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VALUE ORIENTATIONS, EXPECTATIONS AND VOLUNTARY CONTRIBUTIONS IN PUBLIC GOODS*

Theo Offerman, Joep Sonnemans and Arthur Schram

An experimental analysis of voluntary, binary contributions for step-level public goods is presented. Independent information is obtained on individual value orientation and expectations about the behaviour of other subjects using incentive compatible mechanisms. The effects of increasing payoffs for the public good and of decreasing groupsize are investigated. Attention is focused on (1) the determination of expectations; (2) the use of expectations when deciding on behaviour; (3) differences in expectations and behaviour between individuals with different value orientations.

Many important public goods are only provided if enough money is raised to fund them, and then do not increase significantly in quality or quantity if further money is raised. Bridges, lighthouses and dikes are large scale examples of these so-called step-level public goods (SLPG). Small(er)-scale examples are a law in parliament, which may only pass if enough members are willing to vote for it, or the restoration of a public building. Fundraising for the provision of public goods is often left over to a regulatory authority like the government. Nevertheless, tremendous amounts of money are raised for public goods by voluntary actions of non-government institutions as well.

This paper presents an experimental analysis of voluntary, binary contributions for SLPG (where either a prespecified amount of money or nothing is contributed). When explaining behaviour in this situation, economic as well as psychological theories appoint a central role towards the beliefs people have with respect to the behaviour of others. Economists emphasise that individuals will contribute if the expected benefits from doing so are large enough, which depends on what they believe that others will do. Social psychologists, on the other hand, stress the importance of the interaction of beliefs and 'value orientations' when explaining contributions. Roughly speaking, a value orientation represents the weight an individual attaches to her or his own welfare relative to the welfare of other individuals.

As a consequence of these theories, laboratory experiments are often designed to take account of beliefs and/or value orientations. As far as beliefs are concerned, social psychologists sometimes ask subjects to report their

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estimates of the probabilities that their own contribution is futile, critical or redundant (e.g. Dawes *et al.* 1986; Suleiman and Rapoport, 1992). Economists tend to be more sceptical about this type of data, because subjects are not provided with an incentive to carry out the estimation task seriously. Measurement problems can be avoided by focusing on choice-data only, but then the data concerning beliefs are not independent of the data concerning behaviour.

As for value orientations, evidence from economic as well as psychological experiments on the voluntary provision of public goods indicates that substantial differences exist in the attitudes of subjects towards contributing (e.g. Kelley and Stahelski, 1970; Liebrand, 1984; Palfrey and Rosenthal, 1988; Suleiman and Rapoport, 1992; Ledyard, 1995; Schram and Sonnemans, 1996). Unfortunately, most of these studies lack an independent measure of value orientation: a subject is simply believed to have a cooperative preference because (s)he is observed to contribute a lot. Naturally these preferences cannot subsequently be used to explain the behaviour which was used to derive them.

The present paper tries to avoid the aforementioned problems concerning beliefs by using an incentive compatible mechanism to reward subjects for reported expectations, such that it is advantageous to report them seriously and honestly. The problems concerning value orientations are avoided by measuring these independently in a short experiment preceding the SLPG experiment.

The organisation of this paper is as follows. Section I contains a brief discussion of some models on individual behaviour from both economic and psychological origin. Section II presents the experimental design and the procedures used. In Section III the results are presented: Section III A contains a general description and Section III B describes the results with respect to the models. Section IV provides a concluding discussion.

I. MODELS OF INDIVIDUAL BEHAVIOUR

In this section some general hypotheses and models concerning individual behaviour in SLPG games are presented and elaborated. In the games studied here, individuals either contribute to a public good (at a fixed cost) or not. The public good is provided if and only if at least a prespecified number of individuals contribute. We shall start with some general psychological hypotheses from the literature. Then, some economic (utility-based) models are discussed for homogeneous individuals. These models are subsequently extended to allow for heterogeneous individuals.

I A *Value Orientation and the Relationship between Expectations and Behaviour*

According to many social psychologists, people pursue different goals when making decisions that affect others. Preferences regarding one's own well-being relative to the well-being of others appear to vary across individuals. An often used classification distinguishes various value orientations: competitors usually want to be better off than their neighbours; individualists try to do best for

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themselves and cooperators pursue the best for both themselves and the others. Rare orientations are altruism and aggression: altruists want to do best for others, regardless of the outcome for themselves and aggressors want to do worst for others, regardless of the outcome for themselves.[1] The majority of the people is classified either as individualistic or as cooperative (cf. Kelley and Stahelski, 1970; Kuhlman and Wimberley, 1976; Liebrand, 1984). For example, in experiment 1 reported in Liebrand (1984) 10% of the subjects are labelled competitive, 31% of them are labelled individualistic, 53% of them are labelled cooperative, and 5% of them are labelled altruistic. These figures tend to vary across subject pools, however.

Given these value orientations, social psychologists offer two hypotheses in order to account for (the relationship between) expectations and behaviour. These are typically applied to prisoners' dilemma type of games (for tests of these and related hypotheses, see Liebrand, 1984; McClintock and Liebrand, 1988; Van Lange and Kuhlman, 1994 and references quoted there). The first is the triangle hypothesis by Kelley and Stahelski (1970), according to which individualists and competitors tend to expect that other people pursue an individualistic or competitive goal as well, whereas cooperators can imagine that other people may have either a cooperative or an individualistic/competitive value orientation. The rationale behind the hypothesis is that competitors and individualists misjudge the goals pursued by other individuals to some extent, because their own selfish choice behaviour tends to elicit the same behaviour of others regardless of the value orientation of these others. Cooperators usually dislike being the 'sucker' and adapt their preferred cooperative behaviour to selfish behaviour after a while, when they are confronted with selfish behaviour. In this view behaviour is determined by expectations.

For SLPG games the triangle hypothesis implies that competitors will not contribute and expect the same from others. Individualists contribute if and only if they think it is individually beneficial for them to do so; they expect others to act in the same way. Cooperators will contribute as long as they do not think they are being exploited; they expect others to either act cooperatively or not, a fact to be discovered by playing the game.

The other psychological hypothesis concerning expectations and behaviour in prisoners' dilemma type of games is the false consensus hypothesis proposed by Kuhlman and Wimberley (1976). According to this hypothesis, people tend to expect that other people's behaviour is the same as the behaviour prescribed by their own value orientation. Competitors tend to expect competitive behaviour of others, individualists individualistic behaviour and cooperators cooperative behaviour. In this view, expectations are rationalised on the basis of behaviour, or, in other words, expectations are determined by behaviour.

In the SLPG games, this implies that competitors will not contribute and will expect that others will not either; that individualists will contribute if it is

[1] These terms are generally used differently in economics. For example, altruism is usually defined as utility-interdependency.

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beneficial and expect the same from others; and that cooperators will contribute and expect others to do so as well.[2]

The experimental evidence regarding the causal direction between expectations and behaviour, as tested in prisoners' dilemmas, is mixed: some studies show that (manipulated) expectations can affect choices (e.g. Messick *et al.* 1983), while other studies show that own behaviour sometimes is projected on others or that choices sometimes are justified by adjusting expectations (e.g. Messé and Sivacek, 1979; Yamagishi and Sato, 1986).

Economists generally propose other ideas on expectations and behaviour and the relationship between the two. Probably all economists would agree that expectations determine behaviour, or at least that they should affect behaviour. On the matter of expectations, there is less consensus: some economists would rather not restrict expectations at all (expectations are subjective), while others support the rational expectations hypothesis, according to which people's expectations should not suffer from systematic errors: there is only place for white-noise errors (Hargreaves Heap *et al.* 1992, p. 17). In an SLPG setting an individual is supposed to contribute if and only if the expected net benefit from doing so is at least as great as the expected net benefit from not contributing (cf. Section III B ii). This will be denoted the consistent behaviour hypothesis. A comparative static consequence of this hypothesis is that there is a positive correlation between the expected benefit and the propensity to contribute.

The interaction between rational individuals deciding whether or not to contribute in an SLPG situation is explicitly modelled game theoretically by Gradstein and Nitzan (1990), assuming identical individuals. The analysis in Gradstein and Nitzan is adapted in Offerman (1993) to allow for heterogeneous individuals, i.e. for individuals with different value orientations. Details of these models are discussed in Appendix A.

I B *Expectations*

Quite some evidence has been provided against the consistent behaviour hypothesis in the non-economic literature (e.g. Dawes *et al.* 1986; Rapoport, 1988; Caporael *et al.* 1989; Suleiman and Rapoport, 1992; Rapoport does support the comparative static result discussed above, however). The results are typically based on SLPG games in which subjects are asked to estimate the probabilities that their contribution will be futile, critical and redundant for the provision of the public good. These estimates are subsequently used to estimate expected benefits from contributing. This work may be criticised for not providing participants with (financial) incentives to report their expectations seriously. The present paper avoids this shortcoming. Moreover, we shall relax the assumption in the consistent behaviour hypothesis that utility is linear in money.

In the economic approach, Palfrey and Rosenthal (1991) investigate an

[2] It should be noted that the application of these hypotheses to the n-person SLPG game studied in this paper is less straightforward than discussed here. The structure underlying this game is more like the chicken game, which is essentially different from the prisoners' dilemma game for which the hypotheses were originally developed. We shall return to this point in Section IV.

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SLPG with binary contributions using only the actual decisions on contributing to derive information about beliefs. They test different models, but conclude that the data support only the hypothesis that subjects' prior beliefs are biased upwards.

Both the 'economic' and the 'non-economic' approach have an important drawback: in the economic approach one has no independent data on beliefs, so one can never straightforwardly test the inferences made about 'homegrown' beliefs. In the non-economic approach the lack of financial incentives might affect the care with which subjects report beliefs. It would be an improvement on both approaches if subjects are asked to estimate the behaviour of the others and if they are rewarded when they do so accurately. This is undertaken in the present paper. It allows us to test independently the accuracy of expectation formation and the relationship between expectations and behaviour.

I C *Changing Parameters in the SLPG Problem*

Many experiments have been published in the literature on the voluntary provision of public goods. Generally, comparative statics for parameter changes are a major part of the studies. For a survey, see Ledyard (1995). Here, attention is focused on experimental studies where parameters are varied in an SLPG situation.

One of the questions addressed in Dawes *et al.* (1986), Isaac *et al.* (1989), Palfrey and Rosenthal (1991) and Suleiman and Rapoport (1992) is whether an increase in the threshold yields an increase in contributions and/or an increase in the frequency the public good is actually provided. Often it is found that increasing the threshold elicits more contributions but decreases the frequency that the public good is provided, but the evidence is not completely consistent.

None of these studies addresses the related question, what happens if the threshold is kept constant but the payoff for getting the public good provided is increased.[3] A natural thing to expect may be that increasing the payoff while keeping the threshold constant yields more contributions. This follows from the fact that expected benefits are increased, for given expectations about the contributions of others. However, one should take account of the interaction between individuals, e.g. by using game theory. The conclusion is not a straightforward implication of game theory: for symmetric as well as for asymmetric equilibria, it can be shown that an increase in the payoff may yield more or fewer contributions. This game theoretic approach is developed in Appendix A.

Another alternative is to keep the threshold and payoffs constant, but to decrease groupsize. In this case, game theory predicts (on average) more contributions if one focuses on symmetric equilibria only. If one allows for asymmetric equilibria, the effect of decreasing group size is not clear-cut (cf. Appendix A).

[3] Of course, this question has been addressed in environments without thresholds. Usually, it is found that increasing the payoff of the public good increases contributions (cf. Ledyard, 1993; Schram and Sonnemans, 1996).

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II. EXPERIMENTAL DESIGN

There was a show-up fee of 5 guilders. Subjects were told that they would take part in two different experiments: experiment 1 and experiment 2, led by two different experimenters. Both experiments were computerised.[4] A total number of 228 subjects was used in 10 sessions. The subject pool was the undergraduate population of the University of Amsterdam. A majority of 59% of the participants majored in economics or econometrics. In about $2\frac{1}{2}$ hours an average of 49.10 guilders (= \$26.50) was earned by the subjects.

In experiment 1 individual value orientations were measured. In experiment 2 an SLPG game was played in which information about the beliefs about the decisions of others was obtained along with the contribution decisions. We shall start this section with a description of the first experiment. Next, the measurement of beliefs in the second experiment is described. Finally, the design and procedures of the SLPG experiment will be discussed. A translation of the Dutch instructions is presented in Appendix B.

II A *Value Orientations*

In the first experiment, the *Decomposed Game* technique developed by social psychologists (e.g. Griesinger and Livingston, 1973; Liebrand, 1984) was used to assess individual value orientations.[5] In this technique each subject is asked to make 24 choices between two 'own–other' combinations. Each own–other combination allocates an amount of money to the decision-maker and an amount to another subject to which the individual is linked during the experiment. Subjects did not know to which other subject they were paired in this game, but they did know that this partner was the same throughout the 24 decisions. During this experiment, the subjects did not receive any feedback about the other's choices. At the end of the second experiment, each subject was paid privately and was told the (aggregate) choice of the other, without revealing the identity of this other.

The total amount to be allocated by an individual is not constant over combinations. The 24 pairs of outcomes lie equally spaced on a circle with the origin of the outcome plane serving as centre and a radius of 15 units of some currency, which we denote by 'francs'. The horizontal axis measures the amount of money allocated to oneself (x) and the vertical axis measures the amount of money offered to the other (y) (see Fig. 1). The francs earned were payed out in Dutch Guilders at a rate of 1 franc = 0.3 guilder (approximately \$0.18).[6]

[4] We would like to thank CREED-programmer Otto Perdeck for writing the program for the second experiment. This computer program is written in ESL, for an OS/2 environment and is available on request.

[5] We are grateful to Professor Liebrand for providing the computer program used to measure value orientations.

[6] Various experimenters use a slightly different design in order to elicit these value orientations. For example, many psychologists let participants play for fictive money. The effect of using real money has been investigated in Offerman and Schram (1993). No systematic effect appears to evolve, although the consistency of the choices by participants playing for real money is higher than the consistency when playing for fictitious money.

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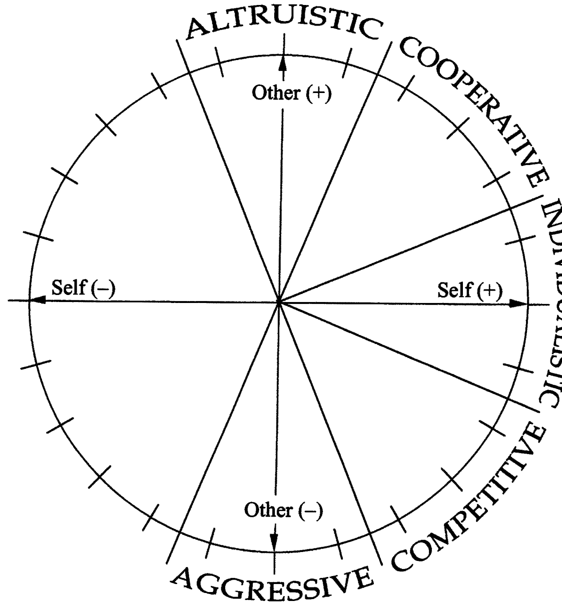

Fig. 1. The value orientation circle.

Note that $x^2+y^2 = 15^2$ and that $x+y$ is not constant. Each question asks the subjects to make a choice between two adjacent outcomes on the circle, for example a choice between 3.90 francs for self and 14.50 francs for the other *vs.* 7.50 francs for self and 13.00 francs for the other (vector **A** = (3.90, 14.50) *vs.* vector **B** = (7.50, 13.00)).

A motivational vector in the circle-space described above is a measure of an individual's preferences regarding outcomes for her- or himself and for the other. Adding up the individual's 24 chosen vectors yields an estimate of the individual's preferred motivational vector. Social psychologists have developed a standard classification of individuals on the basis of the observed motivational vectors. Individuals with an observed vector lying between degree $-112{\cdot}5$ and $-67{\cdot}5$ are classified as aggressive, individuals with vectors between degree $-67{\cdot}5$ and $-22{\cdot}5$ are classified as competitive, individuals with vectors between $-22{\cdot}5$ and $22{\cdot}5$ are classified as individualistic, individuals with vectors between $22{\cdot}5$ and $67{\cdot}5$ are classified as cooperative and individuals with vectors between $67{\cdot}5$ and $112{\cdot}5$ as altruistic.[7]

A choice is called consistent if and only if the alternative closest to the observed motivational vector is selected. For example, if the observed motivational vector is (15, 0) and an individual chooses between alternative **C** ($-10{\cdot}60$, $-10{\cdot}60$) and **D** ($-7{\cdot}50$, $-13{\cdot}00$), then **D** would constitute the consistent choice. If a subject makes 24 consistent choices, then the revealed vectorlength (the sum of the chosen vectors) can be shown to be twice the radius of the circle (i.e. 30 francs). If the subject chooses randomly, the

[7] This classification is *ad hoc*, though very natural. Note that the areas are of equal size and symmetric around the vectors that maximise the motivational goals.

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vectorlength will be small (possibly 0). This suggests that the vectorlength as a percentage of the maximal vectorlength can serve as a measure of the consistency of a subject.

II B *Measurement of Beliefs*

As part of the second experiment each subject was asked to report probabilities about how many of the others in her or his group would 'buy a marker' (the way in which contributing was designed in the SLPG game; see the description of the game below). The quadratic scoring rule $Q_j(p)$ (one of the scoring rules reported in Murphy and Winkler, 1970) was used to encourage subjects to report their beliefs truthfully and seriously. The general form of this rule is as follows. If an individual reports p_i (for $0 \leqslant i \leqslant n-1$, where n is the groupsize), as the probability that exactly i of others buy a marker, and if in reality j of the others buy a marker, then the payoff generated by this rule is equal to:

$$Q_j(p) = a + 2b\,p_j - b \sum_{i=0}^{n-1} (p_i^2).$$

In the experiment, the parameters a and b were both chosen equal to 60 cents. Receiving a payoff generated by this scoring rule induces someone maximising expected value or someone maximising a linear utility function to report her or his beliefs truthfully.

This scoring rule was given on a handout. It was emphasised that subjects did not need mathematical understanding of the equation. It was explained that the expected payoff from this rule would be maximised if probabilities were reported correctly, so that it was in the interest of a subject to report beliefs about probabilities truthfully. A proof of this statement was offered – on request – after the experiment had ended.[8]

II C *Design and Procedure of the SLPG Experiment*

In the second experiment, 20 rounds of an SLPG game were played. In every round, three groups of equal size were formed randomly (cf. the 'stranger' condition, by Andreoni, 1988). A subject did not know with whom (s)he was in a group in any period, but (s)he knew that the composition was changing from round to round. In six out of the ten sessions ('low-7' and 'high-7', see Table 1), groups consisted of seven players, in the remaining four sessions ('high-5') they consisted of five. For this experiment, a randomly appointed observer was used, to guarantee the fact that no deceit was taking place.

[8] Two problems may occur when using scoring rules. First, deviations from true judgements are not punished very severely by them. We do not think that this problem is too severe in our case. Subjects could do two relatively easy things, either gambling, by assigning all probability to a particular event, or reporting beliefs truthfully. The actual choice-data show that only very few data can be interpreted as gambles.

Second, a risk-loving or risk-averse individual does not have a linear utility function and, strictly speaking, will bias the reported probability distribution in order to obtain maximal expected utility. For example, a risk-averse individual will report somewhat more dispersion in the probabilities than truly expected when (s)he is rewarded with the payoff generated by the quadratic scoring rule. The usual hypothesis about risk-attitudes when people can gain money is that they are risk-averse. This hypothesis cannot explain reported probability distributions in the SLPG experiment. If anything, people reported probability distributions with too small dispersion, as will be discussed later.

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Table 1
Parameters of the Design

Session	Condition	Costs	$f(s)$	Players	Spectators
1	Low-7	60	180	3 groups of 7	0
2	Low-7	60	180	3 groups of 7	0
3	High-7	60	245	3 groups of 7	0
4	High-7	60	245	3 groups of 7	0
5	Low-7	60	180	3 groups of 7	0
6	High-7	60	245	3 groups of 7	0
7	High-5	60	245	3 groups of 5	8
8	High-5	60	245	3 groups of 5	7
9	High-5	60	245	3 groups of 5	8
10	High-5	60	245	3 groups of 5	8

Two types of subjects were used, to be denoted by 'players' and 'spectators' (cf. Dawes *et al.* 1977). In each round, a 'player' had to make two decisions, decision A and decision B. When making decision A, players were endowed with an amount c. Decision A concerned a binary choice between either buying a 'marker' at a given cost (equal to $c = 60$ cents) or not buying a marker, in which case no costs were incurred. In this second experiment, payoffs were denoted in Dutch cents. Choices were made simultaneously and anonymously. Communication between the subjects was prohibited. Each group member received a public payoff of $f(s)-c$ if three or more of the group members bought a marker and a public payoff of 0 cent in the other case. Thus, if the threshold was reached, those that bought a marker received a net sum of $f(s)-c$, those that did not received $c+f(s)-c=f(s)$. It was explained to the subjects that the costs of a marker were the same for everybody and that the public payoff was the same for everybody, and that these would remain constant throughout the 20 rounds. The amount $f(s)$ is one of the control variables in the design. The fourth column of Table 1 presents the value chosen in various sessions.

Before any information about the aggregate decisions of other group members in a round was given, each player was asked to report probabilities about how many of the others in her or his group would buy a marker (decision B). Thus, a player had to estimate the probability that exactly 0, exactly 1, ..., exactly $n-1$ others would buy a marker. Incentives were provided by applying the quadratic scoring rule, described above.

In the condition high-5 additional subjects, the 'spectators', were paired anonymously to one player each and given all information that this player received. The spectators only had to make decision B: they were asked to estimate how many of the others in the group of the player to whom they were paired would buy a marker (excluding the possible marker bought by this 'paired' player). They received a lump-sum payment to compensate for the diminished income due to dropping decision A. Subjects were told when round 1 began, whether they were a player or not and, if they were, whether a

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Table 2
Decisions to Be Made

Role	Experiment 1: Decomposed game (DG1–DG24) determines value orientation — Question 1 ... Question 24	Experiment 2: Step-level public good game decision (PGD) + expectations decision (EXD) — Period 1 ... Period 20
Players (sessions 1–10)	DG1 ... DG24	PGD; EXD ... PGD; EXD
Spectators (sessions 7–10)	DG1 ... DG24	EXD ... EXD

spectator was paired to them or not (this was the case for about half of the players). Nobody knew who was paired to whom, however, except the observer.

Table 2 presents an overview of the decisions various participants had to make in both experiments. When everybody had made their decisions, subjects were informed how many markers were bought by their group, the resulting public payoff, and their own 'probability-payoff'. Then the subjects were allocated to new groups and the game proceeded to the next round. The spectators remained spectator throughout all 20 periods. More details of the procedure are provided in Appendix B.

III. RESULTS

In this section, the data obtained in the experiment will be confronted with the theories discussed in Section I. In doing so, these theories will be elaborated to apply them to the specific parameters used. This is undertaken in Section III B. First, Section III A presents some general results and a first evaluation.

III A *General Description and Evaluation*

The 10 sessions were run as planned and without any serious problems. From the questionnaire conducted after the second experiment, it appeared that the subjects had understood the instructions properly. Subjects could read the computerised instructions at their own pace. Nothing in the individual decisions indicates that the subjects did not know what they were doing. Therefore, these experiments potentially provide very rich data, with independent information on individual value orientation, expectations, and voluntary contributions.

(i) *Experiment 1: Value Orientation.* The goals pursued by subjects were assessed by means of the choices observed in the decomposed game in experiment 1. Of the 186 subjects who participated as players in the public good experiment (observers and spectators excluded) 121 were classified as individualistic (65%): 49 individualists participated in low-7, 38 in high-7, and 34 in high-

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5; 50 players were labelled cooperative (27 %): 10, 21, and 19, in low-7, high-7, high-5, respectively; 8 players, 2 in high-7 and 6 in high-5 were labelled competitive (4 %) and 1, in low-7, was labelled aggressive (1 %); 6 subjects appeared to choose randomly in the decomposed games (3 in low-7, 2 in high-7 and 1 in high-5), which means that their consistency measures are below 33 %. These 6 subjects are not classified at all. The overall level of consistency is 90 %, which is relatively high. For example, Liebrand (1984) reports consistency levels of 76 and 80 %. Thus, as in Offerman and Schram (1993), the use of financial incentives seems to have yielded a higher consistency.

(ii) *Experiment 2: Expectations.* Concerning expectations three questions have to be answered. Obviously, the first question is whether individuals reported their beliefs truthfully and seriously. This question can be answered by using information gathered in the questionnaires, by assessing the number of gambles and extreme cautious distributions and by investigating whether decision *A* and decision *B* are perceived as part of one game. The second question is whether beliefs are reasonable, by which we mean, whether the form of the reported probability distribution is reasonable and whether beliefs are adapted in a reasonable way in the light of the history of a subject. The third question is whether beliefs are rational or accurate. Unless explicitly stated otherwise, these questions are only addressed for the players, not for the spectators.

To start with the first question, the data and the questionnaires strongly suggest that the subjects reported their subjective probabilities about the behaviour of others seriously and truthfully.[9] When asked in the questionnaire, 50 % of the subjects reported that their estimates would have been different without incentives, primarily, that they would not have taken the estimation task as seriously and that they would have reported distributions with less dispersion (which is the easy thing to do).

In addition, only a few probability assignments are extreme: in 156 of all cases (4·2 %) subjects assigned a probability of 100 % to one of the possible events. In 47 of these cases, the allocation of 100 % to the event that 0 of the others would buy a marker was a response to the fact that (s)he had observed 0 % contributions of the others in the former round(s). The remaining 109 cases (2·9 %) may represent gambles or otherwise implausible expectations. In addition, extreme risk-averse distributions are very rare: in low-7 and high-7, in a total of 16 cases (less than 1 % of the total) the probabilities were assigned such that the smallest probability was greater than 9 % and the greatest probability less than 21 %. In high-5, 12 cases (1 %) were observed where all (5) possible events were given a probability of 20 %. In all other cases in high-5, the difference between the highest and lowest probability was at least 10 %-points.

Another bias of truthfully reporting distributions could occur if people perceive the contribution decision and the reporting of expectations as parts of

[9] Despite our emphasis on the contrary, four subjects erroneously thought that if they bought a marker themselves, they should automatically add 1 to the 'number of others that bought a marker' or that 'the event that 0 of the others bought a marker logically could not occur' in that case.

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one game, with related decisions.[10] If players consider both decisions as part of one game, the analysis of this game could become very complicated. Our distinction of players and spectators allows for a test for an unintended influence of the contribution decision on the expectation decisions. Spectators only report expectations, and if no systematic differences are observed between their reported distributions and those reported by players, it may be assumed that both decisions are taken independently.

We added 31 spectators in the high-5 condition, implying that 31 players were paired to an anonymous spectator, and 29 were not.[11] Comparing the distributions reported by spectators and players, there is no systematic difference between the means of their reported distributions.[12] There is a slight difference in the variance of the reported distributions, however. It turns out that 20 spectators report distributions with a lower variance and 11 spectators report distributions with a higher variance than the corresponding players do. Spectators make less money on the reported distributions than players do. If players would consider the two decisions as part of one game, one would expect that they would do worse than spectators, which is certainly not the case. Therefore, we are confident that decisions *A* and *B* are considered independently by the players.

The second question is whether beliefs are reasonable. One way to answer this question may be to investigate the forms of reported probability distributions. Decisions might be rationally based upon expectations which themselves are unreasonable (for example, someone estimates the probability that her or his contribution is critical to be 90% and contributes; this decision is in line with the consistent behaviour hypothesis, but the belief itself is not very reasonable in an experiment where the composition of the groups changes every period). Although it is hard to determine objectively whether beliefs are reasonable or not, with the design used something can be said about it.

In each period, a subject is randomly grouped with six other subjects out of the total of 20 in low-7 and high-7 and with four others out of 14 in high-5. If the expectations of a subject are based on the probability p that a randomly drawn subject will contribute, the reported distributions should resemble the binomial. In this sense, distributions with more than one mode (e.g. 10%, 40%, 0%, 10%, 50%, 0%, 0%) are not reasonable. Moreover, given that subjects do not know p precisely and that p may shift during the experiment, one would expect the variance of the reported distribution to be at least as great as the variance of the binomial distribution with the same mean as the reported distribution.

A large majority of 97·4% of the reported probability distributions is

[10] A simple case is where participants use one game to try to 'insure' themselves against bad outcomes in the other. We have tested this in various ways and conclude that insurance is not taking place. More information is available from the authors.

[11] There is no difference in the decisions of players that have spectators paired to them and players that do not.

[12] A Wilcoxon rank test does not reject the hypothesis that the average mean of a player is equal in rank to the average mean of the corresponding spectator ($p = 0{\cdot}23$). There are too few sessions (4) to use average data per session as observations for this hypothesis.

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unimodal. In this respect, reported distributions are very reasonable. The actual mean and the actual variance of each reported probability distribution for each subject in all periods is computed. Each actual mean is used to calculate the corresponding hypothetical variance of the binomial distribution with the same mean. The hypothesis that the actual variance is equal to the hypothetical variance is rejected: the actual variance is significantly smaller ($p = 0{\cdot}001$).[13] Spectators also report distributions with smaller variances than the binomial in all sessions. In this sense subjects are overconfident in their predictions. In different contexts, overconfidence effects when people make judgements have been reported before (Schmalensee, 1976; Dunning *et al.*, 1990; Vallone *et al.*, 1990; Griffin and Tversky, 1992).

Another way to evaluate whether beliefs are reasonable is to investigate whether the adjustment of reported expectations in response to observed behaviour is reasonable. It turns out that subjects clearly take their own history into account. The reported probability of a certain event is (significantly) higher if that event occurred in the former round than when another event occurred in the former round. Furthermore, the mean of the reported probability distribution responds positively to the number of markers bought by her or his group in the former round: if the mean of the reported distribution in the former period is too high (low), the new reported mean decreases (increases). The changes are statistically significant. This suggests that beliefs are updated in a very reasonable way.

The results with respect to the first two questions posed support the idea that subjects report their expectations truthfully and use reasonable distributions when doing so. As for the third question about the 'rationality', or accuracy of the distributions, people tend to overestimate the contributions of others when reporting beliefs on what others do: the rational expectations hypothesis is rejected by the data. Both individualists and cooperators in all conditions report distributions with means greater than the mean number of markers bought by the others in the group. This holds for spectators as well as players. The difference between reported mean and number of markers bought by the others is significant ($p = 0{\cdot}028$). As reported above, spectators and players do not show significant differences in the mean of the reported distributions, but spectators appear to be slightly more overconfident.

All in all, it seems that expectations are reported seriously and truthfully, and that these expectations are reasonable but not rational.[14] We can therefore use the reported expectations to check whether observed behaviour is consistent with them. This is part of the analysis to be undertaken in Section III B.

(iii) *Experiment 2: Voluntary Contributions.* Fig. 2 presents the contribution rates over rounds, for the three conditions. In low-7 a marker was bought in 19·8% of the cases, in high-7 in 41·0% of the cases, and in high-5 in 50·40% (cf. Fig.

[13] Unless indicated otherwise, tests are Wilcoxon rank tests with average values for the relevant variables per session as observations. The results are stronger when individual data are used as observations, but observations in a session may not be independent.

[14] Refer to the first paragraph of this subsection for the way in which we distinguish serious and truthful/reasonable/rational.

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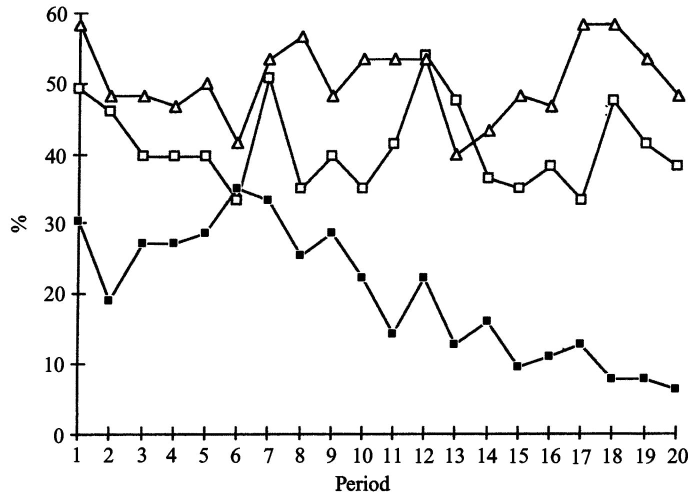

Fig. 2. Markers bought per condition. ■, Low-7; □, high-7; △, high-5.

2). The public good was provided in 18·3, 61·7, and 51·30% of the cases, respectively. The treatment effects are as expected: the effect of increasing the public good payoff from low-7 to high-7 is significant: subjects in high-7 contribute more than subjects in low-7 (Mann–Whitney test with average values per session as observations, $p = 0{\cdot}0495$); the difference between high-7 and high-5 is significant as well: subjects in high-5 contribute more than subjects in high-7 (similar Mann–Whitney test, $p = 0{\cdot}03$).[15]

Note that with repetition the decline in contributions often reported for VCMs (cf. Ledyard, 1995) is only found for low-7. Given the declining contributions in the last two rounds in high-5 and high-7, it might be argued that there is a general final round effect. However, the fact that there is an increase in the contributions in these conditions just before these last two rounds renders such a conclusion less straightforward.

(iv) *Experiment 2: Value Orientations.* Cooperators bought more markers than individualists did in all periods taken together ($p = 0{\cdot}009$). The difference is most noteworthy in the first 5 periods ($p = 0{\cdot}007$; the difference in periods 6–20 just misses statistical significance at a 5%-level, $p = 0{\cdot}059$). The fact that cooperators buy more markers than individualists cannot be explained merely by their estimated probability of being critical for the provision of the good. In fact, cooperators do estimate this probability to be higher, but differences are very small.

[15] An anonymous referee suggested a different test for testing the treatment effects of groupsize and payoff level, in order to include more of the variation in group contributions. (S)he suggested we pool the group data by treatment and test the coincidence of the distributions of group contributions in high-7 and low-7 using a Mann–Whitney test. The same test can be used to test the coincidence of the distributions of the percent of total potential markers purchased in high-7 and high-5 (percentages because these treatments differ in groupsize). The results for these tests are similar but stronger ($p = 0{\cdot}00$; $p = 0{\cdot}00$) than the results in the main text. However, one should keep in kind that group contributions are not completely independent (though, of course, with groups scrambled after each round, they are not completely dependent either).

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Table 3
Mean Contribution Percentage per Treatment

All subjects			Individualists			Cooperators		
Low-7	High-7	High-5	Low-7	High-7	High-5	Low-7	High-7	High-5
20 (1)	40 (3)	53 (7)	16 (1)	44 (3)	41 (7)	38 (1)	44 (3)	74 (7)
11 (2)	42 (4)	49 (8)	9 (2)	39 (4)	48 (8)	23 (2)	42 (4)	51 (8)
29 (5)	42 (6)	55 (9)	26 (5)	32 (6)	51 (9)	25 (5)	55 (6)	68 (9)
		45 (10)			43 (10)			51 (10)

Note: The particular session number is shown in parentheses.

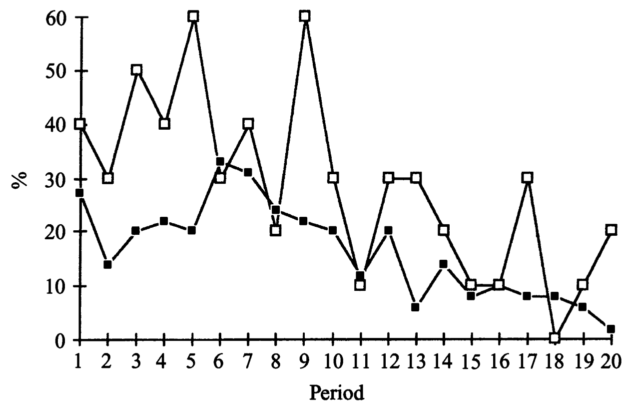

Fig. 3. Markers bought per orientation in low-7. ■, Individualistic; □, cooperative.

The treatment effects carry over to both individualists and cooperators, as can be seen in Table 3. Both orientations contribute most in high-5, and least in low-7 (Fig. 3). In fact, the differences in marker purchases between high-7 (Fig. 4) and low-7 are significant for individualists as well as for cooperators (Mann–Whitney test with average values per session as observations, $p = 0{\cdot}0495$ and $p = 0{\cdot}0495$ respectively). The differences between high-7 and high-5 (Fig. 5) miss the significance level (similar testing, $p = 0{\cdot}16$ for both orientations; note that only seven observations are used for the two tests on differences between high-7 and high-5).

An interesting aspect is that, on average, cooperators made as much money as individualists did in the public good experiment (decision *A*), only in high-5 the individualists did slightly better. In low-7, the average total payoff for individualists was f. 14.06 and for cooperators f. 14.10, whereas they were f. 29.76 and 30.02, respectively, in high-7, and f. 25.28 and 23.88 in high-5.[16]

III B *Testing Models and General Hypotheses of Individual Behaviour*

(i) *The Triangle and False Consensus Hypotheses.* As discussed in Section I, both hypotheses claim that cooperators will contribute more than individualists do.

[16] The average probability-payoffs were similar as well: for individualists f. 14.21, 13.55, 14.39 in low-7, high 7 and high-5; for cooperators f. 14.19, 13.38, and 13.67, respectively.

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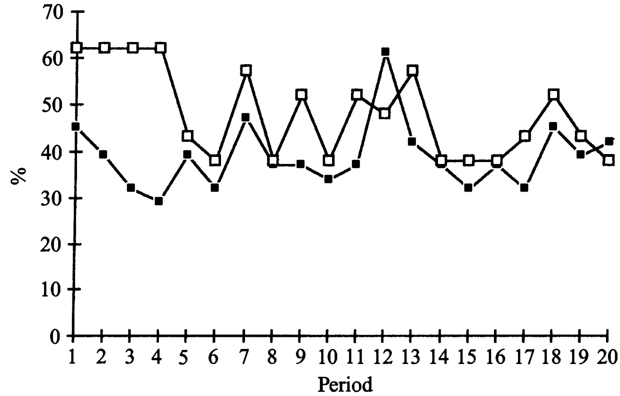

Fig. 4. Markers bought per orientation in high-7. ■, Individualistic; □, cooperative.

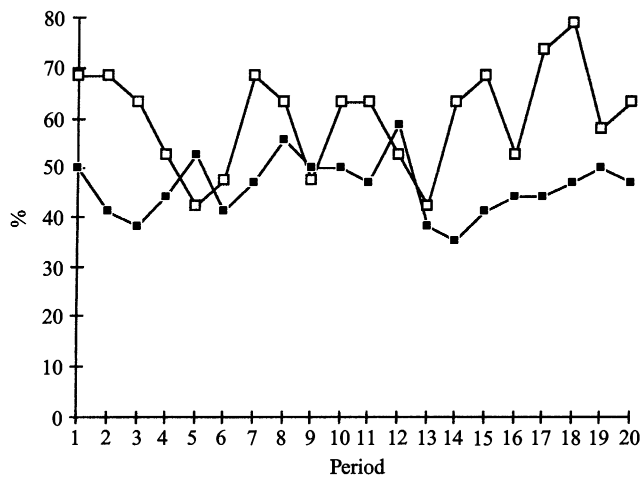

Fig. 5. Markers bought per orientation in high-5. ■, Individualistic; □, cooperative.

In both hypotheses, cooperators expect more contributions by others than individualists do, especially in early rounds. The difference between these two is that the triangle hypothesis predicts that behaviour is determined by expectations, whereas the reverse is predicted by the false consensus hypothesis.

First we consider the two common predictions of these models. The first prediction is supported by our finding that cooperators contribute significantly more than individualists do. The second, concerning the difference in expectations, is checked by considering the means of the reported distributions. Based on these hypotheses, one would expect that (on average) the mean reported by a cooperator would be higher than the equivalent mean reported by an individualist. The data do not provide strong support for this. Table 4 presents the mean of the probability distribution reported by individualists and cooperators in the various conditions. Note that it is in line with the triangle hypothesis to look at the first five periods only, because cooperators are

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Table 4
Mean Value of the Reported Distribution (Players Only)

	Period 1–5		Period 6–20		Period 1–20	
	Individualists	Cooperators	Individualists	Cooperators	Individualists	Cooperators
Low-7	2·24	2·51	1·46	1·68	1·66	1·89
High-7	2·93	2·93	2·71	2·64	2·77	2·71
High-5	2·08	2·11	2·07	2·09	2·07	2·10

expected to adjust their expectations after having played against individualists for a while.[17] This does not change the conclusion.

Now we turn to the difference between both theories. The difference in causality between expectations and behaviour can be tested using the distinction in players and spectators. According to the false consensus hypothesis the variance of the player's expectations should be smaller than the variance of the (paired) spectator's expectations, because expectations are determined by behaviour and spectators do not make any decisions. On the other hand, according to the triangle hypothesis there should only be room for white noise errors between these two variances, because behaviour is determined by expectations and not the other way around. On the basis of this comparison, the triangle hypothesis does better than the false consensus hypothesis: if anything, players report distributions with variances greater than those of spectators.

(ii) *The Consistent Behaviour Hypotheses – Homogeneous Individuals.* According to the consistent behaviour hypothesis all individuals are individualists and choose as if they maximise expected value. Individuals are endowed with an amount c, which they may contribute or not to obtain the public payoff $f(s)-c$, where s contributors are needed to have the public good provided. Let $\mathrm{P}(<s-1)$, $\mathrm{P}(s-1)$ and $\mathrm{P}(>s-1)$ denote the subjective probabilities that fewer than $s-1$ others contribute, $s-1$ others contribute and more than $s-1$ others contribute. It can easily be seen that individualists should contribute if and only if they estimate $\mathrm{P}(s-1) \geqslant c/[f(s)-c]$. This implies that in low-7 they should contribute if and only if $\mathrm{P}(2) \geqslant 0{\cdot}50$ and in high-7 and high-5 if and only if $\mathrm{P}(2) \geqslant 0{\cdot}32$. This hypothesis is not confirmed by the data: only 75 % of the decisions not to buy and 45 % of the decisions to buy are in line with the hypothesis.

Because especially the decisions to buy are not consistent with reported expectations, it was examined whether the value orientation makes any difference. It turns out that individualists behave more consistently with their reported probabilities than cooperators do. Table 5 shows the data aggregated over individuals in various condition/orientation combinations. Italicised

[17] Instead of using the psychological classification in individualists and cooperators, one can also test for a relationship between the mean of the distribution and (the angle of) the motivational vector itself. This yields the same results.

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Table 5
Observed Percentage of Behaviour in Line with Expectations

	According to expectations		Does not buy	Buys
Low-7				
Individualistic	Should not buy	$N = 905$	*85·6 (90·9)*	14·4 (9·1)
	Should buy	$N = 75$	57·3 (82·1)	*42·7 (17·9)*
Cooperative	Should not buy	$N = 187$	*72·2 (83·5)*	24·8 (16·5)
	Should buy	$N = 13$	61·5 (66·7)	*38·5 (33·3)*
High-7				
Individualistic	Should not buy	$N = 549$	*73·2 (64·2)*	26·8 (35·8)
	Should buy	$N = 211$	56·9 (50·8)	*43·1 (49·2)*
Cooperative	Should not buy	$N = 270$	*54·4 (56·8)*	45·6 (43·2)
	Should buy	$N = 150$	47·3 (52·6)	*52·7 (47·4)*
High-5				
Individualistic	Should not buy	$N = 252$	*65·9 (72·2)*	34·1 (27·8)
	Should buy	$N = 428$	46·7 (46·6)	*53·3 (53·4)*
Cooperative	Should not buy	$N = 158$	*39·2 (43·8)*	60·8 (56·3)
	Should buy	$N = 222$	40·5 (35·7)	*59·5 (64·3)*

Notes: The number of decisions (n) refers to all 20 rounds. The numbers in parentheses are the figures for periods 11–20 only. Italic data are in line with consistent behaviour hypothesis.

percentages are in line with the consistent expectations hypothesis. Note that cooperators buy a marker more often, when this is not justified on the basis of their reported expectations than individualists do. However, even though the behaviour of individualists is more in line with the hypothesis than that of cooperators, there is still quite some discrepancy between their observed and predicted behaviour. This conclusion does not change if only decisions in the last 10 periods are considered.

Underlying the consistent behaviour hypothesis is the simple idea that people maximise expected value. Showing that many people do not maximise expected value does not imply that they do not maximise expected utility. For example, cooperators may attach additional utility to the act of cooperation, implying that a lower probability of being decisive is sufficient to buy a marker. Results from somewhat more sophisticated models of individual behaviour will be discussed below.

Although the consistent behaviour hypothesis cannot be maintained in the light of this evidence, a natural question is whether comparative statics following from this hypothesis are supported. A straightforward result is that there is a positive correlation between the estimated probability of being critical and the propensity to contribute. This hypothesis is not rejected, as can be seen from Table 6. Over all 20 periods, the reported probability of being critical is significantly higher when a marker is bought than when no marker is bought ($p = 0{\cdot}02$). This is mainly caused by periods 11–20, however, which could imply that some learning takes place.

The interaction between individuals can also be analysed game-theoretically. This is done in Appendix A. In all cases, Nash equilibria for this game are rejected as point predictions. This is not surprising given the fact that expectations are biased and given the lack of support for the consistent

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Table 6

Mean Reported Probabilities of Being Critical

		Individualistic		Cooperative	
	Period	Does not buy	Buys	Does not buy	Buys
Low-7	1–10	28·59	32·37	34·95	27·45
	11–20	20·78	36·00	20·41	25·41
	1–20	24·36	33·42	26·51	26·84
High-7	1–10	25·13	24·38	24·35	30·84
	11–20	25·38	31·93	27·67	32·37
	1–20	25·25	28·31	26·12	31·55
High-5	1–10	32·31	37·82	39·13	34·23
	11–20	33·46	45·40	38·95	42·97
	1–20	32·89	41·54	39·04	38·72

Table 7

Utility Transformations of the Payoff Matrix

Others	No	Yes	Others	No	Yes
	Individualists			x-cooperators	
$< s-1$	c	0	$< s-1$	c	0
$s-1$	c	$f(s)-c$	$s-1$	c	$f(s)-c+x$
$> s-1$	$f(s)$	$f(s)-c$	$> s-1$	$f(s)+x$	$f(s)-c+x$
	y-cooperators			z-cooperators	
$< s-1$	c	$0+y$	$< s-1$	c	0
$s-1$	c	$f(s)-c+y$	$s-1$	c	$f(s)-c+z$
$> s-1$	$f(s)$	$f(s)-c+y$	$> s-1$	$f(s)$	$f(s)-c+z$

Note: No means not contributing, yes means contributing.

behaviour hypothesis. Nevertheless, some support for comparative statics to be derived from game theory is obtained. More details may be found in Appendix A.

(iii) *The Consistent Behaviour Hypothesis – Heterogeneous Individuals.* A natural interpretation of the differences in behaviour of individuals in terms of a utility-based approach may be the following: assume that each individual transforms the payoff matrix to a different matrix of utilities. Three possible transformations are discussed here: *x-cooperators* acquire an extra utility if the public good is provided; *y-cooperators* acquire utility from the act of contributing ('contributing yields a good feeling or a warm glow', cf. Andreoni, 1990, 1993) and *z-cooperators* form the intersection of x- and y-cooperators: they acquire an extra utility of the act of contributing, but only if the public good is provided ('knowing that you contributed your bit makes you feel good if and only if the public good is provided'). The corresponding utility matrices are given in Table 7. Although the terms x-, y- and z-cooperator may suggest otherwise, we allow for the possibility that x, y and z are zero or even negative.

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The consistent behaviour hypothesis for heterogeneous individuals assumes expected utility maximisation. In this case, it can easily be seen that x-cooperators should contribute if and only if they estimate $P(s-1) \geqslant c/[f(s)-c+x]$, that y-cooperators should contribute if and only if they estimate $P(s-1) \geqslant (c-y)/[f(s)-c]$ and that z-cooperators should contribute if and only if they estimate $P(s-1) \geqslant [c-zP(>s-1)]/[f(s)-c+z]$. Thus, for z-cooperators the decision is not only dependent on $P(s-1)$, but also on one other probability.

On the basis of their choices, for each individual the 'optimal' x, y, and z value can be computed. Optimality is defined such, that the observed choices fit the theory best. For the x and y transformation, each value of x or y yields a cut-off point in terms of the probability that exactly two other individuals will contribute ($P(s-1) = P(2)$).[18] For z-cooperators the decision whether to buy a marker or not should not only depend on $P(s-1)$, but also on $P(>s-1)$. When $z > [c-f(s)\,P(s-1)+cP(s-1)]/[P(>s-1)+P(s-1)]$, a z-cooperator should buy. For each individual the 'optimal' z can be computed by ordering her or his 20 realisations for $[c-f(s)\,P(s-1)+cP(s-1)]/[P(>s-1)+P(s-1)]$ and subsequently choosing z such that (s)he makes the least possible errors against this bench-mark.[19]

For 31 of the 186 players no cut-off points could be computed, because they always or never bought a marker. For these subjects only an upper bound or a lower bound on the cut-off points can be derived and so they are excluded from the analysis. In a trivial sense, these 31 participants act in line with the heterogeneous version of the consistent behaviour hypothesis.

Of the remaining 155 subjects, 52 made five or more mistakes against their optimal x-y cut-off point. In addition, 23 subjects bought less than five or more than 15 markers but each decision to buy or not to buy, respectively, was an error against their optimal x-y cut-off point. For the remaining 80 subjects, the x-y transformations of the payoff matrix worked reasonably well.

Of the 155 subjects, 83 made five or more mistakes against their optimal z cut-off point and an additional 32 subjects bought less than five or more than 15 markers, while each decision to, respectively, buy or not to buy was an error against their optimal z cut-off point. For another five subjects, the z matrix transformation was not suitable because their z value became infinitely large. For the remaining 35 subjects the z transformation of the payoff matrix worked reasonably well. For 24 of these 35 subjects, the x-y transformation worked reasonably well too. Thus, the x-y transformation appears to work better than the z transformation.

In this analysis, the level of cooperativeness was derived from actual choice

[18] Note that if one computes the 'optimal' x or y as described, one is actually determining the value of $P(2)$ – the cut-off point – such, that the individual makes the least possible errors from an economic point of view. Therefore, the cut-off points in terms of $P(2)$ are the same for both transformations (though one value of $P(2)$ yields different values of x and y).

[19] Of course, other utility transformations of the payoff matrix are possible. A similar transformation could be proposed if people are assumed to be risk-averse. We do not pursue this possibility here, because risk-aversion cannot explain the positive amounts often observed to be contributed in VCMs without a threshold, which could potentially be explained by the possibilities discussed above.

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behaviour. The optimal x-y-z values found can be linked to the results of the decomposed game. Subjects classified as cooperators on the basis of this game should have higher x-y-z values than subjects classified as individualists. This is corroborated by the data: cooperators' average x-y-z values are 60, -4, and 139 cents, respectively, whereas these figures for individualists are 21, 0, and 32 cents.[20]

On the basis of the results in Appendix A, one can also undertake a game theoretic analysis of the SLPG game for heterogeneous individuals. This analysis provides an improvement compared to the model for homogeneous individuals because of its more realistic assumption about individuals' preferences. However, the model still needs to prove itself as far as point predictions for actual behaviour are concerned. More details are provided in Appendix A.[21]

IV. CONCLUDING DISCUSSION

A key observation from former experiments in public good environments used as the basis for the experiments described here was that individual propensities to contribute vary substantially. This paper has provided a way to acquire an independent measure of these different attitudes by means of the decomposed game technique. Individuals classified as individualists on the basis of this technique contribute less in the step-level public good game than individuals classified as cooperators. The difference is most noteworthy in the first periods. After these periods the difference decreases (except when groupsize is small and payoff high). If value orientations are not taken into account in the analysis explicitly, then it appears to be very difficult to explain what is going on in a step-level public good game.

Furthermore it has been shown that it is possible to measure individuals' expectations about the behaviour of the others in their group. A scoring rule was used to encourage the subjects to report their probability distribution about the behaviour of others truthfully and seriously. Only a few distributions were extreme or otherwise implausible. On the basis of the reported distributions, it appears that expectations are reasonable but not rational: individuals are too optimistic about the behaviour of others and they tend to be overconfident in their predictions. On the other hand, they tend to take their own history into account and update their beliefs in the expected direction.

The analysis of the experimental results shows that a relationship between expectations and behaviour exists, but it is not as strong as is usually assumed in economics. The consistent behaviour hypothesis – that individuals contribute if and only if the expected value of contributing is higher than the

[20] The negative average y value for cooperators is caused by one outlier. If this subject is excluded from the analysis, the average y-value for cooperators is $+3$ cents.

[21] We also considered two non-utility-based models, a simple learning model and a reciprocity model. The Pavlov learning hypothesis states that individuals repeat a choice if it proved to be a success in the former period and abandon a decision which proved to be a failure in the former period. The reciprocity hypothesis we considered predicts that an individual will contribute if and only if the mean of the reported probability distribution exceeds a subjective cut-off point. These hypotheses find only limited support. More information about these models may be obtained from the authors.

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expected value of not contributing – cannot be supported in the light of the present data. However, a weaker version of this hypothesis – that a positive relation exists between the subjective probability of being decisive and the propensity to contribute – is in accordance with the data.

Finally, increasing the payoff for getting the step-level public good provided results in more contributions in the present study. The same effect on contributions is observed if groupsize is decreased. These results are in line with the predictions of game theoretic models.

Further analyses have been undertaken with respect to psychological and economic theories about behaviour. The evidence obtained is not very favourable for psychological hypotheses like the triangle hypothesis and the false consensus hypothesis. Consistent with these hypotheses is the finding that cooperators contribute more than individualists, but inconsistent is that cooperators do not expect more contributions of the others than individualists do. The triangle hypothesis did somewhat better than the false consensus hypothesis, because expectations were not affected systematically by behaviour. However, it could be argued that the present design did not give these hypotheses a fair chance of succeeding. In this game the Pareto optimum coincides with one of the Nash equilibria, allowing for the possibility that both types of individuals focus on the same point: the threshold.

As for the economic theories on individual behaviour, the hypothesis that people maximise expected utility after transforming the payoff matrix as if they are x- or y-cooperators (acquire an extra utility for getting the public good provided or feel a warm glow when they contribute) covered most choices, certainly more than the same hypothesis for z-cooperators (feeling good if and only if the public good is provided and they contribute). Although the present study clearly indicates that individuals do vary in their preferences regarding outcomes for others, it turns out to be very difficult to rationalise all choices. Some decisions simply seem to be errors from an economic point of view.

Nevertheless, it may be argued that individuals learn to behave rationally in a stable environment with clear feedback about the consequences of the choices. In at least a weak sense some learning is observed: in periods 11–20 the estimated probability of being decisive is significantly higher when a marker was bought than when no marker was bought, while this difference was not found to be significant in the first ten periods.

The results in this experiment support both Andreoni's (1990) and Palfrey and Rosenthal's (1991) conjectures about the behaviour and the expectations of people in VCMs. Andreoni's idea is that people acquire a 'warm glow' from giving to the public good, like the y-cooperator in this paper. Palfrey and Rosenthal suggest that people's expectations about other people's behaviour suffer from wishful thinking: they expect too many contributions from others. The present paper clearly shows that both hypotheses can be supported by the data, but that neither hypothesis can adequately account for the observations on its own. This seems to limit the prospects for conventional game theoretic modelling. Not only is an altruism component needed in the utility function (which can be done straightforwardly as shown in Appendix A), but also an

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equilibrium concept which relaxes the assumption of accurate expectations (the usual assumption of the Bayesian Nash equilibrium).

All in all, this paper has provided some insights into the relationship between expectations, orientation and behaviour in the experiment. Naturally, many interesting questions remain, e.g. can the process of expectation formation be described in a model with testable implications? Do people learn to behave rationally, and if so, what is the process according to which this happens? We think that the type of experiments described in this paper can play an important role in answering these, and other questions.

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Appendix A: *Game Theoretic Analysis*

The game theoretic analysis in this section extends the model of Gradstein and Nitzan (1990). The individual decision of subject i not to contribute is denoted by $s_i = 0$ and her or his decision to contribute by $s_i = 1$. First the case of homogeneous individuals is considered. Assume $f(s) > 2c$ and $s > 1$. It may be shown that only the following two types of equilibria in pure strategies exist: first, $s_i = 0$ for all i. Second, $n!/[s!(n-s)!]$ different Nash equilibria where exactly s players contribute.

Furthermore, a Nash equilibrium in symmetric mixed strategies is reached if all players contribute with the same probability p^*, such that:

$$\binom{n-1}{s-1} (p^*)^{s-1} (1-p^*)^{n-s} [f(s)-c] = c.$$

This equation is analogous to equation (14) in Gradstein and Nitzan (1990). The equilibrium condition is referred to as: $f(n^*,p) = c/[f(s)-c]$. It can easily be shown that in general two symmetric mixed strategies p^*_1 and p^*_2 exist, with $p^*_1 < p^*_2$. If groupsize decreases, at most two new equilibria $p_1{}^{**}$ and $p_2{}^{**}$ will arise with $p_1{}^* < p_1{}^{**}$ and $p_2{}^* < p_2{}^{**}$. So, on average one would expect that decreasing groupsize will yield more contributions, as can be seen in Fig. 6 (for a proof of this statement, see Offerman, 1993).

As a complement to the analysis in the main text, a test for game theoretic predictions without making use of the data obtained on expectations is given. Only symmetric Nash equilibria will be considered here. In low-7, the only symmetric equilibrium is obtained if nobody buys a marker. In only 52 of the 180 groups was this observed. In high-7, three symmetric equilibria exist: one consisting of pure strategies, nobody buys, and two consisting of mixed strategies such that all individuals buy with a probability of 30·1 or 36·7%. No support of the pure strategy equilibrium can be found; only in 5 of the 180 groups were no markers bought. Using a Kolmogorov–Smirnov One-Sample test the hypotheses can be tested that all subjects used a mixed strategy with a buying-probability of 30·1 or 36·7%. The number of markers purchased per subject should be (approximately) normally distributed with mean 6·02 and standard deviation 2·05 or with mean 7·34 and standard deviation 2·15. Both hypotheses are rejected ($p = 0{\cdot}000$). Not only is the number of markers bought too high (8·20), the standard deviation is much too high (5·66).

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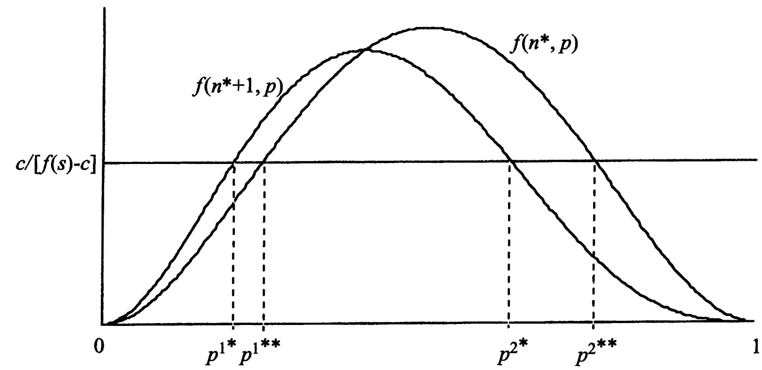

Fig. 6. Mixed strategies for homogeneous individuals.

In high-5 the same kind of results are found. Three symmetric equilibria exist: one consisting of pure strategies, nobody buys, and two consisting of mixed strategies such that all individuals buy with a probability of 36·8 or 63·2%. No support of the pure strategy equilibrium can be found; only in 7 of the 240 groups were no markers bought. The number of markers purchased per subject should be (approximately) normally distributed with mean 7·36 and standard deviation 2·16 or with mean 12·64 and standard deviation 2·16. Both hypotheses are rejected (Kolmogorov–Smirnov test, $p = 0{\cdot}000$). The standard deviation is much too high (5·09). The fact that symmetric equilibria are rejected suggests that the assumption of homogeneity should be relaxed.

Nevertheless, the comparative static result is confirmed, that for homogeneous individuals a decrease in groupsize yields lower contributions on average.

Next, assume that two types of individuals are present. In the following, Q denotes the true probability that an arbitrary individual is of the x-cooperative type. Suppose $Q > 0$. Although players receive the same amount of money if the step level is exceeded by individual contributions (a payoff of $f(s) - c$), it is now assumed that x-cooperators (c) and individualists (i) acquire different utility levels from this amount:

$$f_c(s) \equiv f_i(s) + x, x > 0.$$

It is assumed that individuals know their own type with certainty and have consistent expectations of the types of the others. Specifically, each individual assigns a probability q to the event that an arbitrary other individual is of the cooperative type and a probability $1 - q$ to the event that this individual is of the individualistic type. In equilibrium, the subjective estimate that an arbitrary other individual is of the cooperative type (q) is equal to the actual probability (Q).

If $f_i(s) > 2c$ and $s > 1$, then the same equilibria in pure strategies as for $Q = 0$ can be derived. For equilibria in mixed strategies, assume that participants from the homogenous group individualists contribute with probability p_1, while participants from the homogenous group cooperators contribute with probability p_2 (thus, a kind of quasi-symmetry is assumed). The probability of providing the critical contribution is the same for all individuals and equal to:

$$\sum_{k=0}^{n-1}\Bigg[\binom{n-1}{k} q^k (1-q)^{(n-k-1)} \times \sum_{i=0}^{\min(s-1,n-k-1)} \binom{n-k-1}{i} p_1{}^i (1-p_1)^{(n-k-i-1)} \binom{k}{s-i-1} p_2{}^{(s-i-1)} (1-p_2)^{k-s+i+1)}\Bigg].$$

This probability is a polynomial in p_1 and p_2 for given q, n and s, denoted by $\mathrm{pol}(p_1,p_2)$.

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If $0 < p_1 < 1$, then for a Bayesian Nash equilibrium in quasi-symmetric strategies it is required that:

$$\text{pol}(p_1,p_2)\,[f_i(s)-c] = c.$$

And if $0 < p_2 < 1$, then for such an equilibrium to evolve it is required that:

$$\text{pol}(p_1,p_2)\,[f_c(s)-c] = c.$$

One can distinguish nine cases.

	$p_2 = 0$	$0 < p_2 < 1$	$p_2 = 1$
$p_1 = 0$	Case 1	Case 2	Case 3
$0 < p_1 < 1$	Case 4 X	Case 5 X	Case 6
$p_1 = 1$	Case 7 X	Case 8 X	Case 9

It is not difficult to see that cases 4, 5, 7 and 8 cannot occur because $f_c(s) > f_i(s)$, while cases 1, 3 and 9 degenerate to the equilibria in pure strategies. Cases 6 and 2 represent the more interesting cases.

Case 6: $0 < p_1 < 1$ and $p_2 = 1$.

The Bayesian Nash equilibrium where individualists contribute with probability p_1 and cooperators contribute for sure will be realised if the following three conditions are fulfilled:

$$\text{pol}(p_1,1)\,[f_i(s)-c] = c$$
$$\text{pol}(p_1,1)\,[f_c(s)-c] > c$$
$$q = Q.$$

Case 2: $p_1 = 0$ and $0 < p_2 < 1$.

The Bayesian Nash equilibrium where individualists do not contribute and cooperators contribute with probability p_2 will occur if the following conditions hold:

$$\text{pol}(0,p_2)\,[f_i(s)-c] < c$$
$$\text{pol}(0,p_2)\,[f_c(s)-c] = c$$
$$q = Q.$$

In Offerman (1993) sufficient conditions for the uniqueness of the Bayesian Nash equilibria in these cases are given.

Of course, a natural question to ask is what would happen if more than two types of individuals were present, or what would happen if the groups of cooperators and individualists were not internally homogeneous. Assume that there are m types of individuals ($2 < m \leqslant n$) and that the common knowledge of the players includes the (utility-) payoffs to the other player types besides the knowledge of the own (utility-) payoff. All players estimate the probability that an arbitrary other individual belongs to type j consistently.

If there are m different types of individuals, assimilation of behaviour will result. In a Bayesian Nash equilibrium at most one type of player will randomise with probability p. All players who acquire less utility from the provision of the public good than this randomising type will not contribute and all players who acquire more utility will contribute for sure.

For the proof of this statement, see Offerman (1993). This statement is useful, because it allows any number of types of individuals to be reduced to three groups,

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those always contributing, those randomising, and those never contributing. Any violation of this stratification is a violation of the model.

In the experiments conducted, for any number of individual types, the results of the decomposed game can be used to categorise individuals. The analysis in this appendix may then be used to determine whether observed behaviour corresponds to equilibria for the model.

Game theoretic testing analogous to the case of homogeneous individuals has been undertaken using our results. Although the model for heterogeneous individuals performs better than the model for homogeneous individuals, the point predictions of this model are not supported by the data. More information is available from the authors.

Appendix B: *Instructions*

What follows is a translation of a sample of the instructions of experiment 1 and of low-7 of experiment 2.[22]

Instructions experiment 1

For the next twenty-four questions you will be asked to make choices involving money. In twenty-four situations you will have to choose between two options: Option A and Option B.

For each option *two amounts* will be depicted: one amount you will receive or pay *yourself and* one amount that the '*other*' will receive or pay. The 'other' is another participant with whom you are paired in the experiment. The pairing of the participant is arbitrary (randomly determined) and secret: during and after the experiment you will *not* know with whom you have been paired.

During the experiment you will not get any information about the choices of the participant with whom you are paired. Nor will the participant with whom you are paired get any information about your choices.

Your total payoff is the sum of the amounts that you make in each round. Each round you receive or pay the sum of the amount that you assign to yourself and the amount that 'the other' assigns to you. The sum of the amounts assigned to you by 'the other' will only be revealed to you after the second experiment has ended.

(...) You are not allowed to speak with the participants or to communicate in any other way. If you want to ask a question, please raise your hand.'

On the upper left part of each computer-screen a box was given for option A. In the box were two bars, one to depict the amount available to oneself and the other to depict the amount available for the other. If an amount was positive, the bar was above the axis and the colour of the bar was green. If an amount was negative, the bar was below the axis and the colour of the bar was red. The length of the bar was an indication of the magnitude of the amount. The amounts themselves were also written in the box. On the upper right part of the screen a similar box was depicted for option B. First the participants were given an example, where the amounts for option A were +f. 14.50 to oneself and −f. 3.90 to the other and the amounts for option B were +f. 13.00 to oneself and −f. 7.50 to the other. The consequences of the choices were carefully explained. Then subjects had to answer some questions testing understanding. Each subject made the same 24 choices between option A and B in a different random order.

Instructions experiment 2

After all participants had ended all the choices of experiment 1, experiment 2 started. These instructions were computerised such that each participant could read at her or his own pace. After a short introduction about how to use the computer, the instructions continued with the rules of the game:

[22] The data and the complete translation of the instructions will be sent by the authors on request.

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'The second experiment will last twenty periods. Each period you are assigned to a new group of seven persons. The composition of the groups changes in each period. You will not know the identity of your other group members in a period, and no other participant will know the identity of her or his group members. The assignment to the groups is made randomly. The probability is zero that you will meet exactly the same people in a group twice.

In each period you will be asked to make two decisions. First you will be asked whether you want to buy a marker or not (decision A). Then you will be asked to estimate the probabilities concerning how many of the others in your group will buy a marker (decision B).

DECISION A: You will make the decision whether or not to buy a marker. In this example the COSTS for buying a marker will be equal to 75 cents. During the experiment the COSTS will be a different amount. The COSTS for buying a marker are equal for everybody and will not change in the twenty periods.

If you buy a marker in a period, you will not literally receive a marker. You will get a revenue which depends on the number of members of your group that buy a marker. This revenue will be called the GROUP-REVENUE, because it is equal for everyone in a group. Your payoff in this part of the experiment, your MARKER-PAYOFF, will be equal to the GROUP-REVENUE, if you decided not to buy a marker, and will be equal to the GROUP-REVENUE minus the COSTS if you decided to buy a marker.

Your decision whether or not to buy a marker will not be revealed to the other participants.

GROUP-REVENUE TABLE: As already mentioned, the GROUP-REVENUE for a group depends on the total number of participants in a group that buy a marker. The GROUP-REVENUE will be presented in a GROUP-REVENUE TABLE. Here you see an example of such a table for an imaginary case.

Number of markers	0	1	2	3	4	5	6	7
Group revenue	30	40	50	140	180	200	200	225

The table will not change during the experiment. Each participant will have the same table, but it will be a different table from the one presented here. The form of the table will be the same but the amounts will differ. (...)

Next, an example was given explaining in detail how the GROUP-REVENUE table should be read. Subjects had to answer some questions testing understanding before they proceeded with the instructions on decision B.

DECISION B: The second decision you will be asked to make in each period concerns your estimation of the probabilities about the number of OTHER people in your group that will buy a marker. Before you get to know how many participants in your group bought a marker, you are asked to estimate the probability that exactly 0, 1, 2, 3, 4, 5 or 6 of the others will buy a marker. You are asked to report these probabilities in percentages. These 7 percentages should add up to 100%.

NOTE: this question concerns the number of markers bought by the OTHERS in your group, EXCLUDING YOUR OWN CHOICE.

You will receive a payoff dependent on your reported probabilities and the actual number of markers bought by the others in your group: the PROBABILITY-

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PAYOFF. This payoff is calculated on the basis of a formula. It is not important that you have (mathematical) insight into this formula. But it is important to know that your expected PROBABILITY-PAYOFF is maximised if you report probabilities truthfully. It is to your advantage to report probabilities honestly. It will never be the case that your PROBABILITY-PAYOFF is negative. Other participants will not get to know your reported probabilities, just like you will not know which probabilities are reported by the others.

For completeness the formula will be given in a handout. People who want to check the mathematical proof of the statement that for this formula the expected PROBABILITY-PAYOFF is maximised if the probabilities are reported seriously and honestly, can get this proof after the experiment.

Again, subjects had to answer questions. Then it was explained how they could recall information about their own results in earlier periods. Two practice periods were conducted where the decisions of the others were simulated, as explained to the participants. In the practice periods participants played for fictitious money.

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