Risk, heterogenous returns and cooperation: an experimental inquiry*

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Abstract

Individuals often benefit differently from cooperation. Using data from a laboratory experiment, I study contributions when subjects in a group differ in the benefit they get from a public good, in comparison with when they get a homogeneous return. In addition, I contrast the case where the return is certain with the case where it is subject to risk (uncertain). I investigate whether the effect of uncertainty differs when returns are homogenous or heterogenous. I elicit both unconditional and conditional contribution behaviour to test if my results are robust to possible changes in subjects' beliefs regarding the contributions of others. I find that unconditional contributions under uncertainty are lower than under certainty. Heterogeneity in returns also decreases unconditional contributions, but this effect is much weaker under uncertainty. Risk and heterogeneity do not affect conditional contributions.

Keywords: Public goods, Uncertainty, Experiment.

JEL classification codes: C91, C92, H41

1 Introduction

Collective action is an important example of a public good, and a common feature of modern democracies. However, the benefit from collective action is often unknown at the time that people organise themselves, because people do not know if the movement will be successful. Even if collective action is sucessful in the sense that the government or organisation that was appealed to, accedes to the demands of the group, the benefits accruing to the individual members of the group may vary widely. Consider, for instance, the case of collective action in the villages of India. Self-help groups(SHGs) have become an important developmental force in rural communities. The finances of local governments (called gram panchayats) are limited, and the provision of amenities in villages, such as

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schools, may be prioritised based on collective action by SHGs. Two features of this type of collective action stand out: first, individuals face the risk that the collective action yields no benefit because the panchayat rejects their proposal. Secondly, the SHG can be composed of villagers from diverse castes who stand to benefit very differently from the collective action. A person belonging to a low-caste may fear exclusion: his/her children could be discriminated against at the school. Such an individual has a very high risk of not benefiting from the collective action at all. Similarly, an individual from a high caste family faces no such constraints, and hence has a very high probability of benefiting from the collective action. Government policies which promote social inclusion and acceptance may reduce this dispersion in risks within a village community, and increase collective action. However, without further analysis, the effect of this dispersion in risk on collective action is unclear.

As a first step in this endeavour, this paper proposes to use data from a lab experiment conducted in India to investigate how introducing within-group heterogenity in the risk of not benefiting from a public good affects voluntary contributions in a linear, repeated public good game. Specifically, I address the following research questions:

- How does risk of losing the public good affect individual contributions as compared to the situation where there is no such risk?
- How does within-group heterogeneity in this risk affect contributions?
- How does reducing the dispersion in risk amongst members of a group affect contributions ?

There is substantial literature combining uncertainty and heterogeneity in returns in public goods experiments, but the type of uncertainty studied is that subjects may lack information about their own benefit, or the benefit of others in their group. There is a second line of research where there is a risk of losing the public good, in context is environmental or resource dilemmas. Despite investing efforts to conserve a natural resource, people might lose the resource because of the unpredictability of natural events, but in contrast to this paper, the people in the community face the same risk of loss.

This paper attempts to bridge these two strains of literature. In the current experimental setting, the return from the public good may be certain or uncertain, and its (expected) marginal return may be homogeneous or heterogeneous among individuals playing the game in groups of 4. The uncertainty is formulated as follows: there are two possible states of the world. In the favourable state, the sum of contributions is available to subjects in the experiment. In the unfavourable state, it's not: players get nothing by contributing to the public good. Each individual is told his π and that of each group member. $\pi \in (0, 1)$ is the probability with which the favourable outcome will occur for him/her. By changing πs across periods, I alter the probability of the 'favourable' state, or alternatively, the riskiness of the public good for the subject. In the heterogeneous treatments, the π is 'low' for two members of the group or 'high' for the two other members. In the 'reducing dispersion' treatments, all four group members may have different πs. The average social return from the public good stays constant throughout the experiment. The contribution of this design to the literature is two-fold: first, we use a within-subject treatment design where there is an individual-specific risk of losing the public good, which is different from the common resources dilemma literature where individuals face the same risk of loss. In addition, the levels of risk of group members are known to everyone in the group, in contrast to the literature on heterogeneity in expected marginal benefit of public goods. Secondly, we also elicit conditional contributions in this framework. In a standard public goods game, subjects do not know what the other members of the group are contributing at the time they choose their contributions. Eliciting conditional contributions allows for isolating the effect of risk on participants' contributions independent of their beliefs regarding the contributions of others.

There are two main results. Unconditional contributions are lower when all subjects face the same risk of losing the public good, as compared to the situation where there is no risk. Secondly, heterogeneity in returns reduces contributions as compared to the case when the risk is the same for all members, under both certainty and uncertainty. However, the decrease in contributions due to heterogeneity is much stronger under certainty than under uncertainty. A reduction in the dispersion of risk for subjects in the same group reduces contributions, but this effect is very weak and not significant. These results do not hold once we control for subjects' beliefs regarding the contributions of others using conditional contributions. These results are in line with existing evidence from the literature where the effect of uncertainty regarding the marginal benefits of other group members reduces contributions, but the effects are not robust to controlling for conditional contributions (see for instance)Fischbacher, Schudy, and Teyssier (2014)).

In the standard experimental setting version of a public goods game, the marginal per capita return (MPCR), or the marginal return from contributing an extra unit of experimental currency to the public good, is certain and the identical for every subject, and this case has been well-studied(for a survey, see, for example, Ledyard (1995)). The only uncertainty in this setting comes from the fact that at the time of contributions, subjects do not know what other subjects might contribute. Our paper relates to two alternative ways in which uncertainty has been studied in the literature. In the first case, MPCRs may be heterogenous for different individuals, and subjects may be uncertain about what about the MPCR of the other subjects or their own MPCR. Though the returns to the public good may vary, subjects will typically get a positive benefit from the public good as long as someone in the group contributes. The second way to address uncertainty is linked with resource uncertainty in environmental economics, where people stand to lose a common pool resource with a certain probability due to environmental factors. The source of the uncertainty here is not the uncertainty regarding MPCRs or others, but the risk of losing the public good even if people contribute.

The evidence in the literature seems mixed at best in the first strand of literature when subjects lack information about MPCRs of other subjects. Fisher, Isaac, Schatzberg, and Walker (1995) are amongst the first to compare the case where every subject has the same MPCR, with the heterogeneous treatment where, within a group, subjects can have high or low MPCRs (0.75 and 0.30, respectively). Subjects do not know the distribution of MPCRs in the group, and they find no significant effect of this treatment. They conclude that subjects care only about their own MPCR, against the alternative hypothesis that they care about the distribution of MPCRs in the group. Levati, Morone, and Fiore

(2009) and Levati and Morone (2013) also study uncertainty with high and low MPCRs, and show that while uncertainty reduces contributions, changing parameter values of the MPCR may lead to this effect disappearing. Fischbacher, Schudy, and Teyssier (2014) introduce a treatment design which controls for expectations that subjects could have regarding the contributions of others by eliciting conditional contributions in one-shot games. Their results indicate that conditional contributions do not change significantly under heterogeneity, and when uncertainty and heterogeneity are combined. Björk, Kocher, Martinsson, and Nam Khanh (2016) use both a one-shot and a repeated game setting, and show that risk does not appear to harm cooperation. More recently, Zylbersztejn and Théroude (2017) also find that drawing MPCRs from an exogeneous discrete distribution does not affect contributions either. Boulu-Reshef, Brott, and Zylbersztejn (2017) draws similar conclusions when subjects face uncertainty about both their own MPCRs as well as the distribution of MPCRs. The current paper differs from the above literature in that subjects always know the (expected) MPCRs of other group members in my design, and the type of uncertainty studied is not the lack of information about the MPCR.

This paper is also related to an alternate literature on the uncertainty regarding returns from a public good, or the risk that even after contributing to the public good, people may not get the public good at all, because of environmental factors. This approach is common in the study of common property resources management or dealing with externalities such as pollution and climate change. Gangadharan and Nemes (2009) incorporate treatments with different types of risks and uncertainties, where risk is associated to either the private good or the public good, and where the probability of getting the public good is endogenous in the size of the contribution. Specifically, the probability of getting the public good increases with the amount of contributions. This approach is commonly used with common property resources (see, for instance, Dickinson (1998), Keser and Montmarquette (2008),Blanco, Lopez, and Walker (2016), Blanco, Haller, and Walker (2017) or Colasante, García-Gallego, Morone, and Temerario (2017)). In contrast to the literature on heterogeneity in MPCRs, uncertainty on returns from the public good often leads to a substantial reduction in contributions. However, though MPCRs may be heterogenous ex-post (because public good may or may not be provided), they are typically ex-ante identical across subjects.

There is very little research on combining heterogeneity with uncertainty on the returns from the public good. Stoddard (2015) studies contributions when the return from a public good is drawn from a distribution, and looks at effect of increasing the variance of this distribution. His design does not incorporate within-group heterogeneity in that the probability of getting a return is constant and identical across subjects. The rest of the paper is organised as follows: Section 3 sets up the experimental design and hypotheses. The results are discussed in Section 4, and Section 5 concludes.

2 Experimental Design

No form of communication between the subjects was allowed during the experiment. A set of control questions is provided at the beginning of the experiment to ensure the understanding of the game. If any subject failed to answer correctly, they were separately explained the solution. The experiment did not proceed until all subjects understood the experiment instructions. [1]

2.1 Description of a session

A session consists of a 24 period repeated public goods game in groups of 4 with partner matching. I use a within-subject design, where each subject is told that they will participate in all of the 24 periods, always with the same anonymous partners. Each session of the experiment had either 12 or 16 students, and the number of permutations possible of groups was much lower than the number of periods in the experiment. A within-subject design controls for the uncertainty that subjects could have about whether they are playing with the same partner, or a different one.

At the beginning of each session, subjects are informed that 10 experimental currency units (ECUs) will be given to them for every period. A fixed exchange rate converts the ECUs to INR (indian rupees) (1 ECU = Rs. 50 [2]). They are told that their basic decision is to divide these units between contributions to a common account, and a private account. Subject i chooses g_i, his contribution to the common account, and keeps $x_i = 10 - g_i$ as his income in his private account. Returns to the private account equal exactly the number of units that a subject puts in that account. This return is risk free, and does not change during the experiment. Returns from the common account equal $ef \sum_{j}^{n=4} \frac{g_j}{4}$. The variable ef denotes the *efficiency factor*. The efficiency factor denotes the increase in returns from the common account when average contributions increase by one unit. The marginal per capita return from the public good, or the MPCR, equals $\frac{ef}{4}$. Participants are shown their payoff and the sum of contributions at the end of every period.

Each session consists of 6 parts. Instructions are read out aloud to the participants before each of the six parts, and the sequence of the parts are never changed. The first part is the treatment 'Certainty', and has three periods. Returns are certain; there is no risk of losing the public good. However, participants were informed that the efficiency factors could be homogeneous or heteregenous amongst the members of a group, and they were shown the efficiency factor of each member in their group at the time that they decided their contribution. Figure 7 in the appendix illustrates the subjects' experiment screen in Part 1. The payoff (earnings) function of subject i in period t of part 1 is the following:

$$Earnings_{it} = x_{it} + ef_{it} \frac{\sum_{j=1}^{4} g_{jt}}{4}$$

The second part has six periods split into two treatments: 'Uncertainty' and 'Reducing dispersion under uncertainty'. In both treatments, subjects face a risk of losing the public good with a probability $1 - \pi$. The two treatments only differ in the values of π alloted to the group members. Participants are told

[1] In a feedback survey taken at the end, % of the subjects said that they had understood the experiment.The risk preferences of subjects were also elicited at the beginning of each session by using a multiple price list survey a la Holt and Laury (2002). Since Holt and Laury uses US dollars, I used an adaptation of their survey to Indian currencies as used by Chakravarty, Harrison, Haruvy, and Rutström (2011)

[2] Approximately €0.60

that each member in their group has been allotted a level of risk π, a probability between 0 and 1, which could be different or same for different members in their group. A computer would pick a real number R at random between 0 and 1 for each group member separately. If the number picked was less that π, then the member would receive the public good. If R was more than π, then group member i would get nothing from the common account. If the public good is provided, then the efficiency factor would always equal 3. Subjects were shown the πs of each member in their group at the time that they decided their contribution. The *expected* payoff (earnings) function of subject i in period t of part 2 is the following:

$$ExpectedEarnings_{it} = x_{it} + \pi_{it} * 3\frac{\sum_{j=1}^{4} g_{jt}}{4} + (1 - \pi_{it}) * 0$$

Table 1 summarises the parameterisation of the efficiency factors(efs) and the πs in parts 1 and 2. Since there is no risk of losing the public good in part 1, πs always equal 1. The efficiency factors are homogeneous in period 1 of part 1 and equal 1.5 for each group member. Heterogeneity is introduced in period 2 and 3: two members in the group have a *high* efficiency factor (1.95) and the other two get a *low* one (1.05). To control for the effect of a subject's own MPCR on his contribution, the member who gets a high ef in period 2 gets a low one in period 3, and vice versa. Correspondingly, all group members have the same risk $\pi = 0.5$ in period 1 of part 2a , 'Uncertainty'. The *expected* MPCR ($\frac{0.5*3}{4}$) thus equals the MPCR in period 1 of part 1 in expectation. Likewise, in periods 2 and 3, two members in the group have a *high* π (.65) and the others *low* one(.35). In the last three periods, or the treatment 'Reducing dispersion under uncertainty', the dispersion in πs amongst the members of a group is reduced. In period 1, all four members have different πs - 0.35, 0.45, 0.55 and 0.65. In the second period, two members have 0.55 and the other two have 0.45, and in the last period, everyone has 0.5. The average (expected) efficiency factor for a group is always 1.5 throughout the experiment.

		ef				π			
		Subject1	Subject 2	Subject 3	Subject 4	Subject1	Subject 2	Subject 3	Subject 4
Part1: Certainty	Period 1 Period 2 Period 3	1.5 1.05 1.95	1.5 1.95 1.05	1.5 1.05 1.95	1.5 1.95 1.05	1	1	1	1
Part 2a: Uncertainty	Period 1 Period 2 Period 3	3	3	3	3	0.5 0.35 0.65	0.5 0.65 0.35	0.5 0.35 0.65	0.5 0.65 0.35
Part 2b: Reducing dispersion under uncertainty	Period 1 Period 2 Period 3	3	3	3	3	0.55 0.55 0.5	0.35 0.55 0.5	0.65 0.45 0.5	0.45 0.45 0.5

Table 1: Summary of parameters

Since the experiment gets progressively complex, the sequence of parts 1 and 2 is never altered. However, this raises a concern for order effects. Part 3 of the experiment repeats part 1 (identically), and this enables us to compare parts 1 and 3 to cross-check for order effects. Another potential concern is that subjects might have beliefs over the contributions of others that change over the course of the experiment. The difference in contributions that we observe could then be attributed to these beliefs rather than the changes in parameters. To test for this, we repeat parts 1, 2 and 3 in parts 4, 5 and 6 of the experiment respectively, with one difference: we also elicit the conditional contributions of the subjects using the strategy method as used by Fischbacher, Gächter, and Fehr (2001) and Fischbacher, Schudy, and Teyssier (2014). In each period, subjects are first asked to state their unconditional contributions, and then fill out a conditional contribution table, as illustrated in Figure ?, where they state their contributions conditional on the average contribution of the other group members. The conditional contribution is incentivised by calculating the sum of contributions in the following way: one of the four group members is randomly chosen by a computer. The conditional contribution becomes relevant for the chosen group member, and for the other three, the unconditional contribution becomes relevant. Apart from this, treatment parameterisation in Parts 4-6 are identical to Parts 1-3: part 4 corresponds to part 1 with conditional contributions, and so on.

All sessions were conducted at Ashoka University, Sonepat, India in July 2018. The experiment was implemented in 14 sessions, over two weeks. 200 subjects were drawn from a pool of undergraduate and graduate students (46% female) across various programmes of study at Ashoka. The experiment lasted for around 1h 30 minutes. One of the 24 periods in the session is chosen at random at the end of the experiment for determining the participant's final payoff. Subjects earned an average of Rs. 950 per session (approximately €12), which included a show up fee of Rs. 300 (€3.7). The experiment was programmed and conducted using Ztree Fischbacher (2007). The format and text of the instructions for the experiment have been borrowed from those provided by Fischbacher, Schudy, and Teyssier (2012).

2.2 Hypotheses

If participants care only about their earnings, their Nash equilibrium, dominant strategy in any period of the experiment should be to contribute nothing. However, subjects are known to typically contribute a positive amount in public goods experiments (Ledyard (1995)).To the best of my knowledge, there is no precedent literature which corresponds to an exact theoretical framework for the current experimental design. Empirical evidence is not complete either. Gangadharan and Nemes (2009) find evidence for their hypothesis that contributions under uncertainty are lower than contributions under certainty in pay-off equivalent situations, when the risk of losing the public good is identical across members of each group. Isaac, Walker, and Thomas (1984) find behavioural differences between groups whose members faced a low MPCR as compared to groups which faced a high MPCR. More recently, Banerjee and Gravel (2018) build a theoretical framework of a one-shot public goods game where agents have heterogeneous risk of benefiting from the public good, in situations where the benefit of a public good is subject to risk. Under specific conditions on the utility function, they show that a mean-preserving reduction in the dispersion of risk within members of a group can increase the sum of contributions to the public good. The current research differs from this setting in that it is a

Treatment	Group Count	Contribution	Profit	Contribution	Profit
		Mean		Standard Deviation	
Certainty	600	3.9433	11.9717	3.1305	2.6729
Uncertainty	600	2.6483	11.2579	2.5876	4.9193
Reducing dispersion under uncertainty	600	2.2700	11.3338	2.5254	4.4875
Certainty (Repeated)	600	3.1050	11.5525	2.9572	2.2970

Table 2: Summary of treatments: unconditional contributions

repeated game (instead of a one-shot game). Moreover, Banerjee and Gravel (2018) indicate an increase in the sum of contributions, but the model does not provide a hypothesis for individual contributions.

Following previous research, we propose to test the following hypotheses:

- Hypothesis 1. If MPCRs are homogeneous in a group, subjects contribute less to the public good when there is risk of losing the public good, than when there is no risk of losing the public good. To test this, we compare period 1 of Treatment Certainty with period 1 of the treatment Uncertainty.
- Hypothesis 2: When there is no risk of losing the public good, subjects contribute less when MPCRs are heterogenous amongst members of a group than when MPCRs are homogeneous. To test this, we compare the average of period 2 and 3 against that of period 1 in the treatment Certainty.
- Hypothesis 3: When there is a risk of losing the public good, subjects contribute less when expected MPCRs are heterogenous amongst members of a group than when expected MPCRs are homogeneous. To test this, we compare the average of period 2 and 3 against that of period 1 in the treatment Uncertainty.
- Hypothesis 4: Heterogeneity in MPCRs does not affect contributions differently in situations when there is a risk of losing the public good, than in situations where there is no risk. To test this, we compare the differences between averages of periods 2 and 3, and periods 1, across treatments Uncertainty and Certainty (calculated for Hypothesis 2 and 3).
- Hypothesis 5: When there is a risk of losing the public good, reducing the dispersion of risk among members of a group always increases individual contributions. We compare period 1 with period 2 and 3 of the treatment 'Reducing dispersion under uncertainty'.

3 Results

3.1 Results from the unconditional contribution games

I present the results of the unconditional contribution games (the first 12 games of the experiment) in this section. Table 2 summarises the average contribu-

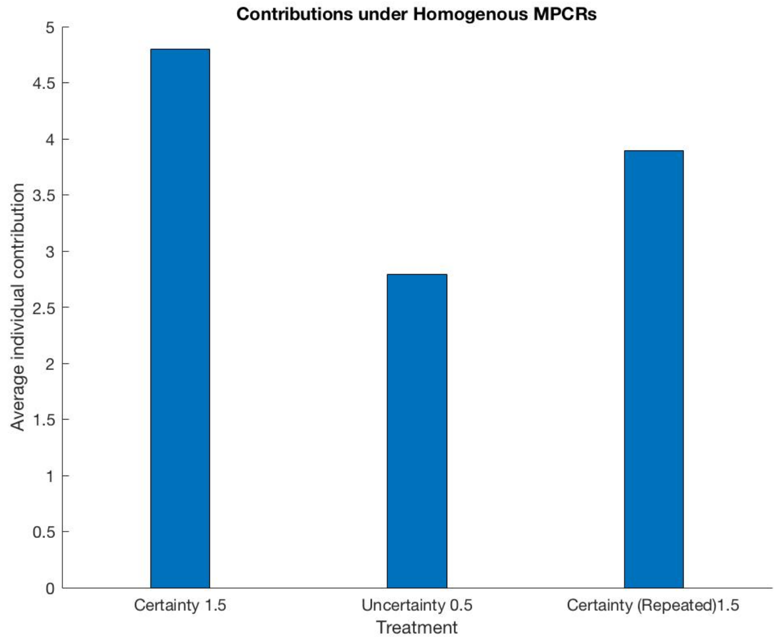


Figure 1: Contributions under Certainty and Uncertainty

tions of each of the four treatments. Contributions are always below 50% of the endowment on an average, lower than what is expected in typical public goods games, usually 50- 60% Ledyard (1995).

Result 1. Average individual unconditional contributions are lower when subjects face a risk of losing the public good, as compared to the case when they face no risk of losing the public good, when the risk of loss is identical for all members in a group.

Figure 1 presents average unconditional contributions for period 1 of the treatments 'Certainty' and 'Uncertainty', parts 1 and 2a of the experiment respectively. The expected efficiency factor of the subjects in these two treatments is equal to 1.5 and is identical across subjects. To check for order effects, the average contributions in these two treatments is compared with the average contribution of subjects in part 3, where part 1 is repeated identically. Contributions under certainty are consistently higher than contributions under certainty, irrespective of the order (rank-sum wilcoxon signed test: Part 1, Period 1 $>$ Part 2, Period 1: $z = 6.4$, $p < 0.0001$; Part2, Period 1 $<$ Part3, Period 1 : $z = -3.34$, $p < 0.0001$). The rank-wilcoxon test is a conservative, non-parametric test which checks if two distributions of observations are different without making assumptions on the form of the distributions.

However, time trends seem to matter as well. Contributions in period 1 of part 3 (treatment: certainty (repeated)) are lower than those in period 1 part 1

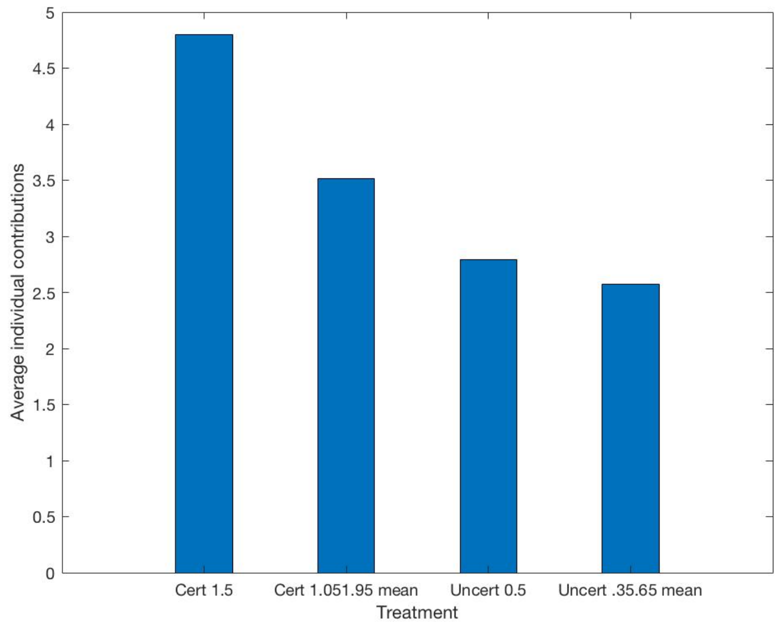


Figure 2: Contributions with Homogeneous and Heterogeneous MPCRs under certainty and uncertainty

(rank-sum wilcoxon signed test: Part 1, Period 1 > Part 2a, Period 1: $z = 2.89$, $p < 0.0001$). Even though time trends matter, the effect of uncertainty appears to be dominate the order effect for unconditional contributions.

Result 2. When subjects face no risk of losing the public good, average individual unconditional contributions are significantly lower, when the marginal return is heterogeneous among group members as compared to when marginal returns are homogeneous.

Figure 2 presents average unconditional contributions for all 3 periods of the treatments 'Certainty' and 'Uncertainty'. Since the last two periods of the two treatments have heterogenous returns, with the subject getting 'low' (expected) MPCRs in one period and 'high' in the other, the average of contributions in the two periods is presented to compare it with period 1 of each treatment where subjects have the same marginal returns. The effect of time is quite clear; there average contributions drop by half between the first and the last period. However the effect of heterogeneity is strong as well. The first two columns of Figure 2 compare average individual contributions under the treatment 'Certainty'. Returns from the public good are certain, but in period 1 efficiency factors are homogeneous and equal 1.5, and in periods 2 and 3, two subjects get an 'low' efficiency factor of 1.05, and two subjects get a 'high' efficiency factor of '1.95'. To control for the effect of an individual's own MPCR on their contribution, I compare the average of individual contributions in periods 2 and 3 with the average in period 1 of the treatment certainty. Introducing heterogeneity reduces the contributions of individuals significantly (rank-sum wilcoxon signed test: Part 1, Period 1 > Part 1, Average of Period 2 and 3: z = 3.8, p < 0.0001). Average contributions drop from 4.8 to 3.5, a significant amount considering that the maximum average contribution is less than 5.

Result 3. When subjects face a risk of losing the public good, average individual unconditional contributions are not significantly lower when the expected marginal return is heterogeneous among group members as compared to when expected marginal returns are homogeneous.

The last two columns of Figure 2 compare average individual contributions under the treatment 'Uncertainty'. To recall, returns from the public good are uncertain, but in period 1 the risk of getting the public good is homogeneous and equals 0.5, and in periods 2 and 3, two subjects get an 'low' risk of .35, and two subjects get a 'high' risk of '.65'. To control for the effect of an individual's own risk on their contribution, I compare the average of individual contributions in periods 2 and 3 with the average in period 1 of the treatment uncertainty. Introducing heterogeneity reduces the contributions of individuals, but the reduction is not significant (rank-sum wilcoxon signed test: Part 2a, Period 1 > Part 2a, Average of Period 2 and 3: z = 0.39, p > 0.1). Average contributions drop from 2.8 to 2.5. Results 2 and 3 combined lead us to conclude that heterogeneity has a much larger effect under certainty as compared to uncertainty. Clearly, heterogeneity affects contributions differently uncer certainty and uncertainty (rank-sum wilcoxon signed test: Part 1, Average of Period 2 and 3 > Part 2a, Average of Period 2 and 3: z = 3.89 , p< 0.001).

Result 4. The effect of within -group heterogeneity in expected returns on average individual unconditional contributions is higher when subjects face no risk of losing the public good as compared to when they face a risk of losing the public good.

Result 5. A reduction in dispersion in within-group heterogeneity in risk has no significant effect on contributions.

Figure 3 presents average unconditional contributions for each period of the treatment 'Reducing dispersion under uncertainty'. Column 1 plots average contributions in period 1, and columns 2 and 3 plot average contributions in periods 2 and 3, respectively. The level of risk π of all four subjects are different in period 1: .55, .35, .65 and .45 for subjects 1,2,3 and 4 respectively. The order in which πs were assigned were changed for half of the sessions: .35, .45, .55 and .65 was assigned to subjects 1,2,3 and 4 respectively. In period 2, two of the 4 subjects in each group were assigned a 'high' π of .55, and two others were assigned a 'low' π of .45. In period 3, all the subjects were assigned the same π, 0.5. Average contributions appear to be lowest when πs are polarised as 'low' or 'high', as in period 2. Contributions are higher in both period 1 and period

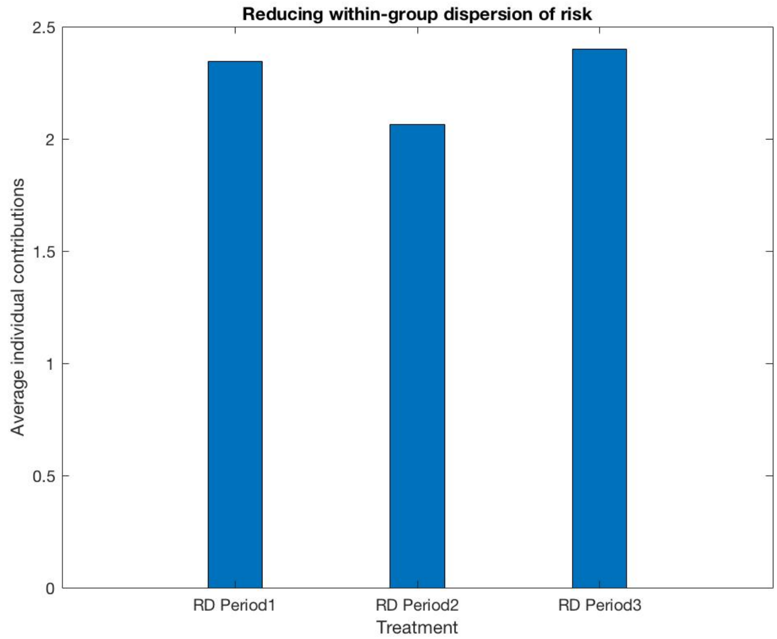


Figure 3: Reducing the within-group dispersion of risk with heterogeneous MPCRs under uncertainty

3, however, this difference is not significant (rank-sum wilcoxon two-sided test: Part 2b, Period 1 vs Part 2b, Period 2: z = 1.68, p > 0.1; Part 2b, Period 2 vs Part 2b, Period 3: z = -1.14, p > 0.1; Part 2b, Period 1 vs Part 2b, Period 3: z = 0.51, p > 0.1).

Since we have a repeated game setting, time trends are a cause for concern. Table 3 summarises the OLS regressions run on the unconditional contribution games for hypotheses 1-5. Columns (1), (3) and (5) report treatment effects without any controls for time trends or individual characteristics, and columns (2), (4) and (6) include the same. Columns (1) and (2) test for Hypothesis 1 on the subsample of observations from the first periods of treatments Certainty, Uncertainty and Certainty (Repeated). Column (1) regresses the unconditional contributions with a dummy for treatment 'Uncertainty' without any controls for individual characteristics or time trends. The effect is negative and significant at a 1% level. Standard errors, reported in parantheses, are corrected for heteroskedasticity and auto-correlation (HAC standard errors) but not grouped at the individual or a group level. Column (2) reports results for the same regression, but now includes time trends. The variable Loutcome measures the lag of the outcome variable, and is a dummy variable whose value equals 1 if the public good is provided in the previous period. InvPeriod is $(\frac{1}{logt})$ where $t = \{1, 2, ..., 24\}$, for each of the 24 periods of the game. Ldeviation is a lag variable on contribution, and measures the difference between the individual's own contribution and the average contribution by other players in the previous period. The controls for personal characteristics are sex and gender of the

Dependent variable: Unconditional contributions						
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	4.34*** (0.18)	2.26*** (0.98)	4.35*** (0.18)	2.93*** (0.57)	2.35*** (0.19)	0.00 (0.00)
Treatment Dummy (=1 if uncertainty)	-1.55*** (0.25)	-1.27*** (0.22)	-1.55*** (0.26)	-1.4*** (0.22)		
Treatment Dummy (=1 if heterogeneous)			-1.24*** (0.22)	-1.15*** (0.18)		
Interaction: Uncertainty x Heterogenous			1.02*** (0.31)	1.05*** (0.27)		
Treatment Dummy RD (=1 if Period = 2)					-0.28 (0.28)	0.00 (0.00)
Treatment Dummy RD (=1 if Period = 3)					0.05 (0.3)	0.00 (0.00)
Loutcome		0.29* (0.18)		-0.04 (0.11)		
InvPeriod (1/log t)		1.50*** (0.47)		1.12*** (0.25)		0.00 (0.00)
Ldeviation		0.85*** (0.03)		0.88*** (0.02)		0.92 (0.00)
Age		0.02 (0.04)		0.02 (0.02)		-0.09 (0.00)
Sex		0.22 (0.17)		0.3*** (0.1)		0.27 (0.00)
Control for personal characteristics	No	Yes	No	Yes		
Control for time trends	No	Yes	No	Yes	No	Yes
Observations	600	600	1800	1800	600	600
R squared	0.06	0.59	0.05	0.61	0.00	0.61

Table 3: OLS regressions: unconditional contributions

participant. The time trend variables have all been constructed following Gangadharan and Nemes (2009), except InvPeriod where I substituted ($\frac{1}{logt}$) in place of $1/t$ as used by them, because the value of this variable ws too close to zero as t increased in this experiment. The effect of the treatment 'Uncertainty' is still significant even after we control for time trends. Gender does not seem to matter, with women contributing the same as men on an average. Time trends are indeed important, and the effect of increasing one period is much stronger than the effect of learning the difference between the participants' own contribution and that of other players. We can thus conclude that InvPeriod effectively captures the effect of learning in course of the experiment.

Columns (2) and (3) offer evidence in support of Result 2, 3 and 4. Regressions are run over the sub-sample of observations from all periods of treaments Certainty, Uncertainty, and Certainty (repeated), a total of 1800 observations from 9 periods. We keep the treatment dummy Uncertainty from regression (1) and we add the dummy 'Heterogeneous' which equals 1 for periods 2 and 3 of the three treatments. The interaction effect variable 'Uncertainty x Heterogeneity' equals 1 when the treatment is Uncertainty, and it tests for whether heterogeneity in (expected) marginal returns has an additional effect when returns from the public good are uncertain. All three treatments have a significant effect. Uncertainty has a negative effect on contributions, and so does heterogeneity. However, uncertainty combined with heterogeneity has a positive effect on contributions. This suggests that heterogeneity in returns could counteract the effect of uncertainty on contributions. If people contribute less when there is heterogeneity in returns as in a model where people are inequality-averse as presented by Fischbacher, Schudy, and Teyssier (2014), then heterogeneity matters less when there is individual-specific risk, as compared to when there is an individual specific benefit from the public good. These results hold even after we control for time trends and individual characteristics, the control variables remaining the same as in regression (2).

Columns (5) and (6) test Hypothesis 5, where we check if progressively reducing within-group heterogeneity has a positive effect on contributions on the sub-sample of observations from Treatment 'Reducing dispersion under uncertainty'. Since there is heterogeneity in risk in all three periods, we only include dummies for period 2 where the variance of the distribution of πs within the group is first reduced, and period 3, where risks are homogeneous again. As discussed, reducing the variance in the dispersion of risk (period 2) has a slight negative effect on contributions and making risks homogeneous increases contributions, but these effects are almost negligible. even after introduing controls. We thus reject hypothesis 5.

3.2 Results from the conditional contribution games

I present the results of the conditional contribution games (the last 12 games of the experiment) in this section. In unconditional contribution games, such as the first 12 games played in the experiment, subjects do not know what other members in their group contribute at the time that they choose their contributions. This may lead them to form expectations regarding what others might contribute. These expectations, or beliefs, may change over the course of treatments, and it could be that the results in the section above capture a change in contributions due to a change in the expectations of subjects which is independent of the effect of the treatment. To capture belief-independent changes in contributions, we use the strategy method as used by Fischbacher, Gächter, and Fehr (2001). Subjects first state theit unconditional contributions, then fill out a table where they state the amount they wish to contribute for each possible average contribution of the other group members, as shown in Figure 8. Their entries in this table are incentivised by informing them that out of the four group members, for 3, the unconditional contribution would be chosen, and for one randomly selected member, the conditional contribution would be chosen for calculating the sum of contributions. For instance, if player 1 of the group is randomly chosen, and the three other members have an average unconditional contribution of 5, then if player 1 has put in his table that he would contribute 5 if others contribute 5, the sum of contributions equals 20. Since the conditional contribution chosen is dependent on the average that subjects expect others to contribute, by using the conditional contribution as a dependent variable in the regressions and including the average contributed by others' in the group as a regressor, we can calculate the effect of the treatments independent of changes in beliefs regarding contributions of others.

Figure 10 in the appendix summarises the average contributions in each of the four treatments, conditional on each possible average contribution by other group members. Conditional contributions are increasing in the average

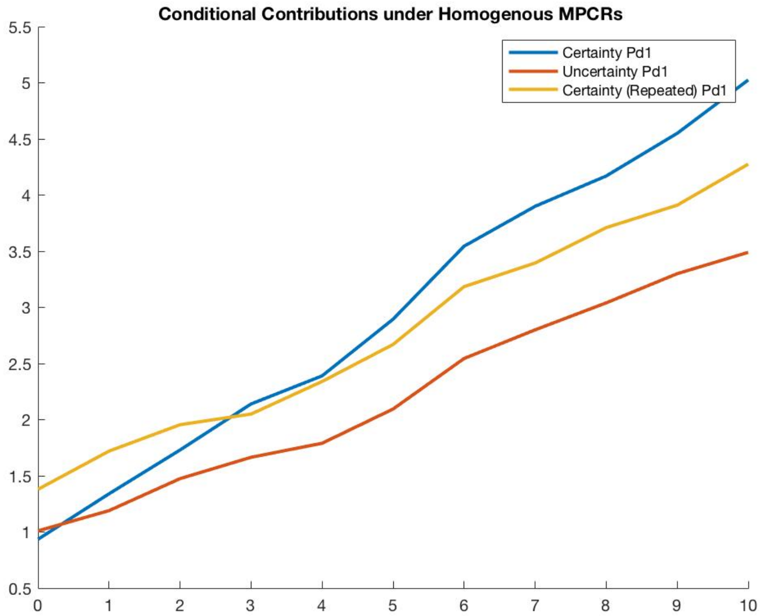


Figure 4: Conditional contributions under certainty and uncertainty

contribution of others, suggesting that a majority of participants are conditional contributors. Contributions are lie well below 50% of the endowment on an average, even when the possible contribution by others equals the endowment. This is much lower than what is expected in typical public goods games, where subjects are classified as conditional co-operators, unconditional cooperators, or free riders, depending on how much they choose to contribute to Ledyard (1995).

Figure 4 presents the results on average contributions conditional on each possible level of contributions by others in the group for period 1 of the treatments 'Certainty' and 'Uncertainty' repeated with conditional contributions. In effect these graphs report the average inputs by players in Figure 8, calculated for each treatment of the conditional contribution games. Contributions under certainty seem to be higher than contributions under uncertainty for every possible level of contributions by other members; however, this effect is not significant, as we discuss in the regression results on conditional contributions below. Similarly, Figure 5 shows the average conditional contributions for treatments certainty, uncertainty and certainty (repeated) of the experiment, respectively, where the results are separated by whether the (expected) MPCRs were homogeneous, that is period 1, or heterogeneous (where the average of periods 2 and 3 are presented.) Figure 6 reports the conditional contributions for each of the three periods of the treatment 'Reducing dispersion under uncertainty'.

Table 4 reports the results from OLS regressions on conditional contributions. These regressions in Table 4 differ from the unconditional contribution regressions reported in Table 3 in two fundamental ways. The dependent vari-

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.43 (0.27)	0.71 (0.95)	0.72*** (0.22)	0.46 (0.65)	0.42 (0.29)	0.69 (1.01)
Treatment Dummy (=1 if uncertainty)	0.13 (0.32)	0.13 (0.31)	0.07 (0.32)	0.06 (0.32)		
Treatment Dummy (=1 if heterogeneous)			0.32 (0.24)	0.32 (0.24)		
Interaction: Uncertainty x Treatment			-0.34 (0.42)	-0.35 (0.41)		
Treatment Dummy RD (=1 if Period = 2)					0.36 (0.47)	0.36 (0.47)
Treatment Dummy RD (=1 if Period = 3)					0.29 (0.38)	0.29 (0.37)
Av_Others	0.53*** (0.09)	0.53*** (0.09)	0.42*** (0.06)	0.41*** (0.06)	0.52*** (0.09)	0.51*** (0.09)
Age		-0.02 (0.05)		0.00 (0.03)		-0.02 (0.05)
Sex		0.53*** (0.19)		0.43*** (0.14)		0.32 (0.24)
Control for personal characteristics	No	Yes	No	Yes	No	Yes
Control for time trends	No	No	No	No	No	No
Observations	600	600	1800	1800	600	600
R squared	0.17	0.18	0.08	0.09	0.11	0.11

Table 4: OLS regressions with conditional contributions

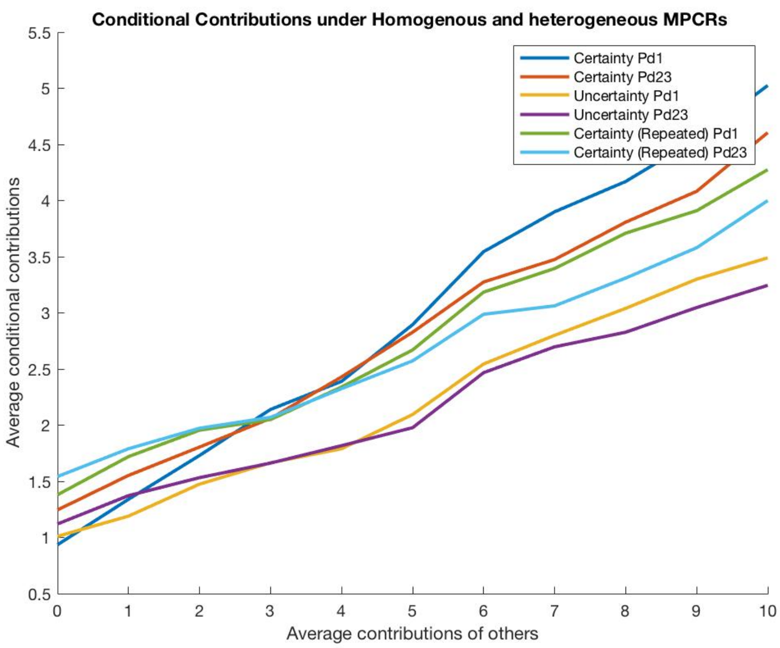


Figure 5: Conditional contributions with Homogeneous and Heterogeneous MPCRs under certainty and uncertainty

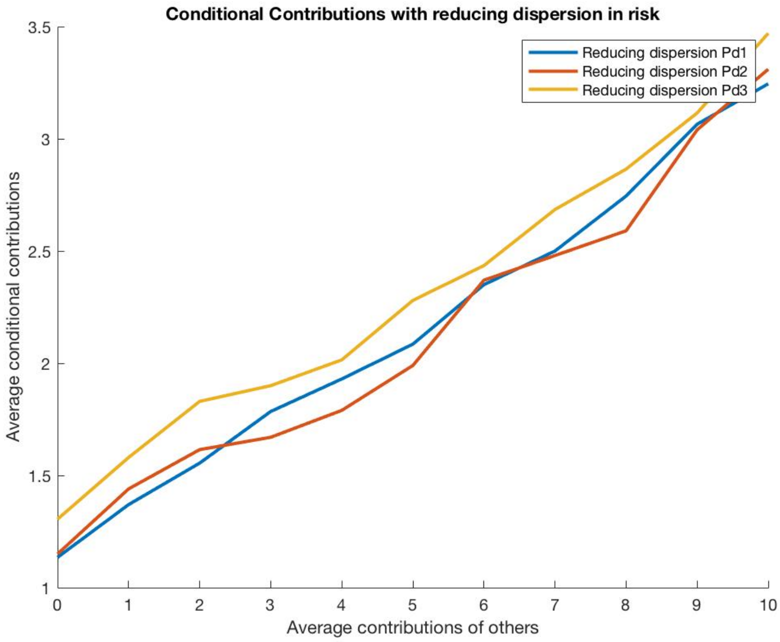


Figure 6: Conditional contributions: Reducing the within-group dispersion of risk with heterogeneous MPCRs under uncertainty

able is the conditional contributions in each period, and not the unconditional contributions. Secondly, since we use conditional contributions, we include a new variable, Av_Others, which simply corresponds to the average of the three unconditional contributions for that period. The regressions follow the same format as the regressions with unconditional contributions: regressions (1) and (2) test for result 1, regressions (3) and (4) test for result 2,3 and 4 and regressions (5) and (6) test for result 5. As before, regressions (1), (3) and (5) show only treatment effects without any additional controls, and regressions (2), (4) and (6) include controls for personal characteristics. Since the time trend variables very highly correlated in these later regressions, they have been dropped. Only age and gender have been kept as controls.

We see that the treatment effects found in the results on unconditional contributions disappear once we control for expectations regarding the contributions of others, using conditional contributions. The only significant effect consistent across regressions (1) to (6) is that of the variable Av_Others, which of course predicts that on an average, participants are conditional contributors, and they contribute more conditionally if they expect others to contribute more. What is remarkable is that the effect of the risk of loss of the public good is not significant once we control for the expectations of others. This is in its way, good news: in public goods problems, if we can eliminate concerns regarding whether others' would contribute, uncertainty regarding the state of the world does not seem to affect contributions so strongly.

4 Conclusion

This paper attempts to present the first evidence in the literature of combining within-group heterogeneity in returns with uncertainty regarding the return from the public good. There are several obvious ways in which the research design could be improved. Introducing a between-subject design with one-shot games would be a straightforward way to modify the current design to correct for the confounding effects of learning which are prevalent in a repeated-game design. This paper is intended as a preliminary analysis for designing a lab-in-the-field experiment for testing our research hypotheses.

Appendices

A Additional Regressions

Table 5: Uncertainty vs Certainty, Pooled Regressions

	(1)	(2)
Constant	3.9145***	3.2747***
	(0.4012)	(0.6365)
Treatment Dummy (=1 if uncertainty)	-1.2622***	-1.2583***
	(0.2039)	(0.2032)
Loutcome	-0.0632	-0.0553
	(0.1238)	(0.1237)
InvPeriod (1/log t)	0.0741	0.0742
	(0.3334)	(0.3330)
Ldeviation	0.8939***	0.8961***
	(0.0221)	(0.0224)
Age		0.0247
		(0.0229)
Sex		0.2293**
		(0.1058)
Control for personal characteristics	No	Yes
Observations	1200	1200
R squared	0.6074	0.6094

	Certainty vs Uncertainty: Pooled		Only Heterogeneous	Only Homogeneous
	(1)	(2)	(3)	(4)
Constant	3.9145***	3.2747***	2.1222***	-3.7529E+14
	(0.4012)	(0.6365)	(0.9066)	(0.0000)
Treatment Dummy (=1 if uncertainty)	-1.2622***	-1.2583***	-0.6007*	1.0457E+14
	(0.2039)	(0.2032)	(0.3639)	(0.0000)
Loutcome	-0.0632	-0.0553	-0.2356*	0.3213
	(0.1238)	(0.1237)	(0.1358)	(0.0000)
InvPeriod (1/log t)	0.0741	0.0742	0.8491*	3.7529E+14
	(0.3334)	(0.3330)	(0.5217)	(0.0000)
Ldeviation	0.8939***	0.8961***	0.9026***	0.8740
	(0.0221)	(0.0224)	(0.0211)	(0.0000)
Age		0.0247	0.0256	0.0263
		(0.0229)	(0.0328)	(0.0000)
Sex		0.2293**	0.2798**	0.1657
		(0.1058)	(0.1316)	(0.0000)
Control for personal characteristics	No	Yes	Yes	Yes
Observations	1200	1200	800	400
R squared	0.6074	0.6094	0.6264	0.6128

Table 6: Certainty vs Uncertainty

	(1)	(2)
Constant	3.8710***	3.2345***
	(0.5760)	(0.7994)
Treatment Dummy (=1 if uncertainty)	-1.6290***	-1.6253***
	(0.2959)	(0.2925)
Treatment Dummy (=1 if heterogeneous)	-1.2705***	-1.2705***
	(0.2792)	(0.2756)
Interaction: Uncertainty x Treatment	1.1303***	1.1307***
	(0.3785)	(0.3729)
Loutcome	-0.0413	-0.0335
	(0.1124)	(0.1111)
InvPeriod	0.8516	0.8519
	(0.5481)	(0.5401)
Ldeviation	0.8906***	0.8928***
	(0.0178)	(0.0182)
Age		0.0245
		(0.0272)
Sex		0.2293**
		(0.1112)
Control for personal characteristics	No	Yes
Observations	1200	1200
R squared	0.6263	0.6283

Table 7: Heterogeneity vs Homogeneity

	(1)	(2)	(3)
Constant	4.2994	10.3860	0.6730
	(5.8155)	(15.0598)	(1.0197)
Treatment Dummy (=1 if uncertainty)	-0.2200	-0.5981	
	(0.5385)	(1.1795)	
Treatment Dummy (=1 if heterogeneous)		-0.2608	
		(0.6443)	
Interaction: Uncertainty x Treatment		-0.0423	
		(0.4630)	
Treatment Dummy RD (=1 if Period = 2)			0.3611
			(0.2417)
Treatment Dummy RD (=1 if Period = 3)			0.2996
			(0.2078)
Loutcome	0.2800	0.2857	0.0375
	(0.1901)	(0.1909)	(1.2109)
InvPeriod	-10.1171	-25.7139	
	(15.2930)	(38.6247)	
Ldeviation	-0.1643***	-0.1644***	
	(0.0457)	(0.0453)	
Av_Others	0.4479***	0.4462***	0.5090***
	(0.0728)	(0.0729)	(0.0511)
Age	-0.0086	-0.0085	-0.0191
	(0.0333)	(0.0334)	(0.0398)
Sex	0.5627***	0.5632***	0.3224*
	(0.1643)	(0.1641)	(0.1963)
Observations	1200	1200	600
R squared	0.12	0.12	0.12

Table 8: Conditional contributions

	Period 1 and 2	Period 2 and 3	Pooled
	(1)	(2)	(3)
Constant	2.4391*	-1.6134	1.9197*
	(1.3076)	(2.0861)	(1.1488)
Treatment Dummy (=1 if Period = 2)	-0.2807		0.0547
	(0.2742)		(0.2544)
Treatment Dummy (=1 if Period = 3)		0.3276	-0.2791
		(0.2537)	(0.2358)
π	4.8945***	10.2533***	4.8198***
	(1.1558)	(3.3330)	(1.3150)
Loutcome	0.0243	-0.1838	-0.0300
	(0.2563)	(0.2577)	(0.2041)
InvPeriod			
Ldeviation			
Age	-0.1240**	-0.0665	-0.0953**
	(0.0547)	(0.0574)	(0.0449)
Sex	0.1901	0.1500	0.1329
	(0.2559)	(0.2573)	(0.2030)
Control for personal characteristics	Yes	Yes	Yes
Observations	400	400	600
R squared	0.04	0.03	0.02

Table 9: Reducing Dispersion

B Additional Figures

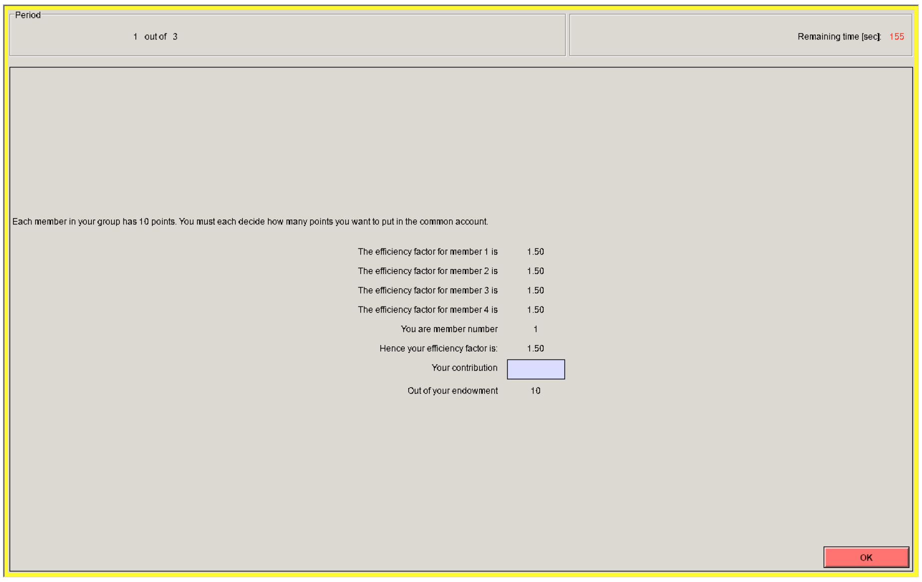


Figure 7: The unconditional contribution screen for participants

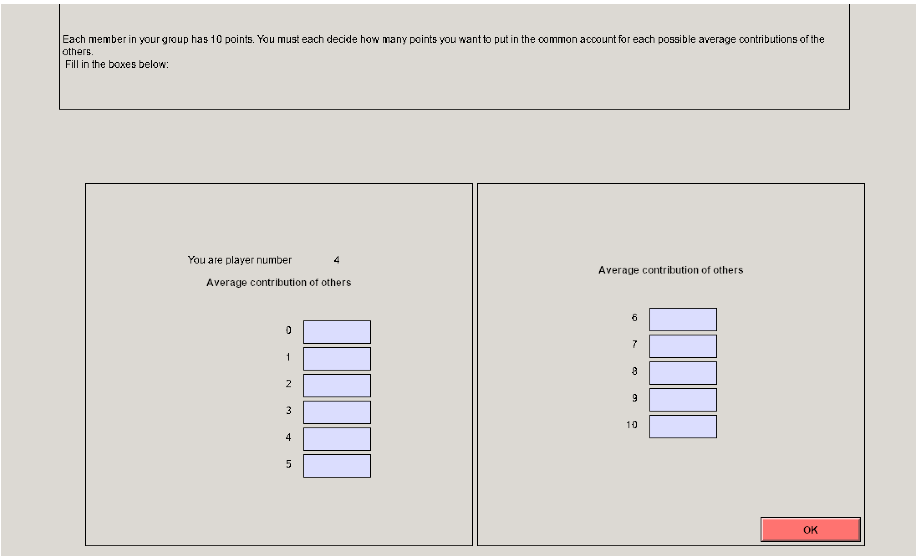


Figure 8: The conditional contribution screen for participants

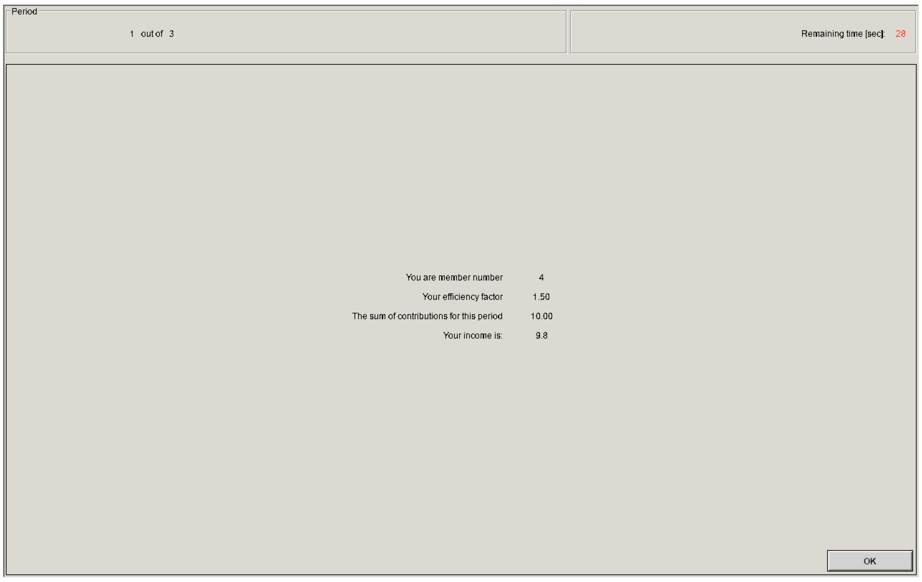


Figure 9: The information displayed to participants at the end of each period

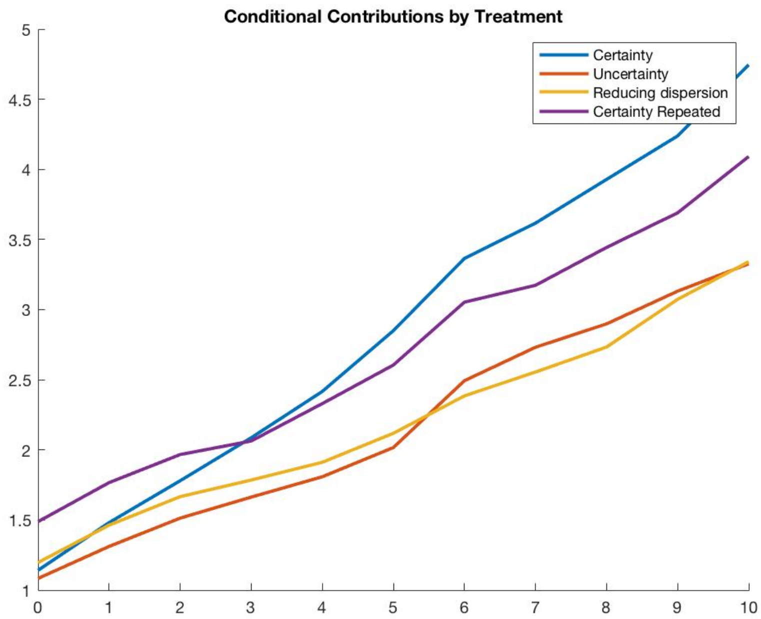


Figure 10: Conditional Contributions: Averages across the treatments

C Instructions to participants

Please read these instructions carefully. Please switch off your mobile phones before you proceed.

You will make a series of decisions involving money in this experiment. You can earn money during the experiment. Your final earnings will depend on your decisions as well as the decisions of other participants. You will participate in 24 experiment decisions in total. Each of these decisions should be made independently of the others. Out of these 24 decisions, one experiment decision will be randomly chosen by a computer draw to determine your earning. The decision selected is the same for all participants, and you will be informed of this at the end of the experiment. Hence, you must make each of your decisions carefully since any one of them could be chosen for the final payment.

These 24 decisions are split into 6 parts:

- Part I consists of 3 decisions.
- Part II consists of 6 decisions.
- Part III repeats Part I.
- Part IV consists of 3 decisions.
- Part V consists of 6 decisions.
- Part VI repeats Part IV.

Instructions will be read out aloud before each part begins. If you have any questions, please raise your hand after the instructions are read out.

Your earnings during the experiment will be in points. These points shall be converted to Indian Rupees at the time of the payment. The conversion rate is the following: **1 point = Rs. 50**. All payments will be made in cash at the end of the experiment and in private. You will also receive Rs. 300 as a show up fee for coming to this experiment.

No form of communication with other participants is allowed during the experiment until you are explicitly told so at the end of the experiment. Any violation of this will be taken very seriously. You will no longer be considered as a participant if you do not follow this instruction; you will have to leave and you will not be paid.

Before the experiment begins, you will be asked to answer a series of questions to ensure that you have correctly understood the experiment instructions. If you have any questions, either during or before the experiment, please raise your hand. We will immediately come to your assistance. You will also be asked to fill some questionnaires during the experiment.

Please note that there are no right or wrong decisions. Any decision you choose to make is a correct decision. All your decisions will remain anonymous for the experiment.

The experiment will now begin. More instructions will be provided to you before each of the decisions. Thank you for participating.

The basic decision

Here, we will describe the basic decision of the experiment. Please read these instructions carefully. At the end of these instructions, we will provide you with some questions to ensure that you have understood the basic decision. Please answer the questions seriously. We will proceed with the experiment once everyone has correctly answered these questions.

You are a member of a group of 4 people, you do not know the identity of the participants in this group. This will never be revealed, not even after the experiment. This group will not change during the experiment. You will only have a membership number: 1, 2, 3 or 4. This number has been randomly allotted to you by a computer.

You are given 10 points at the beginning of each decision. You can either choose to keep all the points in your private account, or invest them fully or partially in a common account. **Your basic decision during the experiment is to choose the number of points that you wish to put in the common account.**

Your earnings from a decision will be determined as a sum of the earnings you make from the private account and the common account.

- **Earnings from the private account:**

  You earn exactly the number of points you put in that account.

  Earnings from your private account = 10 - the number of points you put in the common account

- **Earnings from the common account:**

  Each group member in your group earns money from the points you choose to put in that account. You also earn money from the points others in the group put in the common account. Once every member has made their contribution to the common account, the average of all contributions gets multiplied by a number is called the **efficiency factor (denoted by** ef**)** of the experiment decision. To recall:

  Your earning from the common account =

$$ef * \frac{\textbf{Sum of all contributions to the common account}}{4}$$

- **Example. Suppose the efficiency factor is equal to 3.**

  Your earning from the common account =

$$3 * \frac{\textbf{Sum of all contributions to the common account}}{4}$$

- **To summarise:**

Your total earnings = Earnings from private account + Earnings from common account

Or,

Your total earning

$$= 10 - \textbf{your contribution to the common account} + 3 * \frac{\textbf{Sum of all contributions to the common account}}{4} \quad (1)$$

Please answer all the following questions now. They will help you understand how your earnings will change depending on the amount of points you put in the common account. Please write down all your calculations using the paper and pen provided. **Assume that the efficiency factor $ef = 3$.**

1. Each group member has 10 points. Suppose no one in your group, including you, contributes anything to the common account.

   What will your total earnings be? __________
   What will the earnings of other group members be? __________

2. Each group member has 10 points. Suppose everyone in your group, including you, contributes 10 points to the common account.

   What will your total earnings be? __________
   What will the earnings of other group members be? __________

3. Each group member has 10 points. Suppose the other three members in the group contribute 15 points in total.

   Suppose you contribute 0 points to the common account, in addition to the 15 points put in by the others. What will your total earnings be? __________

   Suppose you contribute 8 points to the common account, in addition to the 15 points put in by the others. What will your total earnings be? __________

   Suppose you contribute 10 points to the common account, in addition to the 15 points put in by the others. What will your total earnings be? __________

4. Each group member has 10 points. Suppose you contribute 8 points to the common account.

   Suppose the three other members contribute 7 points total to the common account, in addition to the 8 points put in by you. What will your total earnings be? __________

   Suppose the three other members contribute 15 points total to the common account, in addition to the 8 points put in by you. What will your total earnings be? __________

   Suppose the three other members contribute 24 points total to the common account, in addition to the 8 points put in by you. What will your total earnings be? __________

The experiment session will now begin. You are a member of a group consisting of 4 persons as in the basic situation described before. Your member number will be indicated on your computer screen during every experiment. Each new experiment will begin once everybody in the session finishes with the previous one.

Part 1

We will now begin with Part 1. This part consists of three experiments.

Each member in your group has 10 points. You must decide how many points you want to put in the common account. Earnings from the private account remain the same as in the basic situation:

Earnings from your private account = 10 - the number of points you put in the common account

The earnings from the common account are different in one aspect from the basic situation. *That is: the efficiency factor ef may not be the same for all group members. However, in each period, all of you will know the efficiency factor of each of the other group members.* These will be clearly displayed on your screen when you make your contribution. Your earnings from the common account are calculated as follows:

Your earning from the common account =

$$\textbf{(your efficiency factor } ef\textbf{)}*\frac{\textbf{Sum of all contributions to the common account}}{4}$$

Your total earnings are the sum of your earnings from the private and common account.

Example: Suppose the efficiency factors of the 4 members in your group are as follows:

- If you are member 1, your efficiency factor is 3.
- If you are member 2, your efficiency factor is 0.
- If you are member 3, your efficiency factor is 3.
- If you are member 4, your efficiency factor is 0.

Suppose you are member 2 and you decide to put 5 points in the common account. Suppose the other players put in 1 point each in the common account. The sum of contributions is hence $5 + 1 + 1 + 1 = 8$ points.

Your earnings from the common account is equal to $0 * \frac{8}{4} = 0$ points. Your earnings from your private account are 5 points. So your total earnings will be 5 points.

What about member 3? His/her earnings will be $3 * \frac{8}{4} = 6$ points from the common account, plus 9 points from his private account. His/her total earnings will be 15 points.

You must choose the number of points you want to put in the common account. You can put in any integer number between 0 and 10 as your entry. Please indicate your contribution on the screen, and press ok once you are sure. Remember that once you press ok, you cannot change your decision for this round of the experiment.

Part 2

We will now begin with Part 2. This part consists of 6 experiments.

Each member in your group has 10 points for each of these decisions, as before. In each decision, you must decide how many points you want to put in the common account. Earnings from the private account remain the same as in the basic situation:

Earnings from your private account = 10 - the number of points you put in the common account

The earnings from the common account will change from the previous decision. Please note this carefully. The returns from the common account are now *uncertain.*

Each member in your group has been allotted a level of risk π, a probability between 0 and 1.

A computer will pick a real number R at random between 0 and 1 for *each group member separately.* If the number picked is less that π, then the earning from the common account for group member i is equal to

$$3 * \frac{\text{Sum of all contributions to the common account}}{4}$$

Note that the efficiency factor $ef = 3$ is the same for all group members.

If it is more than π, then the earning from the common account for group member i is equal to 0. Note that the efficiency factor $ef = 0$ is the same for all group members.

The πs may be different or same for different members. The πs allotted to each player will be displayed on your computer screen for the decision. You will know every player's π.

Example: Suppose the πs of the 4 members in your group are as follows:

- If you are member 1, your π is 0.2
- If you are member 2, your π is 1
- If you are member 3, your π is 0.2
- If you are member 4, your π is 1

Suppose you are member 2 and you decide to put 5 points in the common account. Suppose the other players put in 1 point each in the common account. The sum of contributions is hence $5 + 1 + 1 + 1 = 8$ points.

Now the computer chooses a number between 0 and 1. Say this number R = 0.5. Your $\pi = 1$. Since $R < 1$, your earnings from the common account is equal to $3 * \frac{8}{4} = 6$ points. Your earnings from your private account are 5 points. So your total earnings will be 11 points.

What about member 3? Say the computer draws a number R = 0.4. His/her $\pi = 0.2$. Since $R > 0.2$, his/her earnings from the common account is equal to 0 points. His/her earnings will be only be 9 points from his private account. His/her total earnings will be 9 points.

Choose the number of points you want to put in the common account. Please indicate your contribution on the screen, and press ok once you are sure. You can put in any integer number between 0 and 10 as your entry. Remember that once you press ok, you cannot change your decision for that particular round of the experiment.

Part 3

This is identical to Part 1. Please read the instructions to Part 1 by yourself. Please raise your hand in case you have any questions.

Part 4

This part consists of three experiments.

Each member in your group has 10 points. You must decide how many points you want to put in the common account. Earnings from the private account remain the same as in the basic situation:

Earnings from your private account = 10 - the number of points you put in the common account

As in Part 1, the efficiency factor ef may not be the same for all group members. However, in each period, all of you will know the efficiency factor of each of the other group members. These will be clearly displayed on your screen when you make your contribution. Your earnings from the common account are calculated as follows:

Your earning from the common account =

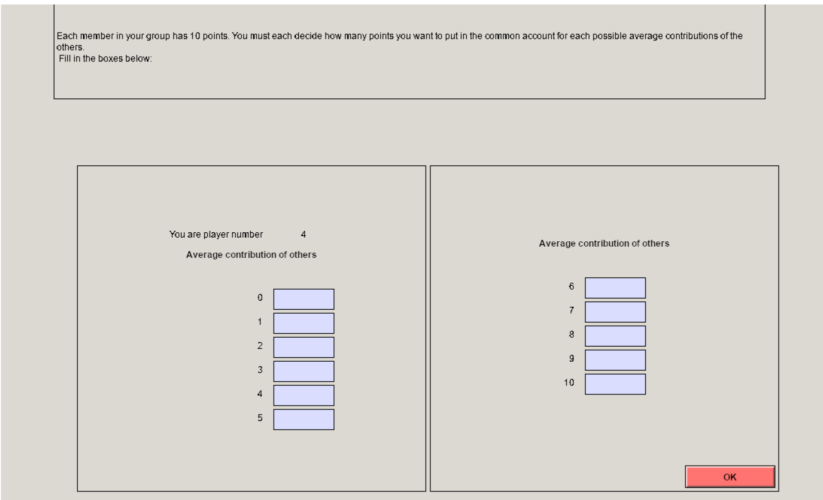
$$\textbf{(your efficiency factor } ef\textbf{)}*\frac{\textbf{Sum of all contributions to the common account}}{4}$$

Your total earnings are the sum of your earnings from the private and common account.

You now have two tasks.

First, choose the number of points you want to put in the common account. This is your unconditional contribution. Please indicate your contribution on the screen, and press ok once you are sure. Remember that once you press ok, you cannot change your decision for this round of the experiment.

Second, you must fill in a contribution table. You must indicate on the screen how many points you wish to contribute for each possible average contribution of the other group members (rounded to the next integer). Your contribution can depend on what the average contribution of others is. To understand this better, take a look at the table which follows.



The numbers indicated are the possible contributions of the other group members to the project. Next to each number is a box where you have to fill in how many points you want to put in the common account conditional on the average amount contributed by the others. Fill in all the boxes. For instance, you have to put the number of points you want to put in the common account if the others contribute 0 points, or 1 point, or 2 points, etc. You can put in any integer number between 0 and 10 as your entry. Once you have filled all the boxes, click OK. *Please fill in all the boxes. Do not leave any empty.*

After all the group members have made an unconditional contribution and filled their contribution tables, the computer will randomly select one group member from your group. For the other 3 group members, their earnings will be determined by the points they put in the unconditional contribution box. For the randomly selected member, his/her earning will be be based on the conditional contribution table. You do not know beforehand if you will be the randomly selected member, so you have to think carefully about both the decisions because both can become relevant for you. Here are two examples to make this clear.

For the purpose of these examples, assume that:
Suppose the efficiency factors of the 4 members in your group are as follows:

- If you are member 1, your efficiency factor is 1.05.
- If you are member 2, your efficiency factor is 1.95.
- If you are member 3, your efficiency factor is 1.05.
- If you are member 4, your efficiency factor is 1.95.

EXAMPLE 1: Assume that the computer selects you and you are group member 1. 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 members 2,3 and 4 made unconditional contributions of 0, 2, and 4 points respectively. 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 common account is given by $0 + 2 + 4 + 1 = 7$. You will therefore earn $\frac{1.05*7}{4} \approx 2$ points from the project plus your earning from the private account, 9 points. Your total earnings will be 11 points.

What will the earnings of the other group members be? Take for example member 2, who has contributed 0 points. His/her earnings from the common account will be $\frac{1.95*7}{4} \approx 3$ points, plus he/she earns 10 points from the private account. His/her total earnings will be 13 points.

If, instead, you indicated in your contribution table that you would contribute 9 points if the others contribute two points on average, then the total contribution of the group to the project is given by $0+2+4+9 = 15$. You will therefore earn $\frac{1.05*15}{4} \approx 4$ points from the common account plus 1 point from your private account, a total of 5 points.

EXAMPLE 2: Assume that the computer does not select you and you are group member 1. Group member 2 is selected by the computer. Assume your unconditional contribution is 6 points and those of group members 3 and 4 are 8 and 10 points respectively. Your average unconditional contribution and that of the two other group members, therefore, is 8 points. If member 2 indicates in her contribution table that she will contribute 1 point if the other three group members contribute on average 8 points, then the total contribution of the group to the project is given by $6+8+10+1 = 25$. You will therefore earn $\frac{1.95*25}{4} \approx 12$ points from the common account plus 4 points from your private account. Your total earnings are therefore 16 points for this round.

If, instead, member 2 indicates in her contribution table that she contributes 9 if the others contribute on average 8 points, then the total contribution of that group to the project is $6+8+10+9 = 33$. You will therefore earn $\frac{1.95*33}{4} \approx 16$ points from the common account plus 4 points from your private account. Your total earnings are therefore 20 points for this round.

Part 5

This part consists of 6 experiments.

Each member in your group has 10 points as always. You must decide how many points you want to put in the common account. Earnings from the private account remain the same as in the basic situation:

Earnings from your private account = 10 - the number of points you put in the common account

The returns from the common account are now *uncertain.*

Each member $i = 1, 2, 3$ or 4 in your group has been allotted a different level of risk π between 0 and 1. The πs may be different or same for different members. The πs allotted to each player will be displayed on your computer screen for the decision. You will know every player's π.

A computer will pick a real number at random between 0 and 1. If the number picked is less that π, then the earning from the common account for group member i is equal to

$$3 * \frac{\text{Sum of all contributions to the common account}}{4}$$

Note that the efficiency factor $ef = 3$ is the same for all group members.

If it is more than π, then the earning from the common account for group member i is equal to 0.

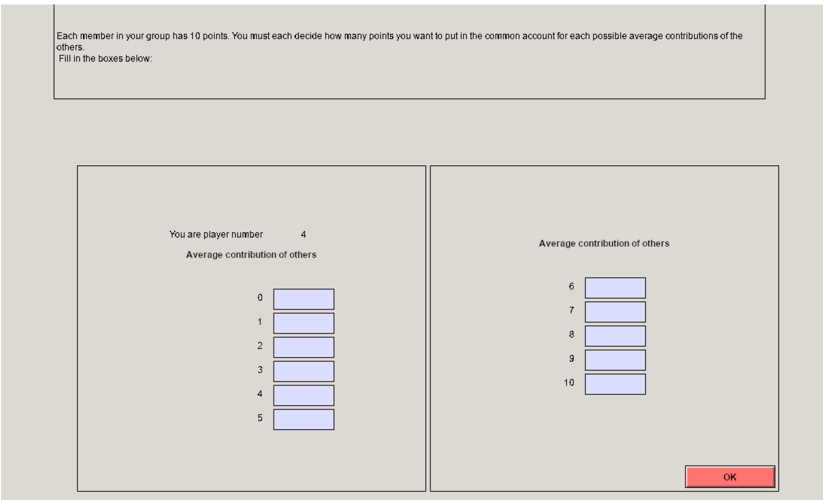
Note that the efficiency factor $ef = 0$ is the same for all group members.

Your total earnings are the sum of your earnings from the private and common account.

You now have two tasks.

First, choose the number of points you want to put in the common account. This is your unconditional contribution. Please indicate your contribution on the screen, and press ok once you are sure. Remember that once you press ok, you cannot change your decision for this round of the experiment.

Second, you must fill in a contribution table. You must indicate on the screen how many points you wish to contribute for each possible average contribution of the other group members (rounded to the next integer). Your contribution can depend on what the average contribution of others is. To understand this better, take a look at the table which follows.



The numbers indicated are the possible contributions of the other group members to the project. Next to each number is a box where you have to fill in how many points you want to put in the common account conditional on the average amount contributed by the others. Fill in all the boxes. For instance, you have to put the number of points you want to put in the common account if the others contribute 0 points, or 1 point, or 2 points, etc. You can put in any integer number between 0 and 10 as your entry. Once you have filled all the boxes, click OK. *Please fill in all the boxes. Do not leave any empty.*

After all the group members have made an unconditional contribution and filled their contribution tables, the computer will randomly select one group member from your group. For the other 3 group members, their earnings will be determined by the points they put in the unconditional contribution box. For the randomly selected member, his/her earning will be be based on the conditional contribution table. You do not know beforehand if you will be the randomly selected member, so you have to think carefully about both the decisions because either can become relevant for you. Here are two examples to make this clear.

EXAMPLE 1: Assume that the computer selects you and you are group member 1. 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 members 2,3 and 4 made unconditional contributions of 0, 2, and 4 points respectively. 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 common account is given by $0 + 2 + 4 + 1 = 7$.

Now two cases are possible:

- Suppose now that the random draw of number by the computer is 0 and your π is 0.2. Since $0 < 0.2$, your $ef = 3$. You will therefore earn $\frac{3*7}{4} \approx 5$ points from the project plus your earning from the private account, 9 points. Your total earnings will be 14 points.
- Suppose now that the random draw of number by the computer is 0.5 and

your π is 0.2. Since $0.5 > 0.2$ your $ef = 0$ and you will get nothing from the public account. Your total earnings will be 9 points.

What will the earnings of the other group members be? Take for example member 2, who has contributed 0 points.

- Suppose the random draw is 0.02 and his/her $\pi = 0.1$. Since $0.02 < 0.1$, his/her $ef = 3$. His/her earnings from the common account will be $\frac{3*7}{4} \approx 5$ points, plus he/she earns 10 points from the private account. His/her total earnings will be 15 points.

If, instead, you indicated in your contribution table that you would contribute 9 points if the others contribute two points on average, then the total contribution of the group to the project is given by $0+2+4+9 = 15$. As before, two cases are possible.

- The random drawn number could be less than your π which equals 0.2. Then, $ef = 3$. You will therefore earn $\frac{3*15}{4} \approx 11$ points from the common account plus 1 point from your private account. Your total earnings will be 12 points.

- Otherwise, you get $ef = 0$, in which case you earn nothing from the common account. Your total earnings will be 1 point.

EXAMPLE 2: Assume that the computer does not select you and you are group member 1. Group member 2 is selected by the computer. Assume your unconditional contribution is 6 points and those of group members 3 and 4 are 8 and 10 points respectively. Your average unconditional contribution and that of the two other group members, therefore, is 8 points. If member 2 indicates in her contribution table that she will contribute 1 point if the other three group members contribute on average 8 points, then the total contribution of the group to the project is given by $6 + 8 + 10 + 1 = 25$.

Now two cases are possible:

- Suppose now that the random draw of number by the computer is 0 and your π is 0.2. Since $0 < 0.2$, your $ef = 3$. You will therefore earn $\frac{3*25}{4} \approx 19$ points from the project plus your earning from the private account, 4 points. Your total earnings will be 23 points.
- Suppose now that the random draw of number by the computer is 0.5 and your π is 0.2. Since $0.5 > 0.2$ your $ef = 0$ and you will get nothing from the public account. Your total earnings will be 4 points.

If, instead, member 2 indicates in her contribution table that she contributes 9 if the others contribute on average 8 points, then the total contribution of that group to the project is $6 + 8 + 10 + 9 = 33$.

As before, two cases are possible.

- The random drawn number could be less than your π which equals 0.2. Then, $ef = 3$. You will therefore earn $\frac{3*33}{4} \approx 25$ points from the common account plus 4 points from your private account. Your total earnings will be 29 points.

- Otherwise, you get $ef = 0$, in which case you earn nothing from the common account. Your total earnings will be 4 points.

Part 6

This is identical to Part 4. Please read the instructions to Part 4 by yourself. Please raise your hand in case you have any questions.

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