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Heterogeneous Reactions to Heterogeneity in Returns from Public Goods[1]

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Abstract

In many cases individuals benefit differently from the provision of a public good. We study in a laboratory experiment how heterogeneity in returns and uncertainty affects unconditional and conditional contribution behavior in a linear public goods game. The elicitation of conditional contributions in combination with a within subject design allows us to investigate belief-independent and type-specific reactions to heterogeneity. We find that, on average, heterogeneity in returns decreases unconditional contributions but does not affects conditional contributions only weakly. Uncertainty in addition to heterogeneity reduces conditional contributions slightly. Individual reactions to heterogeneity differ systematically. Selfish subjects and one third of conditional cooperators do not react to heterogeneity whereas the reactions of the remaining conditional cooperators vary. A substantial part of heterogeneity in reactions can be explained by inequity aversion which accounts for different reference groups subjects compare to.

Keywords: public goods, social preferences, conditional cooperation, heterogeneity.

JEL-Classification: C91, C72, H41.

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1. Introduction

Investments in public goods (e.g. investments in energy-saving measures) benefit the investor and others. The value of obtained benefits (e.g. individual cost savings, reduction in CO2 emissions or clean air) is in many cases difficult to assert and different individuals benefit differently from the public good. In order to develop policies to sustain the provision of public goods, it is thus crucial to understand how uncertainty and heterogeneity in returns from public goods affect contribution behavior. Previous experimental work has focused on aggregate effects of heterogeneous returns from public goods on people's unconditional contributions to public goods (see e.g. Fisher et al. (1995)) and uncertainty of returns (see e.g. Dickinson (1998) and Levati et al. (2009)). However, unconditional contributions depend on beliefs about others' contributions whereas the analysis of conditional contributions allows to eliminate the effect of beliefs. Further if people have heterogeneous preferences or differ in their reference points (i.e. they compare to different reference groups), individual reactions to heterogeneity will differ in systematic ways. Studying aggregate effects may then lead to wrong conclusions and entail wrong policy implications. The aim of our paper is therefore to focus on belief-independent and type-specific reactions to heterogeneity.

The novelty of our experimental design is twofold: First, on top of unconditional contributions we elicit conditional contributions of subjects and thereby isolate belief-independent reactions to heterogeneity. Second, we use a within-subject design which allows us to identify type specific reactions to heterogeneity. Additionally, we provide insights on how people perceive heterogeneity in returns by relating our results to theoretical predictions based on two social preference models which we extend to allow for different reference groups to which people may compare.

In the experiment participants play several one-shot linear public goods games in groups of four. The social return from the public good is identical in all the games but we vary the marginal per capita returns (MPCRs). Subjects make unconditional and conditional contributions with certain and homogeneous MPCRs, certain and heterogeneous MPCRs and uncertain and heterogeneous MPCRs. In each game with heterogeneity in MPCRs, two group members receive a high MPCR while the two others receive a low MPCR. Uncertainty only concerns subjects' own MPCRs whereas the distribution of MPCRs is always known.

We find that unconditional contributions are negatively affected by the introduction of heterogeneity in MPCRs from the public good. Conditional contributions are however not significantly affected by heterogeneity. This indicates that negative effects of heterogeneity on contributions to public goods mainly stem from pessimistic beliefs about other's contributions. In heterogeneous environments, uncertainty about the own MPCR does not decrease unconditional contributions further and affects conditional contributions only weakly. Further we show that individual reactions to heterogeneity differ systematically. Selfish subjects and one third of conditional cooperators do not modify their conditional contributions to the public good when heterogeneity in returns is introduced. Around 17 percent of conditional cooperators increase contributions when receiving the high return and decrease contributions when receiving the low return. Additionally, we observe that 27 percent of conditional cooperators react only to either high or low MPCRs. Another 25 percent of conditional cooperators show the same reaction (an increase or a decrease) regarding both returns.

Since the early experiments reported in Bohm (1972), a vast experimental literature on public goods has grown, showing that individuals invest in public goods even though the individual marginal return from investments to the public good is lower than the individual marginal cost.[2] Because contributions vary with the own returns from the public good (see e.g. Ledyard (1995)), heterogeneity in returns may affect contribution behavior. An early experiment by Fisher et al. (1995) focused on the comparison of contributions to a public good by subjects with the same MPCR under homogeneity and heterogeneity in MPCRs. They neither find strong support for so-called "seeding" (i.e. higher contributions by subjects with low MPCRs in case of heterogeneity in MPCRs) nor for a "poisoning of the well" (i.e. lower contributions by subjects with high MPCRs in case of heterogeneity in MPCRs). However, in their experiment, subjects were only told that heterogeneity in returns is possible. Subjects did not know whether returns were actually different. Other experimental studies indicate that heterogeneous valuations of the public good lead less frequently to the efficient outcome (see e.g. Marwell and Ames (1980), Bagnoli and McKee (1991), Chan et al. (1999), Carpenter et al. (2009) and Reuben and Riedl (2009)).[3] However, these studies do not elicit

[2] See e.g. Ledyard (1995), Anderson (2001) or Gächter (2007) for surveys.

[3] Note that we only consider heterogeneity in valuations of public goods. For heterogeneity in productivity see e.g. Tan (2008) or Fellner, et al. (2010) and for heterogeneity in valuations of the private good see e.g. Falkinger, et al. (2000). For a meta study on determinants of contributions in linear public goods games

conditional contributions and thus cannot disentangle whether the decrease in average contributions is due to pessimistic beliefs about other group members' contributions or due to "pure" inequity considerations. Our experimental design allows us to go beyond this limitation. In particular, the data indicate that heterogeneity matters for unconditional but not necessarily for conditional contributions and thus suggest that heterogeneity primarily affects beliefs about others' contributions.

Heterogeneity in returns is also closely related to uncertainty about returns because the latter involves different possible returns by construction. Dickinson (1998) and Levati et al. (2009) study the effects of uncertainty in MPCRs and find significantly lower unconditional contributions when the MPCR is stochastic compared to a certain return. Gangadharan and Nemes (2009) differentiate between situations in which the probabilities for low and high MPCRs are known by the subjects and situations with unknown probabilities. In both situations, unconditional contributions are significantly lower when there is uncertainty in the returns compared to a certain homogeneous return. However, these studies do not separate the effects of uncertainty from the effects of heterogeneity in returns additionally to the fact that they only analyze unconditional contributions. We isolate the effect of uncertainty by comparing unconditional and conditional contributions to the public good when there is heterogeneity in returns and the own returns are known with unconditional and conditional contributions when there is heterogeneity in returns but own returns are uncertain.

The remainder of this paper is organized as follows. In section 2 we present the experimental design. In section 3 we propose theoretical predictions and highlight the importance of subjects' reference group. Section 4 presents the results of the experiment and section 5 concludes.

2. Experimental Design and Procedures

Subjects played six different versions of a standard one-shot linear public goods game in groups of four. At the beginning of the experiment we informed subjects that they would participate in several experiments, but we did not inform them in advance about the specific features of the six versions of the linear public goods game. Because we distributed the instructions for each game just before the game started, subjects'

see Zelmer (2003). Her findings indicate that heterogeneity decreases contributions; strongly for endowment heterogeneity and weakly for heterogeneity in MPCRs.

decisions in each public good game did not depend on any of the characteristics of the subsequent public good games. Subjects received feedback only after the last game and were informed about this at the beginning of the experiment. In all six games, subjects received an endowment of 20 points each and the monetary payoff function was the following:

$$y_i = 20 - g_i + \gamma_i \sum_{j=1}^{4} g_j \qquad (1)$$

with y_i representing subject i's monetary income, g_i denoting i's contribution to the public good, and γ_i equal to the marginal per capita return (MPCR) of an investment by subject i. In the first three public good games subjects made unconditional contribution decisions (UC games). In the second three public good games we elicited conditional contributions (CC games).

In treatment UC04, all group members received the same MPCR from the public good: γ_i = 0.4. Each subject decided on her unconditional contribution and the game ended. In UCu0305, we introduced heterogeneity of MPCRs with uncertainty about each subject's own MPCR. Two subjects received $\gamma_L = 0.3$ and two subjects received $\gamma_H = 0.5$. When making their contribution decisions, subjects did not know whether they would receive γ_L or γ_H but they did know that two subjects in the group would receive γ_L and two would receive γ_H. Thus, there was uncertainty about the own MPCR, but the distribution of MPCRs was known. Note further that the marginal social return from the public good is unchanged. In the third game, there is heterogeneity of MPCRs but each subject knew her own MPCR. Subjects again faced a situation in which two subjects received γ_L and two subjects received γ_H. We used the strategy method in this decision. Subjects stated their contribution conditional on having the low (UC03) or high (UC05) MPCR.

In the CC games, we elicited conditional contributions which do not depend on subjects' beliefs about the average contribution of their group members. We used the procedure introduced by Fischbacher et al. (2001) in order to elicit conditional contributions. The procedure uses a variant of the strategy method (Selten (1967)). Subjects first decide on their unconditional contribution and then fill in a conditional contribution table. They state how many points they wish to contribute dependent on the average contribution of their group members' $\bar{g}$.[4] For each group, a random device (a die) selects one subject for whom the conditional contribution is relevant and three subjects for whom the unconditional contribution is relevant. MPCRs and information about possible MPCRs are equivalent to the information in the UC games. Table 1 summarizes the treatments.

In all sessions, CC games were conducted after UC games to have a progression of complexity in games. However, we altered the order among UC and CC games to control for changes in subjects' contributions as the session progresses. In six sessions, the order was first UC04, then UCu0305 and finally UC03/UC05 (first homogeneity then heterogeneity) while in four sessions the order was UC03/UC05, UCu0305 and finally UC04 (first heterogeneity then homogeneity). The order in CC games followed the order in UC games. At the end of the session, we selected one of the games to be payoff relevant.[5]

We computerized the experiment using z-Tree (Fischbacher (2007)). Each subject sat at a randomly assigned and separated computer terminal and was given a copy of instructions.[6] A set of control questions was provided to ensure the understanding of the game. If any participant repeatedly failed to answer correctly, the experimenter provided an oral explanation. No form of communication between the subjects was allowed during the experiment. We conducted all sessions at the LakeLab

Type of game and MPCR	**Name**
Unconditional cooperation games (UC games)	
γ_i = 0.4	UC04
γ_i =0.3 or γ_i =0.5, with uncertainty	UCu0305
γ_i =0.3 (with heterogeneity)	UC03
γ_i =0.5 (with heterogeneity)	UC05
Conditional cooperation games (CC games)	
γ_i = 0.4	CC04
γ_i =0.3 or γ_i =0.5, with uncertainty	CCu0305
γ_i =0.3 (with heterogeneity)	CC03
γ_i =0.5 (with heterogeneity)	CC05

Table 1. Treatments

[4] Averages are rounded to integer numbers, i.e. subjects have to fill in 21 values. The translated instructions in the appendix provide a screenshot.

[5] We do not report results on a seventh decision (a donation decision) made by our subjects which was also elicited and included in the random selection of payoffs.

[6] A copy of translated instructions can be found in the appendix.

(University of Konstanz, Germany). The data were collected over ten sessions with 228 participants in total. The sessions took place between November 2009 and January 2010 and in February 2011. The experiment lasted about 1 hour and 30 minutes. Participants received on average 21.96 euros including a show-up fee of 4 euros. We recruited participants from the local subject pool including undergraduate and graduate students of all fields of studies (46 percent male) using ORSEE (Greiner (2004)).

3. Theoretical predictions

Selfish subjects have a dominant strategy not to contribute in the UC games. In the CC games, the conditional cooperation of selfish subjects is also zero for all contribution levels of the other subjects. These predictions do not depend on our treatment variations. However, experimental research on public goods games has shown that people are willing to contribute significantly more to the public good than suggested by the assumption of selfishness. Several models have been suggested to explain such behavior: reciprocity models (e.g. Rabin (1993); Dufwenberg and Kirchsteiger (2004) and Falk and Fischbacher (2006)) or models of inequity aversion (e.g. Fehr and Schmidt (1999) and Bolton and Ockenfels (2000)). All these theories predict some form of conditional cooperation if the players have a sufficiently strong social motive.

In this section, we discuss the theoretical predictions for conditional contributions by players with non-selfish preferences for our versions of the linear public goods game. We focus on conditional contribution behavior, because players' unconditional contributions in the CC games depend on players' beliefs about other players' contributions. In particular, we analyze how distributional-based concerns of players affect their behavior and then discuss predictions of two well known inequity aversion models by Fehr and Schmidt (1999) and Bolton and Ockenfels (2000)). Additionally, we discuss how players should behave according to these models if they have specific reference groups to which they compare themselves.[7]

In the model of Fehr and Schmidt (1999) (from now on FS-model), individuals maximize a utility function of the following type:

[7] Note that in our experiment, subjects do not have explicit information about inequity in contributions of the other group members but only condition on the average contribution of their group members. Cheung (2011) shows however, that information on individual contributions may additionally affect conditional contributions.

$$U(y_i, y_j) = \begin{cases} y_i - \frac{\alpha_i}{n-1} \sum_{j \neq i}(y_j - y_i) & y_j > y_i \\ y_i & \text{if } y_j = y_i \\ y_i - \frac{\beta_i}{n-1} \sum_{j \neq i}(y_i - y_j) & y_j < y_i \end{cases} \quad (2)$$

with $\alpha_i \geq \beta_i$ and $0 \leq \beta_i < 1$. The parameter α_i represents individual i's disadvantageous inequity aversion (or envy) while β_i corresponds to her advantageous inequity aversion In the linear public good game with four players the monetary payoff of individual i is $y_i = 20 - g_i + \gamma_i \sum_{j=1}^{4} g_j$. y_j denotes the income of players j. According to the FS-model, subjects with a sufficiently high disutility from advantageous inequality (β_i) are willing to contribute to the public good in order to reduce the advantageous inequality, given others contribute. In particular, players will only contribute positive amounts if their β is larger than or equal to a threshold $\hat{\beta} = \frac{1-\gamma_i}{1-\gamma_i+\bar{\gamma}}$ with $\bar{\gamma} = \frac{1}{n-1} \sum_{j \neq i} \gamma_j$. Because of the linearity of the public good game and of the FS-model, for all but a finite set of values of border case parameters the best reply is zero contribution, full contribution, or a contribution that generates equal payoffs with some player. In particular, if all players have the same MPCR, $\gamma = 0.4$, then conditional cooperation is either zero or perfect (i.e. $g_i = \bar{g}$): it is perfect for players with $\beta > 0.6$.

In the heterogeneous case, players with high MPCRs have to contribute more than players with low MPCRs to reduce inequality resulting from positive contributions (and players expect this in an equilibrium with positive contributions in which beliefs match actions).[8] The logic of the FS-model can be put in a nutshell as follows: First, each player never wants to be materially worse off than the richest of its three group members[9] and second, players who are sufficiently advantageously inequity averse will contribute as much as is necessary to realize payoff equalization with the richest of the other players[10]. Thus, in an equilibrium with positive contributions all payoffs have to be the same. Theory shows that players with $\gamma_i = 0.5$ achieve payoff equality if they

[8] Note that all members making the same contribution is not plausible in an equilibrium with positive contributions. With equal contributions, it is optimal for individuals with the high MPCR to contribute the same amount as the group average but for individuals with the low MPCR it is optimal to contribute 1/3 of the group average.

[9] It can be shown that for every player, the marginal utility of contributing is strictly smaller than zero as soon as one other player receives a higher payoff due to $\alpha_i \geq \beta_i$ and $0 \leq \beta_i < 1$.

[10] The marginal utility of contributing will be strictly positive for a low MPCR player who is richer than any other player, if her $> \hat{\beta}_{0.3} = \frac{21}{34} \sim 0.62$. The marginal utility of contributing will be strictly positive for a high MPCR player who is richer than any other player, if her $\beta > \hat{\beta}_{0.5} = \frac{26}{45} \sim 0.58$.

contribute 7/3 times as much as the players with $\gamma_i = 0.3$ (and vice versa).[11] Conditional contributions of players with $\gamma_i = 0.5$ (with $\gamma_i = 0.3$) are higher (lower) than conditional contributions of players receiving $\gamma = 0.4$ in the game with homogenous MPCRs. Moreover, because the threshold for a payoff equalizing contribution is lower for the player with the high MPCR and higher for those with the low MPCR than the threshold for the situation in which all individuals face the same MPCR of 0.4, we should also observe more people contributing positive amounts in situation CC05 than in CC04, and more in CC04 than in CC03. Therefore, heterogeneity in MPCRs will lead to higher average conditional contributions in CC05 than in CC04 than in CC03. Because of the fixed upper-bound of contributions, heterogeneity in MPCRs should lead (on average) to lower conditional contributions than in CC04.

If uncertainty is introduced, the FS-model allows for positive conditional contributions but predicts a strong decrease in total conditional contributions. Positive conditional contributions will be lower or equal to 35% of the group members' average contribution.[12] Uncertainty will then make the average of conditional contributions lower than in the games without uncertainty with or without heterogeneity.

As a further benchmark, we extend the FS-model by assuming that some players compare only to a specific reference group.[13] Players who compare only to the counterpart who has the same MPCR (although there is heterogeneity in MPCRs) contribute exactly the average contribution of their group members if their β is sufficiently high.[14] If players compare only with group members who have a different MPCR, players with $\gamma_i = 0.3$ contribute 1/3 of the average contributions whereas

[11] In other words, equilibria with positive contribution are characterized by the fact that players with an MPCR of 0.5 contribute 61.5% above the average of the other players and players with an MPCR of 0.3 contribute 52.9% of the average contribution of the other players.

[12] With uncertainty, players are identical when making their contribution. Thus it is plausible to assume that one's group members make the same contribution. If an expected utility maximizer is confronted with a positive average contribution by her group members and she cares sufficiently strongly about advantageous inequality (β>0.6), she will contribute a positive amount even if her own MPCR is uncertain. Players thus face a tradeoff between contributing too little when facing the high MPCR and contributing too much when facing the low MPCR. The sharp drop in contributions results from the fact that "over-contributing" in the case of facing the low MPCR weights stronger than "under-contributing" when facing the high MPCR.

[13] We do so because we belief that subjects may have a different level of reasoning or cognitive ability, which may results in expecting higher average contributions by others when facing a high MPCR (although only one other group member faces a high MPCR and two other group members face a low MPCR).

[14] The thresholds of advantageous inequity aversion leading to positive contributions are $\hat{\beta}_{0.3} = 0.7$ and $\hat{\beta}_{0.5} = 0.5$.

players with $\gamma_i = 0.5$ contribute twice the average.[15] Consequently, optimal conditional contribution levels are different depending on the reference group of players: they are identical in CC04 and in CC03 and CC05 if players' reference group includes the player with the same MPCR whereas they are higher in CC05 than in CC04 and than in CC03 if players' reference group includes all other players or only players with the other MPCR. We show all predictions in figure 1 for $\beta = 0.8$.

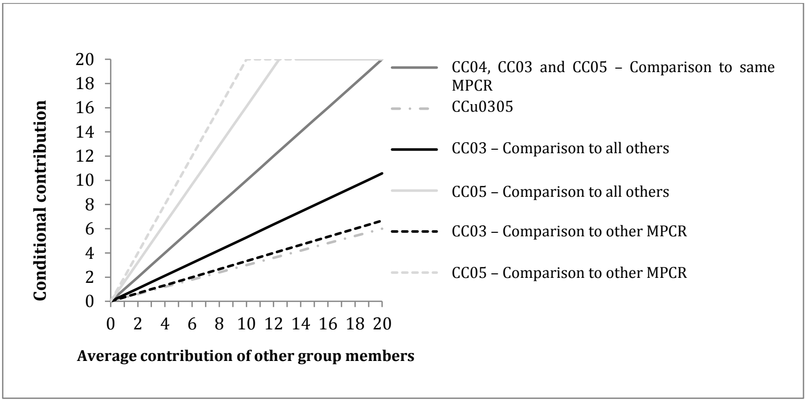


Figure 1. Optimal conditional contributions (FS-model, β=0.8)

We now turn to the predictions of the model of Equity, Reciprocity and Competition by Bolton and Ockenfels (2000) (from now on ERC-model). In the ERC-model it is assumed that each agent i maximizes the following utility function:

$$U_i = U_i\left(y_i, \frac{y_i}{c}\right) \quad (3)$$

The utility of each agent depends on her monetary payoff y_i and her relative payoff $\frac{y_i}{c}$. The sum of all group members' monetary payoffs is represented by c, $c = \sum_{j=1}^{n} y_i$. Based on Bolton and Ockenfels (2000), in our framework each agent maximizes the following utility function:

[15] The thresholds of advantageous inequity aversion leading to positive contributions are $\hat{\beta}_{0.3} = 0.58$ and $\hat{\beta}_{0.5} = 0.63$. Note that the threshold is smaller for a player with the low MPCR who compares only to high MPCR individuals than for an individual with a high MPCR comparing only to low MPCR individuals because it is less costly for the player with the low MPCR to reduce inequality (he loses 0.7 by contributing a unit and each member of his reference group gains 0.5 whereas a player with the high MPCR loses 0.5 when contributing 1 unit while his reference group members gain only 0.3 each).

$$U_i = y_i - \vartheta_i \left(\frac{y_i}{y_i + 3\bar{y}} - \frac{1}{4} \right)^2 \quad (4)$$

with $\bar{y}$ being the average payoff of the other group members. The parameter $\vartheta_i, \vartheta_i \geq 0$, represents an individual preference parameter and expresses the importance of disutility from inequality. The higher ϑ_i, the more inequity averse the subject i. When all players have the same MPCR, if this parameter is sufficiently high, players will conditionally contribute to the public good. Indeed, if the other players contribute, an increase of the own contribution will reduce the difference between the own and the other players' payoffs. For this reason, conditional cooperation is weakly increasing in ϑ_i.

If there is heterogeneity in the MPCRs, it is not generally true that an increase in the own MPCR generates an increase of the own contribution. However, it can be shown numerically to hold for the parameters chosen in the experiment. Using the numerical approach we obtain weakly higher average conditional contributions and a steeper slope of contribution schedules in CC05 than in CC04 than in CC03. The logic of the numerical analysis works as follows. First, it can be shown that conditional contributions are monotonically increasing in ϑ_i. Because this is the case, it is sufficient to show in a second step that increasing ϑ_i leads to a successive increase in the components of the vector of conditional contributions in the different situations ($g_{cc05}, g_{CC04}, g_{CCu0305}, g_{CC03}$). Again, for sufficiently high values of ϑ_i, heterogeneity in MPCRs should lead to lower average conditional contributions than in CC04 because of the fixed upper-bound of contributions. Using this procedure reveals also that according to the ERC-model conditional contributions are weakly higher in CC04 than in CCu0305 but the difference amounts to at most one point. Conditional contributions in games with heterogeneity in MPCRs without uncertainty and with uncertainty should not differ strongly.

In order to understand systematic differences in reactions to heterogeneity, we extend the ERC-model by allowing subjects to differ in their reference group. Formally, we replace the value of $\bar{y}$ in (4) by the average payoff of the respective reference group. Figure 2 includes optimal conditional contributions for all games with certainty about the own MPCR.[16] Additionally, for treatments CC03 and CC05, we include optimal conditional contributions for subjects who compare to a specific reference group only,

[16] We do not include the optimal contributions for CCu0305, which are weakly below optimal contribution in CC04, in order not to charge the figure unnecessarily here.

i.e. to the player with the same MPCR or to players with the other MPCR. Optimal conditional contributions are for value $\vartheta_i = 2000$ but the order of the conditional contribution schedules shown in Figure 2 does not depend on the parameter value of ϑ_i. The spread between conditional contributions in CC03 and CC05 will be larger if subjects compare their own payoff only to the average payoff of group members with the other MPCR than if they compare their payoff to all group members. Instead, they will roughly contribute the same in CC03, CC04 and CC05, if they compare their own payoff to the payoff of the other group member receiving the same MPCR.

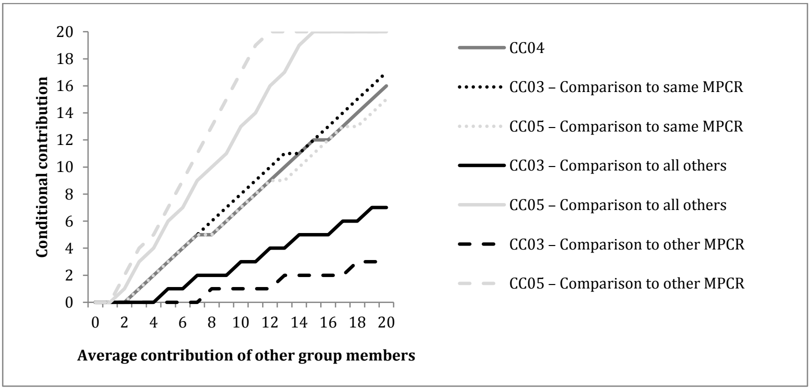


Figure 2. Optimal conditional contributions – ERC-model (with $\vartheta_i = 2000$)

Predictions of the FS- and ERC-model allow us to test four hypotheses experimentally. Both the FS- and the ERC-model predict that individuals may modify their contribution behavior when heterogeneity of returns from the public good is introduced. In the FS-model, participants have to be less inequity averse to make positive conditional contributions in CC05 than in CC04 than in CC03. Also subjects, who contribute positive amounts, contribute less with the low MPCR than with the high MPCR. The ERC-model comes to a similar conclusion, because each individual contributes weakly higher amounts in CC05 than in CC04 than in CC03 for a positive inequity parameter ϑ. Therefore, we should expect higher contributions in CC05 than in CC04 than in CC03.

Hypothesis 1 (MPCR effect): Compared to the homogeneous MPCR of 0.4, the average of conditional contributions are higher in CC05 and lower in CC03.

Further both models suggest that for sufficiently strong inequity considerations heterogeneity affects conditional contributions on average negatively.

Hypothesis 2 (heterogeneity effect): The average of conditional contributions in CC05 and CC03 is lower than the conditional contributions in the homogeneous case with an MPCR of 0.4.

The predictions with respect to conditional contributions under uncertainty about the own MPCR differ between the two models: the FS-model predicts that subjects strongly reduce conditional contributions whereas the ERC-model predicts that contributions in CCu0305 are only weakly smaller than contributions in CC04 and do not differ by more than one point. Therefore, we formulate hypotheses 3a and 3b with respect to conditional contributions under uncertainty.

Hypothesis 3a (uncertainty effect): Conditional contributions in CCu0305 are much lower than conditional contributions in CC04 and than the average of conditional contributions in CC03 and CC05.

Hypothesis 3b (uncertainty effect): Conditional contributions in CCu0305 do not differ by more than one point from conditional contributions in CC04 and from the average of conditional contributions in CC03 and CC05.

Because different players may perceive the game differently, we also derived predictions for the FS- and ERC-model for subjects who compare only to a specific reference group. Both models suggest that conditional contributions should strongly react to heterogeneity if subjects compare themselves only to group members with the other MPCR, and that reactions to heterogeneity are rather weak if subjects compare only to group members with the same MPCR.

Hypothesis 3 (Type-specific reactions): Conditional cooperators' reactions to heterogeneity differ such that one fraction of conditional cooperators strongly increase conditional contributions in CC05 and strongly decrease conditional contributions in CC03 whereas another fraction reacts only weakly to heterogeneity in returns.

4. Results

4.1. Results from unconditional cooperation games (UC games)

Figure 3 presents average unconditional contributions in the UC games as well as the mean of UC03 and UC05 as an additional benchmark. We observe significantly higher contributions to the public good when MPCRs are homogeneous rather than heterogeneous, irrespective of uncertainty (Wilcoxon signed-rank test: UC04 vs. UCu0305, $z=5.526$, $p<0.001$ and UC04 vs. MeanUC03UC05, $z=3.894$, $p<0.001$).[17] Subjects on average contribute positive amounts even under uncertainty about the own MPCR.

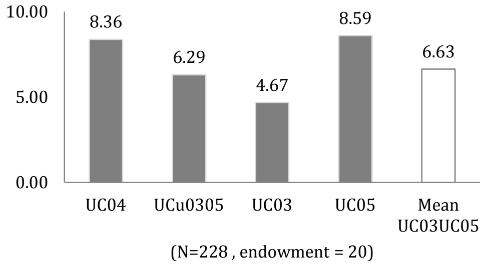


Figure 3. Average unconditional contributions in UC games

The introduction of uncertainty in addition to heterogeneity only slightly lowers subjects' contributions (Wilcoxon signed-rank test: UCu0305 vs. MeanUC03UC05, $z=2.316$, $p=0.021$). In UC03, average unconditional contributions are lower than in UC04 (Wilcoxon signed-rank test: $z=8.094$, $p<0.001$) and weakly higher in UC05 than in UC04 (Wilcoxon signed-rank test: $z=1.775$, $p=0.076$). Nevertheless, the decrease of contributions between UC04 and UC03 is much stronger than the increase of contributions between UC04 and UC05 (Wilcoxon signed-rank test: $z=3.894$, $p<0.001$). Isaac and Walker (1988) showed that MPCRs and contributions are positively related in homogeneous environments. We cannot completely confirm this finding for heterogeneous environments. We find that lower returns induce a decrease of contributions when MPCRs are heterogeneous; we only observe a weak increase in contributions with high MPCRs in the heterogeneous environment. Thus the (positive)

[17] This results holds irrespective of the order in which subjects played the game.

effect of the value of the MPCR seems to interact with the (negative) effect of heterogeneity of group members' MPCRs.

The results on unconditional contributions give the global effect of heterogeneity in returns on average contributions to the public good. However, the decrease in unconditional contributions might be driven by pessimistic beliefs about other group members' contributions. Therefore we focus next on subjects' conditional contributions, which are independent of beliefs about group members' average contributions.

4.2. Results from conditional cooperation games (CC games)

Figure 4 shows average conditional contributions for all subjects in all treatments. On average, conditional contributions in CC04 are 5.81, in CC05 6.31 and in CC03 5.10. Subjects (on average) increase their conditional contributions in CC05 compared to CC04 whereas they decrease conditional contributions in CC03. The average of conditional contributions in CC03 and CC05 is equal to 5.70, which is not significantly different from the average of conditional contributions in CC04. Hence, introducing heterogeneity in MPCRs does not modify the average of conditional contributions. Regarding uncertainty, the average of conditional contributions in CCu0305 is equal to 5.45 and is significantly lower than the average of conditional contributions in CC03 and CC05 (significant at the 10 percent level), and in CC04. Therefore, uncertainty about MPCRs adds a negative impact of heterogeneity on the average of conditional contributions. Unless otherwise specified, all averages are significantly different from another at the 1 percent level according to Wilcoxon signed rank tests.

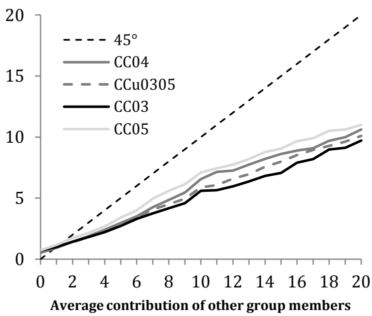


Figure 4. Average conditional contributions (N=228)

To investigate whether subjects adjust conditional contributions by changing their conditional contribution for every given average contribution level (i.e. they adjust the slope of their contribution schedule) or whether subjects simply become more or less generous when heterogeneity is introduced (i.e. they shift their schedule), we regress subjects' conditional contributions in model (1) of table 2 on the average contribution by their group members for the different treatments. The first column of table 2 presents estimates of model (1) for all subjects.

Dependent variable : Conditional contribution	Model (1) All subjects	Model (1) Conditional Cooperators	Model (2) All subjects	Model (2) Conditional Cooperators
CC04	Ref.	Ref.	Ref.	Ref.
CCu0305	-0.048	-0.009	-0.048	-0.009
	(0.108)	(0.110)	(0.108)	(0.110)
MeanCC03CC05			0.134	**0.285****
			(0.121)	(0.143)
CC03	-0.044	0.045		
	(0.151)	(0.183)		
CC05	**0.311****	**0.524*****		
	(0.134)	(0.150)		
Average contribution of other group members (Group average)	**0.523*****	**0.816*****	**0.523*****	**0.816*****
	(0.031)	(0.028)	(0.031)	(0.028)
Group average × CCu0305	**-0.031***	**-0.078*****	**-0.031***	**-0.078*****
	(0.016)	(0.020)	(0.016)	(0.020)
Group average × MeanCC03CC05			-0.024	**-0.097*****
			(0.022)	(0.026)
Group average × CC03	**-0.067*****	**-0.146*****		
	(0.023)	(0.028)		
Group average × CC05	0.019	**-0.048***		
	(0.024)	(0.028)		
Constant	**0.582*****	-0.205	**0.582*****	-0.205
	(0.208)	(0.193)	(0.208)	(0.193)
Observations	19,152	12,096	14,364	9,072
# clusters	228	144	228	144
R^2	0.225	0.489	0.229	0.516

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 2. OLS regressions on conditional contributions[18]

[18] We ran additional regressions controlling for order effects. We find that subjects become less generous as the experiment progresses. Considering model (1) for all subjects, those who first face the heterogeneous case contribute in CC04 about the average of their conditional contribution in CC03 and CC05. Subjects who face the homogeneous situation first contribute slightly less than the average of their conditional contribution in CC03 and CC05. For conditional cooperators we find qualitatively similar results with both orders.

We first observe that if MPCRs are homogeneous, an increase of the average contributions of group members by one point will lead to an increase in conditional contribution by 0.523. The results show that in CC03 subjects decrease their slope significantly by 0.067 whereas they do not significantly increase their slope in CC05. Instead, they behave more generously in CC05 by shifting up the intercept of their schedule by 0.311. Result 1 summarizes results regarding the MPCR effect. Hypothesis 1 cannot be rejected.

Result 1: On average, conditional contributions are higher in CC05 and lower in CC03 compared to the homogeneous MPCR of 0.4.

In order to test hypothesis 2, we consider the average conditional contribution of CC03 and CC05 for each individual subject and each average of group members' contributions to measure the aggregate effect of the introduction of heterogeneity in returns in model (2). Interestingly, heterogeneity does not significantly affect neither the slope of players' conditional contributions nor their generosity level. This suggests that heterogeneity in particular affects subjects' beliefs about others' contributions. We summarize findings related to the heterogeneity effect in result 2.

Result 2: On average, conditional contributions of subjects with heterogeneous MPCRs do not significantly differ from conditional contributions with homogenous MPCRs.

The joint-effect of uncertainty and heterogeneity from MPCRs on the slope of contribution schedules is significantly negative but it is insignificant on the generosity of players. Uncertainty additionally to heterogeneity increases a little the generosity of players (F-test for equality of coefficients 'Group average × CCu0305' and 'Group average × MeanCC03CC05': p=0.078) but has no significant effect on the slope of contribution schedules (F-test: p=0.681). We can thus reject hypothesis 3a. Further contributions in CC04 are by more than 1 point higher than in CCu0305 for almost all group average contributions larger than 10.[19] Hence we also have to reject hypothesis 3b. We summarize the findings related to the uncertainty effect in Result 3.

Result 3: Uncertainty in MPCRs reduces the average of conditional contributions compared to homogenous MPCRs and heterogeneous MPCRs without uncertainty.

[19] The exceptions are group averages of 12 and 17.

4.3. Type-specific reactions

To study individual and type-specific reactions, we classify subjects based on their behavior in CC04 for the subsequent analysis. We define preference types according to the procedure introduced by Fischbacher et al. (2001): Selfish subjects are subjects who always contribute zero to the public good; conditionally cooperative subjects are subjects who monotonically increase their contribution to the public good as the average contribution of other group members increases or whose contributions are significantly positively correlated to the average contribution of other group members. The last type of subject shows a hump-shaped contribution pattern, i.e. these subjects' contributions are increasing in the average contribution of other group members until a specific value and then decrease in it.

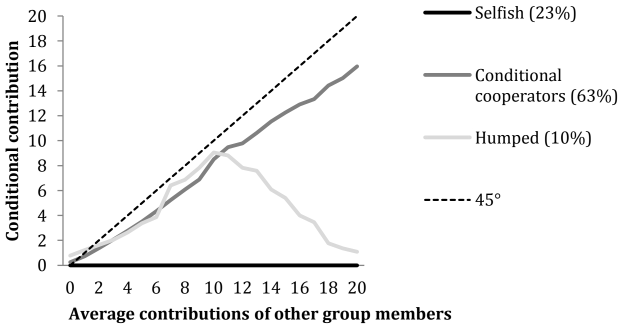


Figure 5. Average of conditional contributions in CC04 by type

Over the 228 participants, we observe 23% of selfish subjects, 10% show a humped-shaped pattern and 63% are conditional cooperators. Only 4% of the participants do not fit in any of these categories.[20] The contribution of each type for all potential average contributions of other group members in CC04 is depicted in Figure 5. Subjects with a humped-shaped pattern and subjects who do not follow a specific strategy are few (in total they represent 14% of the subjects) and display behavior that is not consistent with stability of other-regarding preferences. We briefly report the

[20] As a comparison, Fischbacher, et al. (2001) find about one third of subjects classified as free riders whereas about 50 percent are conditionally cooperative.

results for subjects categorized as humped-shaped and selfish but concentrate our analysis on conditionally cooperative subjects.

Selfish subjects and subjects with a humped-shaped contribution schedule

Almost all subjects who are classified as selfish in CC04 contribute zero to the public good for any average contribution of other group members in CC03, CC05 and CCu0305. Thus heterogeneity does not significantly affect contribution behavior of these subjects.[21] Conditional contribution schedules with humped-shaped patterns are rare (22 subjects out of 228). Subjects with such schedules contribute on average 4.43 in CC04. Average contributions are higher when heterogeneity is introduced, weakly in CC03 (5.66, Wilcoxon signed-rank tests, $p = 0.0998$) and strongly in CC05 (7.02, $p = 0.0002$). Changes in average contributions are mainly caused by 8 subjects, who show a humped-shaped pattern in CC04 but are conditionally cooperative either in CC03, CC05 or both. Subjects showing a humped-shaped pattern in all three situations (CC04, CC03, CC05) are only weakly affected by heterogeneity.

Conditional cooperators - At the aggregate level

Figure 6 presents conditional contributions for subjects classified in CC04 as conditional cooperators. As for the whole sample, the average of conditional contributions by conditional cooperators is higher in CC05 than in CC04 than in CC03, and lower in CCu0305 than in CC04. Average conditional contributions in CC04 are 7.96, in CC05 8.00, in CC03 6.54, in CCu0305 7.17 and the average of CC03 and CC05 is 7.27. All these averages are significantly different at the five percent level (using the Wilcoxon signed-rank test) except the difference between CCu0305 and the average of CC03 and CC05. In contrast to the reactions of the full sample, conditional cooperators (on average) slightly reduce their contributions when heterogeneity is introduced. However, the decrease in average conditional contributions of conditional cooperators is small (about 9 percent) compared to the decrease in average unconditional contributions (about 20 percent) when heterogeneity is introduced. Also, uncertainty about the own MPCR does not (additionally) affect conditional contributions by conditional cooperators on average.

[21] Six out of 52 as selfish classified subjects contribute more than zero in UC03, UC05. Among them four who slightly increase contributions in both UC03 and UC05 and two who only increase their contributions in UC05.

To study conditional contributions by conditional cooperators in more detail, we re-run our regressions (models (1) and (2)) for conditional cooperators separately (see table 2, columns two and four). The regressions show that if MPCRs are homogeneous, an increase of the average contributions of group members by one point will lead to an increase in conditional contribution by 0.816. According to model (1), when the own MPCR is certain, the positive effect of group members' average contribution is significantly smaller in CC03 and CC05 than in CC04 and is also smaller in CC03 than in CC05 (F-tests: p<0.001). Besides, a high MPCR makes conditional cooperators on average more generous (+0.524 points irrespective of the group average compared to CC04) but a low MPCR does not shift their conditional contribution schedule. Model (2) shows that the slope of contribution schedules is significantly lower when heterogeneity of MPCRs is introduced, with and without uncertainty about the own MPCR (partly as a result of the higher intercept in CC05). Regarding the additional effect of uncertainty to heterogeneity in returns, we find that subjects are more generous when they know their own MPCR (F-test, *p=0.013*) but the slope coefficients do not significantly differ (F-test, *p=0.359*). Overall, the regression results of the full sample are similar to the results for conditional cooperators. We only observe a different behavior when heterogeneity from returns without uncertainty is introduced.

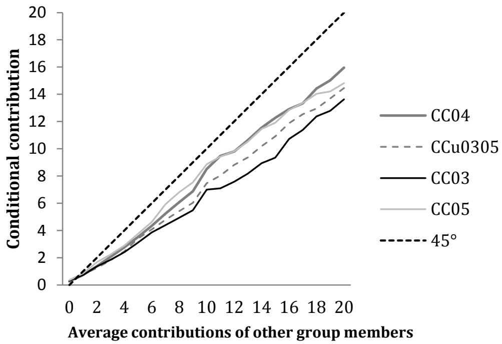


Figure 6. Average of conditional contributions by conditional cooperators

Conditional cooperators - At the individual level

Hypothesis 4 suggests heterogeneous reactions to heterogeneity in MPCRs. To investigate hypothesis 4, we use the hierarchical cluster analysis of Ward (1963).

Results are reported in table 3. This method is based on the minimization of the intra-group variance. At each step in the analysis, the union of every possible cluster pair is considered and the two clusters whose fusion results in minimum increase in variance are combined. To classify subjects, we use two variables reporting how subjects' conditional cooperation differs between CC04 and CC03 and between CC04 and CC05. The first variable is the average of each subject's difference in conditional contributions in CC03 and CC04. We call this variable Diff03 (Diff03 = average of ($g_{i03} - g_{i04}$). Diff03 being negative indicates that subjects' conditional cooperation is less perfect when the subject's MPCR equals 0.3 (with heterogeneity of MPCRs) than when it equals 0.4 (with homogeneity of MPCRs). To compute the second variable, we do the same but replace the low MPCR by the high MPCR. We name this second variable Diff05 = $g_{i05} - g_{i04}$.

On average, the difference between the average contribution of other group members and the conditional contribution of a conditional cooperator is equal to 2.04 in CC04. When there is heterogeneity in MPCRs, this value is equal to 3.45 if subjects receive the low MPCR, 2.00 if subjects receive the high MPCR and 2.83 if they do not know which MPCR they will receive. We have thus Diff03 = -1.41 and Diff05 = 0.04. We identify six categories of subjects with the Ward's classification method. For each category of subjects, the average and standard deviation of Diff03 and Diff05 as well as the share of conditional cooperators it includes are presented in table 3. From Ward's classification of conditional cooperators, we can infer whether behavior corresponds to the classifications suggested by theory.

On the one hand, 31.9% of conditional cooperators behave as if they compare their payoff to the payoff of the other group member receiving the same MPCR. They do not significantly change their behavior as heterogeneity in MPCRs is introduced (Wilcoxon signed rank test, for Diff03: p-value=0.65, for Diff05: p-value=0.34). On the other hand, 17.4% of conditional cooperators behave as if they compare their payoff to the average payoff of all other group members, or to the two group members having the opposite MPCR. These subjects modify their conditional contributions to the public goods as heterogeneity of MPCRs is introduced: they significantly decrease their contributions to the public good when they receive the low MPCR and increase it when they receive the high MPCR (Wilcoxon signed rank test for difference with 0, $p < 0.01$ for Diff03 and Diff05). Hence, we cannot reject hypothesis 4.

Result 4: A positive share of conditional cooperators do not modify their conditional contributions as heterogeneity in MPCRs is introduced while another positive share increase them in CC05 and decrease them in CC03 compared to CC04.

Ward's classification yields two further categories, in which behavior corresponds roughly to the theoretical predictions for subjects who compare their payoff only to payoffs of subjects with a specific MPCR of either 0.3 or 0.5. According to the theoretical model, for subjects who only compare to others with an MPCR of 0.5 their conditional contributions in CC04 should be higher than in CC03 and higher than or equal to in CC05. Indeed, 12.5% of conditional cooperators roughly behave in this way (Wilcoxon signed rank test for difference with 0, $p < 0.01$ for Diff03 and $p=0.123$ for Diff05). Behavior of another 14.6% of conditional cooperators roughly coincides with the predictions for subjects who compare their payoff only to payoffs of members receiving an MPCR of 0.3. They significantly increase their contribution when they receive the high MPCR and slightly increase it when they receive the low MPCR (Wilcoxon signed rank test for difference with 0, $p < 0.01$ for Diff03 and Diff05).

	Share	Average Diff03	Average Diff05	SD Diff03	SD Diff05
Comparison with the same MPCR subject[22]	31,9%	0,06	0,01	0,29	0,45
Comparison to all others & to opp. MPCR[23]	17,4%	-1,60***	0,59***	0,65	0,61
Comparison to 05 subject(s)	12,5%	-5,39***	0,76	2,07	1,55
Comparison to 03 subject(s)	14,6%	0,77***	1,75***	1,04	0,83
Heterogeneity averse[24]	16,7%	-4,95***	-4,70***	2,56	2,78
Heterogeneity lover	6,9%	3,39***	5,28***	2,43	2,96

Stars indicate whether the medians are significantly different from zero according to Wilcoxon sign rank tests, with *= p-value < 0.10, **= p-value < 0.05 and ***= p-value <0.01

Table 3. Classification of conditional cooperators

[22] No reaction to heterogeneity in returns may also result from comparisons in contributions instead of final payoffs.

[23] We cannot separate subjects comparing themselves to subjects with the opposite MPCR from subjects comparing to all others, because the theoretical predictions do not differ qualitatively.

[24] Heterogeneity averse people are actually classified into two different clusters. Although average Diff03 and average Diff05 have the same sign in both clusters, the magnitude is different. We group these two clusters because for both Diff03 and Diff05 are strongly negative. Each cluster presents 8.3% of the population. In the first cluster, average Diff03 is -6.94 and average Diff05 is -6.86 while in the second cluster these values are respectively -2.97 and -2.54.

The two last categories include subjects who are affected by the introduction of heterogeneity in MPCRs in the same way by both CC03 and CC05. We name 16.7% of our subjects "heterogeneity averse" because they significantly decrease their contribution when heterogeneity is introduced irrespective of their own MPCR (Wilcoxon signed rank test for difference with 0, $p < 0.01$ for Diff03 and Diff05). A minority of 6.9 percent of subjects behaves "heterogeneity loving", i.e. they significantly increase their contribution in CC03 and CC05 compared to CC04 (Wilcoxon signed rank test for difference with 0, $p < 0.01$ for Diff03 and Diff05).

5. Conclusion

We investigated whether the introduction of heterogeneity and uncertainty in returns from public goods affects unconditional and in particular conditional contribution behavior. Unconditional contributions depend on beliefs about others' contributions whereas conditional contributions are belief-independent. A within-subject design allowed us to analyze reactions to heterogeneity in MPCRs from the public good at the individual level. Based on the assumption that subjects may compare to different reference groups, we hypothesized that individuals react differently to heterogeneity in returns.

We found that, at the aggregate level, heterogeneity in MPCRs from the public good reduces unconditional contributions significantly, regardless of whether the own MPCR from the public good was certain or uncertain. However, conditional contributions are less strongly affected by heterogeneity, suggesting that negative effects of heterogeneous environments may in particular result from more pessimistic beliefs about others' contribution behavior. Besides, uncertainty about returns added to heterogeneity does not further decrease conditional contributions. To sustain contributions to public goods with heterogeneous returns, policies may thus aim at clarifying that those who gain a lot from the public good are indeed willing to contribute more to it.

Decomposing our results on conditional contributions shows that reactions to heterogeneity in returns are heterogeneous. Differences in reactions are systematic. Heterogeneity does not affect selfish subjects' behavior significantly. Conditional cooperators' reactions are mixed. We detect around one third of conditional cooperators who do not react to heterogeneity in MPCRs. 17 percent of conditional cooperators decrease their contributions when they receive the low MPCR and increase it when they receive the high MPCR. Additionally, some conditional cooperators mainly react to only high or low returns while others have the same reaction regarding both returns when heterogeneity is introduced. A substantial part of this variation can be explained by accounting for different reference groups subjects may compare to.

The decomposition of results on conditional contributions yields an important insight: Heterogeneity decreases conditional contributions mainly for two types of conditional cooperators. The first type dislikes heterogeneity in general. The second type behaves as if comparing only to group members with higher returns from the public good. Thus, in order to mitigate the negative effects of heterogeneity, public policy may aim at counterbalancing reference groups by specific communication policies.

6. Appendix: Instructions (translated from German)

You are about to participate in an experiment on decision-making. During this session, you can earn money. The amount of your earnings depends on your decisions and on the decisions of the participants you will interact with.
In the experimental session, you will make decisions in seven different experiments. One experiment will be randomly chosen to determine your payment. At the very beginning of the experimental session, one participant will be randomly selected to throw a die at the end in order to select the experiment that will be paid and to make all other random selections. The chosen experiment will be announced at the end of the experimental session. The experiment selected for payments is the same for all participants in the session. The payment you will receive will be your income in the selected experiment. In addition, you will receive a show-up fee of 4 Euros. You will be paid in cash at the end of the experimental session.
Each experiment is independent of the previous experiment you play. The next experiment starts as everybody in the room has made his decision in the previous experiment.
Please read the instructions carefully. To make sure that all participants have understood correctly, you will have to answer questions about the instructions.
You are not allowed to communicate during the experiment. If you have any questions, please ask us. Violation of this rule will lead to the exclusion from the experimental session and all payments. If you have questions, please raise your hand. A member of the experimenter team will come to you and answer them in private.
Thank you for your participation.
We will not speak in Euros during the experimental session, but rather in points. Your whole income will first be calculated in points. At the end of the experiment, the total amount of points you earned will be converted to Euros at the following rate:

1 point = 0.75 Euro

All participants will be divided in groups of four members. Except from us – the experimenters – no one knows who is in each group.
We describe the exact experiment process below.

The basic decision situation

We first introduce you to the basic decision situation. Further instructions will be distributed during the session. You will find control questions at the end of the description of the basic decision situation that help to understand the basic decision situation.
You will be a member of a group consisting of **4 people**. These groups will be reconstituted when a new experiment starts. Nobody knows the composition of the groups. Neither before, nor after the experimental session you will learn which people are/were in your group. You will receive a membership number in the group (1, 2, 3 or 4) that will remain the same for the whole experiment.
Each group member has to decide on the allocation of 20 points. You can put these 20 points into your **private account** or you can invest them **fully** or **partially** into a project. Each point you do not invest into the project will automatically remain in your private account.

Your income from the private account

You will earn one point for each point you put into your private account.

Income from your private account = *20 – your contribution to the project*

For example, if you put 20 points into your private account (and therefore do not invest in the project), your income will amount to exactly 20 points out of your private account. If you put 6 points into your private account, your income from this account will be 6 points. **No one except you earns something from your private account.**

<u>Your income from the project</u>

Each group member will profit equally from the amount you invest into the project. On the other hand, you will also get a payoff from the other group members' investments. The income for each group member will be determined as follows:

Income from the project = *sum of all contributions* $\times$ *0.4*

If, for example, the sum of all contributions to the project is 60 points, then you and the other members of your group each earns 60 × 0.4 = 24 points out of the project. If four members of the group contribute a total of 10 points to the project, you and the other members of your group each earns 10 × 0.4 = 4 points.

<u>Total income</u>

Your total income is the sum of your income from your private account and that from the project:

Your total income = *Income from your private account (= 20 – your contribution to the project)* *+ Income from the project (= sum of all contributions to the project* $\times$ *0.4)*

Control questions

Please answer the following control questions. They will help you to gain an understanding of the calculation of your income, which varies with your decision about how you distribute your 20 points. *Please answer all the questions and write down your calculations.*

1. Each group member has 20 points. Assume that none of the four group members (including you) contributes anything to the project.
   What will *your* total income be? __________

What will the total income of the *other* group members be? __________

2. Each group member has 20 points. You invest 20 points in the project. Each of the other three members of the group also contributes 20 points to the project.

What will *your* total income be? __________

What will the total income of the *other* group members be? __________

3. Each group member has 20 points. The other 3 members contribute a total of 30 points to the project.
   a) What will *your* total income be, if you – in addition to the 30 points – invest 0 points into the project?

Your **Income __________**

   b) What will *your* total income be, if you – in addition to the 30 points – invest 8 points into the project?

Your **Income __________**

   c) What will *your* total income be, if you – in addition to the 30 points – invest 15 points into the project?

Your **Income __________**

4. Each group member has 20 points at his or her disposal. Assume that you invest 8 points to the project.
   a) What is your total income if the other group members – in addition to your 8 points – contribute another 7 points to the project?

Your **Income __________**

b) What is your total income if the other group members – in addition to your 8 points – contribute another 12 points to the project?

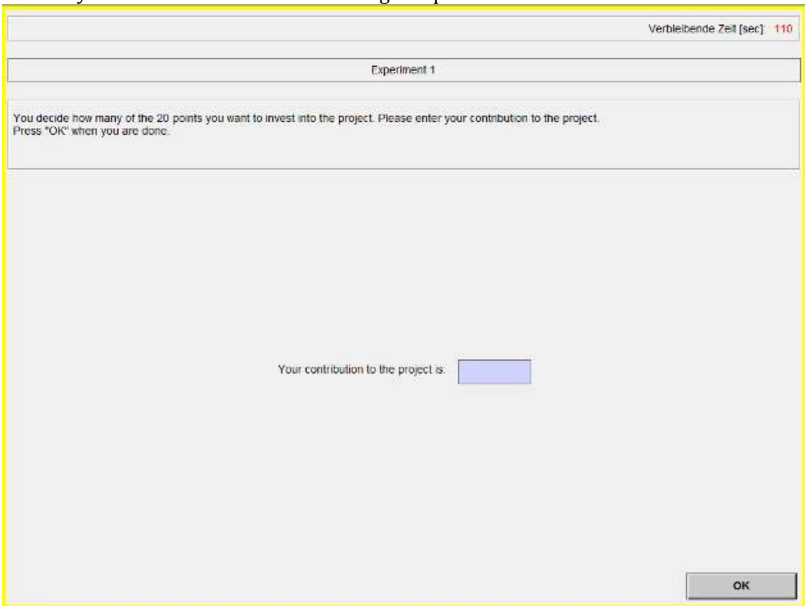
Your **Income __________**

c) What is your income if the other group members – in addition to your 8 points – contribute another 22 points to the project?

Your **Income __________**

Experiment 1

The experiment 1 includes the decision situation just described to you.
As you know, you will be a member of a group consisting of 4 persons and you will have 20 points at your disposal. You can put them into a private account or you can invest them into a project.
You decide how many of the 20 points you want to invest into the project. Please indicate your contribution on the following computer screen.



After you have determined your contribution, please click “OK”.

Experiment 2

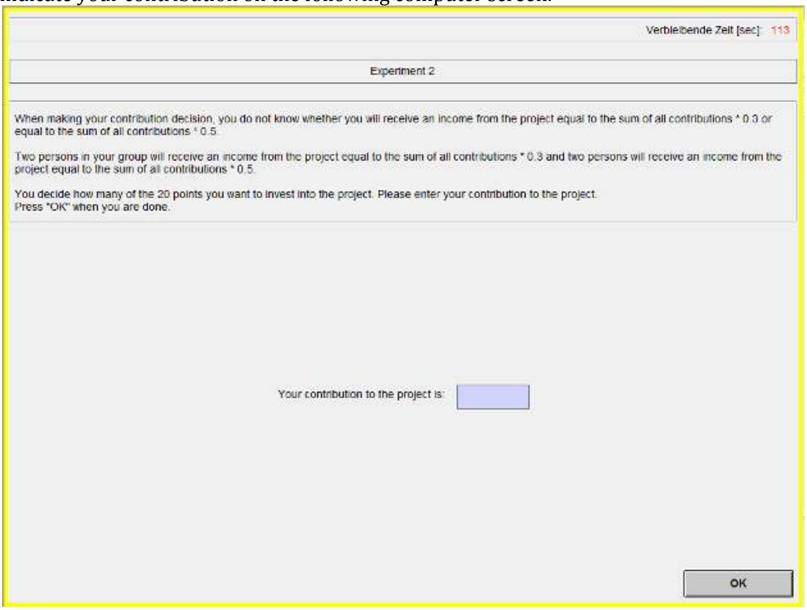
The experiment 2 consists of the basic decision situation, except for one change.
As you know, you will be a member of a group consisting of 4 persons and you will have 20 points at your disposal. You can put them into a private account or you can invest them into a project.
Your income from the project is different from the basic decision situation. In your group, two persons will receive an income from the project equal to:

Income from the project = *sum of all contributions* $\times$ *0.3*

And, two persons will receive an income from the project equal to:

Income from the project = *sum of all contributions* $\times$ *0.5*

When making your contribution decision, you do not know whether you will receive an income from the project equal to the sum of all contributions × 0.3 or equal to the sum of all contributions × 0.5. But you know that two persons in your group will receive an income from the project equal to the sum of all contributions × 0.3 and two persons will receive an income from the project equal to the sum of all contributions × 0.5.
You decide how many of the 20 points you want to invest into the project. Please indicate your contribution on the following computer screen.



After you have determined your contribution, please click "OK".

The random selection of the income from the project will be implemented as follows. Each group member is assigned a number between 1 and 4. As you remember, a participant was randomly selected at the beginning of our experimental session. This participant will throw a 6-sided die at the very end of the experimental session. The resulting number will be entered into the computer.

Your income from the project will be equal to the sum of all contributions × 0.5 or × 0.3, depending on the result of the 6-sided die and on your membership number according to the following table:

Your income from the project will be equal to the sum of all contributions × ...

If the result of the die is:	If your membership number is: 1	2	3	4
1	**0.3**	**0.3**	**0.5**	**0.5**
2	**0.3**	**0.5**	**0.3**	**0.5**
3	**0.3**	**0.5**	**0.5**	**0.3**
4	**0.5**	**0.3**	**0.3**	**0.5**
5	**0.5**	**0.3**	**0.5**	**0.3**
6	**0.5**	**0.5**	**0.3**	**0.3**

Control questions

Please answer the following control questions. They will help you to gain an understanding of the calculation of your income, which varies with your decision about how you distribute your 20 points. *Please answer all the questions and write down your calculations.*

Assume that your membership number is 1.

1. Each group member has 20 points. Assume that none of the four group members (including you) contributes anything to the project. The result of the 6-sided die thrown at the end of the experiment is 4.

What will *your* total income be? __________
What will the total income of the group member 2 be? __________
What will the total income of the group member 3 be? __________
What will the total income of the group member 4 be? __________

2. Each group member has 20 points. You invest 20 points in the project. Each of the other three members of the group also contributes 20 points to the project. The result of the 6-sided die thrown at the end of the experiment is 2.

What will *your* total income be? __________
What will the total income of the group member 2 be? __________
What will the total income of the group member 3 be? __________
What will the total income of the group member 4 be? __________

3. Each group member has 20 points. The other 3 members contribute a total of 30 points to the project. The result of the 6-sided die thrown at the end of the experiment is 1.

    a) What will *your* total income be, if you – in addition to the 30 points – invest 0 points into the project?

***Your* Income __________**

    b) What will *your* total income be, if you – in addition to the 30 points – invest 8 points into the project?

***Your* Income __________**

    c) What will *your* total income be, if you – in addition to the 30 points – invest 15 points into the project?

***Your* Income __________**

4. Each group member has 20 points at his or her disposal. Assume that you invest 8 points to the project. The result of the 6-sided die thrown at the end of the experiment is 5.

a) What is your total income if the other group members – in addition to your 8 points – contribute another 7 points to the project?

Your **Income __________**

b) What is your total income if the other group members – in addition to your 8 points – contribute another 12 points to the project?

Your **Income __________**

c) What is your income if the other group members – in addition to your 8 points – contribute another 22 points to the project?

Your **Income __________**

Experiment 3

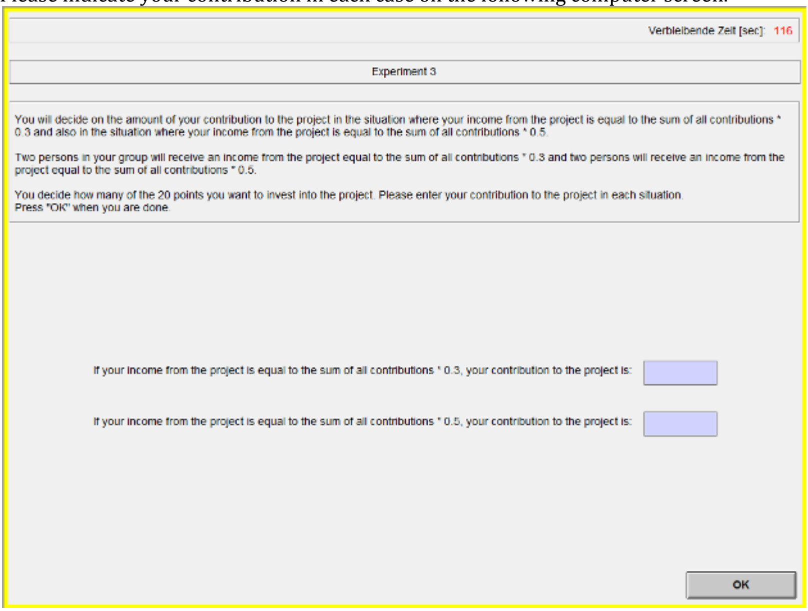
The experiment 3 consists of the situation in the experiment 2 with one change.
As you know, you will be a member of a group consisting of 4 persons and you will have 20 points at your disposal. You can put them into a private account or you can invest them into a project.
As in experiment 2, in your group, two persons will receive an income from the project equal to:

$$\textbf{\textit{Income from the project}} = \textit{sum of all contributions} \times 0.3$$

And, two persons will receive an income from the project equal to:

$$\textbf{\textit{Income from the project}} = \textit{sum of all contributions} \times 0.5$$

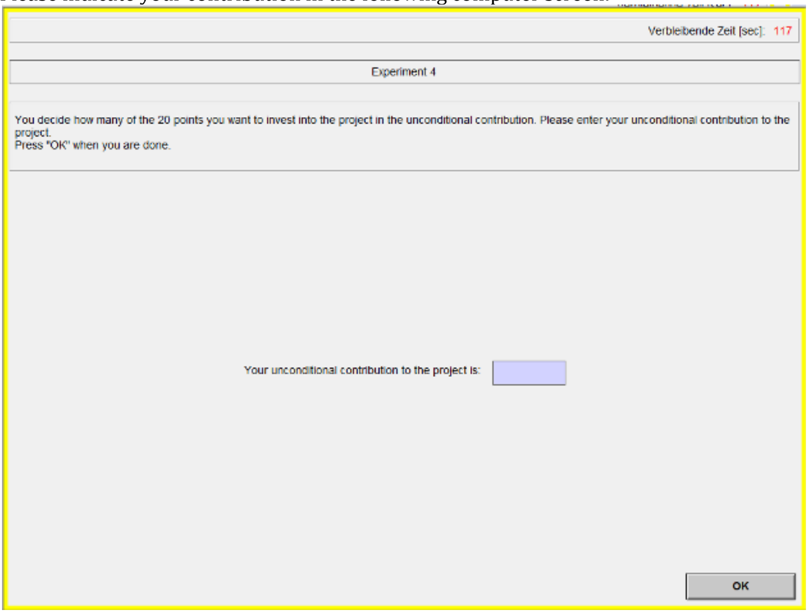
Differently from experiment 2, you will decide on the amount of your contribution to the project for each situation, i.e. if your income from the project is equal to the sum of all contributions × 0.3 and also if your income from the project is equal to the sum of all contributions × 0.5. Recall that two persons in your group will receive an income from the project equal to the sum of all contributions × 0.3 and two persons will receive an income from the project equal to the sum of all contributions × 0.5.
You decide how many of the 20 points you want to invest into the project if your income from the project is equal to the sum of all contributions × 0.3 and also if it is equal to the sum of all contributions × 0.5.
Please indicate your contribution in each case on the following computer screen.



After you have determined your contributions, please click "OK".
The random selection of the income from the project is implemented as in experiment 2.

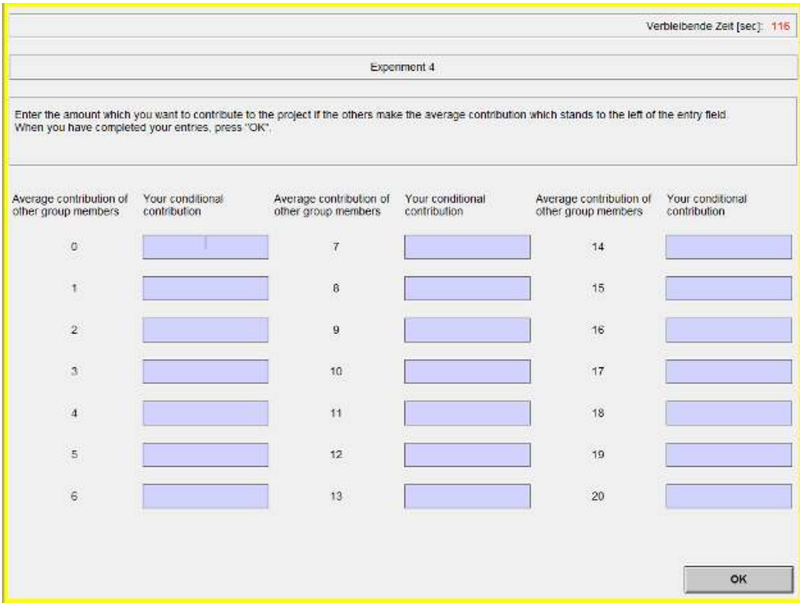
Experiment 4

The experiment 4 includes the basic decision situation just described to you at the beginning of the experimental session.
As you know, you will be a member of a group consisting of 4 persons and you will have 20 points at your disposal. You can put them into a private account or you can invest them into a project.
In this experiment 4, each subject has to make **two types** of decisions, which we will refer to below as the **"unconditional contribution"** and **"contribution table"**.
• You decide how many of the 20 points you want to invest into the project in the **unconditional contribution**.
Please indicate your contribution in the following computer screen:



After you have determined your unconditional contribution, please click "OK".

• Your second task is to fill in a **contribution table** where you indicate how many points **you want to contribute** to the project **for each possible average contribution of the other group members** (rounded to the next integer). You can condition your contribution on that of the other group members. This will be immediately clear to you if you take a look at the following table. This table will be presented to you in the experiment: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Experiment 4

Enter the amount which you want to contribute to the project if the others make the average contribution which stands to the left of the entry field.
When you have completed your entries, press "OK".

Average contribution of other group members	Your conditional contribution	Average contribution of other group members	Your conditional contribution	Average contribution of other group members	Your conditional contribution
0		7		14	
1		8		15	
2		9		16	
3		10		17	
4		11		18	
5		12		19	
6		13		20	

OK

The numbers are the possible (rounded) average contributions of the **other** group members to the project. You simply have to insert how many points you will contribute to the project into each input box – conditional on the indicated average contribution. **You have to make an entry into each input box**. For example, you will have to indicate how much you contribute to the project if the others contribute 0 points to the project, how much you contribute if the others contribute 1, 2, or 3 points, etc. You can insert **any integer numbers from 0 to 20** in each input box. Once you have made an entry in each input box, click "OK".

After all participants have made an unconditional contribution and have filled in their contribution table, a random mechanism will select a group member from every group. Only **the contribution table will be the payoff-relevant decision for the randomly determined subject**. Only the **unconditional contribution** will be the payoff-relevant decision for the **other three group members** not selected by the random mechanism. You obviously do not know whether the random mechanism will select you when you make your unconditional contribution and when you fill in the contribution table. You will therefore have to think carefully about both types of decisions because both can become relevant for you. Two examples should make this clear.

EXAMPLE 1: Assume that **the random mechanism selects you. This implies that your relevant decision will be your contribution table**. The unconditional contribution is the relevant decision for the other three group members. Assume they made unconditional contributions of 0, 2, and 4 points. The average contribution of these three group members, therefore, is 2 points. If you indicated in your contribution table that you will contribute 1 point if the others contribute 2 points on average, then the total contribution to the project is given by 0+2+4+1=7. All group members, therefore, earn 0.4×7=2.8 points from the project plus their respective income from the private account. If, instead, you indicated in your contribution table that you would contribute 19 points if the others contribute two points on average, then the total contribution of the group to the project is given by 0+2+4+19=25. All group members therefore earn 0.4×25=10 points from the project plus their respective income from the private account.

EXAMPLE 2: Assume **that the random mechanism did not select you,** implying that **the unconditional contribution is taken as the payoff-relevant decision** for you and two other group members. Assume your unconditional contribution is 16 points and those of the other two group members are 18 and 20 points. Your average unconditional contribution and that of the two other group members, therefore, is 18 points. If the group member whom the random mechanism selected indicates in her contribution table that she will contribute 1 point if the other three group members contribute on average 18 points, then the total contribution of the group to the project is given by 16+18+20+1=55. All group members will therefore earn 0.4×55=22 points from the project plus their respective income from the private account. If, instead, the randomly selected group member indicates in her contribution table that she contributes 19 if the others contribute on average 18 points, then the total contribution of that group to the project is 16+18+20+19=73. All group members will therefore earn 0.4×73=29.2 points from the project plus their respective income from the private account.

The random selection of the participants will be implemented as follows. Each group member is assigned a number between 1 and 4. As you remember, a participant was randomly selected at the beginning of the experiment. This participant will throw a 4-sided die at the very end of the experiment. The resulting number will be entered into the computer. If the die indicates the membership number that was assigned to you, then your contribution table will be relevant for you and the unconditional contribution will be the payoff-relevant decision for the other group members. Otherwise, your unconditional contribution is the relevant decision.

Experiment 5

The experiment 5 consists of the decision situation you just played in experiment 4, except for one change.
Your income from the project is different from the basic decision situation. In your group, two persons will receive an income from the project equal to:

Income from the project = *sum of all contributions × 0.3*

And, two persons will receive an income from the project equal to:

Income from the project = *sum of all contributions × 0.5*

When making your contribution decision, you do not know whether you will receive an income from the project equal to the sum of all contributions × 0.3 or equal to the sum of all contributions × 0.5. But you know that two persons in your group will receive an income from the project equal to the sum of all contributions × 0.3 and two persons will receive an income from the project equal to the sum of all contributions × 0.5.
As in the experiment 5, you have two tasks to complete.
• Your first task is to decide how many of the 20 points you want to invest into the project in the **unconditional contribution**. After you have determined your conditional contribution, please click "OK".
• Your second task is to fill in a **contribution table** where you indicate how many points **you want to contribute** to the project **for each possible average contribution of the other group members** (rounded to the next integer). You can condition your contribution on that of the other group members. Once you have made an entry in each input box, click "OK".

As in experiment 2, **the random selection of the income from the project** will be implemented as follows. Each group member is assigned a number between 1 and 4. As you remember, a participant was randomly selected at the beginning of our experimental session. This participant will throw a 6-sided die at the very end of the experimental session. The resulting number will be entered into the computer.
Your income from the project will be equal to the sum of all contributions × 0.5 or × 0.3, depending on the result of the 6-sided die and on your membership number according to the following table:
Your income from the project will be equal to the sum of all contributions × ...

If the result of the die is:	If your membership number is: 1	2	3	4
1	**0.3**	**0.3**	**0.5**	**0.5**
2	**0.3**	**0.5**	**0.3**	**0.5**
3	**0.3**	**0.5**	**0.5**	**0.3**
4	**0.5**	**0.3**	**0.3**	**0.5**
5	**0.5**	**0.3**	**0.5**	**0.3**
6	**0.5**	**0.5**	**0.3**	**0.3**

The random selection of the participants is identical as just presented in experiment 4.

Experiment 6

The experiment 6 consists of the situation in the experiment 5 with one change.
As you know, you will be a member of a group consisting of 4 persons and you will have 20 points at your disposal. You can put them into a private account or you can invest them into a project.
As in experiment 5, in your group, two persons will receive an income from the project equal to:

Income from the project = *sum of all contributions* $\times$ *0.3*

And, two persons will receive an income from the project equal to:

Income from the project = *sum of all contributions* $\times$ *0.5*

Differently from experiment 5, you will decide on the amount of your contribution to the project for each situation, i.e. if your income from the project is equal to the sum of all contributions × 0.3 and also if your income from the project is equal to the sum of all contributions × 0.5. Recall that two persons in your group will receive an income from the project equal to the sum of all contributions × 0.3 and two persons will receive an income from the project equal to the sum of all contributions × 0.5.
As in the experiments 4 and 5, you have two tasks to complete.

• Your first task is to decide how many of the 20 points you want to invest into the project in the **unconditional contribution** when your income from the project is equal to the sum of all contributions × 0.5 and also when it is equal to the sum of all contributions × 0.3. After you have determined your conditional contribution, please click "OK".

• Your second task is to fill in a **contribution table** where you indicate how many points **you want to contribute** to the project **for each possible average contribution of the other group members** (rounded to the next integer). You will enter first the contribution table if your income from the project is equal to the sum of all contributions × 0.5 and second the contribution table if your income from the project is equal to the sum of all contributions × 0.3. Once you have made an entry in each input box, click "OK".

The **random selection of the income from the project** and the **random selection of the participants** are organized as previously.

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