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Voting on contributions to a threshold public goods game – an experimental investigation

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Abstract

We introduce a binding unanimous voting rule to a public goods game with an uncertain threshold for the total group contribution. In a laboratory experiment we find that voting generates significantly higher total contributions than making individual voluntary contributions to the public good. Heterogeneity with regard to marginal costs of contribution makes coordination on the threshold value somewhat more difficult when voting, but apparently facilitates coordination when not voting. Homogeneous non-voting groups instead exhibit a breakdown of contributions commonly observed in linear public goods games, but unusual for a threshold setting. We also notice a preference for payoff symmetry over maximization of expected welfare in heterogeneous voting groups, which to a lesser extent also appears in non-voting groups. Using a top-down rule, i.e., splitting the voting process into two separate votes on 1) total contribution and 2) individual contributions does not affect these results.

Keywords: public good, threshold uncertainty, experimental economics, unanimous voting, committee, heterogeneity

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1. Introduction

Public goods games with (uncertain) threshold values can be encountered in several different domains.¹ A prime example, which motivates our research, is constituted by the ongoing climate negotiations to prevent global warming. It is believed that disastrous ecological effects can only be prevented if global warming is kept below a critical “tipping point”, the passing of which can lead to sudden and irreversible damages.² These scientific findings brought about the agreement on the 2°C threshold for acceptable global warming in the 2009 Copenhagen Accord. In particular, the global warming threshold corresponds to an estimated global abatement quantity of greenhouse gas emissions (GHGs) that can only be achieved in a collaborative effort among a large number of countries. The exact value of this quantity, however, remains uncertain (Hansen et al., 2008) and thus this setting is a public goods game with an uncertain threshold value.

In contrast to other types of social dilemmas, which are primarily concerned with cooperation (increasing contribution levels), threshold public goods games are primarily concerned with coordination (reaching the threshold value).³ In two recent experimental studies, Barrett and Dannenberg (2012, 2014) therefore investigate such a threshold public goods game, reporting that threshold uncertainty, by making coordination on the threshold

¹See Rapoport and Suleiman (1993) and Barrett and Dannenberg (2012) for a number of examples.

²See the 2007 IPCC report (Solomon et al., 2007, p.775) and Hansen et al. (2008).

³Compare also Barrett and Dannenberg (2012) who suggest that the lack of success of climate negotiations so far is actually a failure to coordinate, because there is apparently already a global consensus on reaching a threshold, i.e. the 2°C target.

value more difficult, reduces total contributions substantially, despite the possibility of pre-play communication via contribution pledges.

Our experimental design complements theirs by using a binding unanimous vote on the one hand, and a repeated game on the other. The voting rule is further varied between a top-down process (total contribution chosen first, then distributed among individual players) and a bottom-up process (individual contributions chosen first, then added up to total contribution). The distinction between top-down and bottom-up decision rules originally stems from budget negotiations (Ferejohn and Krehbiel, 1987), which Ehrhart et al. (2007) have also simulated in a laboratory experiment by means of a voting rule. We take up this approach for our own experiment. In addition, we compare groups with homogeneous and heterogeneous marginal costs of contribution.

However, our results only partially confirm those by Barrett and Dannenberg (2012, 2014). While non-voting homogeneous groups indeed miss the threshold more often than they reach it, non-voting heterogeneous groups are much more successful right from the start. Success is practically guaranteed in the voting treatments, with top-down voting leading to similar results as the bottom-up process. Moreover, we find a preference for payoff-symmetrical outcomes in favor of welfare maximization in all of our heterogeneous treatments.

Overview articles on (threshold) public goods experiments include Ledyard (1995) and Croson and Marks (2000), the latter being concerned exclusively with threshold public goods games. A number of design elements investigated in the literature have proven to make coordination on the thresh-

old value more difficult, including heterogeneous player endowments (e.g., Rapoport and Suleiman, 1993; Croson and Marks, 2001), and threshold uncertainty (e.g., Suleiman et al., 2001; McBride, 2010; Barrett and Dannenberg, 2012, 2014). Using similar elements in our own experimental design should therefore equally decrease the players' coordination success.

In contrast, the fact that in our model (just like in climate negotiations) players face a negative payment (or penalty) if they fail to reach the threshold (instead of a reward if they succeed) may actually be an additional incentive to cooperate. Although previous studies have found detrimental effects on contributions when using a “public bads” framing, in which players then face a penalty instead of a reward (e.g., Sonnemans et al., 1998), this may be mainly due to the distinction between giving to and taking from a public account. Instead, prospect theory (Kahneman and Tversky, 1979) predicts a higher willingness to pay for avoiding an expected loss than for attaining an expected gain of the same size, meaning that contributions to the public good should be higher if the model is framed as preventing a penalty instead of gaining a reward.

Finally, we employ a unanimous vote, as this is a good representation of the political situation in UN negotiations where each country's interests must be accommodated. Unanimity appears to make agreement more difficult in a social dilemma than a majority rule (e.g., Walker et al., 2000). Heterogeneous costs in a voting context are investigated by Margreiter et al. (2005) who extend the model by Walker et al. (2000), but use only a majority rule. To our knowledge, we are the first to apply a binding vote to determine individual contributions in a threshold public goods game. However, Kroll

et al. (2007) have done this for a linear public goods game and find a similar increase of contributions compared to allowing only voluntary contributions.

The remainder of the paper is structured as follows. The theoretical model and its solutions are described in Section 2, followed by the experimental design and procedure in Section 3. Section 4 presents the results of our experimental investigation, which are further discussed in Section 5. Section 6 concludes with suggestions for future research and possible political implications of this work.

2. Theoretical Model

2.1. Basic model

Our model is based on the experimental study by Suleiman et al. (2001). A group N of n players choose their contributions to a public goods game with a threshold \bar{Q} . This threshold is randomly distributed over all integers between (and including) $Q_{min} < Q_{max}$. Each of these numbers can result with an equal probability of $1/(Q_{max}-Q_{min}+1)$. Each player i starts with the same endowment e which can then be used to pay for his contribution $q_i \in [0, \bar{q}]$ to the public good.

The players differ with respect to their marginal costs of contribution, meaning the conversion rate from endowment to contribution. There are two player types – one with high marginal contribution costs, $c = c_H$, and the other with low marginal costs, $c = c_L$. Hence, the group is split into two subgroups N_H and N_L , containing n_H and n_L players, respectively, with $n_H + n_L = n$. We assume $c_H \geq c_L > 0$.

The total contribution given by $Q = \sum_{i \in N} q_i$ must reach the threshold

\bar{Q} , i.e., $Q \geq \bar{Q}$. Otherwise each player suffers a penalty x which is deducted from his remaining endowment. We set $\bar{q} < Q_{min}$ and $Q_{max} < n\bar{q}$, so that it is always possible to reach the threshold value, but only if multiple players make contributions. Furthermore, we assume $nx > c_H Q_{max}$ to make sure that reaching the threshold is not only feasible, but also collectively profitable.

Player i 's payoff $\pi_i(q_i)$ is given by:

$$\pi_i(q_i) = \begin{cases} e - cq_i & \text{if } Q \geq \bar{Q} \\ e - cq_i - x & \text{if } Q < \bar{Q} \end{cases} \quad (1)$$

2.2. Ex ante social optimum

We will now argue that, with our choice of parameters, the (ex ante) social optimum of this game is reached with a total contribution of $Q^* = Q_{max}$, which is the highest possible threshold level. However, there are many ways in which this total contribution can be allocated among the individual players. Therefore, this is a coordination problem.

A group of $n \in N$ players maximize their expected total payoff, given by $\Pi = E_{\bar{Q}} [\sum_{i \in N} \pi_i(q_i)]$, with a vector of contributions $q^* = (q_1^*, \dots, q_n^*)$. We call this vector q^* the (ex ante) social optimum and refer to $Q^* = \sum_{i \in N} q_i^*$ as the socially optimal total contribution.

In order to find q^* , we first need to know the socially optimal contribution Q^* . Following a similar proof by Suleiman et al. (2001), we realize that for $Q_{min} - 1 \leq Q < Q_{max}$ an increase of the total contribution by 1 leads to a similar increase of the probability of reaching the threshold, $P(\bar{Q} \leq Q)$, by $1/(Q_{max} - Q_{min} + 1)$. Accordingly, in this interval an increase of the total contribution that is large enough to increase the probability of reaching the threshold

can also lead to an increase of the expected total payoff, if the marginal costs of contribution c are sufficiently small or the penalty for missing the threshold x is sufficiently large. Formally this is the case, if $c < nx/(Q_{max} - Q_{min} + 1)$, or equivalently $c(Q_{max} - Q_{min} + 1) < nx$, for $c \in \{c_L, c_H\}$. Since by assumption $nx > c_H Q_{max}$, this condition is satisfied, resulting in $Q^* = Q_{max}$.

Next, we consider the optimal way of allocating Q^* among the individual players, i.e., the optimal contribution vector q^* . If marginal costs of contribution are homogeneous ($c = c_H = c_L$), any allocation of Q^* leads to the same total costs of contribution cQ^* and, consequently, the same expected total payoff. So $q^* \in \{q \mid \sum_{i \in N} q_i = Q^*\}$. But if marginal costs are heterogeneous ($c_H > c_L$), total costs decrease if the low-cost players provide a larger share of the total contribution. Thus, low-cost players should provide either Q^* in its entirety, or $n_L \bar{q}$ if this is smaller than Q^* . Moreover, $cq_i \leq x$ must be satisfied for each individual player i to make this contribution individually rational, resulting in the following characterization of q^* :

$$q^* \in \left\{ q \left| \begin{aligned} \sum_{i \in N_L} q_i &= \min\{Q^*, n_L \bar{q}, n_L x/c_L\} \wedge (\forall i \in N_L : q_i c_L \leq x) \\ \wedge \sum_{j \in N_H} q_j &= Q^* - \sum_{i \in N_L} q_i \wedge (\forall j \in N_H : q_j c_H \leq x) \end{aligned} \right. \right\} \quad (2)$$

According to Equation 2, in order to find q^* , we first assign a share of Q^* to the low-cost players (top line). This share must be technically feasible ($\sum_{i \in N_L} q_i \leq n_L \bar{q}$) and collectively rational ($\sum_{i \in N_L} q_i \leq n_L x/c_L$), and otherwise should be as large as possible. Furthermore, each individual low-

cost player may not be assigned contribution costs higher than the penalty payment, i.e., $\forall i \in N_L : q_i c_L \leq x$. Any remaining share of Q^* is then allocated among the high-cost players (bottom line) in an individually rational manner, i.e., $\forall j \in N_H : q_j c_H \leq x$.

2.3. Voting rule

In our experiment we compare two voting rules to the case of a non-cooperative game in which voting is not possible. In the voting treatments, the group needs to reach a unanimous agreement on a vector of individual contributions (q_1, \dots, q_n) . We compare top-down and bottom-up voting treatments with homogeneous and, respectively, heterogeneous marginal costs of contribution. In all cases the subjects are fully informed about the players' types and the results of the previous voting rounds (individual proposals and votes).

The bottom-up treatments consist of up to ten voting rounds. In every round, each player makes a proposal for a contribution vector q . Identical proposals are combined and their votes are added up. If there is no agreement among the players, the no-contribution vector $q^0 = (0, \dots, 0)$ is used as the group's choice. This outcome, which we call "status quo" (SQ), is always added as an additional proposal.

The top-down treatments consist of two parts of up to five rounds each, again ten rounds in total. In the first part the players vote on their group's total contribution Q . In the second part a vote is used to divide this total contribution among the players. If there is no agreement among the players in either the first or the second part, the SQ is used as the group's choice. The second part does not take place unless a positive total contribution ($Q > 0$)

is chosen in the first part.

Using the (Perfect Bayesian) Nash concept on this voting game is not constructive, because every feasible outcome, in which each player gets an expected payoff higher than in the SQ, can be motivated as a mutual best response: Under a unanimous voting scheme and the expectation that everybody else votes for outcome \hat{q} , a player should also vote for \hat{q} unless he is strictly better off if no agreement is reached.

2.4. Equilibrium selection

Three equilibrium selection criteria seem appropriate here in order to reduce the set of theoretical solutions: welfare maximization (WM), payoff symmetry (PS), and contribution symmetry (CS). The (ex ante) social optimum q^* maximizes the group's total payoff. As an equilibrium of the voting game, it is therefore a possible focal point for coordination. Given that, under the unanimous voting rule, all players have equal power to veto all proposals, this may instead induce these players to coordinate on a vector q^{PS} , which reaches the socially optimal total contribution Q^* by assigning all player types (low-cost and high-cost) the same share of contribution costs and payoffs: $c_i(q_i) = c_j(q_j)$ and $\pi_i(q_i) = \pi_j(q_j)$ for all i, j .

This outcome is consistent with the equity principle (Adams, 1965), according to which inputs (contribution costs) and outputs (payoffs) must be balanced.⁴ The Rawlsian maximin criterion (Rawls, 1971) would similarly select a payoff-symmetrical outcome. In addition, a very simple way to co-

⁴More precisely, the equity principle would allow any allocation for which $c_L q_L / c_H q_H = \pi_L / \pi_H$, but in our model this is only possible if $c_L q_L = c_H q_H$ which is equivalent to $\pi_L = \pi_H$.

ordinate behavior in this game is to just ignore all differences among the players and have each player make the same contribution. The result is a contribution-symmetrical (CS) outcome ($q_i = q_j$, for all $i \neq j$) with a corresponding contribution vector q^{CS} . Even more voting outcomes may be justified by drawing on additional principles of distributive justice and using these as selection criteria. Many of these fairness principles are discussed by Konow (2003).

Finally note that $c_H \neq c_L$ implies $q^* \neq q^{PS} \neq q^{CS}$. This means that, if marginal costs are heterogeneous, an outcome can be either welfare-maximizing or payoff-symmetrical or contribution-symmetrical, but not all at the same time. Accordingly, our experimental design can actually distinguish between these three contribution norms.

2.5. Repeated game

Since negotiations by means of a vote may not be practical in real life, e.g., because the outcome is not considered legally binding, we also conduct two non-voting treatments (homogeneous and heterogeneous costs) in which the basic game is simply played ten times in a row with the same group of players (partner setting). This provides the subjects with the same number of interactions as in the voting treatments. In each round a new threshold value is randomly determined. At the end of the experiment, a single randomly selected round is paid to each player. In the non-voting treatments participants are given complete information on past decisions (contributions and threshold values). These treatments have the same sets of collectively optimal outcomes as the voting treatments, allowing for a similar distinction between preferences for welfare maximization, payoff symmetry, and contri-

bution symmetry. The set of Pareto optimal Perfect Bayesian Nash equilibria of these no-vote treatments can be derived in a similar fashion as the ex ante socially optimal total contribution. In addition, contributing nothing in every round (the SQ outcome) is also always an equilibrium in all treatments, albeit a Pareto inferior one.

3. Experimental Design and Procedure

Based on the preceding theoretical sections, we use the following experimental design:

A group consists of $n = 5$ players, each endowed with $e = 25$ ExCU (“Experimental Currency Units”). Every player can convert his endowment into up to $\bar{q} = 10$ CU (“Contribution Units”) which are then collected in a public account (a common project).

In total, we consider six treatments which differ with respect to the voting rule (top-down, bottom-up, no vote) and with respect to the marginal costs of contribution (homogeneous vs. heterogeneous), as displayed in Table 1.⁵ In the case of homogeneous marginal contribution costs, all players have the same costs $c_H = c_L = 1^{\text{ExCU}/\text{CU}}$. In the case of heterogeneous marginal costs, three of the five players have high costs, $c_H = 1.25^{\text{ExCU}/\text{CU}}$, and the remaining two players have low costs, $c_L = 0.77^{\text{ExCU}/\text{CU}}$. Contributions can be made in steps of 0.01 CU, and costs are rounded to 0.01 ExCU.

Unless the sum of contributions reaches a threshold value \bar{Q} , a penalty of $x = 10$ ExCU is deducted from each player’s payoff at the end of the experiment. This means that high-cost players should rationally contribute

⁵The participant instructions to all treatments are included in the appendix.

at most $q_H = 10/1.25$ CU = 8 CU. The threshold value takes on a whole number between (and including) $Q_{min} = 16$ CU and $Q_{max} = 24$ CU, each with equal probability, yielding $k = 9$ possible outcomes, each occurring with a probability of $1/9$.

Proposals, votes, and individual contributions are all publicly displayed immediately afterwards with the IDs of the associated players (e.g., “Player C”). Furthermore, after the first round, subjects can call up the results from past rounds whenever they have to make a decision.

In line with the theory presented above, all treatments are expected to lead to the same (ex ante) socially optimal contribution of $Q^* = 24$ CU (the maximum possible threshold value). For all three focal points – welfare maximization (WM), payoff symmetry (PS), and contribution symmetry (CS) – Table 1 also contains the numerical predictions for individual contributions by cost-type as well as the expected total group payoffs.

The parameter choice for the heterogeneous marginal costs ensures that any one of the nine possible threshold values can be allocated as individual contributions among the five players in such a way that a payoff-symmetrical outcome can be attained, which is identical in terms of individual payoffs to that of the homogeneous counterpart. For example, in all treatments a total contribution of 21 CU can be allocated among players so that each player receives 20.6 ExCU if the threshold is reached, or 10.6 ExCU if not. This also makes sure that the optimal outcome does not stand out among the other choices, just because it “looks nice”. However, with these cost parameters it is not individually optimal for high-cost players in the heterogeneous no-vote

Table 1: Investigated treatments and hypotheses for individual contributions q, q_H, q_L (in CU) and expected total group payoffs Π (in ExCU) by player type (H or L) and allocation norm (WM, PS, CS). In the homogeneous treatments, contributions cost $c = 1 \text{ ExCU}/\text{CU}$ for all players. In the heterogeneous treatments, two players (type L) have marginal contribution costs of $c_L = 0.77 \text{ ExCU}/\text{CU}$ whereas the other three players (type H) have costs of $c_H = 1.25 \text{ ExCU}/\text{CU}$. For each treatment, the number of independent observations (groups) is given in brackets.

		Top-down (TD)	Bottom-up (BU)	No vote (NV)
Hom. marginal costs (Hom)		TDHom (n = 8)	BUHom (n = 8)	NVHom (n = 8)
WM/PS/CS	q Π		4.80 CU 101.00 ExCU	
Het. marginal costs (Het)		TDHet (n = 8)	BUHet (n = 8)	NVHet (n = 8)
WM	q_H q_L Π		1.34 CU 10.00 CU 104.62 ExCU	
PS	q_H q_L Π		3.84 CU 6.24 CU 101.00 ExCU	
CS	q_H q_L Π		4.80 CU 4.80 CU 99.61 ExCU	

treatment to reach the threshold value,⁶ leaving only the SQ as a Perfect Bayesian Nash outcome. In contrast, in all other treatments, i.e., the four voting treatments and the homogeneous no-vote treatment, all ex ante socially optimal contribution vectors can also be achieved as part of a Perfect Bayesian Nash equilibrium as an individually optimal choice.

During the experiment the subjects were asked not to talk to each other and to turn off their cell phones. They were seated at computers, which were screened off from the other subjects by plastic screens. The instructions to the experiment were handed out to the subjects in written form as well as read aloud at the beginning of the experiment. Every subject had to complete a comprehension test consisting of 12 to 19 questions depending on the treatment. The experiment did not start until everybody had answered every question correctly.

In order to rule out variations in the results due to different risk preferences, every treatment was followed by a Holt and Laury (2002) decision task, for which the subjects were given separate instructions including a decision sheet for them to fill in. The subjects were asked to copy their decisions into another questionnaire running on their computer, which also included questions related to general personal data (age, gender, experience with experiments) as well as strategies used in the main part of the experiment.⁷

A total of 240 subjects (6x8 groups with five members each) were recruited via ORSEE (Greiner, 2004) from a student pool. The computer-based ex-

⁶Here, this would only be the case for $c_H \leq 10/9 \approx 1.11$.

⁷The results from both the decision task and the accompanying questionnaire showed no treatment differences and are therefore omitted.

Table 2: Average payoffs in ExCU and € (exchange rate: 2 ExCU = €1)

	TD	BU	NV	All
Hom	19.10 ExCU (€9.55)	20.20 ExCU (€10.1)	16.27 ExCU (€8.14)	18.52 ExCU (€9.26)
Het	18.50 ExCU (€9.25)	19.55 ExCU (€9.78)	17.90 ExCU (€8.95)	18.65 ExCU (€9.33)
All	18.80 ExCU (€9.40)	19.88 ExCU (€9.94)	17.09 ExCU (€8.55)	18.59 ExCU (€9.30)

periment was conducted with z-Tree (Fischbacher, 2007). Together with a show-up fee of €3 and the payoff from the Holt and Laury (2002) decision task, the subjects earned on average €14.74 (roughly US\$19 at the time of the experiment) in all six treatments. Table 2 shows the average payoffs by treatment in ExCU and €. In the case of the no-vote treatments, this is the actual payment to the subjects, i.e., the payoff from the randomly selected round. The subjects spent between one hour and one and a half hours in the laboratory.

4. Results

4.1. Total contributions and coordination

The comparison of total contributions is based on the agreed-upon total contribution in the voting treatments, which in the top-down treatments is the result of the first part. For the no-vote treatments, we use Round 10, as this represents the end of the coordination process. Because of the large number of ties in our data, we mostly perform a categorical analysis using

Table 3: Total contributions by category. Average total contributions in CU and relative frequencies of reached thresholds (success rates) given in brackets.

		Inferior ($Q < 16$ CU)	Risky ($16 \text{ CU} \leq Q < 24$ CU)	Optimal ($Q \geq 24$ CU)
BU	All (22.50 CU; 93.75%)	1	0	15
	<i>Hom</i> (24.00 CU; 100.00%)	0	0	8
	<i>Het</i> (21.00 CU; 87.50%)	1	0	7
TD	All (23.07 CU; 87.50%)	0	6	10
	<i>Hom</i> (23.25 CU; 87.50%)	0	2	6
	<i>Het</i> (22.88 CU; 87.50%)	0	4	4
NV (Rd 1)	All (19.27 CU; 37.50%)	3	9	4
	<i>Hom</i> (17.93 CU; 37.50%)	3	3	2
	<i>Het</i> (20.61 CU; 37.50%)	0	6	2
NV (Rd 10)	All (11.37 CU; 50.00%)	8	7	1
	<i>Hom</i> (5.20 CU; 25.00%)	6	2	0
	<i>Het</i> (17.54 CU; 75.00%)	2	5	1
NV (All rds)	All (15.79 CU; 46.25%)	58	76	26
	<i>Hom</i> (11.40 CU; 30.00%)	49	23	8
	<i>Het</i> (20.19 CU; 62.50%)	9	53	18

Fisher’s exact test for pairwise comparisons of treatments.⁸

We categorize total contributions as “optimal” ($Q \geq 24$ CU),⁹ “risky” ($16 \text{ CU} \leq Q < 24 \text{ CU}$), or “inferior” ($Q < 16 \text{ CU}$), as displayed in Table 3. In addition, we compare the success rates, i.e., the relative frequency of reached thresholds. These results, as well as the average total contributions, are also shown in Table 3. There is no appreciable difference among the two voting rules in terms of optimal behavior or success rates, which is also corroborated by a statistical analysis (Fisher’s exact: $p > 0.05$ in all cases).

However, we observe a higher frequency of “inferior” or at least “risky” choices in the no-vote treatments, especially in homogeneous (NVHom) groups,

⁸In each case, we have first checked for differences among all treatments with the same test, which proved significant (Fisher’s exact: $p < 0.05$), unless stated otherwise.

⁹Since in the no-vote treatments pin-point coordination is much harder, we also count contributions greater than 24 CU as “optimal”.

which were also clearly less successful. In contrast, bottom-up voting groups almost exclusively selected “optimal” outcomes. This difference is significant for both homogeneous and heterogeneous groups (Fisher’s exact: $p < 0.001$ for BUHom vs. NVHom, $p = 0.004$ for BUHet vs. NVHet). But, whereas homogeneous bottom-up (BUHom) groups outperformed their NVHom counterparts in terms of success rates (BUHom: 100%, NVHom: 25%; Fisher’s exact: $p = 0.003$), heterogeneous groups were almost equally successful when voting or not voting (BUHet: 87.5%, NVHet: 75%; Fisher’s exact: $p = 1.000$). The results are similar for top-down groups, which achieved significantly better outcomes with homogeneous marginal costs (TDHom vs. NVHom: Fisher’s exact: $p = 0.001$ for optimal behavior, $p = 0.041$ for success rates), but about equally good outcomes in the case of heterogeneous costs (TDHet vs. NVHet: Fisher’s exact: $p = 0.152$ for optimal behavior, $p = 1.000$ for success rates).

Despite the fact that the final voting results do not show this, there is some indication that coordination was more difficult for heterogeneous voting groups than for their homogeneous counterparts. For example, six out of eight BUHom groups (75%) agreed after one or two rounds of voting, compared to only a single BUHet group (12.5%), resulting in a significant difference of these treatments (Fisher’s exact: $p = 0.041$).

In contrast, without a vote, heterogeneous groups were apparently better able to coordinate their actions than homogeneous groups. Initially, players in both NV treatments contributed on a similar level (Round 1: 17.54 CU for NVHom vs. 20.61 CU for NVHet; cf. Table 3), which led their groups to be equally successful (37.5%). As Figure 1 shows, however, while heterogeneous

groups became more successful in later rounds (75% in Round 10), success rates instead decreased in homogeneous groups (only 25% in Round 10). From Figure 2 – which displays average individual contributions for NVHom groups, as well as for low-cost and high-cost players and all groups combined in the NVHet treatment – it becomes obvious that this is a direct effect of decreasing contributions.

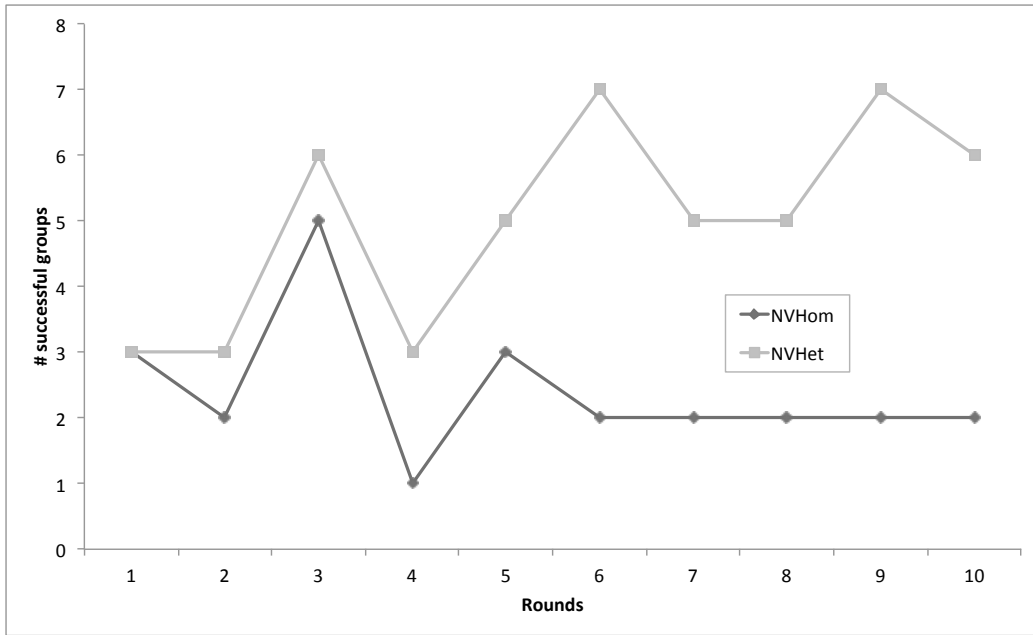


Figure 1: Number of groups by round that reach the threshold value in no-vote (NVHom, NVHet) treatments.

4.2. Individual contributions and distributive fairness

The groups in all four voting treatments displayed an obvious preference for payoff-symmetrical (PS) outcomes, as shown in Table 4. In this table, voting outcomes are assigned to the four categories “ $PS \wedge \neg WM$ ” (payoff-symmetrical, but not welfare-maximizing), “ $WM \wedge \neg PS$ ” (welfare-

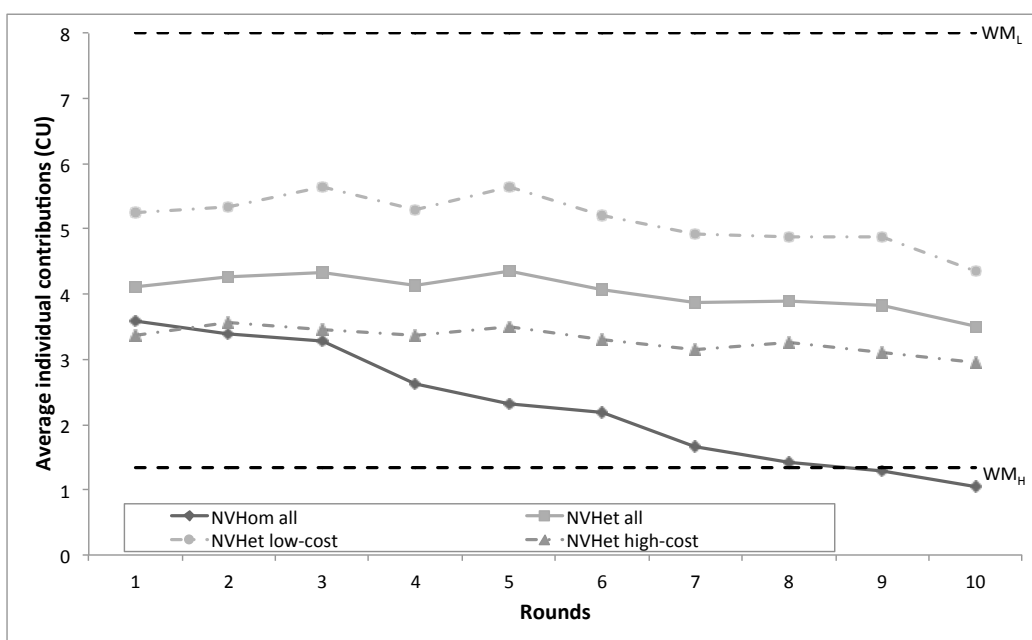


Figure 2: Average individual contributions over ten rounds for the no-vote (NVHom, NVHet) treatments, differentiated by cost type for the heterogeneous treatment. Welfare-maximizing benchmarks (WM_H , WM_L) are included as reference points.

Table 4: Absolute frequency of payoff-symmetrical (PS) and welfare-maximizing (WM) outcomes in bottom-up (BU) and top-down (TD) voting treatments. The combination of both ($PS \wedge WM$) is only possible in treatments with homogeneous marginal costs (Hom).

		PS \wedge \negWM	WM \wedge \negPS	PS \wedge WM	Other
BU	All	8	0	8	0
	Hom	0	0	8	0
	Het	8	0	<i>n.a.</i>	0
TD	All	8	0	6	2
	Hom	2	0	6	0
	Het	6	0	<i>n.a.</i>	2
Total	All	16	0	14	2
	Hom	2	0	14	0
	Het	14	0	<i>n.a.</i>	2

maximizing, but not payoff-symmetrical), “ $PS \wedge WM$ ” (both PS and WM)¹⁰, and “Other”¹¹.

Although all homogeneous outcomes were also contribution-symmetrical (as a prerequisite for reaching equal payoffs), none of the heterogeneous voting groups agreed to contribute equally, leading to the conclusion that contribution symmetry was not the primary motivation in voting groups. We have therefore left out contribution symmetry as an additional category in Table 4 in order to better contrast payoff symmetry and welfare maximization.

While most homogeneous voting groups agreed on a “ $PS \wedge WM$ ” outcome (all of them by payoff-symmetrically allocating the socially optimal total contribution of 24 CU), none of the heterogeneous groups managed to leave

¹⁰Only possible in homogeneous treatments.

¹¹Even these two outcomes are nearly payoff-symmetrical with contribution costs of 4.74 ExCU and 4.87 ExCU as well as 4.85 ExCU and 4.75 ExCU for low- and high-cost players respectively.

the PS focal point in favor of a higher total payoff. Thus, homogeneous and heterogeneous groups differ significantly in their outcome choice (Fisher’s exact: $p < 0.001$ for BUhom vs. BUhet, $p = 0.007$ for TDhom vs. TDhet).

Individual preferences for distributive fairness are more difficult to reveal in the no-vote treatments, as we can only observe individual contribution choices directly. In the following statistical analysis, we always use a two-tailed Wilcoxon signed-rank test for within-treatment comparisons and refer to Table 1 for the individual contribution benchmarks. In the NVHom treatment, there is only a single benchmark of individual contributions (4.8 CU) for welfare-maximizing (WM), payoff-symmetrical (PS) and contribution-symmetrical (CS) outcomes, provided that the players make optimal and identical contributions. With an overall individual average of 2.28 CU, however, NVHom groups remained significantly below this benchmark ($W = 0, p \leq 0.05$) and in fact even below a CS allocation of the minimum possible threshold value (i.e., 3.2 CU each; $W = 3, p \leq 0.05$).

In the NVHet treatment, individual contributions of 8 CU or higher by low-cost players can be taken to indicate a preference for welfare maximization (WM). This benchmark reflects the most conservative scenario, in which the group is satisfied with the minimum possible threshold value of $Q = 16$ CU, instead of the optimal value of $Q = 24$ CU assumed in Table 1. Actual contributions were significantly below this value, though ($W = 0, p \leq 0.05$). A likewise conservative benchmark for high-cost players is 1.34 CU, which is the highest contribution by this player type that can still be considered welfare-maximizing. Again we found that actual contributions were significantly different from this value ($W = 1, p \leq 0.05$). Both benchmarks are

also displayed in Figure 2. Consequently, although our sample size was too small to reliably confirm any allocation norm as a focal point in this treatment, we can at least say that welfare maximization was not the motivator for individual contribution choices. The obvious difference between the two player types in regard to average contributions over all ten rounds (low-cost: 5.14 CU, high-cost: 3.30 CU) – which is also statistically significant ($W = 0, p \leq 0.05$) – indicates that the groups as a whole usually did not coordinate on a contribution-symmetrical outcome, either. Instead, considering that a similar comparison of average individual contribution costs (low-cost: 3.35 ExCU, high-cost: 3.69 ExCU) finds no significant differences between types ($W = 13, p > 0.05$), payoff symmetry remains as the only plausible distribution norm.

5. Discussion

Of the four treatments with threshold uncertainty that Barrett and Dannenberg (2012, 2014) report, three almost exclusively result in coordination failure with total contributions below or at best at the bottom end of possible threshold values. Only the “145/155” treatment has comparable results to ours, with 40% choices that we would classify as “optimal” and the remaining 60% in the “risky” range. Since all of these treatments are one-shot voluntary contribution games with homogeneous players, these results can best be compared to Round 1 of our NVHom treatment, which has only slightly worse results (25% optimal, 37.5% risky, 37.5% inferior; cf. Table 3). Of course, our homogeneous voting treatments, which are essentially also one-shot, perform much better in terms of optimality (BUHom: 100% optimal,

TDHom: 75% optimal, 25% risky; cf. Table 3), but do not involve voluntary contributions. Remarkably, although Barrett and Dannenberg (2012, 2014) use larger groups of ten players, this does not seem to impede coordination in the “145/155” treatment.

Earlier studies involving heterogeneity in social dilemmas have rarely distinguished between player types in order to discuss (payoff) symmetry as a distribution norm. An experimental study by van Dijk et al. (1999) reports that heterogeneity (in regard to the valuation of the public good) more often leads to proportional than payoff-symmetrical outcomes in a public goods context,¹² but more often to payoff-symmetrical than to proportional outcomes in the context of a resource dilemma.¹³ Similarly, Rapoport and Suleiman (1993) state that contributions in their treatments are proportional to endowments (the variable by which they model player heterogeneity).

The decrease of contribution levels in the homogeneous no-vote treatment is somewhat unusual, as in the case of a non-random threshold value total contributions are normally found to oscillate around the threshold value (e.g., Croson and Marks, 2000, 2001). Apparently, threshold uncertainty leads to a breakdown of cooperation in this treatment that is often observed in linear public goods games (e.g., Kroll et al., 2007). Strikingly, we observe higher contribution levels in non-voting groups with heterogeneous marginal contribution costs, despite the fact that reaching the threshold is not individually optimal for high-cost players. Unlike homogeneous groups, most heteroge-

¹²Here this refers to a proportion of contributions (as inputs) and valuations (as outputs).

¹³Compare in particular (van Dijk et al., 1999, Table 3 on p. 126).

neous groups manage to keep total contributions on a level that is almost comparable to that of voting groups.

A possible explanation for this result might be the presence of multiple and conflicting behavioral norms in the NVHet treatment, which create a morally gray area for “fair” behavior that helps maintain a high level of contributions. Accordingly, low-cost players are able to reduce their contributions from a payoff-symmetrical 6.24 CU to a contribution-symmetrical 4.8 CU without fear of retaliation. Similarly, high-cost players can reduce their contributions below the payoff-symmetrical 3.84 CU and towards the welfare-maximizing 1.34 CU. As long as the threshold value continues to be reached, this reduction of individual contributions is tolerated or even compensated by other players.

6. Conclusion

We show that a unanimous voting rule is able to achieve agreement where individual action apparently fails. But even in a voting committee a welfare-maximizing choice is not guaranteed, since the decision rule can dictate the final outcome. In our experiment this has become evident in a preference for payoff-symmetrical outcomes, despite the fact that payoff symmetry is associated with lower-than-optimal total payoffs in heterogeneous groups.

Future research should investigate the robustness of this payoff symmetry in the presence of other focal points. There are several possible ways of doing so, including, for example, i) allowing transfer payments among players to induce asymmetrical outcomes with higher (expected) social welfare, ii) employing a different voting rule (e.g., a majority rule) that does not require the

agreement of every single player (and therefore a symmetrical solution), iii) concealing the precise location of this payoff-symmetrical focal point, e.g., by means of an uncertain cost component, so that the contribution-symmetrical outcome becomes more attractive as a coordination target, and iv) using heterogeneity in respect to endowments or valuations/penalties instead of costs in order to motivate proportional contributions as a fair outcome (as suggested by the findings of Rapoport and Suleiman, 1993; van Dijk et al., 1999, and others).

As a possible limitation of our work, we point out that the results of our voting treatments might not be easily transferred to other voting rules. There is certainly less reason to allocate payoff-symmetrically under a majority rule instead of unanimity. And reaching an agreement of any kind may be more difficult, if not impossible, if the status quo outcome is changed or if the vote is modeled only as a non-binding precursor to a voluntary contribution mechanism (similar to the non-binding vote in Kroll et al., 2007).

In contrast with Barrett and Dannenberg (2012, 2014), we do not arrive at a quite as negative conclusion in regard to threshold uncertainty in climate negotiations. In the process of repeated negotiations, the international community may still be able to identify an (ex ante) socially optimal reduction target. Moreover, this target may even be achievable by voluntary contributions, all the more so because countries are certainly heterogeneous in their marginal reduction costs.

However, the development and employment of mechanisms (possibly based on emissions trading) to non-cooperatively induce the apparently efficient outcome of a binding agreement would be the preferable way of ensuring

that this reduction target is indeed reached. Whether or not the total quantity of reduced emissions is negotiated first for this purpose, as in a top-down process, does not seem to matter, at least if all national reduction efforts are negotiated at about the same time.

References

- Adams, J.S., 1965. Inequity in social exchange. *Advances in experimental social psychology* 2, 267–299.
- Barrett, S., Dannenberg, A., 2012. Climate negotiations under scientific uncertainty. *Proceedings of the National Academy of Sciences of the United States of America* 109, 17372–17376.
- Barrett, S., Dannenberg, A., 2014. Sensitivity of collective action to uncertainty about climate tipping points. *Nature Climate Change* 4, 36–39. doi:10.1038/NCLIMATE2059.
- Croson, R., Marks, M., 2000. Step returns in threshold public goods: A meta- and experimental analysis. *Experimental Economics* 2, 239–259.
- Croson, R., Marks, M., 2001. The effect of recommended contributions in the voluntary provision of public goods. *Economic Inquiry* 39, 238–249.
- van Dijk, E., Wilke, H., Wilke, M., Metman, L., 1999. What information do we use in social dilemmas? *Environmental uncertainty and the employment of coordination rules. Journal of Experimental Social Psychology* 35, 109–135.

- Ehrhart, K., Gardner, R., von Hagen, J., Keser, C., 2007. Budget processes: Theory and experimental evidence. *Games and Economic Behavior* 59, 279–295.
- Ferejohn, J., Krehbiel, K., 1987. The budget process and the size of budget. *American Journal of Political Science* 31, 296–320.
- Fischbacher, U., 2007. z-Tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics* 10, 171–178.
- Greiner, B., 2004. An online recruitment system for economic experiments, in: Kremer, K., Macho, V. (Eds.), *Forschung und wissenschaftliches Rechnen 2003*. GWDG Bericht 63, pp. 79–93. Göttingen: Ges. für Wiss. Datenverarbeitung.
- Hansen, J., Sato, M., Kharecha, P., Beerling, D., Berner, R., Masson-Delmotte, V., Pagani, M., Raymo, M., Royer, D.L., Zachos, J.C., 2008. Target atmospheric CO₂: Where should humanity aim? *The Open Atmospheric Science Journal* 2, 217–231. doi:10.2174/1874282300802010217.
- Holt, C.A., Laury, S.K., 2002. Risk aversion and incentive effects. *The American Economic Review* 92, 1644–1655.
- Kahneman, D., Tversky, A., 1979. Prospect theory: An analysis of decision under risk. *Econometrica* 47, 263–292.
- Konow, J., 2003. Which is the fairest one of all? A positive analysis of justice theories. *Journal of Economic Literature* 41, 1188–1239.

- Kroll, S., Cherry, T.L., Shogren, J.F., 2007. Voting, punishment, and public goods. *Economic Inquiry* 45, 557–570.
- Ledyard, J.O., 1995. Public goods: A survey of experimental results, in: Kagel, Roth (Eds.), *The Handbook of Experimental Economics*. Princeton University Press. chapter 2, pp. 111–251.
- Margreiter, M., Sutter, M., Dittrich, D., 2005. Individual and collective choice and voting in common pool resource problem with heterogeneous actors. *Environmental & Resource Economics* 32, 241–271.
- McBride, M., 2010. Threshold uncertainty in discrete public good games: an experimental study. *Economics of Governance* 11, 77–99.
- Rapoport, A., Suleiman, R., 1993. Incremental contribution in step-level public goods games with asymmetric players. *Organizational Behavior and Human Decision Processes* 55, 171–194.
- Rawls, J., 1971. *A Theory of Justice*. Harvard University Press, Cambridge, Mass.
- Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., Miller, H.L. (Eds.), 2007. *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Sonnemans, J., Schram, A., Offerman, T., 1998. Public good provision and public bad prevention: The effect of framing. *Journal of Economic Behavior & Organization* 34, 143–161.

Suleiman, R., Budescu, D.V., Rapoport, A., 2001. Provision of step-level public goods with uncertain provision threshold and continuous contribution. *Group Decision and Negotiation* 10, 253–274.

Walker, J.M., Gardner, R., Herr, A., Ostrom, E., 2000. Collective choice in the commons: Experimental results on proposed allocation rules and votes. *The Economic Journal* 110, 212–234.

Appendix: Participant Instructions

The following experimental instructions were translated from German. Please note that the instructions are only translations for information; they are not intended to be used in the lab. The instructions in the original language were carefully polished in grammar, style, comprehensibility, and avoidance of strategic guidance. Treatment differences are indicated by the respective treatment abbreviations in square brackets (e.g., [TDHOM] for the wording in the top-down voting treatment with homogeneous marginal contribution costs).

[All treatments]

Welcome to the experiment!

You are now participating in a scientific experiment. Please read the following instructions carefully. Here you will be told everything that you know for the participation in the experiment. Please also note the following:

From now on as well as during the entire experiment **no communication** is permitted. If you have any questions, please raise your hand. All **decisions are made anonymously**, meaning that none of the other participants learns the identity of those who made a particular decision.

For showing up on time you receive an amount of €3. Over the course of the experiment you can earn two additional amounts of money. The first amount of up to €12.50 results from your decisions in the experiment. This amount is influenced by the decisions of your fellow participants. The second amount lies between €0.10 and €3.85 and results solely from your individual decision in a subsequent questionnaire. The total amount will be paid to you **in cash** at the end of the experiment. The **payment occurs anonymously, too**, meaning that no participant will know another participant's payoff. This experiment uses the currency "Experimental Currency Units" (ExCU).

Two Experimental Currency Units are equal to one euro.

[TDHOM]

Experimental Procedure

In the experiment you form a **group with four other players**. The composition of this group will not change throughout the entire experiment (in both parts and in all rounds). You begin the experiment with an **endowment of 25 Experimental Currency Units**.

Your task in this experiment is to choose your and your fellow players' contributions to a project. Each player can contribute up to 10 Experimental Currency Units. The group's total contribution can therefore amount to up to 50 Experimental Currency Units.

The decision occurs in **two parts**.

1. First you vote on the **total contribution** of all players in your group.
2. Then you vote on which **share of the total contribution** each individual player has to contribute.

For the project to be successful, **your group's total contribution must reach a minimum contribution**. Otherwise, the project fails and the amount you contributed to the project (as well as the amounts from your fellow players) are lost. The exact amount of this minimum contribution is determined randomly. You are told this information only at the end of the experiment. You know however that the **minimum contribution** will take on one of the following **nine values in contribution units, each with the same probability**:

16, 17, 18, 19, 20, 21, 22, 23, 24

If the minimum contribution is not reached, each player must make an additional **payment of 10 Experimental Currency Units**, which is deducted from his payoff.

Total contribution	< 16	16	17	18	19	20	21	22	23	24	> 24
Probability that minimum contribution is reached (absolute)	0	1/9	2/9	3/9	4/9	5/9	6/9	7/9	8/9	1	1
Probability that minimum contribution is reached (% rounded)	0%	11%	22%	33%	44%	56%	67%	78%	89%	100%	100%

PROCEDURE OF THE FIRST PART

In the first part you and your fellow players vote on **your group's total contribution**. This happens in up to five voting rounds and proceeds as follows:

1. At the same time as the other players each player makes a **proposal for the total contribution**. In order to do this, he or she chooses an amount **between 0 and 50 Experimental Currency Units**.
2. The proposals are shown to all players in a table (see Figure 1). Among them is also a proposal called **"Status Quo"**, corresponding to a total contribution of **0 Experimental Currency Units**. Next to each proposal there is a list of the player(s) who made this proposal. If a proposal has been made multiple times, it is displayed only once, together with all players who made this proposal. Accordingly, there can be up to six different proposals.
3. Each player casts a vote for exactly one of these proposals. All votes are cast individually and at the same time. In order to vote for a proposal please click on "Accept" in the column directly to the right of the proposal.
4. Each player learns the result of the vote, i.e., the number of votes for each proposal as well as which player has voted for which alternative. If all players select the same proposal (**unanimous decision**), the **second part of the experiment begins**. Otherwise, Steps 1 to 4 are repeated up to four times. In every repetition new proposals can be made.

5. If there is also **no agreement in the fifth voting round**, the **Status Quo** (total contribution of 0 Experimental Currency Units) is chosen as your group's total contribution.
6. If the first part results in a **total contribution of 0 Experimental Currency Units, no further voting** occurs in this group, meaning that the second part of the experiment is omitted. Each player then automatically makes an individual contribution of 0 Experimental Currency Units and the experiment ends with the calculation of payoffs.

Abstimmungsrunde 2 von maximal 5

Bitte entscheiden Sie sich für einen der folgenden Vorschläge!

Der Mindestbeitrag nimmt einen der folgenden neun Werte an: 16 GE, 17 GE, 18 GE, 19 GE, 20 GE, 21 GE, 22 GE, 23 GE, 24 GE.

Vorschlag	Gesamtbeitrag (GE)	
Spieler A, B, D (Ihr Vorschlag), E	0	<input type="button" value="Akzeptieren"/>
Spieler C	5	<input type="button" value="Akzeptieren"/>
Status Quo	0	<input type="button" value="Akzeptieren"/>

Figure 1[TDHOM] – Voting decision in the first part of the experiment (total contribution)

Example for the procedure of the first part:

- Round 1:
 - A total of six proposals for the total contribution (in ExCU): 0 (Status Quo), 16, 17, 17, 18, 19
 - Total contribution “17 ExCU” has been proposed twice, but only counts as a single alternative.
 - Two players vote for “18 ExCU”, three players for “16 ExCU”. “0 ExCU”, “17 ExCU”, and “19 ExCU” receive no votes at this time.
 - There is no agreement, so the procedure is repeated in an additional round.
- Round 2:
 - Again a total of six proposals for the total contribution (in ExCU): 0 (Status Quo), 16, 17, 17, 17, 19

- Total contribution “17 ExCU” has been proposed three times, but only counts as a single alternative.
- Now all five players vote for “19 ExCU”. “0 ExCU”, “16 ExCU”, and “17 ExCU” receive no votes at this time.
- Thus, a total contribution of “19 ExCU” is accepted and chosen for the second part.

Please note that, starting with the second voting round, you may call up the **results from previous votes** whenever you make a decision by clicking the button “Show earlier round” (see Figure 1). Clicking the button again shows even earlier rounds. By clicking the buttons “Show later round” or “Back to current round” you may advance again in the history or, respectively, jump immediately to the current decision round.

PROCEDURE OF THE SECOND PART

In the second part you and your fellow players vote on how the total contribution determined in the first part is to be provided by the **individual contributions of all group players**. This happens in up to five voting rounds and proceeds as follows:

1. Each player makes a **proposal for the contribution of every single player**. All players make their proposals individually and at the same time. In order to do this, each player chooses an amount between 0 and 10 Experimental Currency Units (in steps of 0.1 ExCU). **Caution! The sum of these contributions must be equal to the total contribution determined in Part 1!**
2. The proposals are shown to all players in a list. Among these is again a proposal called “**Status Quo**”. Here, this proposal means that each player provides a contribution of 0 Experimental Currency Units, **no matter what amount has been chosen as a total contribution in Part 1**. Next to each proposal there is a list of the player(s) who made this proposal. Identical proposals are displayed only once, together with all players who made this proposal. Accordingly, there can be again up to six different distribution proposals.
3. At the same time as all of the other players in his group, each player casts a vote for exactly one of these proposals. In order to vote for a proposal please click on “Accept” in the column directly to the right of the proposal.
4. Each player learns the result of the vote, i.e., the number of votes for each proposal as well as which player has voted for which alternative. If all players select the same proposal (**unanimous decision**), the experiment ends with the calculation of payoffs. Otherwise, Steps 1 to 4 are repeated up to four times.
5. If there is also **no agreement in the fifth voting round**, the **Status Quo** (each player provides a contribution of 0 Experimental Currency Units, total contribution of 0 Experimental Currency Units) is selected to calculate payoffs. **This is true, even if a different total contribution has been chosen in the first part.**

Example for the procedure of the second part (total contribution 19 ExCU):

- Round 1:
 - A total of six proposals for the allocation of the total contribution:

Proposals	Individual contributions (ExCU)				
	Player A	Player B	Player C	Player D	Player E
Players A, C	1	2	4	3	9
Players B, E	3	1	2	6,5	6,5
Player D	9	3	2	1	4
Status Quo	0	0	0	0	0

- The allocation “1 ExCU; 2 ExCU; 4 ExCU; 3 ExCU; 9 ExCU” has been proposed twice, but only counts as a single alternative.
- The same is true for the allocation “3 ExCU; 1 ExCU; 2 ExCU; 6.5 ExCU; 6.5 ExCU”.
- All five players vote for “A, C”. The other three different proposals (“Status Quo”, “B, E”, “D”) receive no votes this time.
- In this example, the voting procedure ends with a total contribution of 19 ExCU and the following individually payable contributions:
 - Player A: 1 ExCU
 - Player B: 2 ExCU
 - Player C: 4 ExCU
 - Player D: 3 ExCU
 - Player E: 9 ExCU

Please note that, starting with the second voting round, you may call up the **results from previous votes in this part** whenever you make a decision by clicking the button “Show earlier round”. Clicking the button again shows even earlier rounds. By clicking the buttons “Show later round” or “Back to current round” you may advance again in the history or, respectively, jump immediately to the current decision round.

YOUR PAYOFF

The payoff of each player calculates as follows:

- Please note that the contributed amount is deducted from your account balance in any case, even if the total contribution has not reached the minimum contribution.
- If the group’s total contribution is greater than or equal to the minimum contribution, then the project is successful and you receive the following payoff:

payoff for reaching the minimum contribution = 25 ExCU - your contributed amount

- If the group’s total contribution is less than the minimum contribution, then the project is not successful and you receive the following payoff:

payoff for missing the minimum contribution = 25 ExCU - your contributed amount - 10 ExCU

In order to determine the total payoff at the end of the experiment, the resulting amount is converted into euros and added to your show-up fee. The payoff from a subsequent separate experiment is later added to this amount.

Example for payoffs (total contribution 19 ExCU):

Assume that the minimum contribution amounts to 20 ExCU. Then a total contribution of 19 ExCU misses this minimum contribution. Accordingly, for Player A from the previous example (contributed amount of 1 ExCU) a payoff of $25 \text{ ExCU} - 1 \text{ ExCU} - 10 \text{ ExCU} = 14 \text{ ExCU}$ results. An amount of 10 ExCU is deducted here, because the minimum contribution has not been reached.

Assume that the minimum contribution amounts to 18 ExCU. Then a total contribution of 19 ExCU reaches this minimum contribution. Now, for a contributed amount of 1 ExCU a payoff of $25 \text{ ExCU} - 1 \text{ ExCU} = 24 \text{ ExCU}$ results. In this case nothing is deducted, because the minimum contribution has been reached.

Experimental Procedure

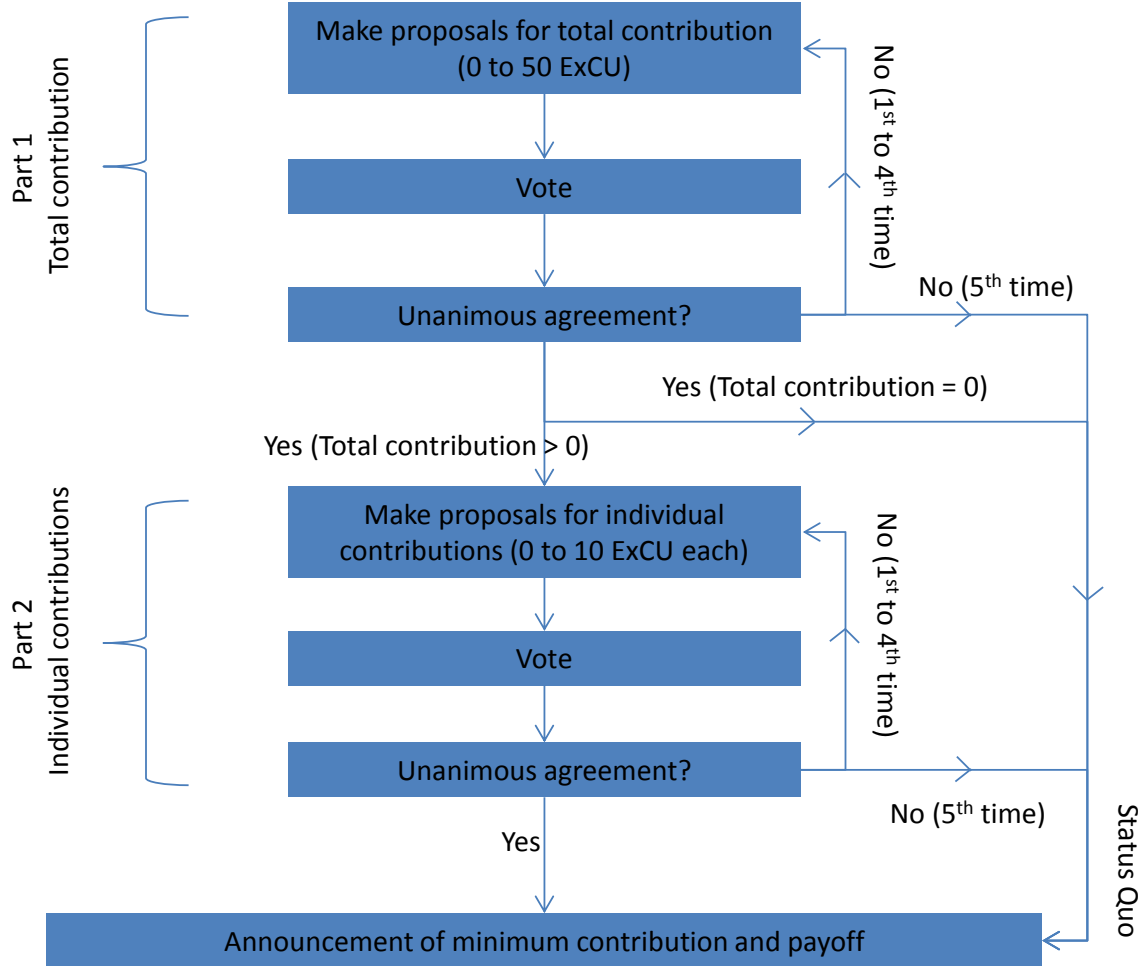


Figure 2[TDHOM] – Experimental procedure

Experimental Procedure

In the experiment you form a **group with four other players**. The composition of this group will not change throughout the entire experiment. You begin the experiment with an **endowment of 25 Experimental Currency Units**.

Your task in this experiment is to choose your and your fellow players' contributions to a project. Each player can contribute up to 10 Experimental Currency Units. The group's total contribution can therefore amount to up to 50 Experimental Currency Units. Your decision consists in a **vote on the individual contributions of all players in a group**. These contributions are added up to a **total contribution**.

For the project to be successful, **your group's total contribution must reach a minimum contribution**. Otherwise, the project fails and the amount you contributed to the project (as well as the amounts from your fellow players) are lost. The exact amount of this minimum contribution is determined randomly. You are told this information only at the end of the experiment. You know however that the **minimum contribution** will take on one of the following **nine values in contribution units, each with the same probability**:

16, 17, 18, 19, 20, 21, 22, 23, 24

If the minimum contribution is not reached, each player must make an additional **payment of 10 Experimental Currency Units**, which is deducted from his payoff.

Total contribution	< 16	16	17	18	19	20	21	22	23	24	> 24
Probability that minimum contribution is reached (absolute)	0	1/9	2/9	3/9	4/9	5/9	6/9	7/9	8/9	1	1
Probability that minimum contribution is reached (% rounded)	0%	11%	22%	33%	44%	56%	67%	78%	89%	100%	100%

VOTING PROCEDURE

In the experiment, you and your fellow players vote on the **individual contributions of all group players**. This happens in **up to ten voting rounds** and proceeds as follows:

- (1) Each player makes a **proposal for the contribution of every single player**. All players make their proposals individually and at the same time. In order to do this, each player chooses an amount between 0 and 10 Experimental Currency Units (in steps of 0.1 ExCU). The individual contributions from each proposal are automatically summed up to a total contribution.
- (2) The proposals and corresponding total contributions are shown to all players in a list. Among these is also a proposal called "**Status Quo**". This proposal means that each player provides a contribution of 0 Experimental Currency Units. Next to each proposal there is a list of the player(s) who made this proposal. Identical proposals are displayed only once, together with all players who made this proposal. Accordingly, there can be up to six different distribution proposals.
- (3) At the same time as all of the other players in his group, each player casts a vote for exactly one of these proposals. In order to vote for a proposal please click on "Accept" in the column directly to the right of the proposal.
- (4) Each player learns the result of the vote, i.e., the number of votes for each proposal as well as which player has voted for which alternative. If all players select the same proposal (**unanimous decision**), the experiment ends with the calculation of payoffs. Otherwise, Steps 1 to 4 are repeated up to nine times.

(5) If there is also **no agreement in the tenth voting round**, the **Status Quo** (each player provides a contribution of 0 Experimental Currency Units, total contribution of 0 Experimental Currency Units) is selected to calculate payoffs.

Abstimmungsrunde 5 von maximal 10							
Sie sind Spieler D							
Bitte entscheiden Sie sich für einen der folgenden Vorschläge!							
Der Mindestbeitrag nimmt einen der folgenden neun Werte an: 16 GE, 17 GE, 18 GE, 19 GE, 20 GE, 21 GE, 22 GE, 23 GE, 24 GE							
<input type="button" value="Zurück zur aktuellen Runde"/> <input type="button" value="Spätere Runde anzeigen"/> <input type="button" value="Frühere Runde anzeigen"/>							
Vorschlag	Beitrag Spieler A (GE)	Beitrag Spieler B (GE)	Beitrag Spieler C (GE)	Ihr Beitrag (Spieler D) (GE)	Beitrag Spieler E (GE)	Gesamtbeitrag (GE)	
Spieler A, C	1.0	2.0	4.0	3.0	9.0	19.0	<input type="button" value="Akzeptieren"/>
Spieler B, E	6.5	1.0	2.0	6.5	0.0	16.0	<input type="button" value="Akzeptieren"/>
Spieler D (Ihr Vorschlag)	9.0	3.0	5.0	4.0	1.0	22.0	<input type="button" value="Akzeptieren"/>
Status Quo	0.0	0.0	0.0	0.0	0.0	0.0	<input type="button" value="Akzeptieren"/>

Figure 1[BUHOM] – Voting decision in the experiment

Example for the procedure of the experiment:

- Round 1:
 - A total of six proposals for the individual contributions of all players in the group:

Proposals	Individual contributions (ExCU)					Total contribution (ExCU)
	Player A	Player B	Player C	Player D	Player E	
Players A, C	1	2	4	3	9	19
Players B, E	6,5	1	2	6,5	0	16
Player D	9	3	5	4	1	22
Status Quo	0	0	0	0	0	0

- The allocation “1 ExCU; 2 ExCU; 4 ExCU; 3 ExCU; 9 ExCU” with a total contribution of 19 ExCU has been proposed twice, but only counts as a single alternative.
- The same is true for the allocation “6.5 ExCU; 1 ExCU; 2 ExCU; 6.5 ExCU; 0 ExCU” with a total contribution of 16 ExCU.

- All five players vote for “A, C”. The other three different proposals (“Status Quo”, “B, E”, “D”) receive no votes this time.
- In this example, the voting procedure ends with a total contribution of 19 ExCU and the following individually payable contributions:
 - Player A: 1 ExCU
 - Player B: 2 ExCU
 - Player C: 4 ExCU
 - Player D: 3 ExCU
 - Player E: 9 ExCU

Please note that, starting with the second voting round, you may call up the **results from previous votes in this part** whenever you make a decision by clicking the button “Show earlier round”. Clicking the button again shows even earlier rounds. By clicking the buttons “Show later round” or “Back to current round” you may advance again in the history or, respectively, jump immediately to the current decision round.

YOUR PAYOFF

The payoff of each player calculates as follows:

- Please note that the contributed amount is deducted from your account balance in any case, even if the total contribution has not reached the minimum contribution.
- If the group’s total contribution is greater than or equal to the minimum contribution, then the project is successful and you receive the following payoff:

payoff for reaching the minimum contribution = 25 ExCU - your contributed amount

- If the group’s total contribution is less than the minimum contribution, then the project is not successful and you receive the following payoff:

payoff for missing the minimum contribution = 25 ExCU - your contributed amount - 10 ExCU

In order to determine the total payoff at the end of the experiment, the resulting amount is converted into euros and added to your show-up fee. The payoff from a subsequent separate experiment is later added to this amount.

Example for payoffs (total contribution 19 ExCU):

Assume that the minimum contribution amounts to 20 ExCU. Then a total contribution of 19 ExCU misses this minimum contribution. Accordingly, for Player A from the previous example (contributed amount of 1 ExCU) a payoff of $25 \text{ ExCU} - 1 \text{ ExCU} - 10 \text{ ExCU} = 14 \text{ ExCU}$ results. An amount of 10 ExCU is deducted here, because the minimum contribution has not been reached.

Assume that the minimum contribution amounts to 18 ExCU. Then a total contribution of 19 ExCU reaches this minimum contribution. Now, for a contributed amount of 1 ExCU a payoff of $25 \text{ ExCU} - 1 \text{ ExCU} = 24 \text{ ExCU}$ results. In this case nothing is deducted, because the minimum contribution has been reached.

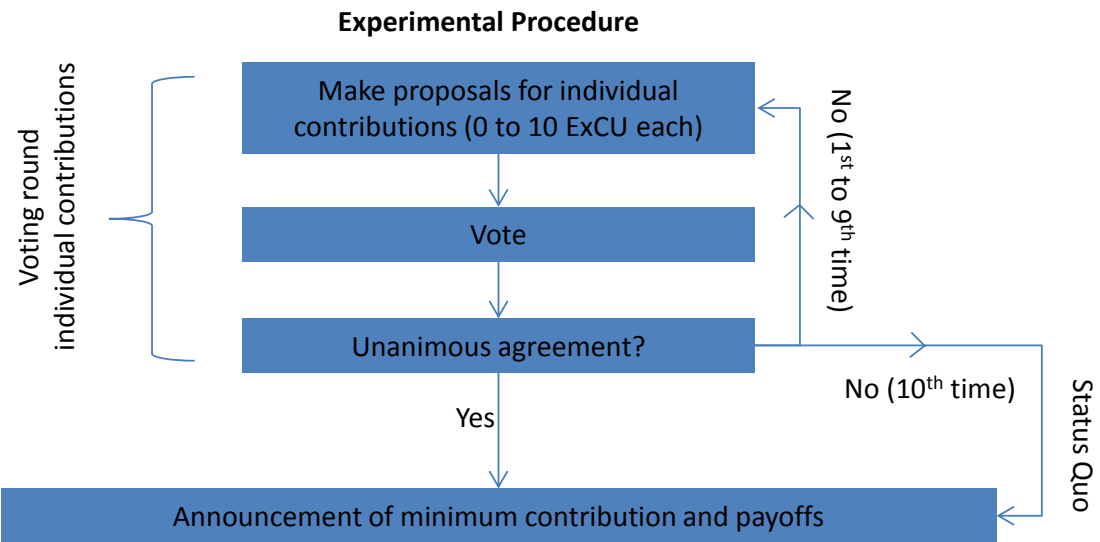


Figure 2[BUHOM] – Experimental procedure

Experimental Procedure

In the experiment you and **four other players** form a **group of five**. The composition of this group will not change throughout the entire experiment, i.e., in all **ten rounds**.

Your task in each of the ten rounds is to choose your contribution to a project. At the same time, every other player in your group chooses his own contribution to this project. The contributions of all players in a group are added up to a **total contribution**. For the project to be successful, **your group's total contribution must reach a minimum contribution**. Otherwise, the project fails and the amount you contributed to the project (as well as the amounts from your fellow players) are lost.

The experiment consists of **a total of ten independent decisions of this kind** in a total of ten rounds. **However, only one of these rounds will matter for your payoff**. Which of these rounds is paid will be determined randomly at the end of the experiment, individually for each player. For this purpose, each of the ten rounds has the same probability of being chosen.

At the beginning of each round, each player has an **endowment of 25 Experimental Currency Units**. In every individual round, each player can contribute up to 10 Experimental Currency Units. The group's total contribution in each round can therefore amount to up to 50 Experimental Currency Units.

The exact amount of this minimum contribution is determined randomly and separately for each round. You are told this information only at the end of the respective round, i.e., after the contributions have been chosen. You know however that the **minimum contribution** will take on one of the following **nine values in contribution units, each with the same probability**:

16, 17, 18, 19, 20, 21, 22, 23, 24

If the minimum contribution is not reached in a given round, each player must make an additional **payment of 10 Experimental Currency Units**, which is deducted from his earnings in the respective round.

Total contribution	< 16	16	17	18	19	20	21	22	23	24	> 24
Probability that minimum contribution is reached (absolute)	0	1/9	2/9	3/9	4/9	5/9	6/9	7/9	8/9	1	1
Probability that minimum contribution is reached (% , rounded)	0%	11%	22%	33%	44%	56%	67%	78%	89%	100%	100%

PROCEDURE OF THE DECISION

In the experiment you and your fellow players each choose **your own contribution to the project**. This happens in **ten decision rounds** which all proceed as follows:

- (1) Each player chooses his own contribution to the project. All players choose their contributions at the same time. In order to do this, each player chooses an amount between 0 and 10 Experimental Currency Units (in steps of 0.1 ExCU). The individual contributions of all players in a group are automatically summed up to a total contribution.
- (2) After all group members have made their contribution choice, each player is told the required minimum contribution, his group's total contribution, as well as his resulting earnings. The contributions of the other players in the group are also displayed.

YOUR PAYOFF

The **earnings of each player in the respective round** calculate as follows:

- Please note that the contributed amount is deducted from your account balance in any case, even if the total contribution has not reached the minimum contribution.

- If the group's total contribution is greater than or equal to the minimum contribution, then the project is successful and you receive the following earnings:

earnings for reaching the minimum contribution = 25 ExCU - your contributed amount

- If the group's total contribution is less than the minimum contribution, then the project is not successful and you receive the following payoff:

earnings for missing the minimum contribution = 25 ExCU - your contributed amount - 10 ExCU

In order to determine the **total payoff at the end of the experiment**, one of the ten rounds is chosen randomly. All rounds have the same probability of being chosen. **This means that you receive the earnings from only a single round.** The results from the remaining rounds are no longer relevant to your payoff, no matter if the minimum contribution has been reached in these rounds or not.

The earnings from the randomly chosen round are converted into euros (**2 ExCU = €1**) and added to your show-up fee (€3). The payoff from a subsequent separate experiment is later added to this amount.

Example for the procedure of a particular round

In this round, the players in a given group make the following individual contributions which add up to a **total contribution of 19 ExCU**:

- Player A: 1 ExCU
- Player B: 2 ExCU
- Player C: 4 ExCU
- Player D: 3 ExCU
- Player E: 9 ExCU

Assume that the **minimum contribution amounts to 20 ExCU**. Then a total contribution of 19 ExCU misses this minimum contribution. Accordingly, Player A from the previous example (contributed amount of 1 ExCU) has earnings of $25 \text{ ExCU} - 1 \text{ ExCU} - 10 \text{ ExCU} = 14 \text{ ExCU}$ in this round. An amount of 10 ExCU is deducted here, because the minimum contribution has not been reached.

Assume that the **minimum contribution amounts to 18 ExCU**. Then a total contribution of 19 ExCU reaches this minimum contribution. Now, a contributed amount of 1 ExCU results in earnings of $25 \text{ ExCU} - 1 \text{ ExCU} = 24 \text{ ExCU}$. In this case nothing is deducted, because the minimum contribution has been reached.

Please note that, starting with the second decision round, you may call up the **results from previous rounds** whenever you make a decision by clicking the button "Show earlier results". By clicking the button "Back" you may return to the current decision round. After having chosen your contribution (by clicking "Confirm choice") you have one additional opportunity to correct your decision if necessary. As soon as you click "Confirm choice and continue", your decision is final.

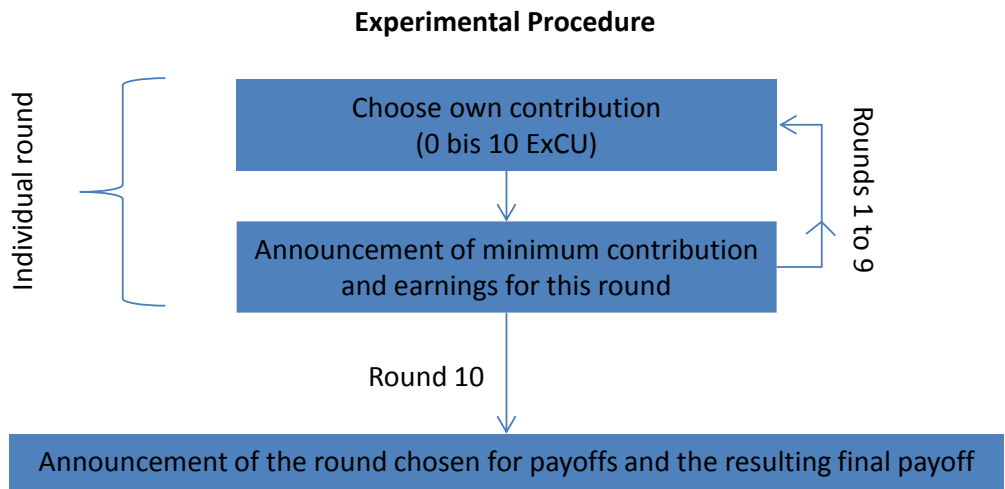


Figure 1[NVHOM] – Experimental procedure

Experimental Procedure

In the experiment you and **four other players** form a **group of five**. The composition of this group is determined randomly at the beginning of the experiment and does not change during the entire experiment (in both parts and in all rounds). You begin the experiment with an **endowment of 25 Experimental Currency Units**.

Your task in this experiment is to choose your and your fellow players' contributions to a project. **Each player's contribution is measured in Contribution Units (CU)**. Each player can contribute **up to 10 Contribution Units**, by investing Experimental Currency Units from his or her endowment. The decision occurs in **two parts**.

- 1) First you take a vote on the **total contribution** of all players of your group. This total contribution can amount to **up to 50 contribution units**.
- 2) Then you take a vote on the **share of total contributions** that is allocated to the individual players.

The costs of contributions in Experimental Currency units vary among the players:

Players A and B 1 Contribution Unit costs 0.77 Experimental Currency Units (**1 CU = 0.77 ExCU**)

Players C, D, and E 1 Contribution Unit costs 1.25 Experimental Currency Units (**1 CU = 1.25 ExCU**)

Which player you are (A, B, C, D, E) is determined randomly at the beginning of the experiment. You are told who you are before the first decision.

For the project to be successful, **your group's total contribution must reach a minimum contribution**. Otherwise, the project fails and the amount you contributed to the project (as well as the amounts from your fellow players) are lost.

The exact amount of this minimum contribution is determined randomly. You are told this information only at the end of the experiment. You know however that the **minimum contribution** will take on one of the following **nine values in contribution units, each with the same probability**:

16, 17, 18, 19, 20, 21, 22, 23, 24

If the minimum contribution is not reached, each player must make an additional **payment of 10 Experimental Currency Units**, which is deducted from his payoff.

Total contribution	< 16	16	17	18	19	20	21	22	23	24	> 24
Probability that minimum contribution is reached (absolute)	0	1/9	2/9	3/9	4/9	5/9	6/9	7/9	8/9	1	1
Probability that minimum contribution is reached (% rounded)	0%	11%	22%	33%	44%	56%	67%	78%	89%	100%	100%

PROCEDURE OF THE FIRST PART

In the first part you and your fellow players vote on **your group's total contribution**. This happens in up to five voting rounds and proceeds as follows:

1. At the same time as the other players each player makes a **proposal for the total contribution**. In order to do this, he or she chooses an amount **between 0 and 50 Contribution Units**.
2. The proposals are shown to all players in a table (see Figure 1). Among them is also a proposal called **"Status Quo"**, corresponding to a total contribution of **0 Contribution Units**. Next to each proposal there is a list of the player(s) who made this proposal. If a proposal has been made multiple times, it is displayed only once, together with all players who made this proposal. Accordingly, there can be up to six different proposals.

3. Each player casts a vote for exactly one of these proposals. All votes are cast individually and at the same time. In order to vote for a proposal please click on “Accept” in the column directly to the right of the proposal.
4. Each player learns the result of the vote, i.e., the number of votes for each proposal as well as which player has voted for which alternative. If all players select the same proposal (**unanimous decision**), the **second part of the experiment begins**. Otherwise, Steps 1 to 4 are repeated up to four times. In every repetition new proposals can be made.
5. If there is also **no agreement in the fifth voting round**, the **Status Quo** (total contribution of 0 Contribution Units) is chosen as your group's total contribution.
6. If the first part results in a **total contribution of 0 Contribution Units**, **no further voting** occurs in this group, meaning that the second part of the experiment is omitted. Each player then automatically makes an individual contribution of 0 Contribution Units and the experiments ends with the calculation of payoffs.

Abstimmungsrunde 2 von maximal 5

Bitte entscheiden Sie sich für einen der folgenden Vorschläge!

Der Mindestbeitrag nimmt einen der folgenden neun Werte an: 16 BE, 17 BE, 18 BE, 19 BE, 20 BE, 21 BE, 22 BE, 23 BE, 24 BE.

Vorschlag	Gesamtbeitrag (BE)	
Spieler A, B, E	17	<input type="button" value="Akzeptieren"/>
Spieler C (Ihr Vorschlag)	19	<input type="button" value="Akzeptieren"/>
Spieler D	16	<input type="button" value="Akzeptieren"/>
Status Quo	0	<input type="button" value="Akzeptieren"/>

Figure 1[TDHET] – Voting decision in the first part of the experiment

Example for the procedure of the first part:

- Round 1:
 - A total of six proposals for the total contribution (in CU): 0 (Status Quo), 16, 17, 17, 18, 19
 - Total contribution “17 CU” has been proposed twice, but only counts as a single alternative.
 - Two players vote for “18 CU”, three players for “16 CU”. “0 CU”, “17 CU”, and “19 CU” receive no votes at this time.
 - There is no agreement, so the procedure is repeated in an additional round.
- Round 2:

- Again a total of six proposals for the total contribution (in CU): 0 (Status Quo), 16, 17, 17, 17, 19
- Total contribution “17 CU” has been proposed three times, but only counts as a single alternative.
- Now all five players vote for “19 CU”. “0 CU”, “16 CU”, and “17 CU” receive no votes at this time.
- Thus, a total contribution of “19 CU” is accepted and chosen for the second part.

Please note that, starting with the second voting round, you may call up the **results from previous votes** whenever you make a decision by clicking the button “Show earlier round” (see Figure 1). Clicking the button again shows even earlier rounds. By clicking the buttons “Show later round” or “Back to current round” you may advance again in the history or, respectively, jump immediately to the current decision round.

PROCEDURE OF THE SECOND PART

In the second part, you and your fellow players take a vote on how the total contribution determined in part one is to be allocated as **individual contributions among all group players**. This occurs as follows in up to five voting rounds:

- (1) At the same time as his fellow players, each player makes a **proposal for the contributions of each individual player**. For this purpose, he or she chooses an amount between 0 and 10 Contribution Units (in steps of 0.01 CU). By clicking on “Calculate values” you can also display the corresponding values in Experimental Currency Units. **Attention! The sum of Contribution Units must be equal to the total contribution determined in Part 1!**
- (2) The proposals are shown to all players in a table (in CU as well as in ExCU). Among these is again a proposal called “**Status Quo**”. Here this proposal means that every player makes a contribution of 0 Contribution Units, **no matter what has been determined as a total contribution in Part 1**. With each proposal, a list of players is given who made this proposal. If the same proposal has been made several times, it is shown only once, with all players that made this proposal. So there can again be up to six different proposals.
- (3) At the same time as his fellow players, each player casts a vote for exactly one of these proposals. In order to vote for a proposal, please click on “Accept” directly to the right of the proposal.
- (4) Each player is told the voting result, i.e., the number of votes for each proposal, as well as which player voted for which proposal. If all players choose the same proposal (**unanimous decision**), the experiment ends with the calculation of payoffs. Otherwise, Steps 1 to 4 are repeated up to four times.
- (5) If **no agreement** has been reached **in the fifth voting round** either, the **Status Quo** (each player makes a contribution of 0 Contribution Units, total contribution of 0 Contribution Units) is used for the calculation of payoffs. **This is true even if a different total contribution has been chosen in the first part.**

Example for the procedure of the second part (total contribution 19 CU):

- Round 1:
 - A total of six proposals for the allocation of the total contribution:

Proposals	Individual contributions in CU (costs in ExCU)				
	Player A	Player B	Player C	Player D	Player E
Player(s) A, C	1 (0.77)	2 (1.54)	4 (5)	3 (3.75)	9 (11.25)
Player(s) B, E	3 (2.31)	1 (0.77)	2 (2.5)	6,5 (8.12)	6,5 (8.12)
Player(s) D	9 (6.93)	3 (2.31)	2 (2.5)	1 (1.25)	4 (5)
Status Quo	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

- Allocation “1 CU; 2 CU; 4 CU; 3 CU; 9 CU” has been proposed twice, but only counts as a single option.
 - The same is true for allocation “3 CU; 1 CU; 2 CU; 6.5 CU; 6.5 CU”.
 - All five players vote for “A, C”. The remaining three different proposals (“Status Quo”, “B, E”, “D”) do not receive any votes this time.
- The voting procedure ends in this example with a total contribution of 19 CU and the following individual contributions:
 - Player A: 1 CU ($1 \cdot 0.77 \text{ ExCU} = 0.77 \text{ ExCU}$)
 - Player B: 2 CU ($2 \cdot 0.77 \text{ ExCU} = 1.54 \text{ ExCU}$)
 - Player C: 4 CU ($4 \cdot 1.25 \text{ ExCU} = 5 \text{ ExCU}$)
 - Player D: 3 CU ($3 \cdot 1.25 \text{ ExCU} = 3.75 \text{ ExCU}$)
 - Player E: 9 CU ($9 \cdot 1.25 \text{ ExCU} = 11.25 \text{ ExCU}$)

Please note that, starting with the second voting round, you may call up the **results from previous votes in this part** whenever you make a decision by clicking the button “Show earlier round”. Clicking the button again shows even earlier rounds. By clicking the buttons “Show later round” or “Back to current round” you may advance again in the history or, respectively, jump immediately to the current decision round.

YOUR PAYOFF

The payoff of every player calculates as follows:

- Please note that you have to pay the costs of your contribution in any case, even if the total contribution did not reach the minimum contribution.
- If the group’s total contribution is greater than or equal to the minimum contribution, then the project is successful and you receive the following payoff:

Payoff if minimum contribution is reached = 25 ExCU – your costs (in ExCU)

- If the group’s total contribution is less than the minimum contribution, then the project is not successful and you receive the following payoff:

Payoff if minimum contribution is not reached = 25 ExCU – your costs (in ExCU) – 10 ExCU

In order to determine the final payoff at the end of the experiment, this amount is converted into euros (**2 ExCU = 1 euro**) and added to your show-up fee. An additional payoff from a subsequent separate experiment is also added to this amount.

Example for the calculation of payoffs (total contribution 19 CU):

Assume a **minimum contribution of 20 CU**. Then a total contribution of 19 CU is less than this minimum contribution. For Player A from the previous example (costs of 0.77 ExCU for 1 CU) this results in a payoff of $25 \text{ ExCU} - 0.77 \text{ ExCU} - 10 \text{ ExCU} = 14.23 \text{ ExCU}$. A payment of 10 ExCU is deducted here, because the minimum contribution was not reached.

Assume a **minimum contribution of 18 CU**. Then a total contribution of 19 CU reaches this minimum contribution. For a contribution of 1 CU (costs of 0.77 CU) this now results in a payoff of $25 \text{ ExCU} - 0.77 \text{ ExCU} = 24.23 \text{ ExCU}$. In this case, no additional payment is deducted, because the minimum contribution has been reached.

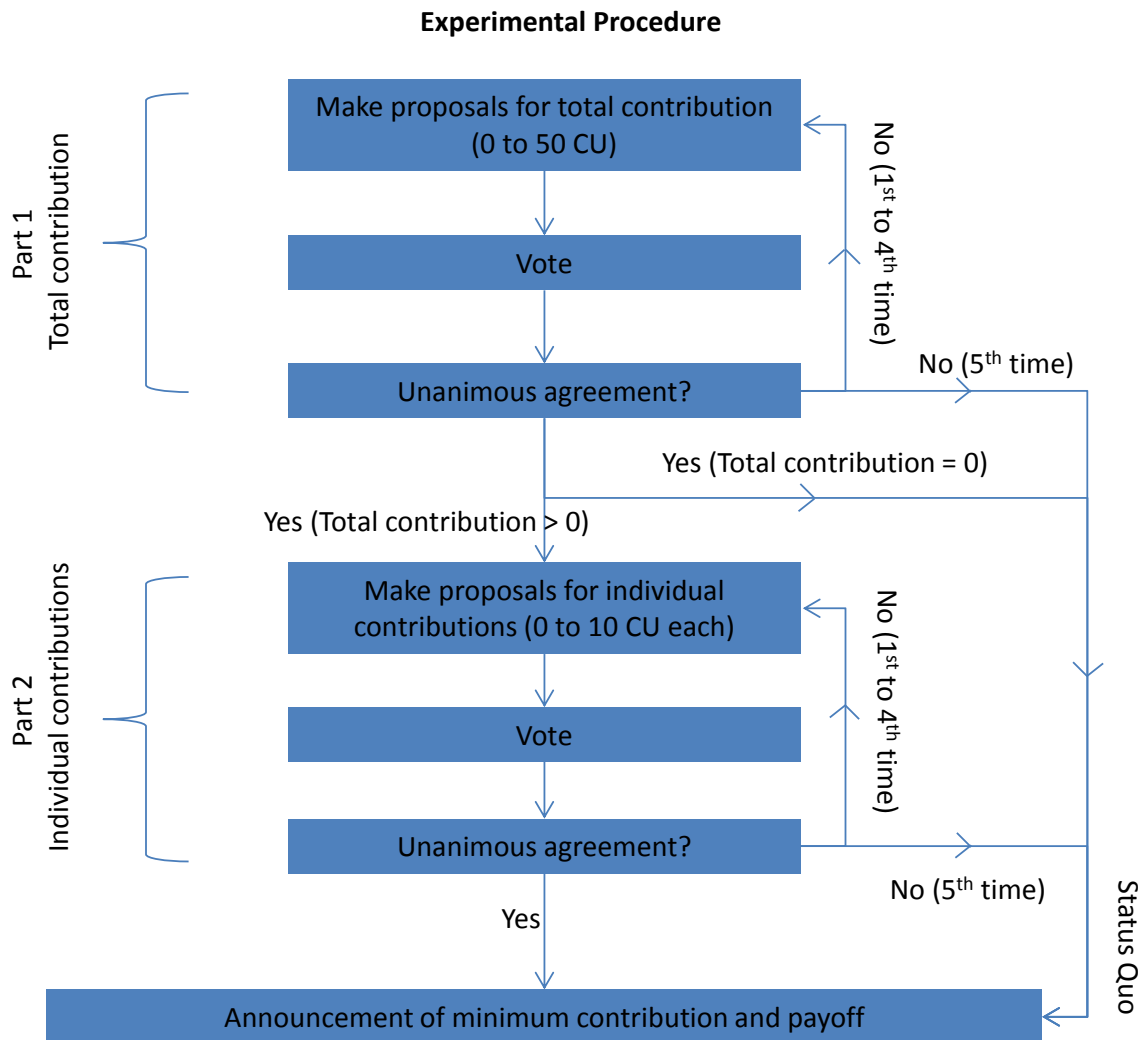


Figure 2[TDHET] – Experimental procedure

Experimental Procedure

In the experiment you and **four other players** form a **group of five**. The composition of this group is determined randomly at the beginning of the experiment and does not change during the entire experiment (in both parts and in all rounds). You begin the experiment with an **endowment of 25 Experimental Currency Units**.

Your task in this experiment is to choose your and your fellow players' contributions to a project. **Each player's contribution is measured in Contribution Units (CU)**. Each player can contribute **up to 10 Contribution Units**, by investing Experimental Currency Units from his or her endowment. Your decision consists in a **vote on the individual contributions of all players in a group**. These contributions are added up to a **total contribution of up to 50 Contribution Units**.

The costs of contributions in Experimental Currency units vary among the players:

Players A and B 1 Contribution Unit costs 0.77 Experimental Currency Units (**1 CU = 0.77 ExCU**)

Players C, D, and E 1 Contribution Unit costs 1.25 Experimental Currency Units (**1 CU = 1.25 ExCU**)

Which player you are (A, B, C, D, E) is determined randomly at the beginning of the experiment. You are told who you are before the first decision.

For the project to be successful, **your group's total contribution must reach a minimum contribution**. Otherwise, the project fails and the amount you contributed to the project (as well as the amounts from your fellow players) are lost. The exact amount of this minimum contribution is determined randomly. You are told this information only at the end of the experiment. You know however that the **minimum contribution** will take on one of the following **nine values in contribution units, each with the same probability**:

16, 17, 18, 19, 20, 21, 22, 23, 24

If the minimum contribution is not reached, each player must make an additional **payment of 10 Experimental Currency Units**, which is deducted from his payoff.

Total contribution	< 16	16	17	18	19	20	21	22	23	24	> 24
Probability that minimum contribution is reached (absolute)	0	1/9	2/9	3/9	4/9	5/9	6/9	7/9	8/9	1	1
Probability that minimum contribution is reached (% rounded)	0%	11%	22%	33%	44%	56%	67%	78%	89%	100%	100%

VOTING PROCEDURE

In the experiment, you and your fellow players vote on the **individual contributions of all group players**. This happens in **up to ten voting rounds** and proceeds as follows:

- (1) Each player makes a **proposal for the contribution of every single player**. All players make their proposals individually and at the same time. In order to do this, each player chooses an amount between 0 and 10 Contribution Units (in steps of 0.01 CU). By clicking on "Calculate values" you can also display the corresponding values in Experimental Currency Units. The individual contributions from each proposal are automatically summed up to a total contribution.
- (2) The proposals and corresponding total contributions are shown to all players in a list (both in CU and ExCU) (see Figure 1). Among these is also a proposal called "**Status Quo**". This proposal means that each player provides a contribution of 0 Contribution Units. Next to each proposal there is a list of the player(s) who made this proposal. Identical proposals are dis-

played only once, together with all players who made this proposal. Accordingly, there can be up to six different distribution proposals.

- (3) At the same time as all of the other players in his group, each player casts a vote for exactly one of these proposals. In order to vote for a proposal please click on “Accept” in the column directly to the right of the proposal.
- (4) Each player learns the result of the vote, i.e., the number of votes for each proposal as well as which player has voted for which alternative. If all players select the same proposal (**unanimous decision**), the experiment ends with the calculation of payoffs. Otherwise, Steps 1 to 4 are repeated up to nine times.
- (5) If there is also **no agreement in the tenth voting round**, the **Status Quo** (each player provides a contribution of 0 Contribution Units, total contribution of 0 Contribution Units) is selected to calculate payoffs.

Abstimmungsrunde 2 von maximal 10							
Sie sind Spieler A							
Bitte entscheiden Sie sich für einen der folgenden Vorschläge!							
Der Mindestbeitrag nimmt einen der folgenden neun Werte an:							
16 BE, 17 BE, 18 BE, 19 BE, 20 BE, 21 BE, 22 BE, 23 BE, 24 BE							
<input type="button" value="Zurück zur aktuellen Runde"/> <input type="button" value="Spätere Runde anzeigen"/> <input type="button" value="Frühere Runde anzeigen"/>							
Vorschlag	Spieler A Beitrag in BE (Kosten in GE)	Spieler B Beitrag in BE (Kosten in GE)	Spieler C Beitrag in BE (Kosten in GE)	Spieler D Beitrag in BE (Kosten in GE)	Spieler E Beitrag in BE (Kosten in GE)	Gesamtbeitrag (BE)	
Spieler A (Ihr Vorschlag), C	1.00 (0.77)	2.00 (1.54)	4.00 (5.00)	3.00 (3.75)	9.00 (11.25)	19.00	<input type="button" value="Akzeptieren"/>
Spieler B, E	6.50 (5.00)	1.00 (0.77)	2.00 (2.50)	6.50 (8.12)	0.00 (0.00)	16.00	<input type="button" value="Akzeptieren"/>
Spieler D	9.00 (6.93)	3.00 (2.31)	5.00 (6.25)	4.00 (5.00)	1.00 (1.25)	22.00	<input type="button" value="Akzeptieren"/>
Status Quo	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00	<input type="button" value="Akzeptieren"/>

Figure 1[BUHET] – Voting decision in the experiment

Example for the voting procedure

- Round 1:
 - A total of six proposals for the individual contributions of all players in the group:

Proposals	Individual contributions in CU (costs in ExCU)					Total contribution in CU
	Player A	Player B	Player C	Player D	Player E	
Player A, C	1 (0.77)	2 (1.54)	4 (5)	3 (3.75)	9 (11.25)	19
Player B, E	6,5 (5)	1 (0.77)	2 (2.5)	6,5 (8.12)	0 (0)	16
Player D	9 (6.93)	3 (2.31)	5 (6.25)	4 (5)	1 (1.25)	22
Status Quo	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0

- Allocation “1 CU; 2 CU; 4 CU; 3 CU; 9 CU” with a total contribution of 19 CU has been proposed twice, but only counts as a single option.
 - The same is true for allocation “6.5 CU; 1 CU; 2 CU; 6.5 CU; 0 CU” with a total contribution of 16 CU.
 - All five players vote for “A, C”. The remaining three different proposals (“Status Quo”, “B, E”, “D”) do not receive any votes this time.
- The voting procedure ends in this example with a total contribution of 19 CU and the following individual contributions:
 - Player A: 1 CU ($1 \cdot 0.77 \text{ ExCU} = 0.77 \text{ ExCU}$)
 - Player B: 2 CU ($2 \cdot 0.77 \text{ ExCU} = 1.54 \text{ ExCU}$)
 - Player C: 4 CU ($4 \cdot 1.25 \text{ ExCU} = 5 \text{ ExCU}$)
 - Player D: 3 CU ($3 \cdot 1.25 \text{ ExCU} = 3.75 \text{ ExCU}$)
 - Player E: 9 CU ($9 \cdot 1.25 \text{ ExCU} = 11.25 \text{ ExCU}$)

Please note that, starting with the second voting round, you may call up the **results from previous votes** whenever you make a decision by clicking the button “Show earlier round”. Clicking the button again shows even earlier rounds. By clicking the buttons “Show later round” or “Back to current round” you may advance again in the history or, respectively, jump immediately to the current decision round.

YOUR PAYOFF

The payoff of every player calculates as follows:

- Please note that you have to pay the costs of your contribution in any case, even if the total contribution did not reach the minimum contribution.
- If the group’s total contribution is greater than or equal to the minimum contribution, then the project is successful and you receive the following payoff:

Payoff if minimum contribution is reached = 25 ExCU – your costs (in ExCU)

- If the group’s total contribution is less than the minimum contribution, then the project is not successful and you receive the following payoff:

Payoff if minimum contribution is not reached = 25 ExCU – your costs (in ExCU) – 10 ExCU

In order to determine the final payoff at the end of the experiment, this amount is converted into euros (**2 ExCU = 1 euro**) and added to your show-up fee. An additional payoff from a subsequent separate experiment is also added to this amount.

Example for the calculation of payoffs (total contribution 19 CU):

Assume a **minimum contribution of 20 CU**. Then a total contribution of 19 CU is less than this minimum contribution. For Player A from the previous example (costs of 0.77 ExCU for 1 CU) this results in a payoff of 25 ExCU – 0.77 ExCU – 10 ExCU = 14.23 ExCU. A payment of 10 ExCU is deducted here, because the minimum contribution was not reached.

Assume a **minimum contribution of 18 CU**. Then a total contribution of 19 CU reaches this minimum contribution. For a contribution of 1 CU (costs of 0.77 CU) this now results in a payoff of 25 ExCU – 0.77 ExCU = 24.23 ExCU. In this case, no additional payment is deducted, because the minimum contribution has been reached.

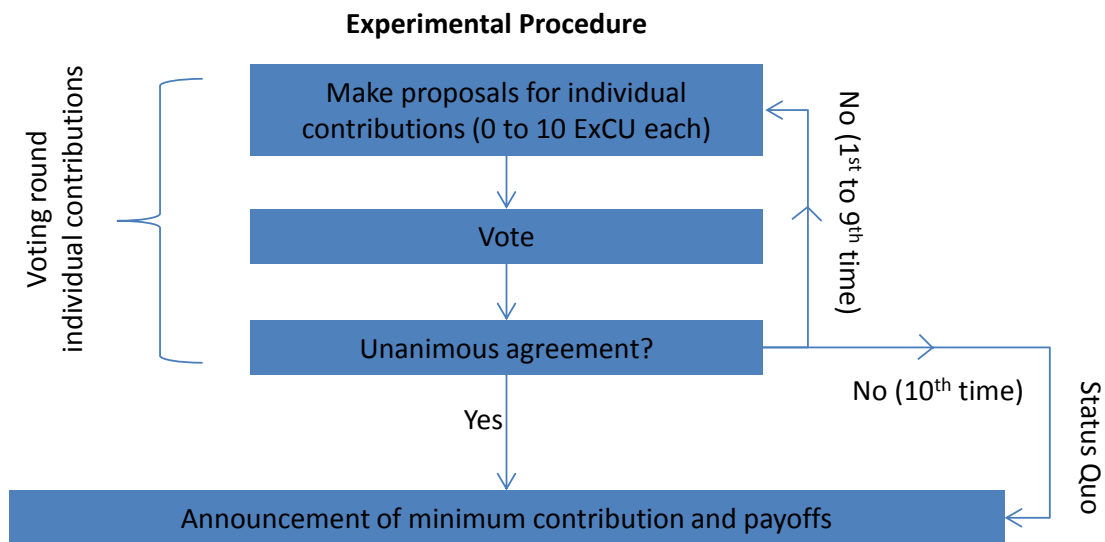


Figure 2[BUHET] – Experimental procedure

Experimental Procedure

In the experiment you and **four other players** form a **group of five**. The composition of this group is determined randomly at the beginning of the experiment. It will not change throughout the entire experiment, i.e., in all **ten rounds**.

Your task in each of the ten rounds is to choose your contribution to a project. At the same time, every other player in your group chooses his own contribution to this project. The contributions of all players in a group are added up to a **total contribution**. For the project to be successful, **your group's total contribution must reach a minimum contribution**. Otherwise, the project fails and the amount you contributed to the project (as well as the amounts from your fellow players) are lost.

The experiment consists of a **total of ten independent decisions of this kind** in a total of ten rounds. **However, only one of these rounds will matter for your payoff**. Which of these rounds is paid will be determined randomly at the end of the experiment, individually for each player. For this purpose, each of the ten rounds has the same probability of being chosen.

At the beginning of each round, each player has an **endowment of 25 Experimental Currency Units**. **Each player's contribution is measured in Contribution Units (CU)**. In every individual round, each player can contribute **up to 10 Contribution Units**, by investing Experimental Currency Units from his or her endowment. The group's total contribution in each round can therefore amount to up to 50 Contribution Units.

The costs of contributions in Experimental Currency units vary among the players:

Players A and B 1 Contribution Unit costs 0.77 Experimental Currency Units (**1 CU = 0.77 Ex-CU**)

Players C, D, and E 1 Contribution Unit costs 1.25 Experimental Currency Units (**1 CU = 1.25 Ex-CU**)

Which player you are (A, B, C, D, E) is determined randomly at the beginning of the experiment. You are told who you are before the first decision.

The exact amount of this **minimum contribution is determined randomly and separately for each round**. You are told this information only at the end of the respective round, i.e., after the contributions have been chosen. You know however that the minimum contribution will take on one of the following **nine values in contribution units, each with the same probability**:

16, 17, 18, 19, 20, 21, 22, 23, 24

If the minimum contribution is not reached in a given round, each player must make an additional **payment of 10 Experimental Currency Units**, which is deducted from his earnings in the respective round.

Total contribution	< 16	16	17	18	19	20	21	22	23	24	> 24
Probability that minimum contribution is reached (absolute)	0	1/9	2/9	3/9	4/9	5/9	6/9	7/9	8/9	1	1
Probability that minimum contribution is reached (% , rounded)	0%	11%	22%	33%	44%	56%	67%	78%	89%	100%	100%

PROCEDURE OF THE DECISION

In the experiment you and your fellow players each choose **your own contribution to the project**. This happens in **ten decision rounds** which all proceed as follows:

- (1) Each player chooses his own contribution to the project. All players choose their contributions at the same time. In order to do this, each player chooses an amount between 0 and 10 Contribution Units (in steps of 0.01 CU). By clicking on "Calculate values" you can also

display the corresponding values in Experimental Currency Units. The individual contributions of all players in a group are automatically summed up to a total contribution.

- (2) After all group members have made their contribution choice, each player is told the required minimum contribution, his group's total contribution, as well as his resulting earnings. The contributions of the other players in the group are also displayed (in CU and ExCU).

YOUR PAYOFF

The **earnings of each player in the respective round** calculate as follows:

- Please note that the contributed amount is deducted from your account balance in any case, even if the total contribution has not reached the minimum contribution.
- If the group's total contribution is greater than or equal to the minimum contribution, then the project is successful and you receive the following earnings:

earnings for reaching the minimum contribution = 25 ExCU – your costs (in ExCU)

- If the group's total contribution is less than the minimum contribution, then the project is not successful and you receive the following payoff:

earnings for missing the minimum contribution = 25 ExCU – your costs (in ExCU) – 10 ExCU

In order to determine the **total payoff at the end of the experiment**, one of the ten rounds is chosen randomly. All rounds have the same probability of being chosen. **This means that you receive the earnings from only a single round.** The results from the remaining rounds are no longer relevant to your payoff, no matter if the minimum contribution has been reached in these rounds or not.

The earnings from the randomly chosen round are converted into euros (**2 ExCU = €1**) and added to your show-up fee (€3). The payoff from a subsequent separate experiment is later added to this amount.

Example for the procedure of a particular round

In this round, the players in a given group make the following individual contributions which add up to a **total contribution of 19 CU**:

- Player A: 1 CU ($1 \cdot 0.77 \text{ ExCU} = 0.77 \text{ ExCU}$)
- Player B: 2 CU ($2 \cdot 0.77 \text{ ExCU} = 1.54 \text{ ExCU}$)
- Player C: 4 CU ($4 \cdot 1.25 \text{ ExCU} = 5 \text{ ExCU}$)
- Player D: 3 CU ($3 \cdot 1.25 \text{ ExCU} = 3.75 \text{ ExCU}$)
- Player E: 9 CU ($9 \cdot 1.25 \text{ ExCU} = 11.25 \text{ ExCU}$)

Assume that the **minimum contribution amounts to 20 CU**. Then a total contribution of 19 CU misses this minimum contribution. Accordingly, Player A from the previous example (costs of 0.77 ExCU for 1 CU) has earnings of $25 \text{ ExCU} - 0.77 \text{ ExCU} - 10 \text{ ExCU} = 14.23 \text{ ExCU}$ in this round. An amount of 10 ExCU is deducted here, because the minimum contribution has not been reached.

Assume that the **minimum contribution amounts to 18 CU**. Then a total contribution of 19 CU reaches this minimum contribution. Now, a contributed amount of 1 CU (costs of 0.77 ExCU) results in earnings of $25 \text{ ExCU} - 0.77 \text{ ExCU} = 24.23 \text{ ExCU}$. In this case nothing is deducted, because the minimum contribution has been reached.

Please note that, starting with the second decision round, you may call up the **results from previous rounds** whenever you make a decision by clicking the button "Show earlier results". By clicking the button "Back"

you may return to the current decision round. After having chosen your contribution (by clicking “Confirm choice”) you have one additional opportunity to correct your decision if necessary. As soon as you click “Confirm choice and continue”, your decision is final.

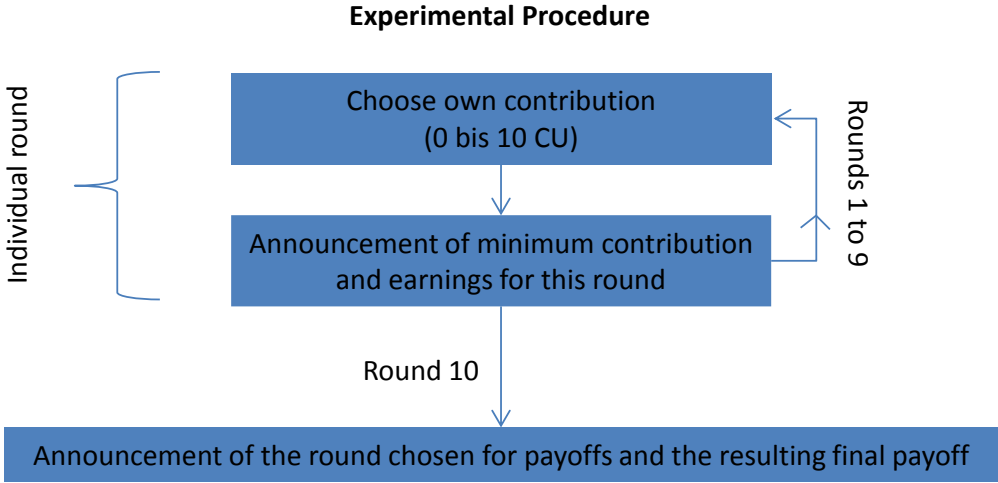


Figure 1[NVHET] – Experimental procedure

[All Treatments]

ADDITIONAL REMARKS

Please think carefully about all of your decisions, because they determine your payoff at the end of the experiment. Before the actual experiment can begin, you must answer a few questions which ensure that you have understood the procedure of the experiment and your task. You find the questions on the left side of the screen, and you can enter your answers on the right side. Please enter decimal numbers with a point instead of a comma (that is, e.g., 12.34 instead of 12,34).

If you have any questions yourself during the experiment, please remain seated quietly and raise your hand. Please wait until the experimenter has come to your seat and then ask your question as quietly as possible. However, questions should only be about the instructions and not about strategies!

Furthermore, please note that the game only continues after all players have made their decisions.

Feel free to use the last sheet of these instructions for your own notes.

END OF THE EXPERIMENT

After the experiment, we ask you to fill in a questionnaire with an additional decision task. When the time has come, we will distribute separate instructions explaining the procedure. Please remain seated after filling in the questionnaire until we call up your place number. Take your instructions with you to the front desk. Only then you can receive your payoff.

Thank you very much for your participation and good luck!

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