Individual behaviour in a free riding experiment

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In standard public good experiments, it has often been observed that contributions decay and reach their minimum in the final round. Up to now there has been no convincing explanation for this phenomenon. In order to find a solution to this puzzle, a series of experiments are conducted, in which the effects of information about individual behaviour and the effects of contributions of other players on subjects' choices are investigated. Furthermore, the partner–stranger experiment of Andreoni (*Journal of Public Economics*, 1988, 37, 291–304) is replicated, but with results which partly differ from Andreoni's findings.

1. Introduction

In the last decade, free riding experiments have shown that people do not behave as is predicted by the standard models of public goods. Voluntary contributions to public good provisions and other kinds of cooperation which are not in line with the economic 'model of man' have widely been observed in experiments [Dawes and Thaler (1988) and Caporael et al. (1989)].

In the typical free riding or public good experiment, subjects form groups of size n and are equipped with a fixed number of tokens w_i, which they can invest in a public or a private good. Each token invested in the private good earns a return of r, each allocated to the public good leads to a payment of v to every subject, with $r > v$ and $nv > r$. The individual payoff is

$$\pi_i = (w_i - g_i)r + v \sum_{i=1}^{n} g_i, \quad i = 1, \dots, n,$$

where g_i is i's contribution to the public good. For the one-shot version of this game, $g_i = 0$ is a dominant strategy for all subjects, and it is the only perfect equilibrium for the repeated game with a fixed and known number of repetitions. But in the experiments carried out by Marwell and Ames (1981), Isaac, Walker and Thomas (1984), Isaac, McCue and Plott (1985), Andreoni (1988), Isaac and Walker (1988), subjects did not choose their perfect equilibrium strategy. Rather, in these and other experiments, the following observations have been made:

(1) Subjects begin with an average contribution of about 50% of their endowment to the public good.

(2) Contributions decay if the game is repeated.

(3) Even in the last round (number of repetitions known) strict free riding (the dominant strategy in this round) is seldom observed.[1]

(4) Although contributions in the last round significantly differ from zero, there is a clear 'final-round-effect': contributions reach their absolute minimum in the last repetition of the game.

Andreoni (1988) adds another surprising observation to these results. He compares two experiments. In the first one, the public good game was played 10 times by groups containing always the same 5 subjects, who are called 'partners'. In the second, 20 subjects formed a group which, after each round, was randomly divided into 4 subgroups of 5 people. In this experiment, the same game was played, but each subject played each round with 4 different players. The surprising result was that in each round the strangers (second experiment) contributed more to the public good than the partners.

All of these observations cannot be explained by the standard model of rational behaviour. In fact, they are unsolved puzzles, which is being realized more and more by the scientific community. For example, there is an increasing interest in evolutionary models, which can be employed in order to explain the bare fact that people are cooperative and not only selfish [Axelrod (1981), Frank (1988), Güth and Yaari (1989), Ockenfels (1989), Miller and Andreoni (1991) and Young and Foster (1991) among others]. On the other hand, only few attempts have been made to explain the behaviour actually observed in public good experiments. Why do contributions decay? Why do they reach their minimum in the final round without falling to zero? Why do strangers contribute more than partners? In general: What rules individual behaviour in public good experiments?

If we look at the experimental and theoretical work that has already been

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[1]An exception is the experiment of Isaac and Walker (1988), in which 35 of 42 subjects, playing in groups with a marginal per capita return (MPCR) of public good contributions of 0.3, choose the strict free riding in the final round. The MPCR is mentioned because Isaac and Walker also ran another similar experiment with MPCR of 0.75, and in this case only 24 of 42 subjects contributed nothing in the final round, although even this is a very high rate of final round free riding compared with other experiments.

done, we must come to realize that there are some open questions. The theories that try to explain cooperative behaviour assume, at least implicitly, that the individual player reacts in a particular way to the behaviour of others. But *how do* subjects react in public good experiments? This question cannot be answered because 'behaviour of others' was never a controlled variable in such experiments. Closely related is the question as to whether *individual* behaviour of others or *group* behaviour influences the single subject. In this connection, the observability of individual behaviour may be an important point. The open question is whether or not it makes a difference if subjects can observe one another. Finally, all observations made in public good experiments concern the *average* behaviour: on average, contributions decay, on average, strict free riding is not observed, and so on. But what about individual behaviour? Can we identify different patterns of behaviour, different types of individuals?

The following experiments have been conducted in order to find answers to these questions. A second aim was to check if the surprising stranger–partner result of Andreoni can be reproduced. In the next section, the experimental design is described and in section 3 the results are presented. The paper ends with some concluding remarks.

2. Experimental design

The experiments were carried out at the University of Dortmund in winter 1990/1991. All subjects were students of economics and social science. In total, 7 experiments with 104 subjects were conducted. All experiments were based on the following standard public good game:

Subjects are divided into groups of size 5. Each player gets an initial endowment of 10 tokens.[2] For each token invested in the private good, the player receives DM 0.50; a token invested in the public good earns a group-payoff of DM 1.25, which is divided equally among the 5 players.

The MPCR of contribution [as introduced by Isaac and Walker (1988)] is therefore 0.5. Subjects know that the game will be played 10 times and that *in each repetition* they can allocate 10 tokens. They also know that at the end of the experiment the payoff of 3 randomly selected rounds will be paid in cash. Subjects have no contact before, after and during the game: they act in strict anonymity.

For the reliability of experiments, it is decisive whether or not the monetary incentives are strong enough to guide individual behaviour. The 'marginal' wage rate of the subjects is a good guide to the optimal payoff schedule. The average wage per hour of a German student is about 15 marks.

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[2]Players were told to look at the tokens as if they were German marks, which could be divided by 10-pfennig pieces. Therefore subjects were endowed with 100 times 0.1 tokens.

One 10-round experiment takes about 45 minutes and a subject can be sure to get a payoff of at least 15 marks by investing all tokens in the private good. On the other hand, cooperative behaviour is costly. If a player chooses to invest all his tokens in the public good all the time he loses 7.5 marks, e.g. his minimal earning is reduced by 50%. Hence, the payoff schedule exactly meets the requirements usually demanded of the monetary incentives in economic experiments [see Hey (1991, p. 13)].

The first two experiments (E1 and E2) focus on the question of whether the observability of individual contributions has an impact on the subjects' behaviour. In E1, each player gets the following information after each round:

- the individual contribution of the 4 other players,
- the individual payoffs of all players,
- the average contribution and the average payoff.

Before the experiment started, the subjects received a record which described the game in detail, including the fact that all group members would receive the same information. Therefore, individual contributions were *common knowledge*.

The procedure in each round was the following. Subjects were placed in 5 different rooms. After reading the description of the game, subjects had the opportunity to clarify open questions with the experimenter. Subjects received 10 blanks, one for each round, on which they had to note their decision. These blanks were collected and the payoffs computed. After this, the subjects received a computer-printout with the pay-off information of the current and all preceding rounds. Therefore, the players were always informed about the whole history of the experiment. E1 was played 3 times with a total of 15 subjects.

E2 differed from E1 only with respect to the information available to the players. The subjects in E2 were informed about their own payoff and the average contribution to the public good only (which was, in fact, redundant information because the average could easily be computed from the players own payoff). E2 also was played 3 times by a total of 15 subjects.

The next two experiments, E3 and E4, were aimed at a comparison of E1 and E2 with an experimental design similar to Andreoni's 'strangers' experiment. Therefore, after each round a group of 15 subjects was randomly divided into 3 subgroups, so that each player knew that he would play each round with different people.

For organizational reasons, E3 and E4 (and all subsequent experiments) were carried out by mail and telephone. Subjects received the game record by mail, the experiment itself was done by telephone. The information subjects were given in E3 was similar to that in E1, and in E4 they received the same information as in E2.

Table 1

Experimental design.

Experiment	Group design	Information	Number of subjects	Contact to experimenter	Manipulated
E1	partner	ind. contr. means	15	in person	no
E2	partner	means	15	in person	no
E3	stranger	ind. contr.	15	by phone	no
E4	stranger	means	15	by phone	no
E5	partner	ind. contr. means	15	by phone	no
E6	partner	ind. contr. means	15	by phone	yes $\approx 90\%$
E7	partner	ind. contr. means	14	by phone	yes $\approx 16\%$

Experiment E5 was similar to E1 (partner/individual contributions were common knowledge) with the only difference being that E5 (as with E3, E4, E6 and E7) was carried out by mail and telephone. This was done mainly because we could not rule out that the way subjects got in contact with the experimenter (in person or by phone) had an impact on the behaviour. E5 was therefore carried out in order to be able to make comparisons of the full-information partner game with the last two experiments, E6 and E7.

Although in E6 and E7 the same public good game was played as in E1–E5, these two experiments are totally different. They were conducted in order to see how the individual behaviour depends on what 'the others' do. To do this, the contributions of the 4 other players must be controlled, and this was done in the following way. Subjects received the same description of the game as those who played E5. But actually each player played on his own against 4 fictitious players whose contributions were made by the experimenter. In E6 these 'phantoms' were very cooperative: they invested on average 89.75% of their tokens in the public good, and in E7 they were very selfish and contributed only 15.75% on average. The 15 subjects in E6 had to believe they were playing with highly cooperative people, the 14 subjects in E7 had to have the impression they were dealing with very uncooperative people.[3] The design of all experiments is summarized in table 1.

A translation of the written instructions offered to the subjects in E5, E6 and E7 can be found in the appendix.

3. Results

Figs. 1(a)–1(g) show the results of E1–E7. On the horizontal axis the 10

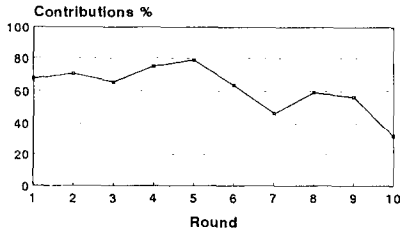[3]In section 4 we will discuss the methodological aspects of manipulated information in economic experiments.
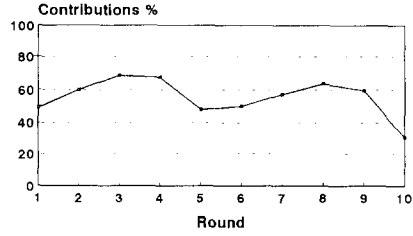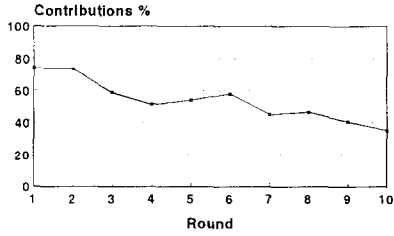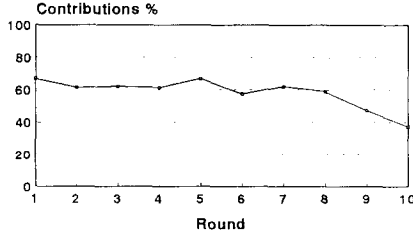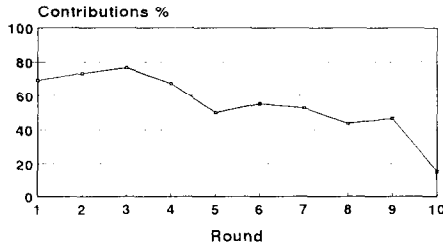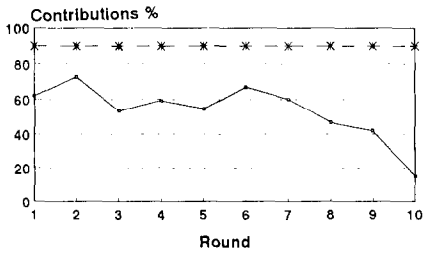
Fig. 1. (a) E1, partner/contributions common knowledge; (b) E2, partner/uninformed; (c) E3, stranger/contributions common knowledge; (d) E4, stranger/uninformed; (e) E5, partner, E1 – by phone; (f) E6, partner/manipulated (90%); (g) E7, partner/manipulated (16%).

Table 2

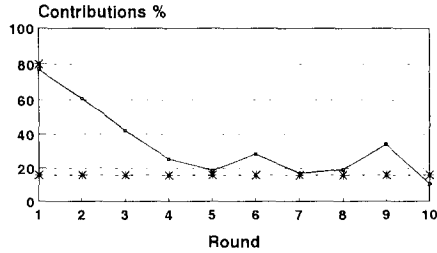Average contribution in percent.

Experiment	Round										Mean
	1	2	3	4	5	6	7	8	9	10	
E1	67.7	70.7	65.5	75.2	79.0	63.5	46.2	59.2	56.3	31.7	61.5
E2	49.3	60.0	68.7	67.6	48.0	50.0	57.3	63.7	59.6	30.3	55.5
E3	74.0	73.3	58.7	51.3	54.0	58.0	45.3	46.7	40.7	35.3	53.7
E4	66.7	61.3	62.0	61.3	66.7	57.3	62.0	58.7	47.3	37.3	58.1
E5	69.3	73.3	76.7	67.3	50.0	55.3	52.7	43.7	46.7	15.3	55.0
Mean E1–E5	65.4	67.7	66.3	62.3	59.5	56.8	52.7	54.4	50.1	29.9	56.8
E6	62.0	72.7	53.3	59.3	54.0	67.0	60.0	46.7	42.0	15.3	53.2
E7	77.1	60.7	42.1	25.7	18.6	28.6	17.1	19.3	34.3	10.7	33.4
Total mean	69.1	67.0	53.9	49.1	52.9	54.2	48.6	48.2	46.7	25.1	52.9

rounds and on the vertical the average contribution (in percent of the endowment) are depicted. Table 2 shows the numerical results.

If we first restrict ourselves to the five unmanipulated experiments E1–E5, we can make the following observations:

Observation 1. On average, subjects behave as 'weak free riders'. In all rounds (including the final one) contributions are significantly different from zero, but also significantly less than the efficient level of 100%.

Observation 2. On average, subjects do not play their dominant strategy in the one-shot situation of the final round.

Observation 3. There is a clear 'final-round effect'; in all experiments contributions reach their absolute minimum in the final round.

Observation 4. Average contributions tend to fall during the experiment.

Observations 1–4 are in line with the findings of other public good experiments. Further results can be obtained if we compare the different settings. Let us first see whether information about individual behaviour has any impact on the contributions.

Table 3 contains the average contributions of informed and uniformed partners (E1 and E2) and strangers (E3 and E4) and the results of a Wilcoxon ranksum W-test, which is non-parametric and equivalent to the U-test of Mann and Whitney. The test hypothesis is that the two means that

Table 3

Contributions (%), Wilcoxon test.

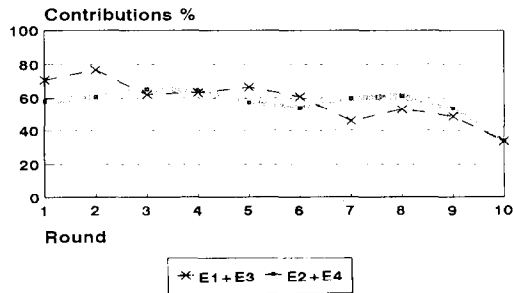| Experiment	Round									
	1	2	3	4	5	6	7	8	9	10
E1	67.7	70.7	65.5	75.2	79.0	63.5	46.2	59.2	56.3	31.7
E2	49.3	60.0	68.7	67.6	48.0	50.0	57.3	63.7	59.6	30.3
W	276.0	256	231	248	282	258	214	222.5	230.5	235.5
P	0.07	0.33	0.97	0.51	0.04	0.29	0.44	0.67	0.93	0.76
E3	74.0	73.3	58.7	51.3	54.0	58.0	45.3	46.7	40.7	35.3
E4	66.7	61.3	62.0	61.3	66.7	57.3	62.0	58.7	47.3	37.3
W	196	229	254.5	259.5	201.5	218	221	244	254	222
P	0.13	0.88	0.59	0.26	0.19	0.54	0.63	0.63	0.36	0.65

Fig. 2. E1 + E3 vs. E2 + E4. Informed/uninformed.

are to be compared are out of the same distribution. If the P-value is smaller than or equal to the significance level α, the hypothesis has to be rejected [see Hartung et al. (1982 p. 513)].

Only in 1 of 20 cases do we get a significant difference (at $\alpha = 0.05$) between the informed and the uninformed groups (round 5 at E1 vs. E2). The same result holds if we pool the data of the informed (E1 and E3) and the uninformed (E2 and E4). Fig. 2 shows the resulting contribution curves.

Summarizing we get

Observation 5. Whether or not the individual contributions are common knowledge has no impact on subjects' behaviour.

Next we compare partners and strangers. Remember that Andreoni found that in each round strangers contributed more than partners. Andreoni's result cannot be reproduced. The Wilcoxon test shows that only for 2 of 20 cases must the hypothesis of equal means be rejected. Therefore, we cannot
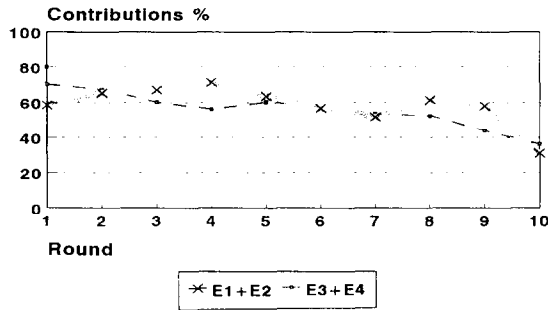
Contributions %

Fig. 3. E1 + E2 vs. E3 + E4. Partner vs. stranger.

conclude that there are statistically significant differences between partners and strangers. As fig. 3 shows, pooling the data of E1 and E2 and comparing them with E3 and E4 makes this point even clearer.

One might argue that this result is due to the fact that partners in E1 and E2 had personal contact with the experimenter while strangers did not. To check whether this could explain why our observation differs from the one made by Andreoni, we compare firstly E1 and E5. These two experiments differ only in respect of the way players are in contact with the experimenter (see table 1). A Wilcoxon test shows that in all 10 rounds there are no significant differences between E1 and E5. Therefore, we can conclude that personal contact has no significant impact on individual contributions.

Observation 6. Only in 4 of 30 cases can significant differences between partners and strangers be observed. In 3 of these cases, the partners make significantly higher contributions.

The last observation does not mean that partner and stranger behave similarly. A closer look at the data reveals some interesting differences. First, obviously the 'final-round effect' is much stronger in the partner groups than in the stranger groups. If we assume that the decision in the final round is independent of the decision in round 9, we can check this point by using the Wilcoxon test in order to investigate whether the contributions in the last round differ significantly from those in round 9. The results show clearly that the hypothesis of equal contributions cannot be rejected for the strangers but must be rejected in the case of the partner groups. Also in the experiment of Andreoni, partners show a stronger final-round effect than strangers.[4] In contrast to Andreoni's finding that strangers contribute more, the differences

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[4]Unfortunately, Andreoni pays no attention to this phenomenon and therefore did not examine whether this difference was significant.
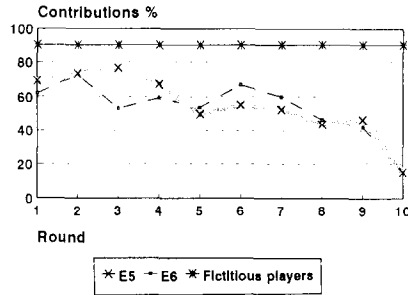
Fig. 4. E5 vs. E6. E6 = manipulated, high contributions.

regarding the final-round behaviour, as summarized in the next observations, seem to be reproducible.

Observation 7. The decay of average contributions in the last round (final-round effect) is significantly stronger in the case of partner groups than in the case of stranger groups.

Looking at the individual behavior in more detail reveals another distinction between partner and stranger. Only few subjects played a stationary strategy. Most of them altered their contribution in nearly every round. The standard deviation of the differences between contributions in consecutive rounds can be used to measure how uniform the group behaviour is. The standard deviation in all rounds was higher for strangers than for partners.

Observation 8. Strangers vary their contributions more than partners do. In this sense, partners show a more uniform behaviour than strangers.

The most interesting observation comes from a comparison of the manipulated experiments, E6 and E7, with their unmanipulated counterpart E5. Fig. 4 depicts the contributions in E5 and E6.

There is no significant difference between the average behaviour in E5 and E6. On the contrary, the similarities are striking. For example, in the last round exactly the same average contributions were made. Obviously, players in E6 were totally unimpressed by the highly cooperative behaviour of their fellows. Neither offsetting nor matching behaviour occurs.

Observation 9. An increase in the contributions of the 4 'other' players above the level which occurs in the unmanipulated experiment leaves the average behaviour unchanged. Fig. 5 shows a totally different picture. It
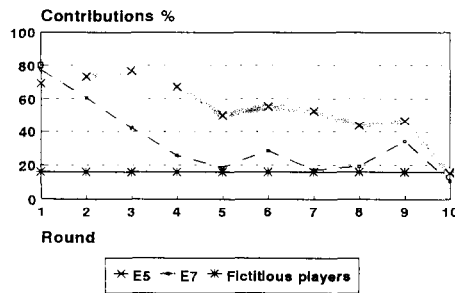
Fig. 5. E5 vs. E7. E7 = manipulated, low contributions.

depicts the contributions in E5 and E7. Beginning with round 2, E5 is always above E7. Therefore we can use a median test for rounds 2–10 in order to check whether the curves have significantly different levels.[5] We compute a χ^2 value of 28.54 for which the hypothesis of equal levels must be rejected at a significance level of $\alpha < 0.001$. Hence, the average contributions in E5 and E7 differ significantly.

Observation 10. If the contributions of the 4 other players fall short of the level that occurs in the unmanipulated experiment, subjects react by lowering their contributions significantly.

One simple explanation for Observation 9 might be that only *on average* contributions do not change in response to the cooperative behaviour of the 'phantoms', while individual contributions do change. For example, if some subjects are matching the cooperation of the 4 others and some are offsetting it, then, on average, both reactions will cancel each other out. In order to examine whether this explanation of Observation 9 is correct, it proves helpful to first check whether typical patterns of behaviour can be found. For this purpose, subjects were discriminated by their average contribution (of all 10 rounds) and divided into three classes. Those who invested more than 2/3 of their 100 tokens in the public good are called 'cooperative', those who spent less than 1/3 are 'free riders' and those with an average contribution between 1/3 and 2/3 are called 'weak free riders'.[6] The investigation of strength and average contributions of these classes shows that not only the average but also the individual behaviour in E5 and E6 was strikingly similar.

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[5]For this test see Hogg and Craig (1970, p. 366).

[6]Of course, this classification is arbitrary. In choosing it, we follow Isaac, Walker and Thomas (1984).
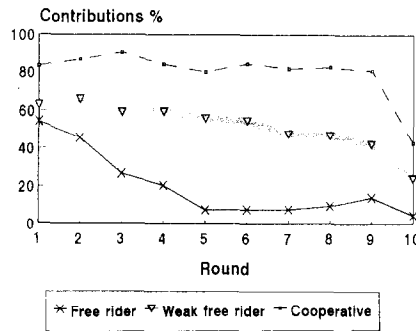
Fig. 6. Classes E1–E7. Free-rider < 33.3%; cooperative > 66.6%.

The class analysis can be extended to the pooled data of all experiments. Nineteen of the 104 participants acted as free riders, 59 showed weak free riding and 26 played cooperatively. Fig. 6 depicts the average contributions in these classes.

In regard to fig. 6, two observations are remarkable:

Observation 11.   It is possible to identify different *types of players*, whose contributions in all rounds differ significantly.

Observation 12.   Also those subjects who in general showed a highly cooperative behaviour (total contributions > 66%) tend to reduce their contributions in the final round dramatically. The final-round effect in this class is even stronger than in the two other classes.

4. Interpretation

Before we start to interpret the observations described in section 3, some remarks on the design of the manipulated experiments E6 and E7 are in order.

Most economists who work in the field of experimental economics look with great scepticism at experiments in which subjects are not told what is actually happening. There are good reasons for this reservation. The main concern is that experimental results could lose their validity if the trust of the subjects in what the experimenter tells them is destroyed. John D. Hey recently made this point very clear when he stated: 'I would not like to see experiments in economics degenerated to the state witnessed in some areas of experimental psychology where it is common knowledge that the experimenters say one thing and do another' (1991, p. 119). This warning should be taken very seriously. But on the other hand, there is no rule without exceptions, as Hey himself shows us: only 20 pages after his warning, he

describes an experiment in which he did not tell the truth to the subjects and admits: 'In fact I cheated.' In some cases, experimenters may come to the conclusion that there is no way around cheating. But it has to be clear that these cases are rare exceptions which can only be justified if there really is no other way than manipulating information and in which the insights derived from the experiment are of great importance for further research. Hence, one always has to consider the pros and cons very carefully before deciding to be dishonest to subjects. In the case of free riding experiments, we can find some examples for designs which do not truthfully reveal all facts. Marwell and Ames (1981) used in their famous experiments the same manipulations which are used here. Furthermore, they told their subjects that 80 persons were involved in the experiment, while actually there were fewer. The same 'trick' is used by Kim and Walker (1984). This list is not comprehensive, but I believe that in all cases the manipulation can be justified. In the case at hand, the reason for the manipulation was that there seems to be no other way to control the 'behaviour of others' in a free riding experiment. In the light of the – in my opinion – very surprising results of E6 and E7, I believe that the attempt to control this variable could be justified – at least ex post. Let us now turn to the interpretation of the observations.

Observations 1–4 simply corroborate the results of earlier experiments. Furthermore, we find strong evidence for Andreoni's (1988) thesis that cooperation does not follow from strategic calculations. Observations 5 and 6 make clear that subjects even cooperate in circumstances in which it is impossible to influence the behaviour of others.

Comparing our findings with the experimental work of Andreoni, the most striking point is that his surprising result that strangers always contribute more could not be reproduced. Andreoni's experiment and the one carried out in Dortmund are very similar. Not only was the rotation scheme in both experiments the same, also the pay-offs were very similar. In both cases the MPCR was 0.5. Hence, there is no obvious explanation for the different results. Nevertheless, the Dortmund experiments indicate that contributions are independent of whether people play in fixed groups or are confronted with different subjects in each round.

It should be noted that the stranger experiments do not absolutely rule out the possibility of strategic behaviour. In early rounds, the possibility of playing in subsequent rounds with one or more of the actual players is fairly high. Nevertheless, in comparison with the partner groups, strategic considerations should play a much less important role. Thus, if cooperation is motivated by strategic considerations, this should be reflected by lower contributions of stranger groups. Because neither in the Andreoni experiment nor in the Dortmund experiment is this observed, cooperative behaviour can hardly be explained by strategic considerations.

The claim that there are distinct types of individuals – with regard to their
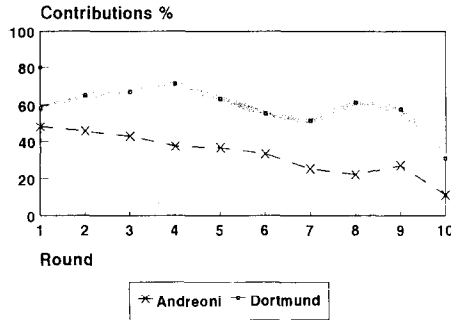
Fig. 7. Partner, Andreoni–Dortmund.

willingness to cooperate – coincides with everyday experiences as well as with the results of experiments made by Marwell and Ames (1981), Andreoni and Miller (1991) and Carter and Irons (1991).

Not only in the Dortmund experiments but also in others did subjects show a strikingly constant behaviour. Aspects like group size, information about others, number of repetitions or even the fact that the other players are highly cooperative seem not to influence individual behaviour. The stimulus of being in a public good game is all that is needed always to provoke the same response. But there is an important exception. In E7 it suddenly *matters* what the others do. If all others do not cooperate, subjects react in a very natural way: because they do not like to be exploited, they also stop cooperation. Let us call this motive 'exploitation aversion'. In a way, the willingness to cooperate is with the reservation that on average the others also are willing to contribute. Free riding of some can be tolerated, but not free riding of all. This is exactly what we observed. Free riding of single participants occurs in all experiments without having any effect. But in the case of E7, subjects do alter their behaviour.

Summarizing: two experimental findings can be regarded as facts which are hard to ignore. The first is that cooperation is a real fact of human societies and economists are called on to explain why it could emerge. Evolutionary approaches as well as behavioural psychology seem to be the appropriate tools. But any explanation should be able not only to show that cooperative individuals can survive in a competitive environment, but also that at the same time free riders and weak free riders can exist. This must be demanded because the second fact, arising from experimental observations, is that there do exist different types of people at the same time. In order to give a last confirmation of this point, we finally present fig. 7, which depicts the contributions of partners in the experiment made by Andreoni and in the Dortmund experiment.

Again it is a matter of taste how to rate this picture. Some may say that American students are less cooperative than German, others may argue that they are more rational. Whatever the case may be, what seems to be clear is that they are of different types.

Appendix

The following instructions were given to each player in E5, E6 and E7. In the other 4 experiments, instructions only differ with respect to the information offered to subjects. For the stranger groups a description of the rotation scheme was also presented.

Description of the game

Together with 4 other players you play the following game:

Each player gets 10 tokens. These tokens can be invested in two assets in arbitrary amounts, namely

(1) In a *private asset*: for each token invested in this asset, you (and only you) receive 0.50 DM.

(2) In a *public asset*: for each token invested in this asset, each of the 5 players receives 0.25 DM.

This game will be played 10 times, that means you have the opportunity to allocate 10 tokens to the two assets 10 times. Each of the 10 rounds proceeds in the following way:

The experimenter will call you and your supporting players. You tell the experimenter how you will allocate your tokens. After collecting the decision of all 5 players, the payoffs will be calculated. The experimenter will call you again and give you the following information:

● how many tokens each individual player invested in the public asset,
● the payoff of each player,
● the average payoff of all 5 players,
● the average investment in the public asset,
● the investments into the private asset will not be reported, because they can easily be calculated on your own (investment in the private asset = 10-investment in the public asset).

After you have received this information the next round of the game begins, and you tell the experimenter your next allocation decision.

At the end of the total game (after 10 rounds), 3 of the 10 rounds will be selected randomly. The payoffs of these three rounds will be paid in cash to the players.

If you have any questions, please consult the experimenter, when he calls you the first time.

I hope you will enjoy the game.

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