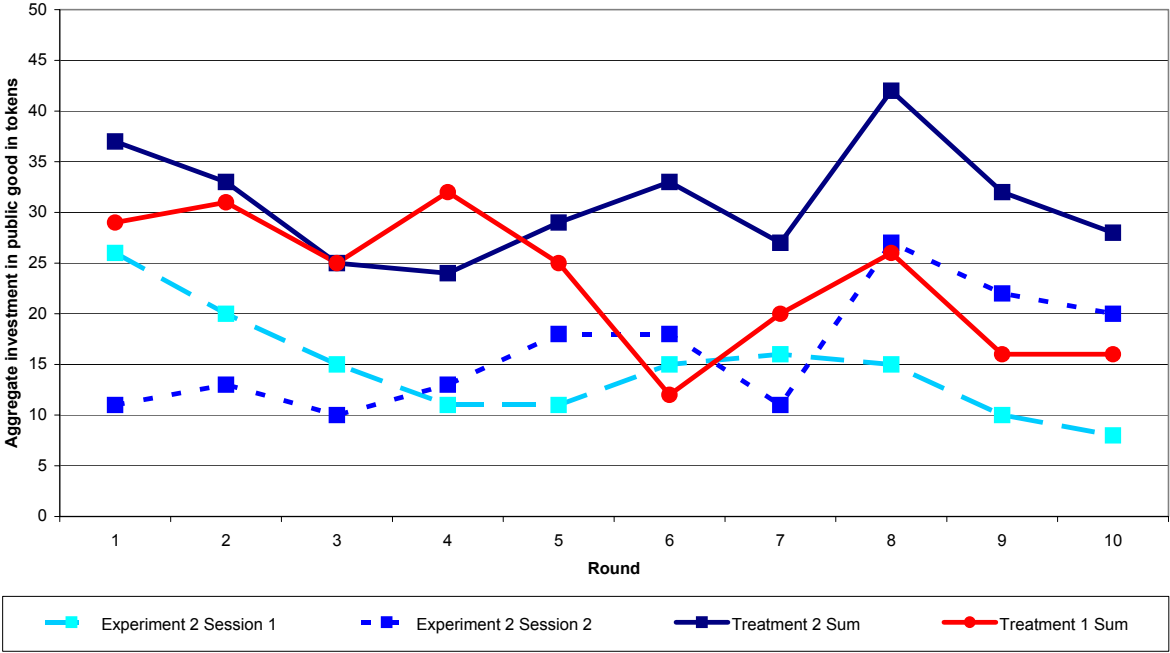


Figure 2: Aggregate investments in public good in treatment 2

<sup>8</sup> In some studies participants were paid according to the accuracy of their guesses (see e.g. Neugebauer and Perote (2002)).

Figure 2 illustrates the development of investments in the public good in the two sessions of treatment 2. Again, in both sessions the participants showed a considerable degree of cooperation. While aggregate investments in the public good seem to display a tendency towards decreasing in session 1, the opposite is true for session 2. When adding the investments of both groups any trend seems to diminish. In order to test for a round trend we again run a fixed effects panel regression. The results presented in table 3 indicate that there is no round trend in treatment 2. Thus, we find a contradiction to the standard public good experiment in which decreasing degrees of cooperation during experimental sessions have been observed. While the average contribution in the last round (2.80) is smaller than the average investment the 9 rounds before (3.13), we again find this last-round effect to be insignificant at the 90-percent-confidence-level using a Mann-Whitney rank-sum-test.<sup>9</sup>

$\beta$	0.006
T-value	0.08
Significance	$p > 0.10$
$r^2$	0.41

**Table 3: Round trend in treatment 2**

In addition, the participants in treatment 2 seem to show a generally higher level of cooperation, especially during the last 5 rounds of the game. While the average contribution to the public good in treatment 1 was 2.32, the participants in treatment 2 invested on average 3.10 tokens in the public good. A Mann-Whitney rank-sum-test reveals that the observed difference in investments is significant at the 95-percent-confidence-level.<sup>10</sup>

Both empirical findings are somewhat surprising, since both treatments differ only in one respect: the participants were asked to guess how much the members of the group would

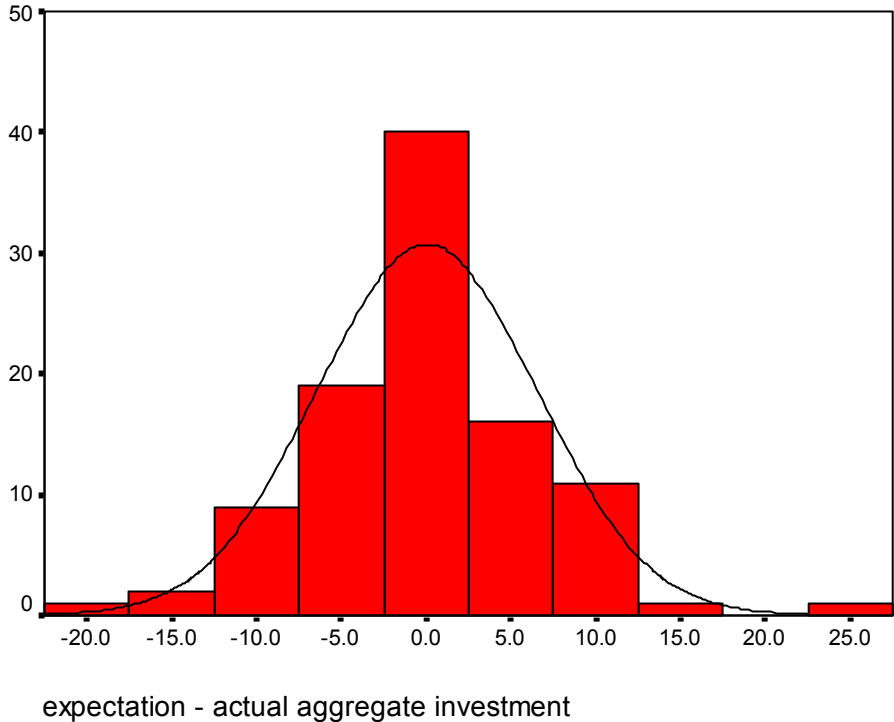
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<sup>9</sup> For detailed results see table A1 in the appendix.

<sup>10</sup> The complete test statistics are reported in table A3 in the appendix.

contribute to the public good before they had to make their investment decisions. Since the accuracy of individual guesses had no influence on the payoff, the incentive structure should be the same as in treatment 1 and thus should not induce different behaviour. However, the data suggests that the simple advice to guess how much the other participants will invest in the public good increases cooperative behaviour.

In order to learn something about participants' predictive abilities we analyze the accuracy of their guesses of the group's cooperative behaviour. In figure 3 we show the empirical distribution of participants' expectation errors. A Kolmogorov-Smirnov-test reveals that expectation errors are normally distributed ( $\mu=0.04$ ,  $\sigma=6.48$ ). Using a t-test we have to reject the hypothesis that the mean of the empirical distribution is different from zero ( $t=-0.062$ ). On average, the participants made an expectation error of 4.7 tokens.



**Figure 3: Empirical distribution of expectation errors in treatment 2**

Earlier experimental studies often found that comparatively cooperative participants expect significantly more cooperation than defectors (Ledyard (1995):163). This might happen as the

result of a false consensus effect, stating that there is a tendency to overestimate one's individual beliefs to be representative of the population.<sup>11</sup> We tested for this hypothesis by analyzing the correlation between the average investment in the public good  $\bar{x}_i^{\text{pub}}$  (as a proxy for cooperativeness) and average expected cooperation  $\bar{g}_i$  respectively the average expectation error  $\bar{e}_i$  per participant (compare table 4). The correlation coefficients are both positive, considerably above 0.5 and significant at a 95-percent-confidence level. Hence, the hypothesis cannot be rejected.

Variables	Correlation coefficient (Pearson)	Significance (double sided)
$\bar{x}_i^{\text{pub}}, \bar{e}_i$	0.671	p<0.05
$\bar{x}_i^{\text{pub}}, \bar{g}_i$	0.714	p<0.05

**Table 4: Cooperativeness and expectations**

According to Frank (1987) cooperative individuals should be able to be generally better at predicting the cooperativeness of others than non-cooperative ones. He argues that the costs resulting from developing the ability to scrutinize others are born only by those individuals, who might profit from that, i.e. cooperative participants. Again we try to verify this hypothesis via a correlation analysis. However, while we find cooperativeness, again measured by average contributions to the public good, to be negatively correlated to the sum of absolute errors (SAE) and to the sum of squared errors (SSE), the correlation coefficients are quite low and insignificant (compare table 5). We thus have to reject the hypothesis that cooperative individuals are better in predicting the group's cooperative behaviour than non-cooperative ones.

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<sup>11</sup> See e.g. Forsythe et al. (1992), pp. 1154-1156.

Variables	Correlation coefficient (Pearson)	Significance (double sided)
$\bar{x}_i^{\text{pub}}$ , SAE	-0.142	p>0.10
$\bar{x}_i^{\text{pub}}$ , SSE	-0.235	p>0.10

**Table 5: Cooperativeness and accuracy of expectations**

A possible explanation for the generally increased level of cooperation in treatment 2 (in comparison with treatment 1) might be that the need of revealing a formal prediction of others' behaviour induced the participants to care more about others' strategies. In this case we should be able to detect a systematic relation between individual behaviour and guesses. A reasonable hypothesis might be that individual willingness to cooperate is positively correlated to the expected cooperative behaviour of other participants as measured by individual guesses of the groups' contributions (see e.g. Croson (1998) or Neugebauer and Perote (2002)). An acceptance of this hypothesis indicates some form of reciprocal behaviour among participants. To test for this hypothesis we run the following fixed effects panel regression:

$$x_{i,r}^{\text{pub}} = \alpha_i + \gamma \cdot \frac{g_{i,r}}{5} + \varepsilon_{i,r},$$

with  $g_{i,r}$  being participant  $i$ 's guess of the group's aggregate investment in the public good in round  $r$ . The regression results are reported in table 6. The results indicate that individual investments are in fact driven by reciprocity, measured by the expected average group investment, thereby corroborating the findings of Croson (1998) and Neugebauer and Perote (2002).

$\gamma$	0.897
T-value	6.91
Significance	$p < 0.01$
$r^2$	0.613

**Table 6: Individual investments and expectations**

One might also expect that participants' willingness to cooperate is related to the accuracy of their guesses regarding other participants' cooperative behaviour. To test for this hypothesis we run an additional fixed effects panel regression of the form:

$$x_{i,r}^{\text{pub}} = \alpha_i + \gamma \cdot \frac{g_{i,r}}{5} + \lambda \cdot \left( g_{i,r-1} - \sum_{j=1}^5 x_{j,r-1}^{\text{pub}} \right) + \varepsilon_{i,r}.$$

Since the accuracy of individual guesses can be judged not before the round is finished, the judgement error enters the regression equation with a one-round lag.

$\gamma$	0.98
T-value	5.95
Significance	$p < 0.01$
$\lambda$	0.10
T-value	3.46
Significance	$p < 0.01$
$r^2$	0.638

**Table 7: Individual investments, expectations and expectation errors**

The results reported in table 7 show that lagged individual prediction errors are positively correlated to individual investments in the public good. An F-Test shows that the predictive power of the latter model is significantly improved by the inclusion of individual prediction errors ( $F^{\text{crit}}=6.93$ ,  $F=20.21$ ). Thus, the participants reacted to a surprisingly low level of



cooperation by increasing individual contributions to the public good. Whenever the participants observed surprisingly high levels of cooperation they tended to decrease their contributions.

## **5 Signalling**

Evolutionary game theorists have recently argued that cooperative behaviour can hardly survive in repeated games when there is no information on the opponents or their behaviour. However, if there are possibilities of signalling, cooperative strategies might survive the contest of strategies (Amann and Yang (1998)).

A lot of research has been done on the effect of communication on cooperative behaviour in public good experiments. Yet it is still not well-understood.<sup>12</sup> In the experiments conducted by Isaak, McCue and Plott (1985), Isaak and Walker (1988) and Brosig, Ockenfels and Weimann (2002) pre-experimental communication increased cooperative behaviour – at least if participants were permitted to talk about the game explicitly. Brosig, Ockenfels and Weimann (2002) recently showed that the success of coordination efforts significantly depends on communication media. Wilson and Sell (1997) studied the effect of a certain type of signalling mechanism. In every round the participants who had no visual contact during the experiment, were asked to make non-binding announcements on their contribution to the public good. Before the final investment decision had to be made all individual announcements as well as the average announcement were communicated to the participants. After the investment decisions had been made, the participants were told in how far other participants stuck to their announcements. While the participants had no direct possibility of communicating, they could use the announcements as signalling devices of cooperative behaviour. Wilson and Sell (1997) observed that the overall degree of cooperation increased

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<sup>12</sup> Brosig, Ockenfels and Weimann (2002), p. 1.

in comparison to the case in which no signalling mechanism was available; yet the trend of diminishing cooperation over time did not diminish. The observation that the participants often used the signalling mechanism to overstate their cooperative behaviour (in 53.4 percent of all cases the participants announced to invest more in the public good than they actually did) made them believe that the signalling mechanism was primarily used for cheating purposes and prevented an even larger degree of cooperation.

Our treatment 3 partially mimics the setting of Wilson and Sell (1997). As in their setting participants in treatment 3 were asked to announce how much tokens they were willing to invest in the next round of the experiment before they had to make their investment decision. However, only the aggregate of announcements was communicated to the participants. Also different from Wilson and Sell (1997), the participants in treatment 3 had no information on individual investment decisions.<sup>13</sup>

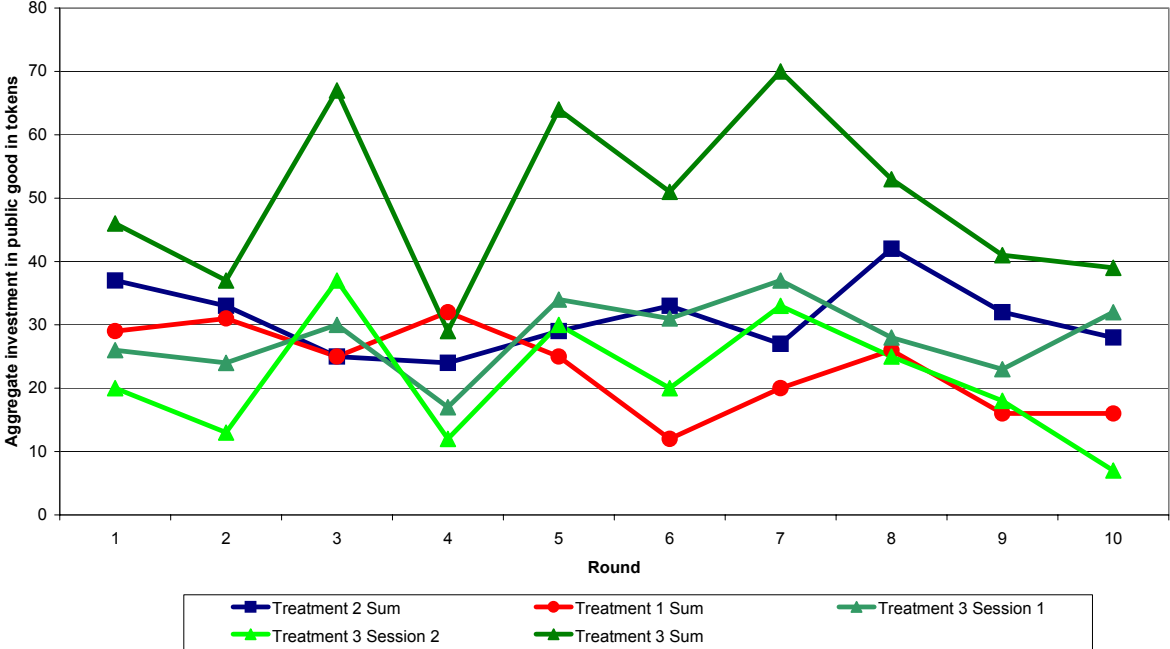
While game theory predicts that a non-binding announcement in a finitely repeated game is nothing else but “cheap talk” and should therefore have no influence on the participants’ behaviour, social psychology is more optimistic in this respect (see Wilson and Sell (1997), Orbell, van de Kragt and Dawes (1990) or Majewski and Fricks (1995)). The basic line of argument is that the possibility of monitoring the honesty of announcements will urge the actors to match their signals. Thus, signals of cooperation will be reinforced and should induce more contributions to the public good.

Figure 4 illustrates the development of investments in the public good in the two sessions of treatment 3. As in treatments 1 and 2, in both sessions of treatment 3 the participants show a considerable degree of cooperation. The average contribution to the public good in treatment

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<sup>13</sup> There is a number of additional differences between the institutional setting in Wilson and Sell (1997) and treatment 3. The settings differ in aspects like the number of repetitions (18/10), organization (computerized/manual) and marginal per capita returns.

3 is 4.97 tokens. Thus, the participants on average contributed almost half of their endowments to the public good.



**Figure 4: Aggregate investments in public good in treatment 3**

Figure 4 suggests that the participants in treatment 3 were more cooperative than those in treatments 1 and 2. Using a Mann-Whitney rank-sum-test, the hypotheses that the average contribution to the public good was highest in treatment 3 can not be rejected at a 99-percent-confidence-level (see table 8). This basic finding is in line with Wilson’s and Sell’s (1997) results.

	treatment 1 (T1)	treatment 2 (T2)	treatment 3 (T3)
Mean	2.32	3.10	4.97
significance mean(T3)>(T1)	p < 0.01		
significance mean(T3)>(T2)	p < 0.01		

**Table 8: Average contribution to public good in treatment 3**

However, our results differ considerably from Wilson’s and Sell’s (1997) with respect to the observed pattern of cooperation during the experiment. While aggregate investment patterns in the two sessions of treatment 3 are quite similar they show no general round trend, although cooperative behaviour decreased throughout the last three rounds. Again we apply a formal test by running a fixed effects panel regression. The results, which are reported in table 9, indicate that there is no significant round trend. As in treatments 1 and 2 we find the average investment in the last round (3.90) to be smaller than the average investment in the 9 rounds before (5.09); however a Mann-Whitney rank-sum-test reveals that this difference is insignificant at the 90-percent-confidence level.<sup>14</sup>

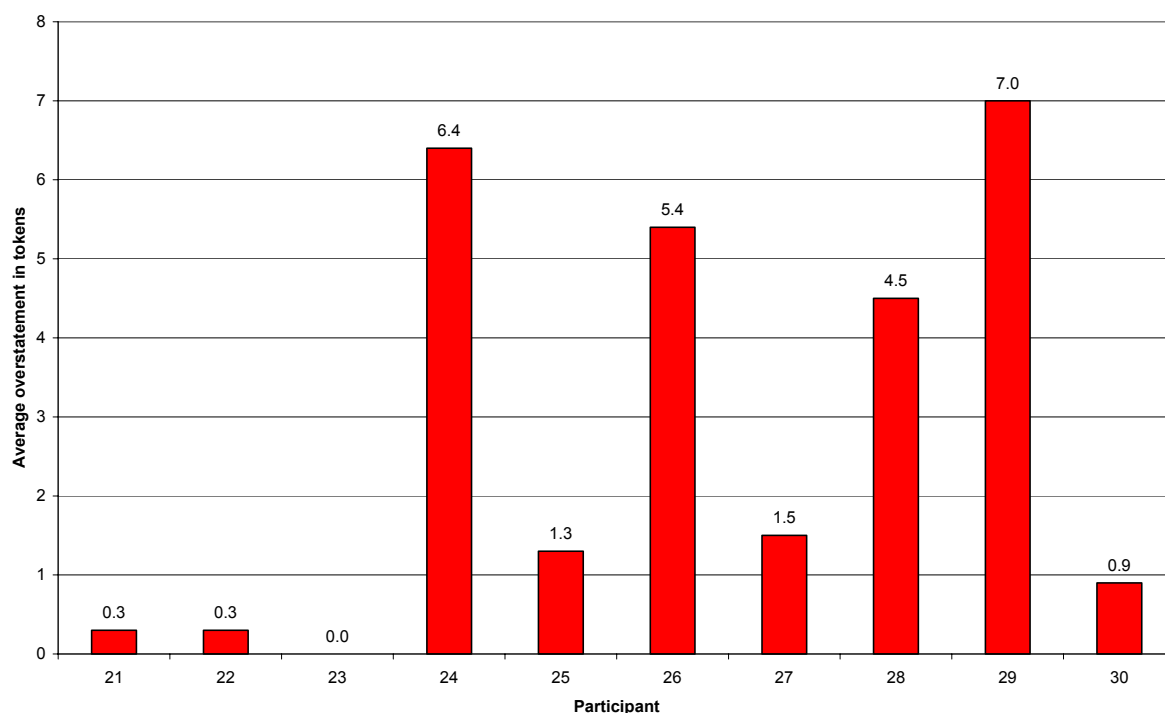
$\beta$	0.003
T-value	0.03
Significance	$p > 0.10$
$r^2$	0.49

**Table 9: Round trend in treatment 3**

Altogether we conclude that although the announcements of the participants were not binding they enabled some form of communication among the participants and contributed to a significant increase in cooperation. While there was no possibility for the participants to check in how far individuals cheated by not fulfilling their announcements (different from the setting in Wilson and Sell (1997)), the overall degree of honesty was revealed after every round. As in Wilson and Sell (1997) the participants often used the possibility to make non-binding announcements to cheat other participants. On average, the participants overstated their true investment in the public good by 2.76 tokens. As figure 5 reveals, the participants differed considerable in their treatment of the possibility of cheating.

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<sup>14</sup> The details are reported in table A1 in the appendix.



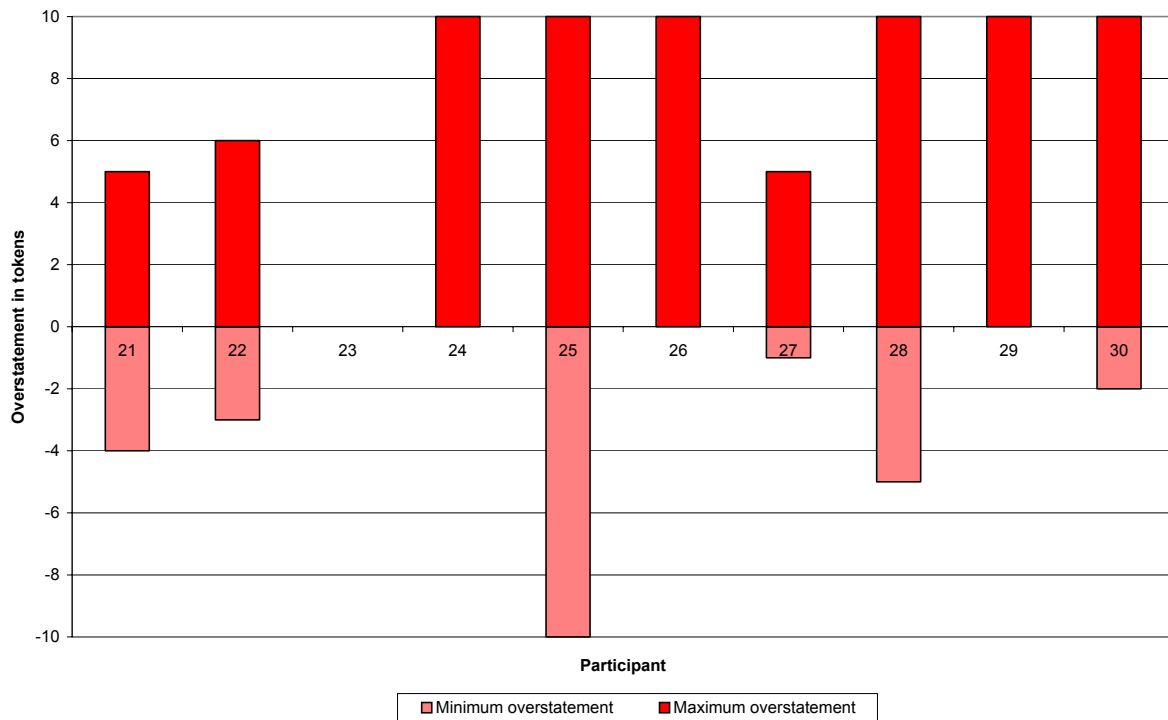
**Figure 5: Overstatement of investment in public good per participant**

Disaggregated data is presented in table 10 and figure 6. Only one out of 10 participants stuck to his announcements in all of the ten rounds. All others made use of the cheating option at least twice. However, none of the participants cheated in every round. Altogether, in slightly more than half of all cases (51 percent) the announcements turned out to be overstated. In one third of the observations the participants fulfilled their announcements. However, the observation could be made that there is a considerable number of observations of participants investing more in the public good than previously announced (16 percent).<sup>15</sup>

<sup>15</sup> Interestingly enough, these numbers match the findings of Wilson and Sell (1997) quite good. They report a share of 53.4% overstatements and 27.8% of honest announcements.

Participant	Overstatement	Honest statement	Understatement
21	5	1	4
22	3	3	4
23	0	10	0
24	8	2	0
25	5	3	2
26	9	1	0
27	6	2	2
28	6	3	1
29	7	3	0
30	2	5	3
All	51	33	16

**Table 10: Announced and factual investments in public good**



**Figure 6: Range of over- and understatements**

Although the participants cheated in more than 50 percent of the cases, the announcements seem to have had a significantly positive effect on individual investment decisions in the public good. In addition to reaching a generally higher level of cooperation we also observed the overall degree of cooperation to be more stable during the experiment. In order to learn more about the individual investment decision we run the following fixed effects panel regression<sup>16</sup>

$$x_{i,r}^{\text{pub}} = \alpha_i + \omega \cdot a_{i,r} + \varepsilon_{i,r},$$

with  $a_{i,r}$  being the announced investment in the public good in round  $r$ . The results are reported in table 11.

$\omega$	0.129
T-value	1.26
Significance	$p > 0.10$
$r^2$	0.501

**Table 11: Individual investments and announcements**

While we find a positive effect of individual announcements on the investment decisions towards the public good, this effect turns out to be insignificant. This finding might be due to the fact that the participants were more concerned with the aggregate announcement of the group than with their own non-binding commitment. To test for this hypothesis we run the panel regression

$$x_{i,r}^{\text{pub}} = \alpha_i + \varphi \cdot \sum_{j=1}^5 a_{j,r} + \varepsilon_{i,r}.$$

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<sup>16</sup> Due to the fact that Wilson and Sell (1997) run a simple OLS-regression with a common intercept the results can hardly be compared.

The results are reported in table 12. We find a significantly positive effect of the aggregate announcement of investments in the public good. Thus, the aggregate announcements have a significant influence on cooperative behaviour.<sup>17</sup>

$\omega$	0.091
T-value	2.06
Significance	$p < 0.05$
$r^2$	0.516

**Table 12: Individual investments and aggregate announcements**

We already illustrated that participants in treatment 3 used the signalling mechanism quite often to cheat others by overstating their willingness to cooperate. The same finding made Wilson and Sell (1997) believe that cooperation can hardly evolve in such a climate. However, if attempts at cheating would in fact discourage groups one should expect that cooperative behaviour will quickly diminish in the course of time. We should at least be able to observe a declining round trend – a hypothesis we already tested earlier and which we had to reject. Thus, participants behaviour in treatment 3 indicates that cheating does not necessarily destroy cooperation. To study the participants' reaction on observed differences between announced and factual investments in the previous round, we run the fixed effects panel regression:

$$x_{i,r}^{\text{pub}} = \alpha_i + \phi \cdot \sum_{j=1}^5 a_{j,r} + \pi \cdot \left( \sum_{j=1}^5 a_{j,r-1} - \sum_{j=1}^5 x_{j,r-1}^{\text{pub}} \right) + \varepsilon_{i,r}.$$

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<sup>17</sup> This finding partially contradicts the results of Wilson and Sell (1997) who find that individual behaviour is more related with the own announcements and the own past behaviour. We suggest that these findings are heavily influenced by the fact that they result from a regression with a common intercept. Such a regression fails to take the general differences of the participants with respect to cooperative behaviour into account. Whenever different types of participants (cooperative, non-cooperative) exist a regression with a common intercept is likely to find an autoregressive component in investment behaviour. We found no significant effect of past investment decisions on the current one when using a fixed effects model.



The results are shown in table 13. An F-Test shows that the predictive power of the latter model is significantly (at a confidence-level of 99 percent) increased by the inclusion of the difference between announced and factual investments as regressor ( $F^{crit}=6.93$ ,  $F=9.09$ ). We find a positive coefficient for  $\pi$  which is significant at the 90-percent-significance-level. One might find this result surprising since it implies that intense cheating in the previous round induces the participants to invest more tokens in the public good in the following round. Thus, cheating does not lead to decreasing cooperation but to attempts at restoring the common belief in future cooperation by increasing investments in the public good. Thus, participants in treatment 3 seem to have had an interest in keeping the signalling device of not-binding announcements in function in order to achieve a high degree of cooperation. This behaviour might serve as an explanation why we do not find a round trend in investments in the public good in treatment 3.

$\Phi$	0.112
T-value	2.27
Significance	$p < 0.05$
$\pi$	0.078
T-value	1.66
Significance	$p = 0.10$
$r^2$	0.531

**Table 13: Individual investments, aggregate announcements and cheating**

## 6 Conclusions

In this paper we presented empirical evidence of cooperative behaviour in a series of public good experiments. While the participants' behaviour in the control treatment is in line with

the stylized facts resulting from earlier studies, the participants in the two additional treatments differed significantly.

Cooperative behaviour significantly increased and became more stable when the participants were asked to guess other participants' contributions to the public good although the accuracy of these guesses had no direct influence on payoffs and although guesses were not communicated. We suggest that the advice of making guesses lead the players to intensifying their efforts in building an expectation on other participants' behaviour and to react accordingly.

Cooperative behaviour increased even more when participants had the possibility of making use of a strictly limited form of communication during the experiment. Although the announcements the participants made in the beginning of every round were not binding and the participants used the announcements for cheating purposes in more than 50 percent of all cases the average investment in the public good increased by more than 100 percent in comparison to the control treatment. We suggest that the stable and high degree of cooperation results from the participants' perception that the signalling mechanism is a valuable means of increasing overall cooperation.

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## Appendix

	Treatment 1	Treatment 2	Treatment 3
Average investment rounds 1-9	2.40	3.13	5.09
Average investment round 10	1.60	2.80	3.90
Average rank rounds 1-9	51.04	51.00	51.35
Average rank round 10	45.60	46.00	42.85
Mann-Whitney U	401.0	405.0	373.5
Significance level	$p > 0.1$	$p > 0.1$	$p > 0.1$

**Table A1: Last round effects (Mann-Whitney rank-sum-test)**

	Treatment 1	Treatment 2	Treatment 3
Average investment	2.32	3.10	4.97
Standard deviation	2.73	2.70	4.05
Kolmogorov-Smirnov-Z	2.026	1.643	2.000
Significance level (distribution is normal)	$p > 0.1$	$p > 0.1$	$p > 0.1$

**Table A2: Normal distribution test (Kolmogorov-Smirnov-test)**

	Difference of average ranks	Mann-Whitney U	Significance level
mean(T2)>mean(T1)	18.94	4052.5	$p < 0.05$
mean(T3)>mean(T1)	34.42	3279.5	$p < 0.01$
mean(T3)>mean(T2)	26.31	3687.0	$p < 0.01$

**Table A3: Comparison of average investments (Mann-Whitney rank-sum-test)**

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