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The Poor, the Rich and the Middle Class: Experimental evidence from heterogeneous public goods games

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Abstract

We present the results of one-shot and repeated public good experiments that seek to understand the interaction between the endowment and marginal return in heterogeneous groups. Our focus is on treatments in which the endowment and the marginal return are either inverse or proportionally related to each other. While two normatively appealing contribution rules are aligned in the proportional treatment, a conflict between the two exists in the inverse treatment. In the one-shot experiments, we do not find significant differences across treatments. Contributions increase when the endowment, the marginal return or both increase. This is observed in all treatments except when the endowment and the marginal return are inversely related. In this case, the 'middle class' participants contribute more than both the high and low endowment types, mirroring real world observations with regards to a 'squeezed middle'. This suggests the presence of a conflict between the highly endowed subjects (but with low marginal return) and those with a high marginal return (but with low endowment). This pattern is similar when we elicit beliefs about others' contributions, whereby the two conflicting types expect others to contribute more than they do for themselves. In the long-run, however, when allowing for repeated interaction, the differences across types vanish in the inverse but not in the proportional treatment. This suggests that over time the conflicting interests arising from the interplay between the endowment and the marginal return can be overcome. Our findings have welfare implications indicating that the inverse treatment reduces inequality measured by the Gini coefficient but this is not the case for the proportional treatment, where inequality remains the same.

Keywords: Public goods; heterogeneity; endowment; marginal return; contribution norms

JEL Codes: H41, C92, D60

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1. Introduction

Many societies are characterised by an uneven income distribution. For example, according to the Office for National Statistics (ONS), the income distribution of the United Kingdom is such that the top quintile of households have a pre-tax income that is four times larger than that of the bottom quintile of households (ONS, 2022). Similarly, 45% of all disposable household income (after housing costs) in the UK belongs to the top quintile of households, compared to just 7% belonging to the lowest quintile (Francis-Devine, 2021). According to the Institute for Fiscal Studies (IFS), approximately 25% of those earning in excess of £100,000 per annum utilise private education and/or healthcare services (IFS, 2010). By contrast, of those earning £20,000, only approximately 5% utilise private healthcare and education services. A recent study by Henseke *et al*. (2021) shows that higher income and/or household wealth is associated with greater likelihood of attending private school. It appears that benefits from public goods provision and income may be inversely related to one another since higher income is associated with higher procurement of privately provided goods. Further, middle income earners' tax payments are a key contributor towards investments in public health and education spending (Organisation of Economic Cooperation and Development (OECD), 2019). Combined with the middle class having experienced stagnant living standards, this has resulted in a 'squeezed' middle class across much of the OECD (OECD, 2019). The purpose of the current study is to investigate how the relationship between income and the benefits from public goods provision impact on the provision of public goods. Do richer people contribute more to the public good provision because they can afford to do so, or do the ones that obtain higher benefits from its use contribute more? What happens to the middle class? Previous studies have looked at these questions in isolation and introduced heterogeneity in income and heterogeneity in the marginal benefit separately, while our study focuses on situations where groups differ along *both* dimensions. As such, both the income *and* marginal benefit vary, either in a proportional way (where the rich also have the greatest benefit) or an inverse way (where the rich derive the smallest benefit), which seems more descriptive of modern societies.

1.1. Heterogeneous Marginal Per Capita Returns

A typical finding in the existing literature is that the higher the (homogeneous) marginal per capita return from the public good, the higher the absolute levels of contributions are. Indeed, in a meta-analysis of 27 studies, Zelmer (2003) finds that the marginal benefit is crucial in affecting pro-social behaviour in public good game environments.

In terms of when marginal per capita returns are heterogeneous, Fisher (1995) provides one of the first such studies and finds that inequalities in marginal per capita return leads to lower contributions. In a related study, Reuben and Riedl (2013) find that those with higher marginal per capita return contribute more, albeit weakly. On the other hand, Fischbacher *et al*. (2014) present evidence that heterogeneous returns lead to lower contributions. Otten *et al*. (2020) present evidence that even in groups with heterogeneous marginal per capita returns contributions can be kept relatively high in the presence of punishment opportunities. They also present evidence that people's normative sense of the fair contribution rule is affected by the participant's own starting position, a finding that echoes Reuben and Riedl (2013). Blanco *et al.* (2016) use a novel appropriation game setting to disentangle the public benefit of contributions from the private benefit of not contributing (keeping the initial endowment becomes worth more or less to different people) and find no overall differences. This is due to a counter-balancing of heterogeneous effects between the heterogeneous groups of participants. Overall, the evidence of heterogeneity in marginal per capita return is somewhat mixed.

1.2. Heterogeneous Endowments

Chan *et al*. (1996) present an experimental test that is broadly supportive of the Bergstrom *et al.* (1995) predictions of higher endowments leading to higher contributions. This result contrasts, however, with Reuben and Riedl (2013) who find no difference in contribution between a 'high' and 'low' endowment type in a baseline control treatment of an investigation into the efficacy of punishment mechanisms in such settings. Further, Cherry *et al*. (2005) present evidence that heterogeneous endowments lead to lower contributions - regardless of whether that endowment is a windfall or earned through a real effort task (see Spraggon and Oxoby, 2009), for a similar study on the effect of endowment source). Lower contributions in heterogeneous groups is echoed by Buckley and Croson (2006). DeGeest and Kingsley (2019) and Anderson *et al*. (2008) both highlight the importance of complete information - especially in the face of punishment opportunities, where knowing who has a high endowment is crucial if contributions are to be maintained. Similarly, Hargreaves Heap *et al*. (2016) present evidence that participants with a high endowment specifically will lower their (percentage) contributions in the face of endowment heterogeneity. Further, Zelmer (2003) finds that heterogeneous endowments have a significant, negative effect on contributions. Thus, it would appear that heterogeneous endowments lead to lower contributions - especially in the absence of punishment opportunities. Kesternich (2017) implement heterogeneous endowments in a modified public goods game that features a first stage in which participants suggest contribution norms which (treatment dependent) bid participants to minimum contribution levels (i.e. enforced contribution rules).

1.3. Other Sources of Heterogeneity

A related but distinct concept can be found in Feige *et al*. (2018), where they implemented heterogeneous contribution costs (i.e. it is cheaper (per contribution) for some participants to contribute than others). Hauser *et al*. (2019) implement groups that have heterogeneities in both endowment and contribution cost (also called productivity). They find that when endowments and productivity are inversely related, contributions are lower than when positively related - due to conflicting normative assessments of fair contribution rules - echoing both Reuben and Riedl (2013) and Otten *et al*., (2020). This focus on normatively appealing contribution rules makes these the most closely related papers. Another distinct but related concept is efficiency or capability - a situation in which the contributions of some participants generate more tokens in the central project than others, see Kolle (2015).

In this paper, we report on two separate experiments. Experiment 1 considers one-shot interactions featuring public goods game groups with both heterogeneous marginal per capita return and endowments. As such, we present two novel treatments in which the marginal return and endowment are either inversely or proportionally related to one another. The inverse treatment features participants that represent members of the lower, middle and upper class. In order to investigate possible dynamics, we run a separate secondary experiment (Experiment 2) in which the public goods game is repeated for 15 periods. The role of normative fairness and contribution rules is examined, as well as the effect on *ex-post* inequality.

In Experiment 1, we find that contributions increase when the endowment, the marginal return or both increase, except for when the endowment and the marginal return are inversely related. In this case, the 'middle class' participants contribute more than both the high and low endowment types, suggesting the presence of a conflict between the highly endowed subjects (but with low marginal return) and those with a high marginal return (but with low endowment). Interestingly, this pattern is similar when we elicit beliefs about others' contributions, whereby the two conflicting types expect others to contribute more than they do for themselves. In

Experiment 2, where we allow for repeated interaction, the differences across types vanish in the inverse but not in the proportional treatment. This offers evidence that over time the conflicting interests arising from the interplay between the endowment and the marginal return can be overcome.

The remainder of the paper is organized as follows. Section 2 introduces our experimental design and methods in detail. Section 3 discusses the results from both experiments. Section 4 analyses the distributional effects of ex-post inequality and Section 5 concludes.

2. Experimental Design

2.1. Experiment 1: One-Shot Public Good Game

In Experiment 1, we conduct a one-shot, six-player public goods game to investigate the relationship (or interaction) between two fundamental parameters of the public goods game; the endowment and the marginal return (commonly called the marginal-per-capita-return or MPCR, but we refrain from using this terminology due to the introduction of heterogeneities that renders the phrase *per-capita* obsolete).

Subjects earn income according to the standard public goods game profit function (of course, we apply an individual subscript to the endowment and return from the project, as they are not necessarily homogeneous);

$$U_i = (E_i - X_i) + r_i \sum_{i=1}^{6} X_i$$

where U_i is payment in ECUs (experimental currency units), E_i is endowment, X_i is contribution and r_i is marginal return.

The treatments are as follows:

Treatment 1 (Control): In the control treatment, all subjects have the same endowment ($E_i = 20$) and same marginal return ($r_i = 0.5$).

Treatment 2 (Heterogeneous Return): Subjects' types vary only by marginal return ($r_i = \{0.25, 0.5, 0.75\}$). All subjects have the same endowment ($E_i = 20$).

Treatment 3 (Heterogeneous Endowment): Subjects' types vary only by endowment ($E_i = \{10, 20, 30\}$. All subjects have the same marginal return ($r_i = 0.5$).

Treatment 4 (Inverse): Subjects' types vary by endowments and marginal returns. Endowments ($E_i = \{10, 20, 30\}$) and marginal returns ($r_i = \{0.25, 0.5, 0.75\}$) are inversely proportional to one another.

Treatment 5 (Proportional): Subjects' types vary by endowments and marginal returns. Endowments ($E_i = \{10, 20, 30\}$) and marginal returns ($r_i = \{0.25, 0.5, 0.75\}$) are proportional to one another.

We therefore implement five treatments where we introduce heterogeneity in; either the endowment (Treatment 3) or the marginal return (Treatment 2), both (Treatments 3 and 4) or neither (Treatment 1). Heterogeneity in both endowment and marginal return is implemented in two opposed ways; either the endowment and marginal return are proportional (Treatment 4) or inversely proportional (Treatment 5) to one another.

The possible endowments are either 10, 20 or 30 ECUs and the marginal return is either 0.25, 0.5 or 0.75. It is worth noting that the five treatments afford us a complete schema of all possible combinations of the endowment and return from the project.

In particular, each subject can be thought of as having a `type' that consists of an (Endowment, Marginal Return) pair, for example (20, 0.5) referring to Endowment = 20 and Marginal Return = 0.5. In treatments 2-5, three types therefore exist and there are exactly two of each type in each group (for a total of six subjects per group). Treatment 1 features only one type and thus all six subjects have the same type. Six subjects were used per group such that we could elicit a given subject's belief about others with the same type as themselves. A full overview of the types available in each of the treatments can be seen in Table 1. In this sense, nine types exist across the five treatments with the baseline (20, 0.5) type present in all treatments. Across the five treatments both the sum of endowments and the sum of marginal returns are identical - eliminating the possibility of any observed differences being due to wealth or social efficiency effects. The sum of endowments represents the total wealth in the 'economy' and by keeping it constant (at 120 ECU), we are only changing the distribution of wealth within the economy. The sum of marginal returns represents the number of tokens generated per token contributed (in that sense, a measure of the social efficiency of contributions) and also kept constant (at a 3:1 ratio) - this is especially important in the presence of pro-social preferences. In this way we retain the typical aspect of a public goods game that each token contributed is multiplied by 3 in all of our treatments – only the distribution of the resulting group fund varies. Note that the fundamental structure of the public goods game remains intact across all types in all treatments - free riding is still a dominant strategy for all types in all treatments.

It is particularly worth mentioning that the types in the Inverse treatment mirror real world observations with respect to patterns of endowment (income) and marginal return (benefit from public goods provision) for members of the lower, middle and upper class in OECD countries (OECD, 2019).

Table 1: An Overview of group composition per treatment

Treatment	**1**		**2**		**3**		**4**		**5**	
	Control		**Heterogeneous Return**		**Heterogeneous Endowment**		**Inverse**		**Proportional**	
Subject	**E**	**r**	**E**	**r**	**E**	**r**	**E**	**r**	**E**	**R**
1	20	0.5	20	0.25	10	0.5	10	0.75	10	0.25
2	20	0.5	20	0.25	10	0.5	10	0.75	10	0.25
3	20	0.5	20	0.5	20	0.5	20	0.5	20	0.5
4	20	0.5	20	0.5	20	0.5	20	0.5	20	0.5
5	20	0.5	20	0.75	30	0.5	30	0.25	30	0.75
6	20	0.5	20	0.75	30	0.5	30	0.25	30	0.75
Total	120	3	120	3	120	3	120	3	120	3

At the beginning of each session, instructions (a copy of which can be found in an appendix) were read aloud to all subjects. Subjects were then required to answer some control questions to ensure that everybody understood the instructions. Subjects were randomly assigned types and each subject was informed of their own type. Subjects then made their contribution decisions. Beliefs were then elicited in an incentivised manner. Subjects were asked to estimate the average contribution of the other subjects in their group for all possible types, i.e. in treatments 2-5 subjects were asked for three separate estimates - one for each of the three possible types. The beliefs were incentivised using a step-loss function (closer estimates earned more money and sufficiently incorrect estimates earned nothing). Subjects were then informed of their earnings for the experiment and asked to fill out a short demographic questionnaire that concluded the experiment.

A total of 312 subjects took part across all five treatments. Each subject participated in only one treatment. All subjects were recruited using ORSEE (Greiner, 2004) and the experimental software was programmed using zTree (Fischbacher, 2007). All sessions were run at Birmingham Experimental Economics Laboratory (BEEL), University of Birmingham (UK) and all subjects were students at the university from across a wide range of disciplines. At the end of each session, tokens were converted to UK pounds at the pre-announced exchange rate of £0.20 per token and subjects were paid in cash. Sessions lasted on average 50 minutes and subjects received an average payment of £9.38 (including a £2.50 show-up fee).

2.2. Experiment 2: Repeated Public Good Game

In an attempt to investigate the robustness and dynamic stability of the results of Experiment 1, we ran a set of additional experiments. In these experiments, Treatments 4 (Inverse) and 5 (Proportional) from Experiment 1 (the novel treatments of this paper) were repeated for 15 periods within fixed groups that remained the same throughout the entire experiment. We refer to these as Treatments 4R and 5R respectively. All other parameterisations were identical to Experiment 1. Subjects were paid according to one randomly selected period to avoid income effects accruing throughout the experiment. A total of 120 subjects took part across the two treatments and all other procedures were identical to those of Experiment 1. At the end of each session, tokens were converted to UK pounds using the same exchange rate as in Experiment 1. Subjects were paid in cash according to a randomly selected period. Sessions lasted on average 80 minutes and subjects received an average payment of £9.82 (including a £2.50 show-up fee).

3. Results

3.1. Experiment 1: One-Shot Public Good Game

3.1.1. Summary Statistics

An overview of the aggregate results for Experiment 1 can be seen in Table 2 which presents the average contributions and beliefs across all five treatments.

Result 1: *There are no substantial overall treatment differences in contributions or beliefs (Experiment 1).*

We conduct tests for significant differences in contribution levels between treatments (a full table of test statistics is available as an appendix; we take as the unit of observation the individual subject since the game is one-shot). Contributions in the Heterogeneous Return treatment are marginally higher than the Control (Mann-Whitney Rank Sum: $p = 0.052$) and Inverse (Mann-Whitney Rank Sum: $p = 0.066$) treatments. No other differences in overall contributions are significant (Mann-Whitney Rank Sum: $p \geq 0.238$). Similarly, the overall beliefs are not significantly different between any treatments (Mann-Whitney Rank Sum: $p \geq 0.426$). This is perhaps unsurprising given that the game is one-shot and that the average type is the same in all treatments (i.e. (20, 0.5)). Therefore, there is little difference in aggregate behaviour across the five treatments. We now move on to a more detailed breakdown of the results within each treatment, parsing the results by type.

Table 2: Summary statistics for Experiment 1.			
Treatment	***n***	**Average absolute contribution**	**Average belief**
1: Control	36	4.22 (5.35)	6.67 (3.94)
2: Heterogeneous Return	66	6.27 (6.14)	6.48 (2.95)
3: Heterogeneous Endowment	72	6.09 (7.21)	6.77 (4.30)
4: Proportional	72	4.58 (5.33)	6.37 (3.37)
5: Inverse	66	5.92 (7.13)	6.99 (3.83)
All	312	5.53 (6.38)	6.65 (3.67)
Notes: Standard deviations are presented in parentheses. *n* refers to the number of observations.			

3.1.2. Within-Treatment Differences

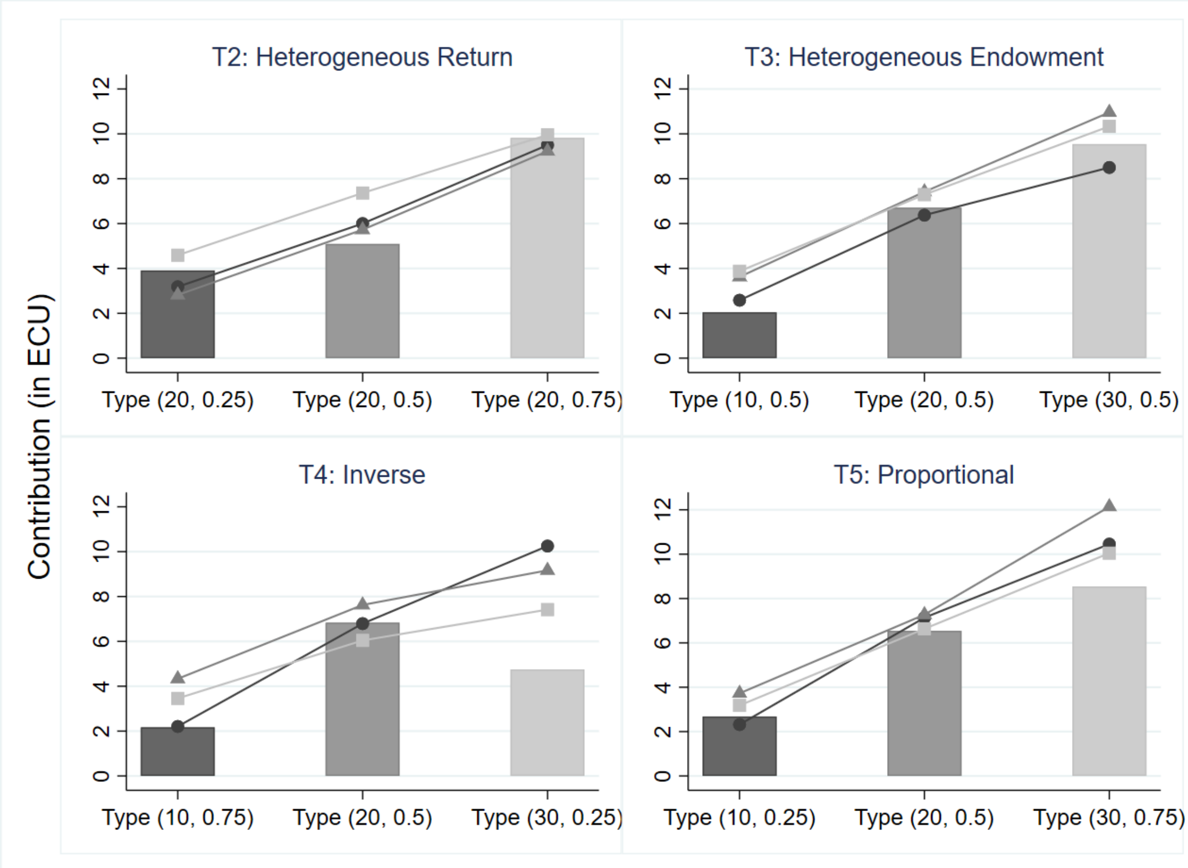
Table 3 shows the average contributions by treatment according to the subjects' types. In addition, it shows the average relative contributions as a proportion of the endowment. Further, Table 4 presents test statistics for within-treatment differences in contributions between the various types present. In both the Heterogeneous Return and the Heterogeneous Endowment treatments, contributions are (weakly) monotonically increasing in the marginal return and endowment, respectively. The effect of the marginal return in heterogeneous groups is similar to that in Reuben and Riedl (2013), though we also find a significant effect of the endowment in heterogeneous groups not reported there.

Table 3: Summary statistics for each treatment by type (Experiment 1)			
Treatment	**Type**	**Average absolute contribution**	**Average relative contributions**
Control	(20, 0.5)	4.22 (5.35)	0.21
Heterogeneous Return	(20, 0.25)	3.91 (4.89)	0.20
	(20, 0.5)	5.09 (5.90)	0.25
	(20, 0.75)	9.82 (6.12)	0.49
Heterogeneous Endowment	(10, 0.5)	2.04 (3.19)	0.20
	(20, 0.5)	6.71 (6.52)	0.34
	(30, 0.5)	9.54 (8.82)	0.32
Inverse	(10, 0.75)	2.17 (2.47)	0.22
	(20, 0.5)	6.83 (6.25)	0.34
	(30, 0,.25)	4.75 (5.58)	0.16
Proportional	(10, 0.25)	2.68 (2.95)	0.27
	(20, 0.5)	6.55 (6.48)	0.33
	(30, 0.75)	8.55 (9.39)	0.29

Similarly, in the Proportional Treatment, as both the marginal return and endowment increase together, contributions (weakly) monotonically increase. This is expected given that it is a compounding of two positive effects on contributions. Behaviour in the Inverse Treatment is however more interesting, with only the (10, 0.75) and (20, 0.5) types being significantly different. It is worth noting that the contributions as a proportion of endowment (see Table 3) are higher for the (20, 0.5) type at 0.34 than the (30, 0.25) type at 0.16. This difference is statistically significant (Mann-Whitney Rank Sum: $p = 0.027$). Therefore, in the Inverse Treatment, the 'middle class' participants contribute more (either in relative or absolute terms) than both the 'lower' and 'middle' class participants. A regression presented in an appendix finds a similar effect of the middle type being squeezed and contributing more (either as a proportion of their endowment or in absolute terms) than the other types.

Table 4: Mann-Whitney Rank Sum tests statistics (*p*-values) for within treatment differences between types (Experiment 1).					
Heterogeneous Return			**Heterogeneous Endowment**		
Type	**(20, 0.5)**	**(20, 0.75)**	**Type**	**(20, 0.5)**	**(30, 0.5)**
(20, 0.25)	0.577	0.001***	(10, 0.5)	0.007***	<0.001***
(20, 0.5)	-	0.006***	(20, 0.5)	-	0.271
Inverse			**Proportional**		
Type	(20, 0.5)	(30, 0.25)	**Type**	**(20, 0.5)**	**(30, 0.75)**
(10, 0.75)	0.002***	0.188	(10, 0.25)	0.031**	0.030**
(20, 0.5)	-	0.212	(20, 0.5)	-	0.785
Note: *** (**) (*) represents significance at the 1% (5%) (10%) level.					

Figure 1: Average absolute contributions by type and average beliefs about each type per treatment.



Notes: *Each bar represents the average contribution of the labelled type. Each line represents the beliefs by the type with the same coloured bar. E.g. the darker line in the T2 panel is the beliefs given by the (20, 0.5) type about the three types in their treatment.*

Result 2: *Within each treatment, contributions increase when the endowment, marginal return or both increase in all treatments except the Inverse Treatment (Experiment 1).*

Subjects were asked their beliefs about the average contributions of each type present. A summary of subjects' responses can be seen in Table 5. This information, in addition to the average contribution decisions, can also be seen in Figure 1. As can be seen, the beliefs are largely consistent with behaviour despite slight over-optimism. It is worth noting that for all types in all treatments, beliefs are monotonically increasing in endowment (or marginal return when endowment is homogeneous, as in the Heterogeneous Return treatment). Beliefs increase in endowment regardless of whether the marginal return co-varies positively or negatively. This difference is significant in all treatments (Wilcoxon Signed-Rank: $p \leq 0.006$ in all cases, we take the group as the unit of observation since we are implicitly comparing beliefs by the same subjects). This suggests that the endowment 'dominates' the marginal return in determining subjects' beliefs (though notably these beliefs are incorrect in the Inverse treatment for the (30, 0.25) type).

Table 5: Average beliefs by each type about each type per treatment (Experiment 1)				
Heterogeneous Return	**Beliefs about...**			
Type	**(20, 0.25)**	**(20, 0.5)**	**(20, 0.75)**	**All**
(20, 0.25)	3.18	6	9.5	6.22
(20, 0.5)	2.81	5.72	9.23	5.92
(20, 0.75)	4.59	7.36	9.95	7.30
All	3.53	6.36	9.56	
Heterogeneous Endowment	**Beliefs about...**			
Type	**(10, 0.5)**	**(20, 0.5)**	**(30, 0.5)**	**All**
(10, 0.5)	2.58	6.38	8.5	5.81
(20, 0.5)	3.63	7.42	10.96	7.33
(30, 0.5)	3.88	7.29	10.33	7.16
All	3.36	7.03	9.33	
Inverse	**Beliefs about...**			
Type	**(10, 0.75)**	**(20, 0.5)**	**(30, 0.25)**	**All**
(10, 0.75)	2.21	6.79	10.25	6.42
(20, 0.5)	4.33	7.63	9.17	7.04
(30, 0.25)	3.46	6.04	7.42	5.63
All	3.33	6.81	8.94	
Proportional	**Beliefs about...**			
Type	**(10, 0.25)**	**(20, 0.5)**	**(30, 0.75)**	**All**
(10, 0.25)	2.32	7.14	10.45	6.63
(20, 0.5)	3.73	7.27	12.14	7.71
(30 0.75)	3.18	6.64	10.05	6.62
All	3.08	7.02	10.88	

Result 3: *Overall beliefs about each type's contribution increase as that types' endowment increases, or as the marginal return increases if the endowment is homogeneous (Experiment 1).*

Interestingly, there are also some within-treatment differences in beliefs. These can be seen in Table 6. None of the types present in the Heterogeneous Return Treatment show significantly different beliefs. Similarly, in the Proportional Treatment none of the types have significantly different beliefs about any types. There are some significant differences in the Heterogeneous Endowment Treatment though; in both cases where the difference is significant, the (10, 0.5) type is being significantly more pessimistic in the sense that they expect lower contributions by the other types.

The most interesting case, however, is the Inverse Treatment. In this case, we witness a significant `crossing' effect in beliefs between the (10, 0.75) and (30, 0.25) types, such that each of these two types has higher beliefs about how much the other will contribute then how much the other thinks they are contributing themselves. This can also be seen visually in Figure 1. For example, the (10, 0.75) type believe their own type to contribute 2.21, whereas the (30, 0.25) type has beliefs of 3.46 about the (10, 0.25) type. Thus the (30, 0.25) type believes the (10, 0.75) type will contribute more than they themselves believe they would contribute. In contrast, the (30, 0.25) type has beliefs of 7.42 about their own type, whereas the (10, 0.75) type has beliefs of 10.25 about the (30, 0.25) type. Thus the (10, 0.75) type believes the (30, 0.25) type will contribute more than they themselves believe they would contribute. This difference is significant in both directions (see Table 6; Mann-Whitney Rank Sum: $p = 0.059$ and $p = 0.043$ respectively). No other treatment has this `crossing' effect in terms of beliefs between any of the types. Thus, beliefs in the Inverse Treatment appear to be self-serving. As noted in Reuben and Riedl (2013), contributions being proportional to endowment and contributions being proportional to marginal return represent significant and focal contribution rules. It is worth noting that the Inverse Treatment is the only treatment in which these two contribution rules are directly opposed, leading to tensions that are characteristic of the tensions present in the empirical evidence on the link between income and the benefits from (certain) public goods.

Table 6: Wilcoxon signed-rank tests (*p*-values) for differences for each type's beliefs about each other per treatment (Experiment 1).

Heterogeneous Return	**Beliefs about (20, 0.25)**		**Beliefs about (20, 0.5)**		**Beliefs about (20, 0.75)**	
Type	(20, 0.5)	(20, 0.75)	(20, 0.5)	(20, 0.75)	(20, 0.5)	(20, 0.75)
(20, 0.25)	0.817	0.176	0.430	0.210	0.552	0.552
(20, 0.5)	-	0.104	-	0.071*	-	0.306
Heterogeneous Endowment	**Beliefs about (10, 0.5)**		**Beliefs about (20, 0.5)**		**Beliefs about (30, 0.5)**	
Type	(20, 0.5)	(30, 0.5)	(20, 0.5)	(30, 0.5)	(20, 0.5)	(30, 0.5)
(10, 0.5)	0.146	0.052*	0.505	0.284	0.099*	0.325
(20, 0.5)	-	0.432	-	0.908	-	0.665
Inverse	**Beliefs about (10, 0.75)**		**Beliefs about (20, 0.5)**		**Beliefs about (30, 0.25)**	
Type	(20, 0.5)	(30, 0.25)	(20, 0.5)	(30, 0.25)	(20, 0.5)	(30, 0.25)
(10, 0.75)	0.006***	0.059*	0.400	0.434	0.401	0.043**
(20, 0.5)	-	0.268	-	0.202	-	0.452
Proportional	**Beliefs about (10, 0.25)**		**Beliefs about (20, 0.5)**		**Beliefs about (30, 0.75)**	
Type	(20, 0.5)	(30, 0.75)	(20, 0.5)	(30, 0.75)	(20, 0.5)	(30, 0.75)
(10, 0.25)	0.070*	0.307	0.974	0.669	0.410	0.974
(20, 0.5)	-	0.371	-	0.643	-	0.375

Note: *** (**) (*) represents significance at the 1% (5%) (10%) level.

Result 4: *Beliefs about each type by each type are largely not different except in the Inverse Treatment. In the Inverse Treatment, we witness significantly different beliefs between the (10, 0.75) and (30, 0.25) types about each other in a `self-serving' manner.*

To summarise the results of Experiment 1, whilst we find little difference in aggregate behaviour between the various treatments, we do find important and significant differences both within treatments and between treatments at the individual level (i.e. accounting for the subjects' types). To investigate both the stability and the robustness of these results, a second experiment was designed in which the two novel (Inverse and Proportional) treatments were repeated for 15 periods.

3.2. Experiment 2: Repeated Public Good Game

In this section, we provide an analysis of Experiment 2, the repeated version of Experiment 1 for the Inverse and Proportional Treatments, in a manner analogous to the analysis of Experiment 1.

3.2.1. Summary Statistics

A summary of the average absolute contributions and beliefs across all types and all periods can be seen in Table 7. The difference in average contributions across the two treatments is not significant (Mann-Whitney Rank-Sum: $p = 0.239$). Similarly, the difference in average beliefs across the two treatments is also not significant (Mann-Whitney Rank-Sum: $p = 0.342$). Figure 2 displays the average contributions and beliefs for each type across each of the 15 periods for both treatments. We turn now to more detailed analyses of within-treatment differences across types.

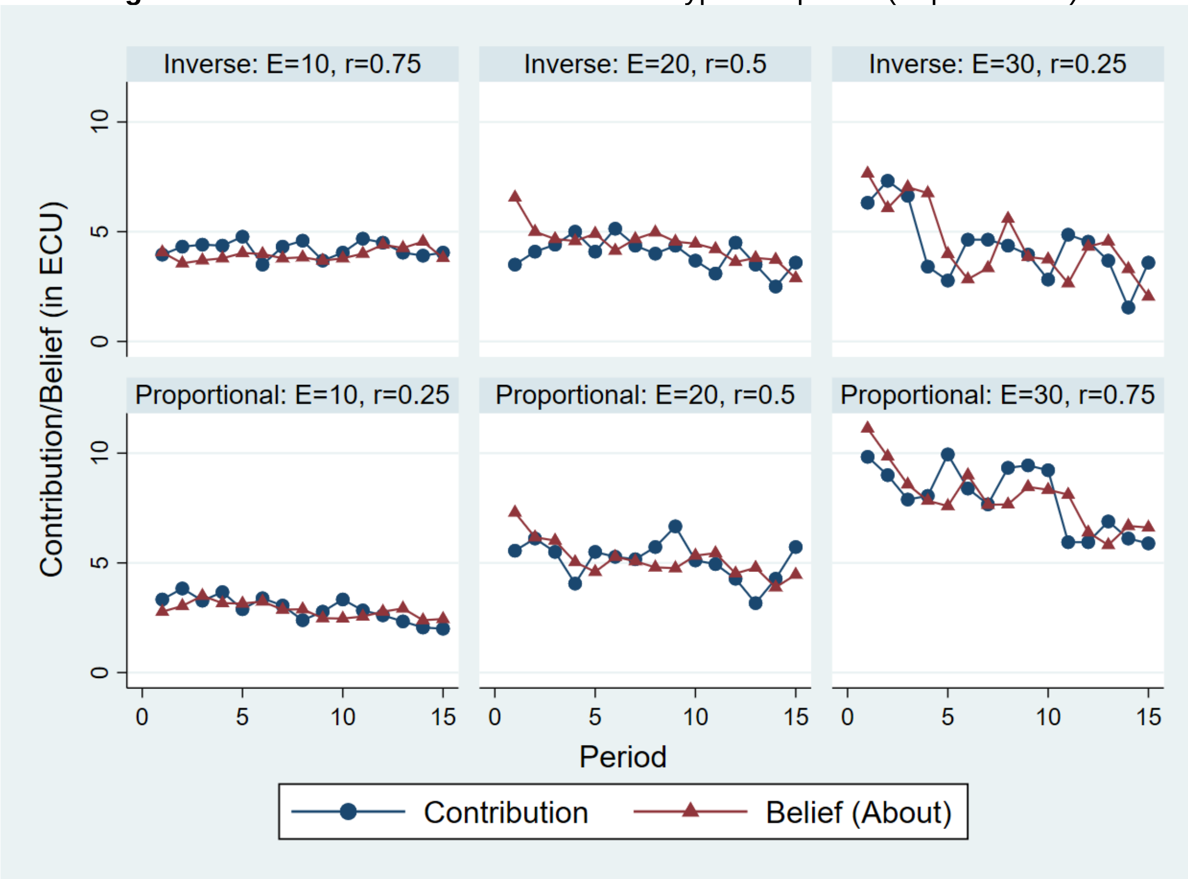
Figure 7: Summary statistics for Experiment 2

Treatment	*n*	Average absolute contributions	Average beliefs
Inverse	9	4.17 (6.05)	4.30 (3.15)
Proportional	11	5.34 (6.25)	5.33 (3.49)
All	20	4.70 (6.16)	4.77 (3.35)

Notes: Standard deviations are presented in parentheses. *n* refers to the number of observations. The unit of observation is taken as the group (6 participants x 15 rounds).

Result 5: *There are no overall differences in contributions or beliefs between the two treatments (Experiment 2).*

Figure 2: Contributions and beliefs for each type and period (Experiment 2)



3.2.2. Within-Treatment Differences

Table 8 shows average absolute contributions and relative contributions as a proportion of the endowment within each treatment, according to the subjects' type. There is no significant difference in contributions between any of the types present in the Inverse Repeated Treatment (Wilcoxon Signed-Rank: $p \geq 0.722$ in all cases). In the Proportional Repeated Treatment, the (10, 0.25) type contributes significantly less than both the (20, 0.5) and (30, 0.75) types (Wilcoxon Signed-Rank: $p = 0.066$ and $p = 0.015$ respectively). The (20, 0.5) and (30, 0.75) types are not significantly different (Wilcoxon Signed-Rank: $p = 0.110$). This mirrors exactly the pattern found in the one-shot Proportional Treatment.

Table 8: Summary statistics for each treatment by type (Experiment 2)

Treatment	Type	Average absolute contribution…	Average relative contributions
Inverse	(10, 0.75)	4.21 (4.06)	0.42
	(20, 0.5)	3.99 (5.34)	0.20
	(30, 0.25)	4.34 (8.04)	0.14
Repeated	(10, 0.25)	2.91 (3.71)	0.29
	(20, 0.5)	5.14 (5.21)	0.26
	(30, 0.75)	7.97 (7.98)	0.27

Note: Standard deviations in parentheses.

It is worth noting that whilst the actual contributions are not significantly different between any of the types in the Inverse Repeated Treatment, the (10, 0.75) type contributes significantly more as a proportion of the endowment, compared to both the (20, 0.5) and (30, 0.25) types

(Wilcoxon Signed-Rank: $p = 0.004$ and $p = 0.013$ respectively). On the other hand, the average contributions as a proportion of the endowment are not significantly different between any of the types in the Proportional Treatment (Wilcoxon Signed-Rank: $p \geq 0.679$), despite significant differences in absolute contributions. This may be due to the establishment of differing fairness norms between the two treatments (for example, equity of absolute contributions in the Inverse Treatment and equity of contributions as a proportion of endowment in the Proportional Treatment).

Result 6: *There are no significant differences in absolute contributions between the types in the Inverse Treatment. In the Proportional Treatment, the type with low endowment and low marginal return contributes significantly less in absolute terms than the other types.*

We now look at overall beliefs between types. Only the difference between the (10, 0.75) and (20, 0.5) types in the Inverse Repeated Treatment is significant (Wilcoxon Signed-Rank: $p = 0.075$). No other differences in overall beliefs are significant ($p \geq 0.168$ in all cases, see the Appendix). This is mostly consistent with the one-shot experiment and the fact that the average type is (20, 0.5) in both treatments.

Table 9: Beliefs by each type about each type per treatment (Experiment 2)

Inverse	**Beliefs about...**			
Type	**(10, 0.75)**	**(20, 0.5)**	**(30, 0.25)**	**All**
(10, 0.75)	3.95	4.80	4.79	4.51
(20, 0.5)	3.98	3.85	4.55	4.12
(30, 0.25)	3.91	4.70	4.21	4.27
All	3.94	4.45	4.52	
Proportional	**Beliefs about...**			
Type	**(10, 0.25)**	**(20, 0.5)**	**(30, 0.75)**	**All**
(10, 0.25)	2.69	5.33	8.19	5.40
(20, 0.5)	2.81	5.15	8.54	5.50
(30 0.75)	3.03	5.01	7.21	5.08
All	2.84	5.16	7.98	

Once again, subjects were asked their beliefs about the average contributions of each type present. A summary of subjects' responses is given in Table 9. As can be seen, there is very little difference in beliefs about each of the types in the Inverse Treatment (Wilcoxon Signed-Rank: $p \geq 0.328$ for 7 of the 9 tests). The only significant differences are between the beliefs about the (10, 0.75) and (20, 0.5) types. On the other hand, all but one of the differences are significant in the Proportional Treatment, showing that beliefs increase as both the endowment and marginal return increases (Wilcoxon Signed-Rank: $p \leq 0.038$ for 8 of the 9 tests).

Result 7: *Overall beliefs about each type are largely not different in the Inverse Repeated Treatment. Overall beliefs about each type increase in that types' endowment (and marginal return) in the Proportional Repeated Treatment.*

There are few significant differences between any of the types in terms of their beliefs about the other types in either treatment. Interestingly, in the Inverse Repeated Treatment, both the (10, 0.75) and (30, 0.25) have significantly higher beliefs about the (20, 0.5) than the (20, 0.5) have about their own type (Wilcoxon Signed-Rank: $p = 0.026$ and $p = 0.041$, respectively). Notably, the `crossing' effect that was seen in the one-shot Inverse Treatment (and was attributed to `self-serving beliefs') is no longer present (Wilcoxon Signed-Rank: $p \geq 0.248$ in all other cases in the Inverse Repeated Treatment). In the Proportional Repeated Treatment, only one difference is (weakly) significant; the beliefs of the (20, 0.5) and (30, 0.75) types about the (10, 0.25) type (Wilcoxon Signed-Rank: $p = 0.066$). No other differences are significant (Wilcoxon Signed-Rank: $p \geq 0.110$ in all cases).

In the Proportional Repeated Treatment, only 12.35% (100/810) of subjects believe the (30, 0.75) type will contribute less than the (10, 0.25) endowment type. By contrast, in the Inverse Repeated Treatment 41.11% (407/990) of subjects believe the (30, 0.25) type will contribute less than the (10, 0.75) type. Similarly, in the Inverse Repeated Treatment, 9.49% (94/990) believe contributions will be equal whereas in the Proportional Repeated Treatment this is only 3.46% (28/810). This lends support to the suggestion that the Inverse and Proportional Repeated Treatments feature different focal points - the equality of absolute versus relative contributions. As was noted before, the Inverse Treatment features a conflict between contributions that are proportional to endowment and contributions that are proportional to marginal return. In this case, it may be that subjects use an equality of contributions rule previously identified in Reuben and Riedl (2013).

To summarise Experiment 2, the Inverse and Proportional Treatments from Experiment 1 were repeated for 15 periods. Whilst in the Inverse Repeated Treatment absolute contributions are the same for all types, in the Proportional Repeated Treatment relative contributions are not different between the various types. Subjects' beliefs across the two treatments are also consistent with this observation. We now move on to assess the welfare implications of the voluntary contribution mechanisms under our various treatment conditions.

4. Inequality, Welfare and Income (Re-)Distribution

In this subsection, we consider the distributional impacts of the voluntary contribution mechanism under our treatment conditions and the differing initial income distributions. To do this, following Gächter *et al.* (2017), we calculate the ex-ante Gini coefficient for each treatment and compare it with the Gini coefficient of the ex-post income distribution. This enables us to see whether the voluntary contribution mechanism has a positive or negative effect on inequality in terms of income (re-)distribution, at least as measured by the Gini coefficient.

We first consider the average ex-post income for each type within each treatment. This information can be seen in Table 10, which shows the ex-ante endowment, the ex-post income and the percentage difference. In all cases, the average ex-post income is higher than the ex-ante endowment such that all types in all treatments benefit from the mechanism on average. In all but the Heterogeneous Return and Proportional Treatments, the types with the lowest endowment experience the greatest percentage increase between their initial endowment and final income.

In the Heterogeneous Return Treatment, the percentage increase in ex-post income compared to ex-ante endowment increases with the marginal return. This is due the nature of the voluntary contribution mechanism (recall that the (20, 0.75) types have significantly higher contributions but still experience the largest percentage increase in income). By contrast, in the Heterogeneous Endowment Treatment, the increase in income is decreasing in the endowment. Since all subjects have the same marginal return, this is again consistent with the observed contributions.

With regards to the Inverse and Proportional Treatments, the first thing to note is the similarity between the one-shot and repeated treatments. In both the Inverse and Inverse Repeated treatments, the percentage increase in income is decreasing in endowment (and thus increasing in marginal return). The Proportional and Proportional Repeated Treatments, however, have similar increases in the percentage increase in income for all the types. This is once again consistent with the observed behaviour. In the Proportional Treatments, contributions as a proportion of endowment are not significantly different and thus the percentage increase in income is not different. In the Inverse Treatments, since contributions are not significantly different the types with the lowest endowments receive the biggest percentage increase as a proportion of their original income. This is further compounded by the lowest endowment types having the highest marginal return.

Table 10: Ex-ante endowment, ex-post income and % increase for each type (Experiment 1 and 2)

Treatment	Type	Ex-Ante	Ex-Post	% Increase
Control	(20, 0.5)	20	28.44	42.20
Heterogeneous Return	(20, 0.25)	20	25.50	27.50
	(20, 0.5)	20	33.73	68.65
	(20, 0.75)	20	38.40	92.00
Heterogeneous Endowment	(10, 0.5)	10	26.25	162.50
	(20, 0.5)	20	31.58	57.90
	(30, 0.5)	30	38.75	29.17
Inverse (One-Shot)	(10, 0.75)	10	28.46	184.60
	(20, 0.5)	20	26.91	34.55
	(30, 0,.25)	30	32.13	7.10
Proportional (One-Shot)	(10, 0.25)	10	16.20	62.00
	(20, 0.5)	20	31.23	56.15
	(30, 0.75)	30	48.11	60.37
Inverse (Repeated)	(10, 0.75)	10	24.59	145.90
	(20, 0.5)	20	28.54	42.70
	(30, 0,.25)	30	31.92	6.40
Proportional (Repeated)	(10, 0.25)	10	15.09	50.90
	(20, 0.5)	20	30.89	54.45
	(30, 0.75)	30	46.06	53.53

Table 11 shows for each treatment both the ex-ante and ex-post Gini coefficient calculated using the ex-ante endowment and ex-post income distribution, as appropriate. Both the Control and Heterogeneous Return Treatments have an initial Gini coefficient of 0 since all subjects have the same endowment. In both cases the voluntary contribution mechanism is therefore inequality increasing. In all other treatments, the initial Gini coefficient is 0.22. Of these, all treatments except the Proportional Treatments have a positive effect on inequality as interpreted by a reduced Gini coefficient (i.e. it reduces the level of inequality). The Proportional Treatments leave the Gini coefficient at largely the same level, which is entirely consistent with all types having similar percentage increase in income due to the nature of the Gini coefficient calculation.

Table 11: Inequality and efficiency measures (Experiment 1 and 2)			
Treatment	**Ex-Ante Gini**	**Ex-Post Gini**	**Efficiency (%)**
Control	0	0.074	21.11
Heterogeneous Endowment	0	0.107	31.36
Heterogeneous Return	0.222	0.132	30.48
Inverse (One-Shot)	0.222	0.111	22.92
Proportional (One-Shot)	0.222	0.245	29.61
Inverse (Repeated)	0.222	0.136	20.89
Proportional (Repeated)	0.222	0.238	26.71

Notes: The ex-ante Gini coefficient is calculated using the initial endowments. The ex-post Gini coefficient is calculated using the final income distribution (in ECUs). Efficiency is calculated as the percentage of maximum possible ECUs (120) contributed to the project, equivalent to the percentage of maximum possible gains realised.

Figure 3: Gini coefficients and 95% confidence intervals per treatment (Experiment 1)

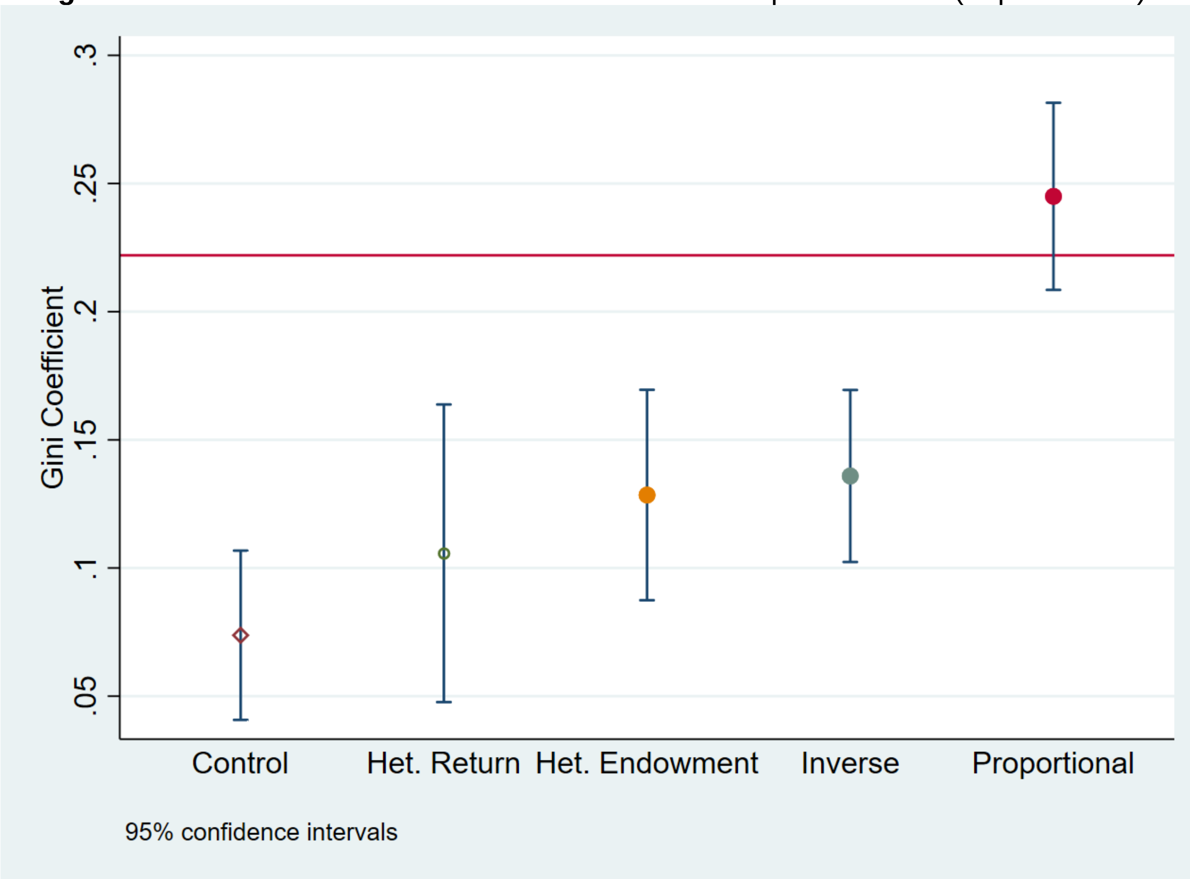
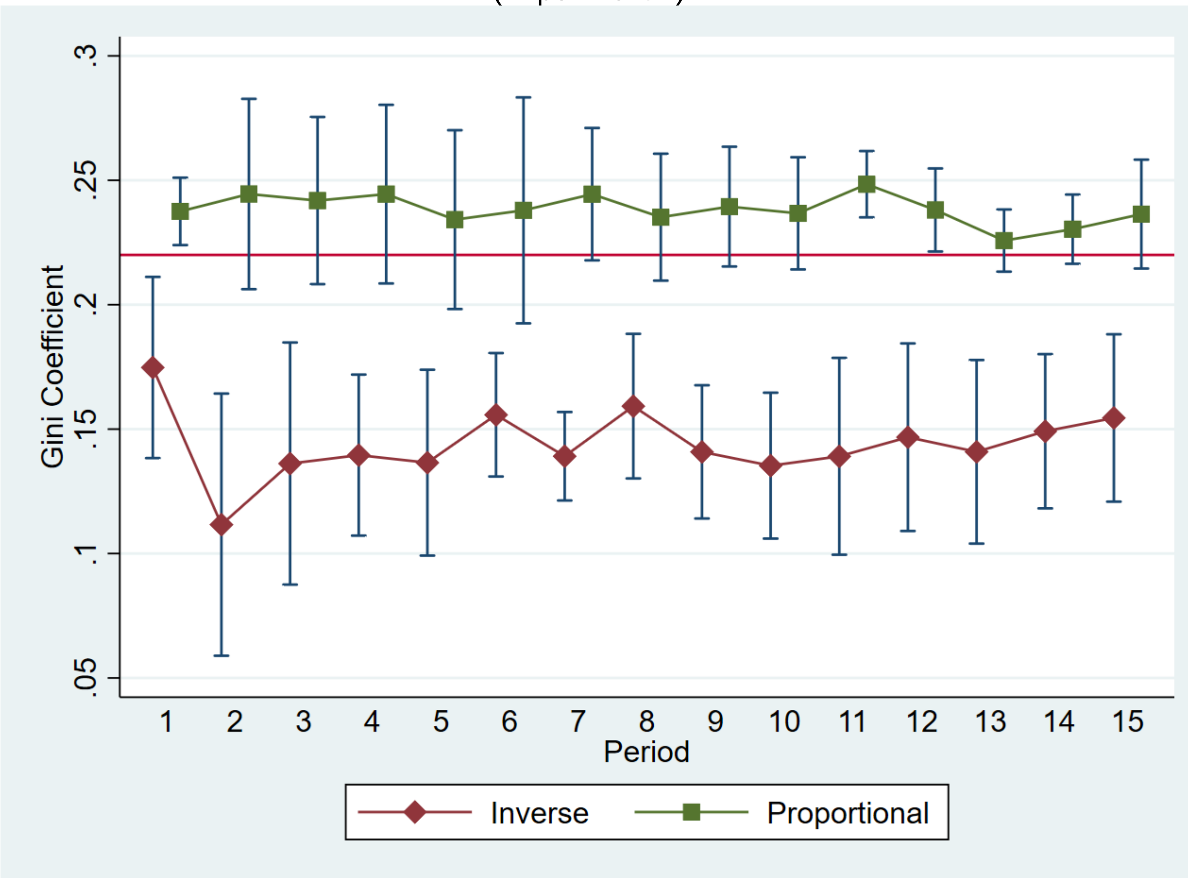


Figure 3 displays the 95% confidence intervals for the Gini coefficient for each of the one-shot treatments (i.e. Experiment 1). As above, the Control and Heterogeneous Return Treatments feature an increase in Gini since the initial Gini was 0. As can also be seen, the Gini coefficient in the Proportional Treatment is not significantly different from the initial value of 0.22. In both the Heterogeneous Endowment and Inverse Treatment the Gini is significantly reduced from the initial value of 0.22. Similarly, Figure 4 displays the 95% confidence intervals for the repeated treatments (i.e. Experiment 2) on a per period basis. The 95% confidence intervals do not overlap for any of the 15 periods. As in Experiment 1, the Proportional Repeated Treatment results in no change in the Gini coefficient from the initial value in any of the 15 periods. By contrast, in the Inverse Repeated Treatment the Gini is significantly reduced in every single period. Thus, whilst the Inverse Treatment features a significant reduction from the initial inequality, the Proportional Treatment leaves this initial inequality the same.

Figure 4: Average Gini coefficient and 95% confidence interval per period per treatment (Experiment 2)



Result 8: *The Inverse and Inverse Repeated Treatments lead to a significant reduction in the ex-post Gini coefficient. The Proportional and Proportional Repeated Treatments have no effect on the ex-post Gini coefficient.*

To summarise, the Control and Heterogeneous Return Treatments lead to an increase in the Gini since they initially have perfect equality. The Heterogeneous Endowment, Inverse and Inverse Repeated Treatments all lead to a significant reduction in inequality as measured by the Gini coefficient. The Proportional and Proportional Repeated Treatments, however, have neither a positive nor a negative effect on the level of inequality.

5. Conclusion

We present the results of two experiments both featuring a voluntary contribution mechanism with heterogeneous groups. Experiment 1 was one-shot and featured four heterogeneous treatment conditions: Heterogeneous Return, Heterogeneous Endowment, Inverse and

Proportional. In the Inverse Treatment, the marginal return and endowment are both heterogeneous and inversely related. In the Proportional Treatment, they are proportionally related. To our knowledge, these are the first experimental results featuring an Inverse or Proportional relationship between the marginal return and the endowment.

Whilst we find no significant differences at the aggregate level, there are significant differences within treatments. We add to the varied literature concerning the effect of income heterogeneity with the Heterogeneous Endowment Treatment, which shows no overall increase in contributions, though contributions do increase with endowment. In the Heterogeneous Return Treatment, we find a (weak) overall increase in contributions and that contributions increase in the marginal return. In the Proportional Treatment, we find that contributions increase as the marginal return and endowment both increase. In the Inverse Treatment, there appears to be a 'squeezing' of the 'middle class' participants, who contribute more (in either absolute or relative terms) than other ('lower' or 'upper class') participants that is consistent with real world observations regarding a 'squeezed middle' across OECD countries (OECD, 2019).

In Experiment 2, the Inverse and Proportional Treatments were repeated for 15 periods. We find that in the Inverse Repeated Treatment, there are no significant differences in absolute contributions, though contributions as a proportion of the endowment decrease as the endowment increases. By contrast, in the Proportional Repeated Treatment, absolute contributions increase as the endowment and marginal return increase and the contributions as a proportion of the endowment are not significantly different.

We also analyse the impact the voluntary contribution mechanism has on the level of inequality by considering the Gini coefficient. Treatments with a homogeneous endowment (i.e. the Control and Heterogeneous Return Treatments) necessarily lead to an increase in inequality since they start with perfect equality. The Heterogeneous Endowment treatment and both Inverse Treatments lead to a reduction in inequality whereas both Proportional Treatments have no effect on inequality at all.

In the Inverse and Inverse Repeated Treatments, two normatively appealing contribution rules are directly opposed - proportional to endowment and proportional to marginal return - since the endowment and marginal return are inversely related. It seems that subjects in this case default to another normatively appealing contribution rule - equality of absolute contributions. On the other hand, these two contribution rules are exactly the same in the Proportional and Proportional Repeated Treatments since they are proportionally related and therefore there is no conflict between them. Our research suggests that the effect of heterogeneities in both the marginal return and endowment may have significant effects on behaviour in the simplest form of the voluntary contribution mechanism. These results are robust across both one-shot and repeated settings.

The voluntary contribution mechanism has consistently proved to be a rich vein of research for an extended period. The current paper contributes to this literature by presenting the first experimental results of heterogeneous groups that vary by both the endowment and marginal return. This opens new avenues for future research into the potentially differential effect of, for examples, pre-play communication or punishment opportunities under inverse or proportional structuring between the endowment and marginal return.

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Appendix A: Experimental Instructions (Inverse Repeated treatment)

Instructions

Welcome! You are about to take part in a decision-making experiment. This experiment is run by the "Birmingham Experimental Economics Laboratory" and has been financed by various research foundations. Just for showing up you have already earned £2.50. You can earn additional money depending on the decisions made by you and other participants. It is therefore very important that you read these instructions with care.

It is important that you remain silent and do not look at other people's work. If you have any questions, or need assistance of any kind, please raise your hand and an experimenter will come to you. If you talk, laugh, exclaim out loud, etc., you will be asked to leave and you will not be paid. We expect and appreciate your following of these rules.

We will first jointly go over the instructions. After we have read the instructions, you will have time to ask clarifying questions. We would like to stress that any choices you make in this experiment are entirely anonymous. Please do not touch the computer or its mouse until you are instructed to do so. Thank you.

The experiment will consist of 15 periods. Each period will consist of 2 parts, detailed below. At the end of the experiment, the computer will randomly select 1 period that will be used to determine your payment from the experiment.

In the instructions, unless otherwise stated, we will not speak in terms of Pounds, but in terms of Experimental Currency Units (ECUs). Your entire earnings will, thus, be calculated in ECUs. At the end of the session the total amount of ECUs you have earned in the randomly selected period will be converted to Pounds at the following rate: **1 ECU = 0.20 Pounds**. The converted amount will privately be paid to you in cash.

Detailed Information about the Experiment

The experiment consists of two parts. The total amount you will earn from the experiment will be the sum of the earnings you make in the two parts of the experiment as specified in the instructions below.

Part 1

At the beginning of Part 1, participants are divided into groups of six. This group will remain the same throughout the entire experiment. You will therefore be in a group with 5 other participants. At no point during the experiment, nor afterwards will you be informed about the identity of the other participants in your group and the other participants will never be informed about your identity.

In Part 1, each of you receives a number of tokens. We call this your endowment. In addition to receiving an endowment, each of you receives a number between 0 and 1. We call this your return from project. How the return from project affects your earnings will be made clear below.

There are three possible combinations of endowment and return from project as follows;

- Endowment = 10 tokens, Return from project = 0.75
- Endowment = 20 tokens, Return from project = 0.5
- Endowment = 30 tokens, Return from project = 0.25

Within each group, exactly 2 participants will be given each of the three possible combinations of the endowment and return from project. This means that in each group, 2 participants will have an endowment of 10 tokens and a return from project of 0.25, 2 participants will have an endowment of 20 tokens and a return from project of 0.5 and 2 participants will have an endowment of 30 tokens and a return from project of 0.75. The allocation of these combinations of endowment and return from project within the group is random. Your combination of endowment and return from project will remain the same throughout the entire experiment.

Your task is to decide how to use your endowment. You have to decide how many of the tokens you want to contribute to a project and how many of them to keep for yourself. The five other members of your group have to make the same decision.

Every token that you do not contribute to the project automatically belongs to you and earns you one ECU.

Every token that you do contribute to the project will earn each group member (including yourself) their respective return from project in ECU.

Your income therefore consists of:

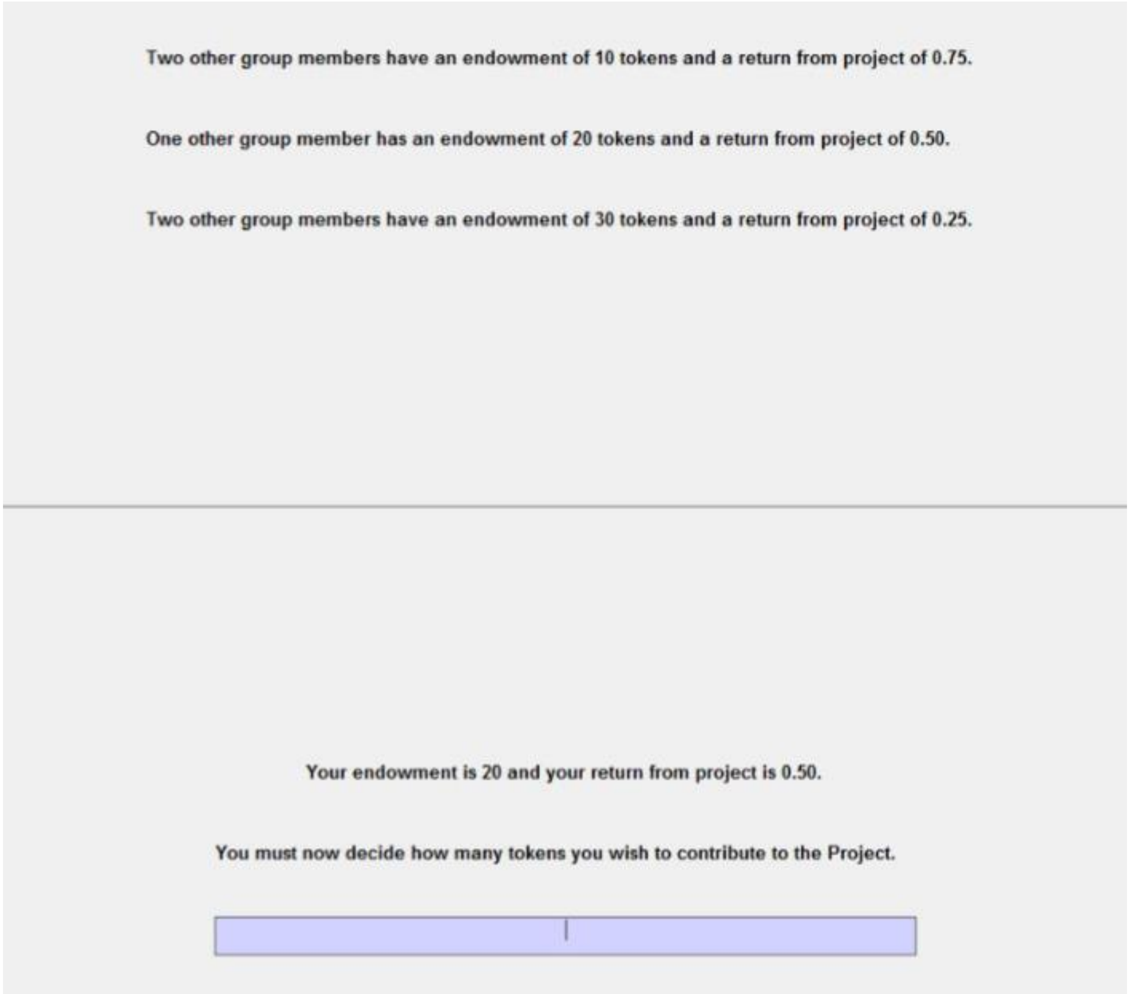
(1) The tokens which you have kept for yourself ("Income from retained tokens") whereby 1 token = 1 ECU.

(2) The "Income from the project". This income is calculated as follows:

Your income from the project = your return from project *times* the total contributions to the project.

Your Part 1 income in ECUs is:
(*Your Endowment* – tokens contributed to the project by you) + *Your Return from project(sum of all tokens contributed to the project by all members of your group)**

When making your decision, the following input-screen will appear:



At the top of the screen, you will be informed of the endowment and return from project of the other members of your group. (The example used above is only for illustrative purposes). You have to decide how many tokens you contribute to the project by typing a number between 0 and *your endowment* in the input field. This field can be reached by clicking it with the mouse. By deciding how many tokens to contribute to the project, you automatically decide how many tokens you keep for yourself. After entering the amount of tokens you contribute you must press the O.K. button using the mouse. Once you have done this, your decision can no longer be revised.

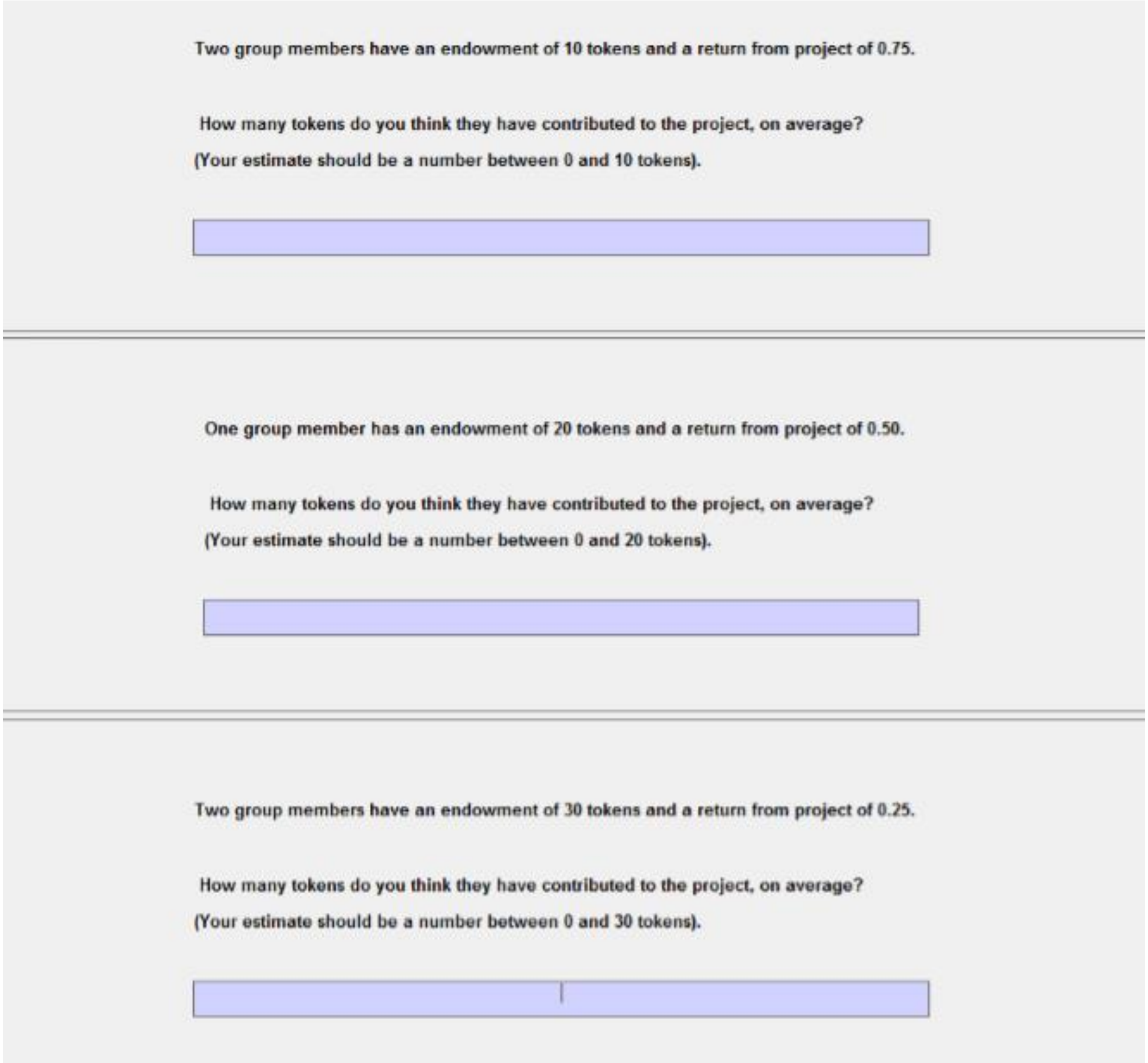
Part 2

In Part 2 of the experiment, you will be asked to estimate for each of the three possible combinations of endowment and return from project the average contribution to the project within your group. You will therefore be required to make three decisions. Note that when estimating the average contribution for your combination of the endowment and return from project, you should estimate the contribution of the other participant with the same combination as you.

You will be paid according to how close your estimate is to the actual average contribution for that particular combination of endowment and return from project. You will be paid £1 for each estimate that is within 0.5 tokens of the actual average contribution value in either direction. You will be paid £0.60 for each estimate between 0.5 and 1.5 tokens from the actual average contribution value in either direction. You will be paid £0.30 for each estimate between 1.5 and 3.5 tokens from the actual average contribution value in either direction. You will receive no additional payment for estimates further than 3.5 tokens from the actual average contribution value.

Your Part 2 earnings are therefore the sum of your earnings for each of three estimates.

When making your decision, the following input-screen will appear:


Two group members have an endowment of 10 tokens and a return from project of 0.75.

How many tokens do you think they have contributed to the project, on average?
(Your estimate should be a number between 0 and 10 tokens).

One group member has an endowment of 20 tokens and a return from project of 0.50.

How many tokens do you think they have contributed to the project, on average?
(Your estimate should be a number between 0 and 20 tokens).

Two group members have an endowment of 30 tokens and a return from project of 0.25.

How many tokens do you think they have contributed to the project, on average?
(Your estimate should be a number between 0 and 30 tokens).

At the top of the screen, you will be reminded of your endowment and return from project. In the remaining three boxes you will see each of the three possible combinations of endowment and return from project. (The example used above is only for illustrative purposes). In all three boxes, you must estimate the average contribution of the other members of your group with that particular combination of endowment and return from project. To input your estimate you must type a number between 0 and the endowment for that particular estimate. For example, when estimating the average contribution for those with endowment of 10 tokens and return from project of 0.25, you must enter a number between 0 and 10. As another example, when estimating the average contribution for those with endowment of 30 and return from project of 0.75, you must enter a number between 0 and 30.

Your total earnings for the experiment are therefore equal to your Part 1 earnings converted into £ at the above rate plus your Part 2 earnings, in addition to the show up fee.

Do you have any questions? Please raise your hand and an experimenter will come to your desk. Please do not ask any question out loud.

To ensure everybody understands, each of you will need to answer a few control questions, which you can find in the next page.

Control Questionnaire

Please complete the questions below. In a couple of minutes someone will come to your desk to check your answers. Once everybody answers the following questions correctly, the experiment will start. (The decisions and earnings used for the questions below are simply for illustrative purposes. In the experiment decisions and earnings will depend on the actual choices of the participants.).

1. Suppose you have an endowment of 20 and a return from project of 0.5 Suppose that nobody (including yourself) contributes any token to the project. What is:

Your income ?...........

The income of the other group members with endowment of 10 tokens?...........

The income of the other group member with endowment of 20 tokens?...........

The income of the other group members with endowment of 30 tokens?...........

2. Please complete the following table:

Endowment	Return from Project	Contribution to Project	Income from Retained Tokens	Income from the Project	Total Income
10	0.75	0			
10	0.75	4			
20	0.5	1			
20	0.5	12			
30	0.25	8			
30	0.25	15			
Total Contributed to Project:					

3. Suppose the average contribution for a particular combination of endowment and return from project was 15.5. Suppose you estimate the average will be 13, another group member estimates 10, another group member estimates 12 and another group member estimates 16. What is the payment for this particular estimate for:

You?...........

The group member with estimate 10?...........

The group member with estimate 12?...........

The group member with estimate 16?...........

4. Will your group change or remain the same during the experiment? …………….

5. How many periods will be relevant in determining your payment from the experiment? ………

Appendix B: Additional Statistics and Testing

Table A1: Test statistics for between treatment differences in contributions (Experiment 1)

	Heterogeneous Endowment	Heterogeneous Return	Inverse	Proportional
Control	0.052*	0.238	0.677	0.261
Heterogeneous Endowment	-	0.398	0.066*	0.358
Heterogeneous Return	-	-	0.380	0.933
Inverse	-	-	-	0.386

Note: The test is Wilcoxon rank-sum test. The figures presented are p-values.

Table A2: Test statistics for between treatment differences in overall beliefs (Experiment 1)

	Heterogeneous Endowment	Heterogeneous Return	Inverse	Proportional
Control	0.726	0.863	0.611	0.858
Heterogeneous Endowment	-	0.942	0.893	0.574
Heterogeneous Return	-	-	0.818	0.588
Inverse	-	-	-	0.426

Note: The test is Wilcoxon rank-sum test. The figures presented are p-values.

Table A3: Wilcoxon signed-rank test z-statistics for within-treatment differences in contributions (Experiment 2)

Inverse				**Proportional**		
	(20, 0.5)	**(30, 0.25)**			**(20, 0.5)**	**(30, 0.75)**
(10, 0.75)	0.859	0.722		**(10, 0.25)**	0.067*	0.015**
(20, 0.5)	-	0.722		**(20, 0.5)**	-	0.110

Table A4: Wilcoxon signed-rank test z-statistics for within-treatment differences in overall beliefs (Experiment 2)

Inverse				**Proportional**		
	(20, 0.5)	**(30, 0.25)**			**(20, 0.5)**	**(30, 0.75)**
(10, 0.75)	0.075*	0.168		**(10, 0.25)**	0.594	0.374
(20, 0.5)	-	0.248		**(20, 0.5)**	-	0.441

Table A5: Wilcoxon signed-rank z-statistics for within-treatment differences in beliefs about each type, by each type (Experiment 2)			
Inverse	**Beliefs About**		
Type	**(10, 0.75) – (20, 0.5)**	**(20, 0.5) – (30, 0.25)**	**(10, 0.75) – (30, 0.25)**
(10, 0.75)	0.062*	0.790	0.328
(20, 0.5)	0.722	0.534	0.534
(30 0.25)	0.033**	0.722	1.000
Proportional	**Beliefs About**		
Type	**(10, 0.25) – (20, 0.5)**	**(20, 0.5) – (30, 0.75)**	**(10, 0.25) – (30, 0.75)**
(10, 0.25)	0.021**	0.028**	0.011**
(20, 0.5)	0.038**	0.015**	0.011**
(30 0.75)	0.021**	0.139	0.033**

Table A6: Wilcoxon signed-rank z statistics for within-treatment differences in beliefs about each type, by each type (Experiment 2)						
Inverse	**Beliefs About**					
	(10, 0.75)		**(20, 0.5)**		**(30, 0.25)**	
Type	(20, 0.5)	(30, 0.25)	(20, 0.5)	(30, 0.25)	(20, 0.5)	(30, 0.25)
(10, 0.75)	0.006***	0.059*	0.400	0.434	0.401	0.043**
(20, 0.5)	-	0.268	-	0.202	-	0.452
Proportional	**Beliefs About**					
	(10, 0.25)		**(20, 0.5)**		**(30, 0.25)**	
Type	(20, 0.5)	(30, 0.75)	(20, 0.5)	(30, 0.75)	(20, 0.5)	(30, 0.75)
(10, 0.25)	0.070*	0.307	0.974	0.669	0.410	0.974
(20, 0.5)	-	0.371	-	0.643	-	0.375

Table A7: Regression analysis for Treatment 4 contributions and proportional contributions (Experiment 1)		
Dependent Variable	**Contribution (Tobit)**	**Proportional Contribution (OLS)**
Dummy (Endowment = 10)	-3.848*** (0.000)	-0.106 (0.152)
Dummy (Endowment = 30)	-0.528 (0.609)	-0.137* (0.071)
Expected contribution	0.982*** (0.000)	0.059*** (0.000)
Constant	-0.656 (0.561)	-0.145* (0.098)
R^2	0.587	0.559
N	72	