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Preface

Social dilemma situations in which collective interests are at odds with private interests are quite ubiquitous in many instances of daily life. Examples range from global issues such as resource depletion, overpopulation, international security and climate protection, to localized issues like teamwork, the private provision of public goods. In these dilemmas, the decision makers have to decide how much effort or time they contribute to the collective actions. If decision makers are rational and selfish, they would have an incentive to free ride on other fellow members' contributions, since they have a chance to enjoy the achievements of the collective actions irrespective of their own investment. However, without enough cooperation, the goal of the collective actions will not be achieved, which sometimes is revealed in the long run. Therefore, it is important to study people's cooperative behavior and explore effective mechanisms to promote cooperation in social dilemmas.

This dissertation consists of three chapters that examine the cooperation in social dilemma situations via laboratory experiments. The first chapter studies the effect of electoral delegation on providing global public goods shared by several groups. The second chapter examines the influence of heterogenous benefits on the effectiveness of leadership in promoting cooperation. The third chapter explores how cooperation and coordination within a group are affected when the group competes with a single individual with equal or less strength.

Chapter 1, which is joint work with Martin Kocher and Fangfang Tan, addresses the effects of electoral delegation in global public goods provision, with a focus on the strategic interactions between voters and the elected delegates. In real life, global public goods are often governed through a delegated institution whose officials (representatives) are elected or appointed by national (or regional) provision collectives. Consider for example the European Union in which each country has a representative who makes decisions on global public goods contributions (e.g., the national contribution to European battle groups) on behalf of the voters in the country she represents. The decisions of all representatives of all EU countries determine the total contributions at the EU level. Is electoral delegation an effective mechanism in sustaining efficient provision levels of a global public good?

To answer this question, we implement two laboratory treatments in a repeated linear public goods setting: one with delegates (*Delegation*) and one without delegates (*Baseline*). In *Baseline*, players in each of the three groups have to make simultaneous and independent decisions about how much to contribute to a global public good. In *Delegation*, groups need to elect a delegate who makes a binding decision for the contributions of each group member. Elections take place every three periods. Based on selfish preference, we predict that in *Baseline*, players will contribute nothing into global public goods; whereas in *Delegation*, all delegates fully exploit their fellow group members, which leads to a high and stable inter-group cooperation level over time.

Our experimental results of *Baseline* are by and large in line with theoretical predictions based on standard preferences. Without delegation, cooperation quickly declines to low levels in the finitely repeated game. Compared to *Baseline*, both contributions and earnings are significantly higher in *Delegation*. However, this is not caused by delegates fully exploiting other group members. In fact, driven either by genuine other-regarding preferences or an opportunistic re-election (reputation) motive, the elected delegates mostly assign equal contributions to the three group members. We observe that the actual contribution levels in Delegation are significantly below the theoretical benchmark with self-regarding preferences, and they steadily decline over time. This is because delegates who over-contribute compared to other delegates in the society are less likely to be re-elected. Our results imply that the delegation mechanism effectively prevents voters to be massively exploited by the delegates, but could not sufficiently solve the inter-group social dilemma. We claim that the reason lies in the heterogeneity in cooperative attitudes across groups, combined with a strong motive among voters for equal contributions within the group.

Chapter 2 aims to explore whether the mechanism of leading by example functions in promoting public goods provision when group members are gaining heterogeneous benefits from public goods. A large number of economics experiments have found that a simple form of leadership - leading by example - could induce more contributions and welfares than without this mechanism in social dilemmas (e.g. Dannenberg, 2015; Güth et al., 2007; Haigner & Wakolbinger, 2010; Moxnes & Van der Heijden, 2003; Pogrebna et al., 2011; Rivas & Sutter, 2011). In those studies, group members are homogeneous with respect to their benefits from the collective action. In reality, however, people may differ in the benefits they could achieve from the common goal of the group. For example, in teamwork, some team members might benefit more from the project compared to others. Will the positive effect of leading by example still prevail in this environment?

In a repeated linear public goods setting, the marginal per capita returns from the public goods are different among players such that there are two high- and two low-benefit members within a group. Parameters are set such that contributing nothing is the dominant strategy for both high- and low-benefit members. In total, I implement four laboratory treatments: one baseline treatment in which all group members contribute simultaneously and independently; two exogenous leadership treatments in which either a high- or low-benefit member is randomly assigned to be the leader; one endogenous leadership treatment in which group members choose by themselves whether they want to be the leader or not. To look at if people cooperate conditionally and how they reciprocate, I elicit subjects' beliefs about others' contributions.

The results show no significant differences in cooperation between the baseline treatment and any leadership treatment. When leaders are assigned exogenously, the type of the leader does not significantly affect the cooperation level either. In the endogenous leadership treatment, high-benefit members are more willing to be the leader than low-benefit members. Compared to the baseline treatment, the cooperation level is significantly higher with a volunteer low-benefit leader and is significantly lower when nobody within the group chooses to be the leader. Overall, we find no significant difference in cooperation between the endogenous leadership treatment and the baseline treatment.

In the process of analyzing the behavior of leaders and followers, we find that in each leadership treatment and situation, leaders do increase contributions significantly compared to their counterparts in the baseline treatment; followers, however, do not increase contributions much. Although the follower who is of the same type as the leader emulates the leader to some extent, they exploit the leader by contributing significantly less. For the followers who are of different type from the leader, we hardly detect a significant correlation between their average contribution and the leader's contribution. Hence, I conclude that leading by example is not a strong enough force in promoting cooperation when people are gaining different benefits from the collective action.

Chapter 3 is joint work with Eva-Maria Steiger. In this chapter, we investigate how cooperation and coordination within a group are affected when the group competes with a single individual who has less resources that could be invested into the competition. In this asymmetric competition, each group member is not able to outperform the opponent, thus, cooperation is crucial for group members to win over the opponent. However, when full cooperation is not essential for the group to win the competition, group members have an incentive to free ride on other fellow members, which may make it more difficult for the group be the winner. This intragroup problem is characterized as a social dilemma. In this respect, the single opponent has an advantage since he has completely control over his resources. Conflicts between a group of players and a single player are abundant in the real world, for instance, unorganized workers striking against their single employer for a pay rise, an alliance composed of small companies competing against a single company for markets.

We implement a repeated winner-takes-all contest game in which one competitor is a group of three players, and the other is a single player. All players independently decide on their contributions towards the competition. Contributions are forfeited. The party with the higher contribution level wins the competition and obtains the full prize. In case of tie, the prize will be shared by the group and the single player. Any prize obtained by the group will be shared by group members, irrespective of their individual contribution. We implement two asymmetric competition treatments: one is under weak asymmetry when only the sum of all three group members' endowments exceeds the single player's endowment; the other is under strong asymmetry when each group member owns as many endowments as the single player. We also implement a symmetric treatment in which the single player has the same endowment as the total group.

We find that when the two parties have equal total endowments at their disposal, the group contributes a high percentage of its endowment to the competition, however, it is at a slight disadvantage compared to the single player after repeated interactions. The higher the asymmetry level is, the lower the group's contributions are and the severer the free-riding problem is. Nonetheless, in both asymmetric competition treatments, the group rarely contributes below the endowment of the single player and is able to outperform the single player in a majority of times. Interestingly, we find no significant difference in the outcome of the repeated competition between the two asymmetric treatments, although fewer group members have to contribute in one treatment than the other.

Chapter 1
Providing the global public goods: Electoral delegation and cooperation[1]

1.1 Introduction

Compared to club goods such as highways or community swimming pools, maintaining an efficient provision of public goods on the international or global level is a difficult task. Despite the large number of examples of global public goods – e.g., climate protection, biodiversity, international security, and scientific knowledge – economic research on the efficient management of these goods is still in its infancy. In general, global public goods (common goods) are vital to human welfare, yet often under-provided, or they are over-exploited because of their non-excludable benefits spilling over country borders. For instance, about 90% of marine fish stocks in the oceans have been over-exploited, fully exploited, or have completely collapsed by 2009 (Froese et al., 2012).

The management of global public goods is usually organized on *multiple, hierarchical* scales. This means that global public goods are often governed through a delegated institution whose officials (representatives) are elected or appointed by national (or regional) provision collectives. As a consequence, there is at least a two-tier or two-level provision organization. Is electoral delegation an effective mechanism in sustaining efficient provision levels of a global public good? Despite its obvious relevance, an empirical assessment of the effectiveness of delegation mechanisms of global public goods provision in the field is difficult due to lack of controlled data. Laboratory experiments based on the public goods game[2] are one possible remedy (see Hamman et al., 2011, and Bernard et al., 2013).

The straightforward advantage of a provision collective consisting of delegates is that delegates can make efficient use of the resources by taking centralized decisions that keep up coordination within and across societies. Nevertheless, the absence of global authority means that there is a temptation to free ride and that global public goods are likely to be under-provided or not provided at all (e.g., Conceicao, 2003; Barrett, 2007; Aronsson and Johansson-Stenman, 2014; Löschel and Rübbelke, 2014). Another possible cause for the failure is related to an interesting behavioral dilemma for voters

[1] This chapter is joint work with Martin Kocher and Fangfang Tan.

[2] Surveys of public goods experiments that do not implement delegation are provided in Ledyard (1995) and Chaudhuri (2011). By design our setup is related to a small body of literature on public goods provision that involves multiple layers of independent contribution decisions (see, e.g., Blackwell and McKee, 2003; Fellner and Lünser, 2014). A key feature that differentiates our study from theirs is that in other papers decision makers in multi-level public goods games need to trade off contributions between a local and a global level public good. Our setting, however, focuses on the provision of global level public goods only.

in the selection of their representatives. Is it better to delegate a pro-social representative who strives for cooperation when interacting with representatives from other groups, but runs the risk of being exploited by the latter? Or, is it better to elect an egoistic representative who increases own-group profit by free-riding on other groups' contributions, but who might be inclined to abusing her power at hand by exploiting her fellow group members?

In this paper, we focus on a key determinant of electoral delegation[3] in the provision of global public goods: the interactions between voters and political representatives/delegates. To do so, we devise a laboratory experiment that abstracts from the complexity in real-world global public goods provision, but highlights the *polycentric* nature. This concept, first discussed in Ostrom et al. (1961), describes the complexity of global public goods provision as involving "many centers of decision making that are formally independent of each other" (for a more detailed discussion, see Ostrom, 2010).

In our two-level provision mechanism, the delegate is able to determine the provision vector of all members of her provision group on the lower level (the *group* level), and she interacts with other delegates on the *super-group* or *society* level when providing a global public good. Think of her as a national minister or a head of state in the European Union (EU), who makes decisions on global public goods contributions (e.g., the national contribution to European battle groups) on behalf of the voters in the country she represents. Notice that the group contribution decision in the real world can also be implicit through a national decision on the distribution of the tax burden or through a decision on the design of the redistributive system of a jurisdiction. The decisions of all representatives of all EU countries determine the total contributions at the EU level.[4] An egoistic representative might be an asset in the interaction on the super-group level because she is not taken advantage of by other representatives, but she might exploit part of her own citizens (the own group members) when financing the contributions to the public good by letting them contribute over-proportionately (and/or free riding on them). In contrast, a cooperative representative might use a fair proportional contribution rule within her own group that does not exploit anybody, but her group could be exploited on the society level by the potentially egoistic representatives of other groups.

To sum up, our setup is able to address empirically (i) the overall effect of electoral delegation on the efficiency of global public goods provision; (ii) to what extent and how precisely delegation might be able to overcome the lack of global authority and to coordinate the provision of global public goods; and (iii) the potential of an election procedure to (partly) curb the abuse of power by representatives. A laboratory experiment allows us to isolate the incentive effects and should be viewed as a platform

[3] Delegation in principal-agent settings has attracted considerable attention in the experimental economics literature recently (see, for instance, Bartling and Fischbacher, 2012).
[4] Likewise, in mitigating global warming, decisions of all representatives of countries determine the total reduction of CO_2 emissions via multilateral agreements such as the Kyoto protocol.

for studying cooperation and delegation, complementary to field studies. It enables us to assess cooperative preferences and their impact on elections and public goods provision by delegates on the individual level.[5]

More precisely, in our experiment, nine decision makers form a society, and they are divided into three groups of population size three each. In the *Baseline* treatment in the experiment, players in each group have to make simultaneous and independent decisions about how much to contribute to a global public good provided on the level of the nine-person society. The total contributions from all members of the three groups are multiplied by a parameter larger than one and are then equally distributed among all players in the groups. The parameter is chosen in a way to induce a linear social dilemma that maximizes the distance between the individually optimal and the socially optimal choices of the group members. In the *Delegation* treatment, we introduce a Borda count as the election rule for the delegation mechanism. The candidate with the smallest total sum of ranks in each group becomes the delegate for her group for the upcoming three periods of interaction. In the contribution stages of the public goods game in each period, only the three delegates make decisions for each of their three group members. More specifically, they submit a contribution vector for the three members of their groups (including themselves). This vector can induce equal or unequal contributions within a group. Other group members than the delegates remain passive observers of the provision decisions. This design feature captures the fact that delegates are able to maximize their personal gain at the expense of the majority of voters. It can, for instance, be viewed as the potential for corrupt office-holding by the delegate or as "pork barrel" politics; but within the logic of the public goods game, it is simply free riding on the benefits of the public good without contributing oneself. In reality, there are of course limits to such kinds of behavior, but in order to have a clear incentive structure, we maximize the potential for exploitation by the delegate in our experiment.

We implement a standard finitely repeated linear public goods game without delegation (*Baseline* treatment). The unique subgame perfect equilibrium of this game is zero contributions for all players. In the *Delegation* treatment, a profit-maximizing delegate would fully exploit the other two members of her group, because she benefits from the contributions of the other group members. More specifically, she would force the two other group members to contribute fully and thus free-ride on them. Therefore, by construction, compared to *Baseline*, efficiency (i.e., the total earnings of all players) in the *Delegation* treatment increases in equilibrium. Models taking inequity-averse preferences into account (e.g., Fehr and Schmidt, 1999) give slightly different predictions, but exploitation is still likely to take place in the stage game.

[5] Having field data on the important aspects in our setup would be desirable. However, some of the variables are, by their very nature, difficult to observe in the field or strongly confounded.

Our experimental results of *Baseline* are by and large in line with theoretical predictions based on standard preferences. Without delegation, cooperation quickly declines to low levels in the finitely repeated game. Compared to *Baseline,* both contributions and earnings are higher in *Delegation*. In contrast to standard predictions, the elected delegates avoid exploiting other group members by assigning equal contributions to the three group members, driven either by genuine other-regarding preferences or an opportunistic re-election (reputation) motive. However, *despite* the existence of other-regarding preferences, we observe that the actual contribution levels in *Delegation* are significantly below the theoretical benchmark with self-regarding preferences, and they steadily decline over time.[6] In effect, delegates who over-contribute compared to other delegates in the society are less likely to be re-elected. As a consequence, a downward spiral of contribution levels for the global public good sets in. It seems that a combination of (i) delegation based on (re)-election and (ii) heterogeneity in other-regarding preferences leads to an inefficiency for which we use the term *P-inefficiency*, associating it with a global public good's polycentric nature. Our data indicate that both ingredients, the re-election concern and heterogeneity across different groups in terms of other-regarding preferences, might be necessary for existence of the P-inefficiency. However, any of the two elements seems natural in the provision and management of global public goods.

Despite the enormous amount of evidence on the private provision of public goods based on laboratory experiments and a growing number of papers on delegation in principal-agent settings, the literature closely related to our setup is very small. Hamman et al. (2011) study the effect of electoral delegation in a linear public goods game. In their delegation treatments, nine players in a group have to choose a single allocator who decides about the amount of contributions for everyone in the group. Although they find that a couple of minimum winning coalitions in the election game for allocation power reap the benefits of the public good at the cost of other players in the group, most groups in their experiment elect high contributors who implement full contribution levels for all group members including themselves. Bolle and Vogel (2011) examine a similar setting and report that both elected and randomly appointed allocators increase the levels of public goods provision over the benchmark of the standard linear public goods game, although the effect becomes smaller with repetition. In addition, Oxoby (2006) and Fleiß and Palan (2013) find that contributions increase when a randomly selected delegate can choose contribution levels for all group members.[7]

The difference between our study and those discussed in the previous paragraph lies in the particular

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[6] Note that efficiency is maximized when all delegates contribute for every group member (including themselves) the entire endowment to the public good. The full exploitation solution according to which the three delegates free ride and make the two other members within their respective groups provide full contributions gives another benchmark for the achievable level of efficiency.

[7] There is a growing body of literature that studies the effects of delegating punishment or implicit punishment to a centralized authority and the willingness of groups to do so (see, e.g., Kosfeld et al., 2009; Baldassarri and Grossman, 2011; Andreoni and Gee, 2012; Tan and Xiao, 2012; Markussen et al., 2014).

group and society structure naturally caused by global public goods provision. In the existing studies, the delegates act like dictators since they can determine the level of contributions for every person in society without any restrictions. In other words, the public goods provision contains no hierarchical structure. In our setting, however, the decision power of the delegate is confined to her own group. The total level of public goods provision is determined by the simultaneous and independent decisions of the three delegates on behalf of their groups. Hence, not only do they face a redistribution problem within their groups, but they also have to deal with the strategic interactions with other delegates across groups. As a consequence inefficiency in the public goods provision quickly arises in our setup, in contrast to the setup in Hamman et al. (2011).

The only study that introduces both the subgroup and the delegation elements, to the best of our knowledge, is Bernard et al. (2013). They compare several voting schemes in extracting common pool resources, which share a similar payoff structure as the public goods game. In one of these mechanisms, a randomly chosen player in every period votes, on behalf of her group, on the level of extractions for the entire group. They find that this mechanism is effective in overcoming the tragedy of the commons, since the decisions of the delegate affect the group as a whole. In their setting, the median of all extraction proposals made by the delegates was implemented automatically, making it easier to prevent a group from implementing an extreme extraction level by construction. In the other mechanism, each player votes for the level of extractions implemented at their own group level in each period. They find that the extraction level is not only higher but it also increases over time with this mechanism due to defection by other groups that extract from the common pool. Compared to their paper, our paper focuses on elected delegates instead of randomly assigned delegates. Data from the elections help us uncover the motives and expectations of players and enable us to assess the preferences of group members with regard to the characteristics of their representatives. Moreover, our study allows the delegates to choose contribution strategies for each member of their own groups without any restrictions throughout their tenures, making exploitation of ordinary group members by the delegates possible.

The remainder of the paper is organized as follows. Section 1.2 presents our experimental design. Section 1.3 derives theoretical predictions based on both self-interested and inequity-averse preferences. In Section 1.4, we present our empirical results, and Section 1.5 concludes the paper.

1.2 Experimental design and procedures

We implement two treatments in our study: *Baseline* (no delegation) as our control treatment and *Delegation*. Every experimental session with 18 experimental participants divides the participants into two cohorts (matching groups) of nine subjects each at the beginning of the experiment. Possible re-matching takes place only within a cohort in order to guarantee strict statistical independence on the level of the super-group (society) of nine subjects. A total of seven experimental sessions provide us with six independent observations for *Baseline* and eight independent observations for *Delegation*. At the beginning of a session, subjects are informed that the experiment will consist of four parts. They receive instructions (see Appendix A.3 for details) for the four parts separately, always before the start of a specific part.

The basic game that we use is a standard linear public goods game, presented in a neutral (i.e., context-free) frame to the participants. The first three parts of the experiment are identical across treatments; the treatment variation was introduced only in the fourth part.

At the beginning of Part 1 subjects are randomly matched within their cohort into groups of three. Each of the three group members receives an endowment of 20 experiment points, and they have to decide simultaneously about their individual contribution (c_i) to a public account. The marginal per-capita return (MPCR) is set at 0.5. The payoff function (π_i) for subject *i* is

$$\pi_i = 20 - c_i + 0.5 \times \sum_{j=1}^{3} c_j, \tag{1}$$

with c_j as the contribution of the *j* group members.

Part 1 measures cooperative preferences on the individual level. It is a one-shot public goods game based on the strategy vector method introduced by Fischbacher et al. (2001) and validated for repeated interactions by Fischbacher and Gächter (2010) as well as Fischbacher et al. (2012). Subjects make an integer unconditional contribution to the public good. Then, they specify conditional contribution levels. In particular, they have to fill in a contribution table that indicates how much they want to put into the public account for each of the 21 possible average contributions of the other two group members (rounded up to the next integer). To make both decisions, the unconditional contribution and the contribution table, incentive compatibility, the computer randomly selects one subject within each group in the end and makes her conditional contribution table payoff-relevant. The two unconditional contributions from the other two group members and the corresponding conditional contribution of the randomly chosen subject constitute the group's contribution to the public account. Then equation (1) is applied. We do not give any feedback on others' choices and earnings from Part 1 until the end of the entire experiment to avoid contamination across parts. All details mentioned so far (except for the existence of two cohorts in one session) are common knowledge among participants. Control questions, examples, screenshots and the possibility to ask questions before the start of Part 1 make sure that participants fully understand their available strategies and the nature of the interaction.

Part 2 collects subjects' distributional preferences as dictators. At the beginning of this part, experimental participants are randomly re-matched into groups of three within their cohorts. Part 2 is a one-shot three-person allocation game (for instructions, see Appendix A.3). It uses exactly the same payoff function as in the previous part (see equation (1)), and it aims to provide a measure of distributive or other-regarding preferences on the individual level that is independent of any reputational concerns. Each group member decides on her own contribution to the public good as well as on the contributions of the other two group members. The program randomly selects one member from each group ex post and implements her allocation decision, i.e. the allocation choice of one of the three group members is implemented for the entire group with equal probability. Similar to the first part, no feedback on the results from Part 2 is provided until the very end of the experiment. All procedures are common knowledge.

Part 3 provides our participants with enough experience for Part 4, which is a more complicated environment due to the delegation procedure in *Delegation*. In Part 3, subjects interact with each other for eight identical periods in a standard linear public goods game based on the payoff function in equation (1). At the beginning of the third part, random matching within the cohort into groups of three takes place, and groups now stay together for the entire eight periods of Part 3 (for the experimental instructions, see Appendix A.3). After each period, subjects receive feedback on the contributions and earnings of all members in their group. Each period and every decision is payoff-relevant in Part 3.

Part 4, the main part of our experiment, differs in the two treatments.[8] In both treatments, subjects are told that the composition of their group and their experimental IDs remain unchanged from the ones in Part 3. They are, further, informed that their group and two other groups (from the same matching cohort) will be matched into a super-group of nine members for the next (and final) 18 periods of interaction.

In *Baseline*, every member in the three groups simultaneously decides on how much to contribute to the super-group account. The super-group account collects the sum of all contributions from the nine super-group members. Define c_{iK} as the contribution of member *i* in group *K*. The payoff function (π_{iK}) for subject *i* in group *K* is

$$\pi_{iK} = 20 - c_{iK} + \frac{1.5}{9}\sum_{K=1}^{3}\sum_{j=1}^{3} c_{jK} \qquad (2)$$

The sum of contributions by all nine super-group members (denoted by *C* in the following) is multiplied by the social marginal benefit 1.5 and then equally distributed across the three groups.

[8] For the Part 4 instruction of the treatment *Delegation*, see Appendix A.3. The instruction of the treatment *Baseline* are available from the authors.

Within each group, the amount is also divided equally, and, hence, each member receives $(0.5\times C)/3$. Therefore, the increase in group size is counterbalanced by the decrease in the MPCR. Moreover, the standard game-theoretic equilibrium and the social optimal choices remain unchanged (see Section 1.3 for details).

In *Delegation*, we use exactly the same payoff function. However, groups need to elect a delegate who makes a binding decision for the contributions of each group member, i.e. she submits a *contribution vector* consisting of three elements, one for each of the three group members including the contribution of herself. Delegates are elected for a three-period tenure. New elections take place after these three periods. The delegate is elected via a Borda count, which is simple to explain and to implement. That is, every member of a group is a voter and ranks the candidates (including herself) in order of individual preferences (with 1 as the most preferable rank). The computer, then, sums up the ranks of the three candidates within a group and appoints the candidate with the lowest rank sum as the delegate. In case of ties, one of the tied candidates is randomly selected as delegate for her group. When casting their vote, subjects can see the average contributions of the three members within their groups from Part 3 of the experiment as well as the following pieces of information from Part 4 (starting from the vote before period 4 in Part 4 onwards): (i) the ID of the delegate of their group in the previous three periods; (ii) the vectors of contributions and earnings of all members in one's own group for the previous three periods; and (iii) the average contributions of the two other groups within the super-group in each of the previous three periods. It is important to note that our design implies that members from the other two groups can neither influence the contribution decisions nor the election/replacement of a delegate outside their groups.

After the election, everyone within a group is informed about the IDs of the three delegates who make contribution choices on behalf of their group members for the next three periods. At the end of each single period in Part 4, everyone within a group receives information regarding the delegate ID, the contributions and earnings of each member in her own group, and the total contributions of each of the three groups. To facilitate comparisons, we present subjects in *Baseline* with exactly the same information without any reference to delegation or elections. Communication is not allowed in either treatment.[9]

The experiment was conducted in the MELESSA laboratory at the University of Munich from February to April 2012. A total number of 126 undergraduate and postgraduate (master) students with various academic backgrounds were recruited via ORSEE (Greiner, 2004). Subjects remained anonymous throughout the experiment, and cash payments were made privately. The experiment was

[9] Obviously, introducing communication is a very interesting extension to our setup. However, we wanted to start with the most parsimonious experimental design and thus do not take communication into account.

programmed and conducted with the software z-Tree (Fischbacher, 2007). An experimental session lasted for a bit less than two hours. Subjects earned an average of € 22.05 (including a € 4 show-up fee).

1.3 Theoretical expectations

In this section, we derive equilibrium predictions for our experiment. We start with standard preferences and extend our analysis to inequity-averse preferences. Our focus is on Parts 3 and 4. Predictions for the earlier parts in our experiment follow immediately from the discussion regarding Parts 3 and 4.

1.3.1 Predictions based on selfish preferences

The predictions for *Baseline* and the eight-period public goods game in Part 3 are straightforward. With rational, selfish, and risk-neutral group members and common knowledge thereof, the unique sub-game perfect equilibrium in the finitely-repeated game is to contribute zero to the linear public good. The marginal per capita return of the public good is always lower than the marginal return of keeping one's endowment in our game. The social optimum, however, is to contribute the entire endowment to the public account, since the social return is larger than one.

Hypothesis 1(a) for Baseline: *Players will contribute zero to the global public good.*

We now turn to *Delegation*. Under the homo oeconomicus assumption, the unique sub-game perfect equilibrium collapses to the following stage game equilibrium of the finitely repeated game: The delegate fully maximizes her monetary payoff by contributing zero and forcing the other two group members to contribute their entire endowment to the public good. Doing so maximizes the delegate's monetary earnings because she can free ride on the contributions of the other two group members.

Hypothesis 1(b) for Delegation: *The elected delegate will assign full contributions for the other two group members and zero contribution for herself.*

Let us now consider the voting stage that takes place every three periods in *Delegation*. We assume here that it takes place at the beginning of the stage game. Since the delegate has the potential to earn more than the other group members, a profit-maximizing player will try to maximize the chance of being elected in the voting stage. There are several voting equilibria, but all imply ex-ante equal chances to be elected as the delegate for one's group if all voters vote rationally. A corollary of this result is that there are no individual characteristics that play a role in the elections. Proofs can be found in Appendix A.1.

Hypothesis 1(c) for the election: *All voting equilibria imply ex ante equal chances to be elected as* *the delegate in a group.*

1.3.2 Predictions based on other-regarding preferences

In this section, we relax the self-interest assumption by considering other-regarding preferences. All other assumptions remain unchanged. The detailed predictions for a popular outcome-based other-regarding preference model, the inequity-aversion model by Fehr and Schmidt (1999) as an example, can be found in Appendix A.1. Here we briefly sketch the intuition.

For Part 4, one can derive predictions that distinguish between two different reference-group concepts: for a delegate or a group member the reference group can either be the own three-person group or the nine-person super-group. The distinction is based on the well-established finding in the social identity literature that people differentiate between their in-group members and members of the out-group (see, e.g., Chen and Li, 2009, Meier et al., 2012). It turns out that how we define the size of the reference group does not affect equilibria in *Baseline*. This is an immediate consequence of the fact that the return of the public good is linear in proportions of contributions. This means, Part 3 predictions and Part 4 predictions for Baseline are identical. A cut-off-level of β for all group members determines whether cooperative equilibria exist.

However, the size of the reference group affects the conditions that determine cooperative equilibria in *Delegation*. When the reference group is the three-person group, a delegate faces two sets of incentives. First, she has to trade-off her monetary earnings and income inequity within her group. Second, she has a monetary incentive to free ride on contributions of other groups, since income in other groups do not affect her utility. When the reference group becomes the nine-person super-group, the weight of each in-group member in the social utility part of the delegate's utility function decreases from 1/2 to 1/8, while the weight of each out-group member increases from 0 to 1/8. Intuitively, free-riding on in-group members becomes comparatively more attractive, while free-riding on out-group members becomes less so, since the disutility from contributing less than them becomes larger. As a consequence, depending on the size of the reference groups and on the other delegates' inequity-aversion parameters, players with sufficient advantageous inequity aversion will be elected as delegates. However, players will vote for themselves and everybody is equally likely to become the delegate within her group if none of the candidates is sufficiently inequity-averse.

The above analysis holds for the stage game. It is noteworthy that in the repeated game, there are many more equilibria, and they only require lower levels of β because of the incentive to build a reputation as a cooperative delegate (e.g., Oechssler, 2013). Our delegation mechanism, however, implies a complication for the reputation-building process because of the election and of the chance that a delegate is suspended from her "job".

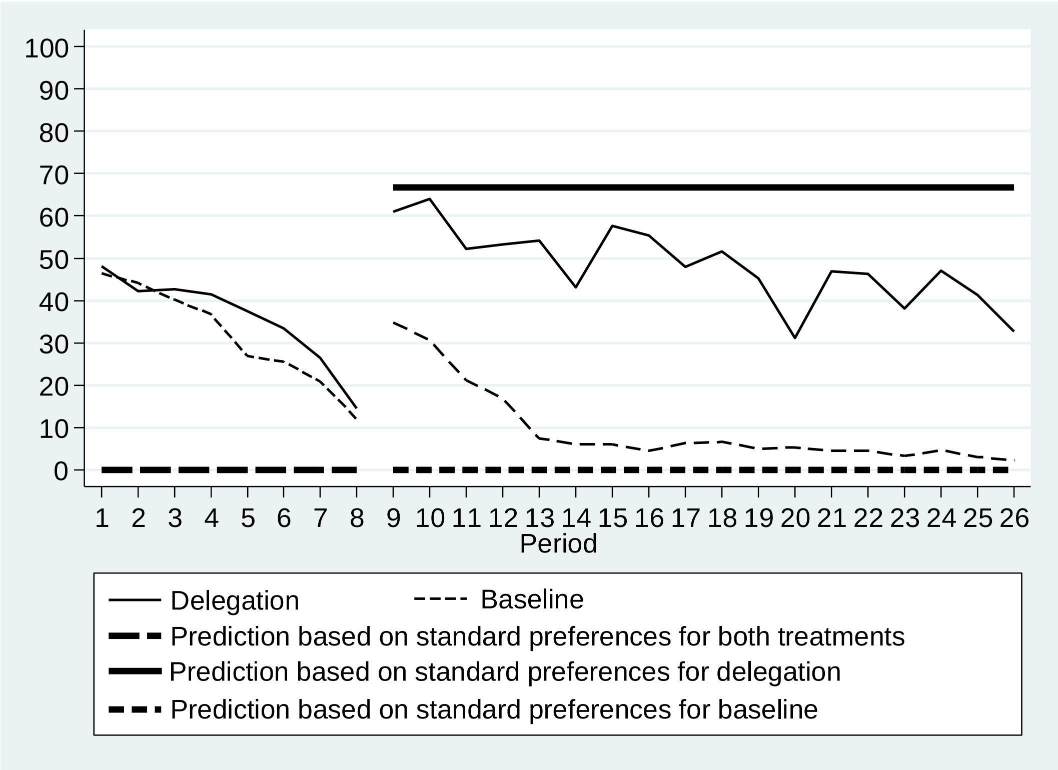
1.4 Experimental results

We organize the presentation of our results as follows. Section 1.4.1 compares average contributions and earnings across the two treatments. Section 1.4.2 studies contribution and allocation choices of the delegates. Section 1.4.3 analyzes how delegates are elected and what determines the rankings of the voters. Section 1.4.4 explains heterogeneous contribution dynamics across societies. Unless specified differently, the non-parametric tests in this section are two-sided Mann-Whitney rank sum tests, with each super-group as a statistically strictly independent observation.

1.4.1 Treatment differences

Figure 1.1 presents the average group contributions to the public good by treatment. Before the treatment manipulation, the dynamics of contributions in both treatments are highly consistent with the previous literature: The average contributions amount to about 45% of the endowment in the first period of the public goods game, and then they decline steadily to about 15% by the eighth period (at the end of Part 3). The two treatments do not exhibit significant differences in contribution levels ($p > 0.4$), making sure that the initial experience is on average the same before the start of Part 4 in the two treatments.

Figure 1.1: Average super-group contribution levels as a percentage of endowment in Parts 3 and 4



After the introduction of the treatment variation, however, the two treatments exhibit stark differences. In *Baseline*, we observe the typical "restart" effect in the voluntary contribution mechanism, with an average contribution level of about 30%, but contributions decay to less than 10% after a couple of periods. This pattern suggests that, without any institution, the free-riding incentive is dominant even in the repeated interaction, and social preferences are not strong enough to sustain high levels of cooperation.

In *Delegation*, average contributions start out at about 60% of the total endowment in period 1, but gradually decline to around 35% in the ultimate period of Part 4. The treatment difference is obviously highly significant (averages for Part 4 are 9.6% versus 48.3%; $p < 0.01$). Due to the linear nature of the public goods game, the significant differences in contributions directly translate into differences in earnings, i.e. efficiency. Controlling for the decay and for the general level of cooperativeness on the group level measured in Part 3, the results of a random-effect regression analysis unambiguously confirm the findings from non-parametric tests (see Table A.2 in Appendix A).

Predictions based on standard preferences for *Delegation* indicate that if the delegates play the stage-game outcome by fully exploiting the other two group members, the average contributions at the society level should stay constant at 66.7% of the total endowment throughout the 18 periods of play in *Delegation*. This is clearly not the case. Contributions in *Delegation* are on average significantly *below* the benchmark ($p = 0.03$; two-sided Wilcoxon signed-rank test). This is evidence for the P-inefficiency. Result 1 summarizes the findings.

Result 1: *Neither hypothesis 1(a) nor an alternative reasoning based on inequity aversion is fully supported. In* Baseline, *average contributions are significantly larger than zero ($p<0.05$, two-sided Wilcoxon signed-rank test), although they quickly decline over time. Average contributions in* Delegation *are significantly higher than in* Baseline*; however, on average, they fall significantly below the theoretical prediction of 66.67%. Delegation is significantly less efficient than standard theory predicts (the "P-inefficiency").*

1.4.2 Delegates' distribution choices

We first analyze the allocation decisions of the delegates within their subgroups, followed by their contributions relative to other sub-groups. Table 1.1 classifies the elected delegates into three types based on their average contributions in Part 3, relative to the two other group members, and denote them *High*, *Middle*, and *Low* delegates. There is a strong correlation between a delegate's own contribution in Part 3 and their allocation to the public goods in Part 4. High contributing delegates assign on average 55.4% of the total endowment to the public account, which is significantly higher than the assignment levels by middle or low contributors.[10] The lower part of Table 1.1 reports contribution assignment frequencies, treating each allocation decision as independent. These figures indicate that, 85.4% of the time, the elected delegates choose equal contributions for all group members. This is particularly true if the delegate has been the high contributor in her group: Roughly 90% of the time she will implement an equal contribution vector, among which 12.9% of the time she requires all group members to contribute fully. Interestingly, middle and low contribution delegates also assign equal contribution levels with very high frequencies (80% and 81.9%, respectively). Overall, only about 10-15% of the time do they attempt to exploit other group members.

Table 1.1: Decisions of the elected delegates

	Contribution ranks of delegates in Part 4			
	High	Middle	Low	All
Contributions in % (mean)	55.4	40.7	40	48.3
Contributions in % (standard dev.)	26.3	25.2	25.3	26.8
	Distribution of allocation decisions (in %)			
EQUAL	89.8	80.0	81.9	85.4
FULL	12.9	2.2	0.0	7.4
EXPLOIT ONE	4.0	9.6	1.4	5.3
EXPLOIT BOTH	6.2	7.4	11.1	7.4
OTHER (ALTRUISTIC)	0.0	3.0	5.6	1.9
No. of observations	225	135	72	432

Notes: FULL means that the delegate contributes the entire endowments of all three group members to the global public good. EQUAL means that the delegate lets every member contribute the same to the global public goods (including full contributions). EXPLOIT ONE means that the delegate contributes the same as or more than one group member and forces the other member to contribute the most (uniquely) of the three. EXPLOIT BOTH means that the delegate contributes the least (uniquely) among the three. OTHER includes all contribution vectors of altruistic types (delegate contributes the most (uniquely or together with one other group member)).

Given such high proportions of equal contributions within subgroups, what about relative contributions across groups and the inter-temporal adjustment? To address this question, Table 1.2 reports results of random-effect panel regressions where the dependent variable is the differences in contributions of the delegate's own group across two periods, either for the delegate herself, for the average of the other two members, or for both. The results from the regression in Table 1.2 and the following regressions have to be taken with a grain of salt. So far in the results sections, we have been relying on treatment differences that provide us with causal inference. When we want to look at the

[10] The random-effect regression results in Table A.3 of Appendix A support this claim. The contribution difference between High and Low delegates is significant at the 10% level (Wald test).

structure of the data within our treatments, endogeneity issues cannot be excluded, since becoming a delegate potentially depends on contributions and contributions potentially depend on elections. We think that addressing the structure of behavior is still interesting, but it should be clearly said that identification is not causal.

The significant coefficients β_2 and β_3, when pooling all data together, suggest that the delegates attempt to coordinate the contributions of their own groups with the average of the entire super-group. Specifically, if they realize that their own group over-contributed in the last period, they lower their contributions in the subsequent period (β_2). Similarly, in case of under-contribution, the delegates adjust their own contributions upwards (β_3).

Table 1.2: Random-effect regressions on contribution dynamics

Changes of contributions across periods	*All*	*Delegates*	*Average of others*
β_1: Changes apply to the other two members (=1 if yes)	-0.442 (0.305)	-	-
β_2: Positive deviation from the super-group average (t-1)	-0.855^{***} (0.148)	-0.829^{***} (0.164)	-0.536^{**} (0.228)
β_3: Negative deviation from the super-group average (t-1)	0.557^{***} (0.139)	0.519^{***} (0.117)	0.532^{***} (0.128)
β_4: Changes apply to the other two members × Positive deviation from super-group average (t-1)	0.304 (0.214)	-	-
β_5: Changes apply to the other two members × Negative deviation from super-group average (t-1)	0.017 (0.075)	-	-
β_6: Period	-0.098 (0.067)	-0.109^{*} (0.060)	-0.051 (0.083)
β_7: Constant	-0.186 (0.632)	0.128 (0.578)	-0.907 (0.712)
R^2 overall	0.141	0.167	0.113
No. of observations	576	288	288

Notes: * $p < .1$, ** $p < .05$, *** $p < .01$. Robust standard errors (clustered at the sub-group level) are reported in parentheses. In particular, the variable "Changes apply to the other two members" is a dummy variable equal to 1 if the dependent variable is the average change of contributions for the other two members across periods of each period. "Positive (Negative) deviation from the super-group average" measures the amount group average contributions exceeds (falls short of) that of the super-group averages in the last period.

The insignificant coefficients β_4 and β_5 indicate that the contribution changes applied to the other two group members do not significantly differ from the changes applied to oneself as delegate. In other words, the delegates adjust contribution behavior similarly for the other group members as for themselves. Only in 4.17% of cases (18 out of 432) a delegate behaves exactly according to standard theory in the stage game by fully exploiting the other two members of her group, 13.66% of the time

(59 out of 432) the delegate assigns zero contributions to everyone, and 7.41% of the time (32 out of 432) she assigns full contributions to everyone.

Two potential explanations are consistent with delegates' egalitarian behavior. First, they are motivated by other-regarding preference. Second, at least some delegates mimic the strategy of the other-regarding type to increase their chances to be re-elected.[11] To tear apart the relative importance of preference and strategic concerns, we look into the correlation between the allocation decisions of delegates in Part 2 (the one-shot allocation game) and their decisions in Part 4. We exclude data in the last three periods of Part 4 for the moment, since then delegates have no incentive anymore to build up reputation.

The main observation from Table 1.3 is that both preferences and strategic concerns explain the behavioral pattern of delegates. The allocators that shared equally in Part 2, if elected as a delegate in Part 4, continue assigning equal contributions for all group members in more than 90% of cases (157/168). The exploiting types based on the behavior in Part 2, on the other hand, also equalize contributions in about 85% of the time (164 out of 189). Result 2 summarizes the above findings.

Table 1.3: Correlation between delegates' distribution preferences in Part 2 and decisions in Part 4 (except for the last three periods)

Part 4 / *Part 2*	*Equal*	*Exploit one member*	*Exploit both members*	*Others*	*Total*
Equal	157	10	0	1	168
Exploit one member	3	0	0	0	3
Exploit both members	164	9	10	6	189
Total	324	19	10	7	360

Notes: The interpretations of the categories "Equal", "Exploit one member", "Exploit both members" and "Others" are the same as in Table 1.1.

Result 2: *Neither Hypothesis 1(b) nor alternative reasoning based on inequity aversion is fully supported when looking at the contribution assignment decisions of the delegates: Instead of completely free-riding on the contributions of the other two group members, they most frequently assign equal non-zero (medium) levels of contributions in their groups.*

[11] A feeling of responsibility on the side of the delegates could be another reason that leads to equal contributions. However, we cannot directly assess its influence and disentangle it from other-regarding preferences in our setup.

1.4.3 Elections and rankings of delegates

Election of delegates

From the previous sections, two main patterns in contradiction with standard theoretical predictions arise. First, contributions fall below the efficiency benchmark, and exhibit a declining trend, even in *Delegation*. Second, the elected delegates mostly assign equal contributions within their groups. This section offers a set of empirical analyses from the elections and from ranking data that allow for a better understanding of our main findings from Section 1.4.2.

Table 1.4: Summary statistics on the first election

	Percentage of rank 1	*Average rank assigned*	*Number elected*
Self	63.9		
High contributor	55.6	1.6	19
Middle contributor	26.4	2	3
Low contributor	18.0	2.4	2
No. of observations	72	72	24

Note: The distinction between High/Medium/Low contributors is based on contribution data from Part 3.

We start by presenting summary statistics from the very first election in Table 1.4. Despite the obvious fact that a lot of subjects assign the most favorable rank to themselves, the majority of groups still favor high contributors as their delegates. In particular, 55.6% of the most preferred ranks go to the high contributor in the group, whereas only 18.1% go to the low contributor. As a result, high contributors receive the most favorable ranks (the lowest average), and are elected most frequently (in 19 out of 24 groups).[12]

Table 1.5 reports the regression analysis for later elections, i.e. the five elections in Part 4 of the experiment excluding the very first. In the first election, the only information voters could condition their ranking on is the average contributions of all players in Part 3. In later elections, however, the voters have extra information on the performance of the incumbent delegate and the previous group-level contributions of the other two groups.

The results from Table 1.5 indicate that there is significant path dependency to elect the incumbent delegate (β_1). The coefficient β_5 is significantly negative, which means that the incumbent delegate is less likely to be re-elected, the more the group she represented was exploited by the other groups in

[12] The regression analysis in Table A.4 in Appendix A further supports this result: the outcome of the first election depends on choices of a subject in (each of) the three previous parts. In all the specifications, the high contributor is more likely to be elected, regardless of whether we control for cooperative or distributive preferences (based on Parts 1 and 2) or not. Since results from Parts 1 and 2 are not public, this is just because of the correlation of behaviour across the parts on the individual level.

the society during her tenure. Moreover, the more delegates exploit both of their own group members during their tenure, the less likely they will be re-elected (β_9).[13] Result 3 summarizes the main findings.

Result 3: *Hypothesis 1(c) is rejected, while predictions from inequity-aversion models are partly supported: Voters significantly prefer pro-social delegates (high contributors in Part 3) in the first election, In later elections, incumbent delegates have a much higher chance to be re-elected. However, their chances decrease, (i) the more the average contributions of their groups exceed that of the society's average, and (ii) the higher contribution levels they choose for the other two group members compared to their own contributions (i.e., how fair their choices are).*

The above findings are consistent with what we observe as the stylized behavior of the elected delegates. In particular, group members use elections as a device to deselect "unsuccessful" delegates, i.e. if the delegate was exploited by other groups. They also refrain to re-elect delegates that act selfishly. In response, the elected delegates assign equal contributions for all members within their groups. Moreover, they try not to over-contribute compared to the two other groups within the society. The latter motive leads to the decaying trend in contributions that was surprising at first sight because it is at odds with most theoretical predictions.

Ranking of delegates

Individual ranking behavior in the course of the election provides a more detailed picture of the election. We employ ordered logit regressions to study the determinants of the ranks that voters assign to different candidates. Similarly to the previous sub-section, we run regressions separately for the first election and the later ones, since ranking behavior might be different if the interaction has a history, which is true from the second election onwards.

The aggregated ranking behavior in later periods is most easily described when we distinguish again between high, middle and low contributors, based on the behavior of group members in Part 3 of the experiment. Table 1.6 provides the results of regressions, with voter i's rank assigned to candidate j. Pooling all data together suggests that voters have a strong preference for self-promotion, i.e., to rank themselves significantly more favorably than others (β_{10}). However, if we break down the voters based on their contributions in Part 3, the ranking patterns vary substantially. The ranking patterns of the high contribution voters are highly consistent with the election outcomes. Namely, voters assign more favorable ranks to the incumbent delegate (β_1), and less favorable ranks to low contributors in Part 3 (β_2), especially if this low contributor is the incumbent delegate (β_3). Negative ranking

[13] All results remain robust if we only consider the final election period (see Table A.5 in Appendix A).

consequences for the candidate are, furthermore, due to contributing more than the super-group average (a higher rank to the incumbent captured by β_5 and a lower rank to other candidates by β_4, or by forcing the other two members to contribute more than oneself in the previous periods (a significantly positive effect on the rank to other candidates by β_8)). Interestingly, there is lack of intention to seek for other candidates if the incumbent delegate under-contributes compared to other groups.

The ranking patterns for middle- and low-contribution voters are less robust. Their idiosyncratic ranking pattern might cancel out during the aggregation process, leading high-contribution voters to win the election. The only consistent pattern in ranking is that they move away from delegates who exploited the two other group members (β_8 and β_9). Result 4 summarizes the findings from our analysis.[14]

Result 4: *Voters unambiguously assign favorable ranks to high contributors in the first election. In later elections, the ranking pattern of the high contribution voters is in line with the aggregated election outcome described in Result 3. Delegates who over-contribute or exploit the two other group members are consistently deselected.*

[14] Not surprisingly, the ranking pattern of the first period is highly consistent with the voting outcome: Voters have a strong preference to vote for themselves. However, after controlling for that, high contributors are the most preferred candidates. Table A.6 in Appendix A provides the regression results.

Table 1.5: Election analysis in later periods (Probit model)

Dependent variable: whether a subject is elected (1=yes)	*Model 1*	*Model 2*	*Model 3*	*Model 4*
β_1: Incumbent delegate (=1 if yes)	2.345***	2.345***	2.335***	2.401***
	(0.575)	(0.574)	(0.580)	(0.591)
β_2: Part 3 rank within group	-0.086	-0.085	-0.077	-0.049
	(0.149)	(0.144)	(0.152)	(0.151)
β_3: Incumbent delegate × Part 3 rank within group	-0.277	-0.277	-0.275	-0.317*
	(0.196)	(0.197)	(0.195)	(0.192)
β_4: Positive deviation from the super-group average	0.123	0.123	0.106	0.116
	(0.082)	(0.084)	(0.077)	(0.082)
β_5: Incumbent delegate × Positive deviation from the super-group average	-0.372*	-0.373*	-0.349*	-0.370*
	(0.194)	(0.200)	(0.184)	(0.192)
β_6: Negative deviation from the super-group average	0.076	0.076	0.081	0.073
	(0.082)	(0.082)	(0.085)	(0.088)
β_7: Incumbent delegate × Negative deviation from the super-group average	-0.160	-0.160	-0.159	-0.155
	(0.185)	(0.185)	(0.184)	(0.187)
β_8: Average extent of exploiting both	0.051***	0.051***	0.055***	0.065***
	(0.017)	(0.017)	(0.017)	(0.019)
β_9: Incumbent delegate × Average extent of exploiting both	-0.754***	-0.754***	-0.783***	-0.802***
	(0.133)	(0.131)	(0.141)	(0.160)
β_{10}: Re-election period (1-5)	0.010	0.010	0.006	0.008
	(0.011)	(0.011)	(0.012)	(0.012)
β_{11}: Constant	-1.007***	-1.009***	-1.039***	-1.043***
	(0.347)	(0.356)	(0.364)	(0.393)
Additional controls	None	Part 1 unconditional contribution	Part 1 cooperative preferences	Part 2 distributive preferences
Log-likelihood	-173.87	-173.87	-172.57	-171.88
N	360	360	360	350

Notes: * $p < .1$, ** $p < .05$, *** $p < .01$. Robust standard errors (clustered at the sub-group level) are reported in parentheses. In particular, the variable "Incumbent delegate" is a dummy variable equal to 1 if the subject was the previous delegate in the last three periods. "Part 3 rank within group" captures the subject's rank in levels of cooperation from Part 3 (low rank means a higher level of cooperativeness). "Positive (Negative) deviation from the super-group average" measures the amount the group average contributions exceed (fall short of) that of the super-group average in the past three periods. The variable "Incumbent delegate× Positive (Negative) deviation from the super-group average" captures the interaction term between these two variables. The variable "Average extent of exploiting both" measures the contribution difference between the delegate and the average of the other two members in the past three periods (only if the delegate exploited the other two members). "Re-election period" takes the value 1 to 5 as there are six elections altogether in Part 4 (and election 1 is omitted). In different specifications, we add the choices of a subject in previous parts of the experiment as additional controls. We do not report marginal effects instead of regression coefficients, because the former make little sense for interaction terms.

Table 1.6: Ranking analysis in later elections (Ordered logit model)

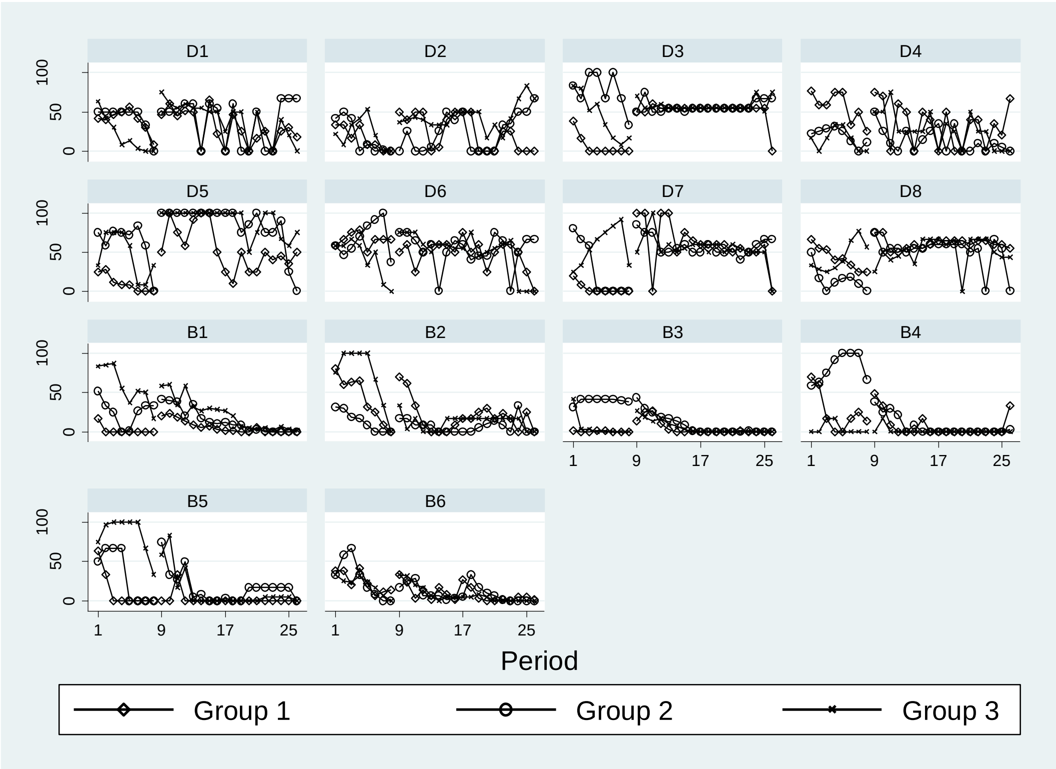
Dependent variable: voter i's rank to candidate j	*High contributor*	*Middle contributor*	*Low contributor*	*Aggregate data*
β_1: Incumbent delegate (= 1 if yes)	-4.374***	0.812	-1.618	-1.308**
	(1.163)	(0.723)	(1.135)	(0.532)
β_2: Part 3 candidate's rank within group	1.323***	0.638**	-1.268***	0.239
	(0.373)	(0.282)	(0.343)	(0.173)
β_3: Incumbent delegate ×Part 3 candidate's rank within group	1.262***	-0.894**	0.497	0.145
	(0.443)	(0.433)	(0.387)	(0.211)
β_4: Positive deviation from the super-group average	-0.169*	-0.139	0.189	-0.031
	(0.093)	(0.136)	(0.156)	(0.078)
β_5: Incumbent delegate × Positive deviation from the super-group average	0.783***	0.232	-0.498	0.120
	(0.296)	(0.353)	(0.490)	(0.225)
β_6: Negative deviation from the super-group average	-0.099	0.099*	-0.004	0.020
	(0.088)	(0.052)	(0.099)	(0.045)
β_7: Incumbent delegate × Negative deviation from the super-group average	0.316	-0.221	-0.110	-0.060
	(0.271)	(0.172)	(0.270)	(0.144)
β_8: Average extent of exploiting both	-0.043***	-0.028	-0.030	-0.035
	(0.016)	(0.020)	(0.030)	(0.024)
β_9: Incumbent delegate × Average extent of exploiting both	0.608	0.207**	0.002	0.105
	(0.676)	(0.087)	(0.106)	(0.087)
β_{10}: Candidate is the voter herself (=1 if yes)	-	-	-	-1.965***
				(0.295)
β_{11}: Re-election period	-0.034	0.030	-0.025	-0.015
	(0.026)	(0.021)	(0.018)	(0.009)
Log-likelihood	-300.69	-391.09	-340.93	-1033.39
No. of observations	360	375	345	1.180

Notes: * $p < .1$, ** $p < .05$, *** $p < .01$. Robust standard errors (clustered at each voter) are reported in parentheses. The variables "Incumbent delegate", "Part 3 candidate's rank within group" and "Candidate is the voter herself" are referring to the candidates. All other variables here are the same as in Table 1.5. We do not report marginal effects instead of regression coefficients, because the former make little sense for interaction terms.

1.4.4 Contribution dynamics and preference heterogeneity

Figure 1.2 gives a descriptive overview of contributions over time by each of the three groups in a super-group. The abbreviations on top of each panel (Bx, Dx) indicate the super-group ID numbers in our two treatments (B for *Baseline* and D for *Delegation*).

Figure 1.2: Contribution dynamics of each super-group in Part 3 and Part 4



Notes: The letters combined with numbers in each panel represent treatment and super-group number (B stands for *Baseline*, and D stands for *Delegation*).

There are stark differences between the *Baseline* and the *Delegation* treatments in terms of the dynamics. In *Baseline*, most super-groups quickly converge to zero contributions after three to four periods of interaction. The dynamics in *Delegation* is much more heterogeneous. Figure 1.2 suggests that very few delegates initially start with full cooperation (two groups in D5 and one group in D7). Most of them contribute cautiously (i.e., about half of the group endowment) supposedly to gauge the inclination to cooperate by the other two delegates in the society. The delegates in some super-groups (such as D3, D7 and to a lesser extent D8) manage to coordinate and sustain a certain cooperation level throughout Part 4 (56% for D3, 58% for D7, and 54.4% for D8). Some other super-groups (such as D1, D2 and D4) exhibit a lot of fluctuations and a lower overall cooperation level (36.0% for D1, 31% for D2, and 25% for D4). Only one super-group consistently contribute more than the benchmark based on self-regarding preferences (76.5% for D5). Results from a hierarchical cluster analysis confirm that the contribution dynamics of the eight super-groups can be divided into three categories:

successful (D5), *failed* (D1, D2, D4) and *mixed* (D3, D6, D7, D8).

What causes electoral delegation to perform worse in some super-groups than in others? One common feature of the three failed super-groups is that contributions of some groups fall to a very low level (usually zero) in early periods. In the first three periods, the average contributions of the three failed super-groups are already significantly lower than those in other super-groups (8.75 versus 13.64, $p < 0.05$). Another feature is that failed super-groups exhibit a steady downward sloping trend in contributions, while the more successful super-groups are better at coordinating at a certain positive contribution level. Based on these features, we conjecture that some delegates in failed super-groups attempt to free ride on the other groups in the initial periods, triggering an immediate response to decrease contributions by other group delegates in subsequent periods, which is in contrast to standard theoretical predictions if it happens below the threshold of the 66.7% contribution level.

To provide more rigorous evidence, we analyze contribution dynamics separately for failed and other super-groups. Results of the regression models are reported in Table A.8 in Appendix A. The contribution dynamics in failed super-groups exhibit two distinctive features from those of other super-groups. Firstly, some delegates attempt to exploit their fellow group members. While the delegates lower contributions for everyone, the magnitude of the decrease is higher for herself than for the other two members within her group. Delegates in other super-groups, on the other hand, treat their fellow group members equally. Secondly, while delegates in other super-groups increase contributions significantly when they learn that they have under-contributed compared to the others, delegates in failed super-groups are insensitive in this respect. Despite the fact that contribution dynamics differ between failed and other super-groups, there are no systematically different patterns in terms of elections. Table A.9 in Appendix A reports random-effect Probit models that assess this issue and confirm the conclusion. Result 5 summarizes our main findings.

Result 5: *Heterogeneity between super-groups in terms of success lies in contribution dynamics combined with the equal contribution norm rather than the way delegates are elected.*

One possible explanation could be that, as long as a previous delegate from a failed super-group protects her group members from being exploited by other groups and does not exploit fellow group members, her performance is viewed as satisfactory, and hence she is re-elected. If this is true, the failed super-groups might elect relatively more defensive and conservative delegates compared to their successful counterparts. According to Fischbacher and Gächter (2010), the observed dynamics of contributions in a public goods game could be influenced by heterogeneity in preferences or beliefs. Can we attribute the observed heterogeneity in contribution dynamics in our data to the composition regarding cooperative/distributive preferences of the players in these super-groups? Table 1.7 compares cooperative and distributive preferences of members in failed and in other (successful and mixed) super-groups. Indeed, failed super-groups consist of a higher fraction of non-cooperators, i.e. the average unconditional contribution of their members is lower in both Part 1 and Part 3. A higher percentage of players in those three super-groups are classified as free riders (according to the classification criteria in Fischbacher et al., 2001), and they also fully free-ride on the other two members in the one-shot distribution decision in Part 2. Nevertheless, none of the comparisons is statistically significant. While this could be caused by the limited number of observations, it also suggests that the composition in terms of cooperative and distributive preferences alone cannot fully account for super-group heterogeneity in performance.

Table 1.7: Average characteristics of failed and other super-groups

Characteristics of members within a super-group	*Failed super-groups (1, 2, 4)*		*Other super-groups (3, 5, 6, 7,8)*
Part 3 average contributions	5.52		8.14
		p = 0.15	
Part 1 unconditional contributions	7.37		8.31
		p = 0.61	
Part 1 Percentage of free-riders	22.22% (6/27)		8.89% (4/45)
		p = 0.11	
Part 2 Percentage of type "Exploit both members"	66.67% (18/27)		53.33% (24/45)
		p = 0.27	

Notes: The tests comparing percentages are two-sided proportional test. Chi-squared tests and Fisher's exact tests yield very similar results.

1.5 Conclusion

This paper examines the effects of electoral delegation in global public goods provision, with a focus on the strategic interactions between voters and the elected delegates. Our results suggest that compared to a non-hierarchical situation, electoral delegation significantly increases inter-group cooperation levels. Moreover, the election process effectively prevents voters to be massively exploited by the delegates. Nevertheless, the actual levels of contribution with delegation fall significantly short of the theoretical predictions, under the assumption of selfish preferences. Interestingly, we observe a decrease in cooperation levels over time, in contrast to theoretical predictions based on selfish preferences and on most parameter combinations for inequity-averse preferences. The reason lies in the heterogeneity in cooperative attitudes across groups, combined with a strong motive among voters for equal contributions within the group.

It seems that the combination of (i) delegation based on (re)-elections and (ii) heterogeneity in other-regarding preferences leads to an inefficiency that we call *P-inefficiency*, because it seems to be related to the poly-centric nature of the public good provision and management. Our data indicate that both ingredients – delegation based on elections (or more generally: reputational concerns) and heterogeneity across different groups in terms of other-regarding preferences – might be necessary for existence of the P-inefficiency. As one of the referees correctly points out that we do not necessarily need heterogeneity in other-regarding preferences. Some noise in the contribution of strongly inequity averse players (for instance, as a consequence of heterogeneous beliefs regarding the cooperation levels of others) create a coordination problem and, potentially, dwindling contribution levels over time. Such reasoning implies that delegation – how we implemented it – solves the intra-group social dilemma, but not the inter-group social dilemma. Still, the explanation requires some underlying heterogeneity, but not necessarily in preferences.

Notice that the level of the inefficiency is not negligible. For our parameters, towards the end of the interaction with delegation, it amounts to almost half of the maximal efficiency level implied by the standard solution. Intuitively, group members neither want to be exploited by their delegates nor by other groups in the society. As a consequence, if the levels of contributions across groups are different, we observe a similar, albeit slower, decay of contribution levels as in the standard linear public goods game. With delegation, groups cannot coordinate on the Pareto-optimal outcome, even in a repeated interaction. Interestingly, when levels of cooperation decay over time, there does not seem to be an increase in the number of exploitation instances in which group members are exploited by their delegates. Rather, contributions levels get stuck on low levels.

On a more general account, we provide evidence for a setup in which the combination of reputational concerns and other-regarding preferences lead to potential inefficiencies. Angelova et al. (2012) study a completely different setup – a principal agent game with partly incomplete contracts in which the principal employs a short-term agent and a long-term agent alongside each other, where only the latter has reputational concerns – but also observe a similar kind of inefficiency whose existence requires a certain level of other-regarding preferences.

Additionally, the results of our experiment are able to offer insights on the general trade-off regarding the appropriate characteristics of representatives in delegation problems: On the one hand, since no one wants to be exploited by other groups, voters would like to be represented by smart and strategic delegates (leaders). On the other hand, voters face the risk that such a delegate (leader) may be opportunistic and thus may favor herself or small interest groups at the cost of the majority. Such sorts of dilemmas in selecting the best candidate do not only exist in politics, but also in corporations, organizations and communities, where the elected delegate has some discretionary power over the distribution of benefits and costs. More research in a similar spirit seems warranted as a perquisite for better understanding delegation decisions and leadership.

The results of this paper imply that the efficiency effects of delegation mechanisms in organizing global public good provision could be problematic. Albeit oversimplified, this conclusion is consistent with the fact that many self-enforcing international environmental agreements (IEA) (such as the Kyoto protocol) seem to fail in improving efficiency substantially over the non-cooperative outcome in the delegation setting. Other results suggest that a big obstacle to such international cooperation is the lack of effective enforcement and monitoring power at the global level. The P-inefficiency seems to be an additional obstacle that has been overlooked so far. Future work is needed to explore issues such as supra-national linkages to reduce the strategic uncertainty in delegates' interactions (Sandler, 1998) and to confirm existence of the P-inefficiency in similar environments, the conditions under which it is relevant, and the external validity of our results. Statements of head of states or envoys like the ones in climate negotiations that explicitly formulate conditional offers for the level of climate gas emission reductions make us confident that our setup is also relevant for the real world, albeit being stylized.

Chapter 2
Leading by example in public goods games with benefit heterogeneity

2.1 Introduction

Social dilemma situations in which collective interests are at odds with private interests are quite ubiquitous in many instances of daily life, like teamwork, local public goods provision and charitable donations. In a lot of such situations, one could gain more material interests by means of free-riding on others; however, if each individual enjoys public services and group achievements without contributing, these public goods would not be provided. In these cases, collective interests reach the optimum when all individuals contribute all their strengths.

Cooperation in social dilemmas has been investigated with laboratory experiments recently and the context implemented frequently is the public goods game. Previous experiments have found that people are not completely rational and selfish as they still contribute certain amounts of their endowments to the public goods; nonetheless, this amount is far from an efficient provision of public goods (Isaac et al., 1985; Ledyard, 1995). One recently studied mechanism to enhance cooperation is "leading by example". That is, instead of the traditional simultaneous voluntary contribution mechanism, one individual contributes first as the leader while the others contribute simultaneously after having observed the contribution level of the leader. A lot of experimental studies have found that in symmetric standard linear public goods or public bads games[15], both exogenous and endogenous leading by example could induce more contributions and welfares than without this mechanism (Dannenberg, 2015; Güth et al., 2007; Haigner & Wakolbinger, 2010; Moxnes & Van der Heijden, 2003; Pogrebna et al., 2011; Rivas & Sutter, 2011). The underlying principle is that leaders have the incentive and responsibility to contribute more and the followers' contributions are therefore driven up[16]. So far, the experimental studies on leading by example, have mainly focused on symmetric players with the same benefit from the group account. In reality, however, people may differ in the benefits they could achieve from the common goal of the group. One common example is a team of members jointly working on a project. Some team members might benefit more from the project compared to others[17]. It is important to investigate the effective mechanisms to promote cooperation in this environment.

[15] Public bad is the opposite of public good. Not investing into a public bad is costly for an individual, but is beneficial for the whole group. Pollution is an example of a public bad.
[16] Followers' influence by the leader can be regarded as conditionally cooperative (e.g., Fischbacher et al., 2001; Fischbacher and Gächter, 2010).
[17] Some more examples are provided by Reuben and Riedl (2013).

Several experimental studies have so far explored the effectiveness of punishment for promoting cooperation in this type of heterogeneous populations (Kölle, 2012, Nikiforakis et al., 2012, Reuben & Riedl, 2009, Reuben & Riedl, 2013). They find that under this environment, punishment has little effect on promoting contributions in public goods games or has a smaller positive effect compared to punishment in homogeneous populations. Moreover, the positive effect of punishment in increasing efficiency is limited due to the costly nature of punishment. A general explanation for this result is that when people gain different benefits from the public goods, there exists a normative conflict between equality and equity. Specifically, high-benefit group members consider equal contributions of all group members as the enforced norm, whereas low-benefit group members try to enforce the norm that all group members earn similarly. Will the effectiveness of leading by example also be affected under this normative conflict? This raises the motivation to check the robustness of the effectiveness of leading by example in heterogeneous benefit populations. To the best of our knowledge, so far there has not been any laboratory study which investigates this[18].

Few experimental studies have addressed sequential contribution mechanisms into heterogeneous populations in other environments, e.g. heterogeneous endowments situations (Levati et al., 2007; Neitzel & Sääksvuori, 2013); heterogeneous capabilities situation (Au et al., 2007)[19]; heterogeneous group identities situation (Drouvelis & Nosenzo, 2012); heterogenous religious cultures situation (Keuschnigg & Schikora, 2014). Due to different game settings, the results are mixed. Levati et al. (2007) find that no matter whether the leader is the rich or the poor, leading by example functions effectively in heterogeneous endowment populations if all group members rotate in the leader's role; whereas Neitzel & Sääksvuori (2013) do not find such a positive effect with some fixed group members being the leader. Au et al. (2007) find that when the leader is the group member with a lower capability, the contributions to public goods are considerably lower compared to the contributions when the leader is with a higher capability. Drouvelis & Nosenzo (2012) and Keuschnigg & Schikora (2014) show that the same group identity or the same religious culture plays an important role in the effectiveness of leading by example. Moreover, Keuschnigg & Schikora (2014) find that with cultural heterogeneity, the followers who have a different religion from the leader do not follow the leader. The main objective of this paper is to investigate the effect of both exogenous and endogenous sequential contribution mechanisms within a linear public goods game setting in which group members obtain heterogeneous benefits from the public good.

In the experiment, half of the group members gain a benefit from the public goods twice as high as the other half. In order to keep the nature of social dilemma situations and to avoid the crowding out

[18] Weisser (2011) investigates the effectiveness of leading by words under benefit heterogeneity and find that leading by words is still effective in promoting contribution levels.
[19] Heterogenous capabilities refers to the situation in which subjects have different impacts on the collective goal.

effect on low-benefit members' contributions, the members who receive higher benefits also have to bear costs if they contribute[20]. Thus, like in the symmetric public goods game, the dominant strategy for all group members in this setting is contributing nothing. To explore the effect of exogenously imposed leadership and find out which sequence of contributing yields higher contributions, the role of the leader is designated to high-benefit members in one treatment, and to low-benefit members in the other treatment. We compare these two treatments with a baseline treatment in which no leadership exists. To explore whether the way of generating the leaders matters, we also implement an endogenous treatment in which all group members can choose to be the leaders themselves. Moreover, to look at if people cooperate conditionally and how they reciprocate, we elicit subjects' beliefs about others' contributions.

In contrast to the previous results on the effect of leading by example, we find that leading by example does not have a significant positive effect on the average group contributions compared to the baseline treatment with no leadership, regardless of whether leading by example is implemented exogenously or endogenously. When the leaders are assigned exogenously, the type of the leader does not affect the average contributions significantly. In the endogenous leadership treatment, there are 3 potential situations arising: no leadership, high-benefit members leading by example or low-benefit members leading by example. We find that the average contributions are highest when low-benefit members act as the leaders and lowest when no leadership exists. However, since low-benefit members volunteer to be the leader much less frequently than high-benefit members, the endogenous leadership treatment as a whole does not yield significant higher contributions compared to other treatments. In the process of analyzing the behavior of the leader and followers, we find that in each leadership treatment and situation, leaders do increase contributions significantly compared to their counterparts in the baseline treatment; followers, however, do not increase contributions much. Although the follower who is of the same type as the leader emulates the leader to some extent, they exploit the leader by contributing significantly less. The contributions of the followers whose type is different from the leader, surprisingly, seem not to be affected by the leader's contributions since we almost do not detect a significant correlation between them. The driving effect of the leader's good example thus seems to depend on the homogeneous environment of the society.

The remainder of the paper is organized as follows. Section 2.2 describes the design and procedures of the experiment. Section 2.3 presents the main findings. Section 2.4 concludes.

[20] Van der Heijden and Moxnes (2013) find that if leading a good example is costless for the leader, the followers would not follow the good example closely, leading to tiny leadership effects. Glöckner et al. (2011) and Cappelen et al. (2014) also report similar findings.

2.2 Experimental design and procedures

We use a four-person linear public goods game which is repeated for 10 periods in fixed groups. In each period, each of the 4 group members receives an endowment of 20 experiment points, which can be either kept privately or contributed to a group account. Each group member's contribution to the group account in period t, C_{it}, must satisfy $0 \leq C_{it} \leq 20$. The sum of all group members' contributions in period t is denoted by $C_t = \sum_{i=1}^{4} C_{it}$. The payoff function for each subject in period t is

$$\pi_{it} = 20 - C_{it} + \beta_i \times C_t$$

Among the 4 group members, two subjects are randomly selected to be of type A, with the remaining two subjects being of type B. The marginal per-capita return (β_i) is set at 0.4 for members of type A and 0.8 for members of type B. That is, each point a subject keeps in his private account is worth 1 point only to him regardless of his type; in addition, he earns 0.4 points for each point she or each other group member contributes to the group account if he is of type A, while he earns 0.8 points for each point he or each other group member contributes to the group account if he is of type B. In this paper, players of type A are referred to as low-benefit members, and players of type B are referred to as high-benefit members. At the beginning of the first period, each group member is randomly assigned an ID from 1 to 4. They are also announced their own type and ID which they know would remain fixed during the whole experiment.

The following 4 treatments[21] are implemented:

1. Baseline (BASE): All 4 group members make contribution decisions simultaneously and privately.
2. Exogenous high-benefit leader (HBL): One high-benefit member is randomly selected in each period to decide on his contribution, which is announced to the other 3 group members. Then the other 3 group members decide about their contributions simultaneously and privately. The probability of each high-benefit member being chosen in each period is the same.
3. Exogenous low-benefit leader (LBL): One low-benefit member is randomly selected in each period to decide on his contribution, which is announced to the other 3 group members. Then the other 3 group members decide about their contributions simultaneously and privately. The probability of each low-benefit member being chosen in each period is the same.
4. Endogenous leader (EN): In each period all members could choose whether they want to be the first mover or not. To ensure a thoughtful decision, we do not impose a time limit. If all members

[21] We followed a between-subject design, i.e. each subject only participates in one treatment.

choose to be the second mover in a given period, the 4 group members would contribute simultaneously and privately in that period, just like in BASE; if there is only one member who chooses to be the first mover in that period, then this member would make his contribution decision before the other 3 group members; if there are at least 2 members who are willing to be the first mover, a random draw determines the actual first mover in that period[22].

After subjects have made their contribution decisions, we elicit their beliefs about others' contributions in each period in an incentivized way: If subjects have to make two estimations in a period, one estimate is randomly selected to count for the earnings. If the belief is correct, the subject receives 3 points; if the belief differs by 1(2) points, the subject receives 2(1) points; in all other cases the subject receives nothing[23]. Specifically, in treatment BASE, each subject estimates the other same-type member's contribution, and the average contribution of the other two members with the different type. In treatments HBL and LBL, the leader also makes the same estimates on the contributions of the followers likewise; while the follower either estimates the average contribution of the other two followers who are of the different type, or estimates the respective contributions of the other two followers separately, depending on the followers' type. The procedures of belief elicitation are also the same in treatment EN: when there is no leader, it is like in treatment BASE; when there is a leader, it is like in treatment HBL or LBL.

At the end of each period, subjects get feedbacks including each group member's type, (first mover or not in leadership treatments,) contribution to the group account and income (excluding earnings from estimating[24]) in that period. They are also informed about their own income from estimating. All 10 periods of play count towards final earnings.

After the 10 periods, all treatments are followed by an incentivized social value orientation questionnaire, known as the ring test (Liebrand, 1984; Liebrand and McClintock, 1988).The results of the test are not reported here. At last, after finishing a short post-experimental questionnaire, subjects learned their total income from contribution behavior (including the income from estimating), and the income from the ring test.

The experiment was conducted in the MELESSA laboratory at the University of Munich in May of 2014 and September of 2015. A total number of 236 subjects were recruited via ORSEE (Greiner, 2015). Subjects remained anonymous throughout the experiment, and cash payments were made privately. The experiment was programmed and conducted with the software z-Tree (Fischbacher,

[22] In this case, the actual leader does not know whether other group members choose to be the first mover or not.
[23] The average actual contribution is rounded to the next integer, which is known by subjects.
[24] We do not include other group members' earnings from estimation at the end of each period in order to avoid unnecessary income effect.

2007). We conducted 2 sessions for each of the treatments BASE, HBL and LBL, and 4 sessions for treatment EN. There are 24 subjects in each session, yielding 24 independent observations in EN and 12 independent observations in other treatments[25]. At the beginning of each session, subjects received the instructions for the public goods game. The instructions for the ring test were handed out to subjects after they accomplished the 10 period public goods game part. At the beginning subjects knew that there would be a further part after the 10 period decision making and that the second part would be uncorrelated with the first part. Instructions are written in neutral language[26]. In order to test the understanding of the mechanisms and the incentive structure subjects were asked to answer control questions. The experiment did not proceed until all subjects had answered all questions correctly. Each session lasted on average about one hour and 15 minutes.

2.3 Experimental results

The experimental results are presented as follows. Section 2.3.1 compares contributions across the four treatments. Section 2.3.2 explores in detail the contribution behavior of the leader and followers. Section 2.3.3 analyzes the consequences of sequential contribution mechanism for the payoff distribution within the society.

2.3.1 Treatment effects

Table 2.1 and Figure 2.1 display the average group level contributions, separately for each treatment. As shown in Table 2.1, over all 10 periods, the average contribution is highest in treatment HBL, followed by treatments EN, LBL, and BASE. However, the two-sided Kruskal-Wallis test shows no significant differences of the average group contributions across the 4 treatments (p=0.82). The differences comparing the average contributions of any two treatments are not significant either[27].

Table 2.1: Average group contributions by treatment

Period	1-10	1-5	6-10	1	10
BASE	7.2	8.89	5.5	10.33	2.63
	(1.91)	(1.49)	(2.7)	(2.51)	(3.13)
HBL	9.17	10.01	8.32	10.55	6.57
	(4.76)	(4.74)	(5.08)	(4.63)	(4.34)
LBL	8.21	9.0	7.42	10.94	5.56
	(3.28)	(2.71)	(4.45)	(3.34)	(4.7)
EN	8.38	9.71	7.04	11.07	4.05
	(3.16)	(3.62)	(3.55)	(3.09)	(4.65)

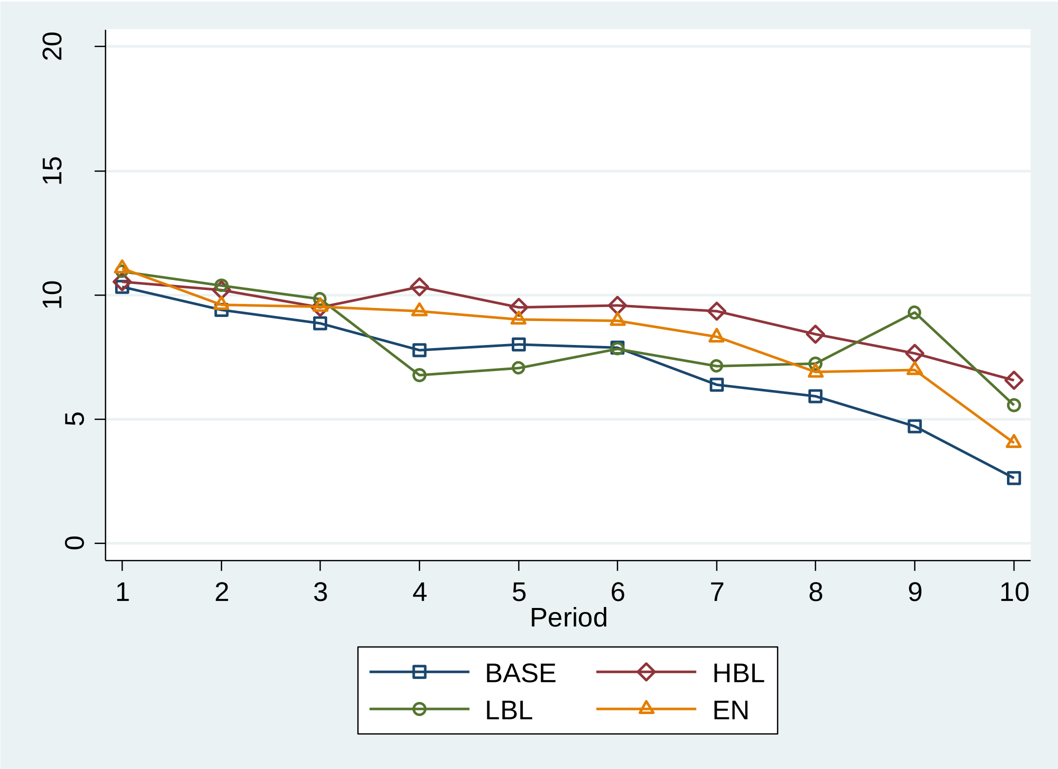
Note: Standard errors in parentheses

[25] One exception is in treatment HBL: there are only 11 independent observations due to no show ups.
[26] Instead of using “leader” or “follower”, we use “First mover” and “Second mover” in the instructions.
[27] Unless specified differently, we use the two-sided Mann-Whitney rank sum tests for comparisons between treatments and two-sided Wilcoxon signed-rank tests for within-treatment comparisons.

The average contributions of all treatments are pretty much the same in the first period (a bit more than 50% of the endowment); however, in the final period, the average contributions in both HBL and LBL are significantly higher than that in BASE ($p<0.01$, BASE vs. HBL; $p<0.1$, BASE vs. LBL). This suggests that subjects in different treatments might not react to treatment variations immediately, but adjust to different treatment environments over time. Hence, we compare the average contributions of these treatments in the early and late five periods separately. Nevertheless, it turns out that the null hypothesis of no difference between exogenous leadership treatments (HBL or LBL) and BASE in the last five periods still could not be rejected ($p=0.14$, BASE vs. HBL; $p=0.17$, BASE vs. LBL)[28].

Result 1: *On the group level, contributions are highest in the treatment HBL, followed by the treatment EN, LBL and BASE. However, differences between any two treatments are not significant.*

Figure 2.1: Average contributions across treatments



Both exogenous and endogenous institutions in our study seem not to promote the contribution rate significantly. We now turn to the endogenous treatment in more detail. There exist three situations in treatment EN: (1) when the chosen voluntary leader is a high-benefit member (hereafter, EN_HBL); (2) when the chosen voluntary leader is a low-benefit member (hereafter, EN_LBL); (3) when nobody

[28] The parametric regression analyzing treatment effect (Table B.1 in the appendix) shows that the contributions in HBL are weakly significantly higher than those in BASE in the last 5 periods, which is mainly attributed to a slower declining trend of contributions in HBL.

volunteers, hence the group has no leader at all (hereafter, EN_NL). Figure 2.2 displays the overall frequency of each situation and the frequency dynamics[29]. Figure 2.3 shows the average group level contribution in each situation.

As shown in Figure 2.2, leading by example is frequently implemented (74% of the times)[30]. Before period 9, at least 75% of groups implement leadership in each period. Only towards the end of the experiment does the frequency of leadership decreases a lot. This is because the percentage of people who choose to be the leader drop from 78% in the first 8 periods to only 26% in the last 2 periods. On average, the relative frequency of high-benefit leadership is 46.25%, which is much higher than 27.92%, the frequency of low-benefit leadership ($p<0.05$, two-sided Wilcoxon signed-rank test). This is in line with the fact that high-benefit members volunteer to be the leader much more often than low-benefit members. In fact, high-benefit members on average choose to be the leader for 39.4% of the times, while low-benefit members on average choose to be the leader only for 22.7% of the times ($p<0.02$, chi-squared test).

Result 2: *Overall, leading by example is frequently implemented, although there is an obvious endgame effect. High-benefit members choose to be the leader significantly more often than low-benefit members, leading to a significantly higher frequency of EN_HBL than EN_LBL.*

As indicated in Figure 2.3, the average contributions are the highest in EN_LBL, followed by EN_HBL and then EN_NL ($p=0.02$, EN_HBL vs. EN_LBL; $p<0.0005$ for other comparisons)[31]. Using each group in the corresponding situation as the unit of independent observation, we compare the average contributions of the three situations with those of the other treatments, it reveals that 1) the average group contributions in EN_LBL are significantly higher than those in BASE and LBL ($p<0.005$, BASE vs. EN_LBL; $p<0.05$, LBL vs. EN_LBL), but are not significantly higher than those in HBL ($p=0.11$, HBL vs. EN_LBL); 2) the average contributions in EN_NL are significantly lower than those in treatments BASE, HBL and LBL ($p<0.01$ for all); 3) the average contributions in EN_HBL are not significantly different from those in other treatments ($p=0.12$, BASE vs. EN_HBL; $p>0.5$ for other comparisons).

[29] Figure B.1 in the appendix displays the frequencies of the 3 potential situations by group.
[30] In treatment EN, 78% of subjects choose to be the leader for at least once.
[31] The pairwise comparisons only include those groups which experienced both corresponding situations and are using two-sided Wilcoxon signed-rank tests.

Figure 2.2: The frequency of each situation in EN on average (left) and over time (right)

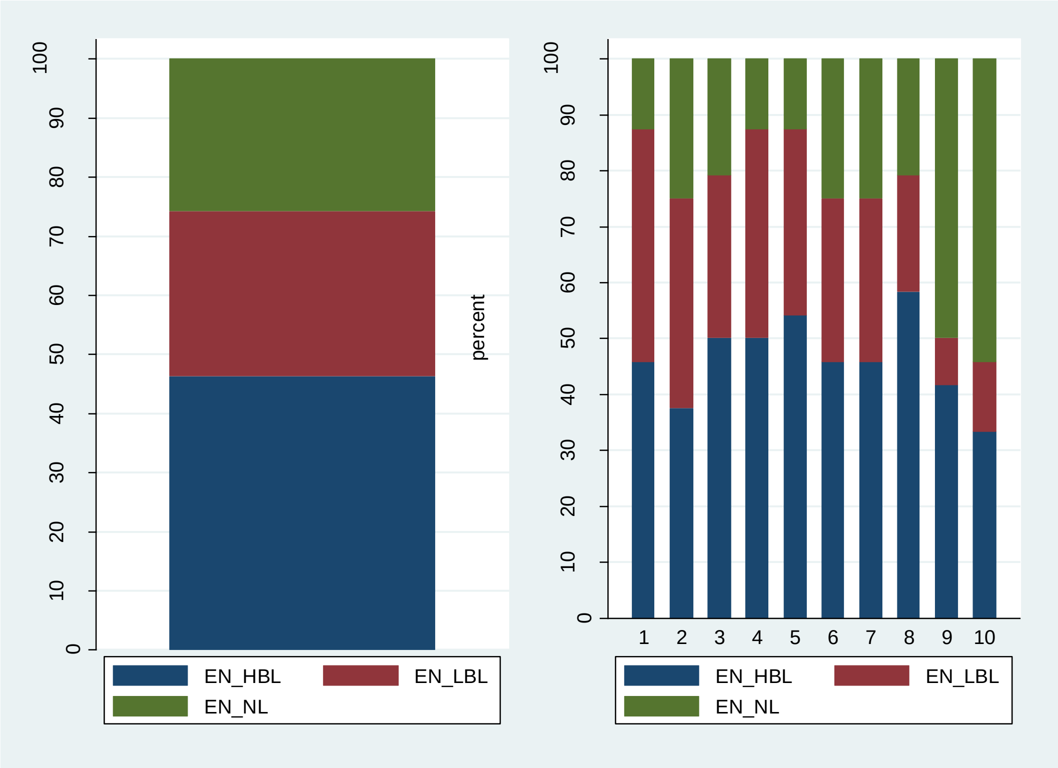
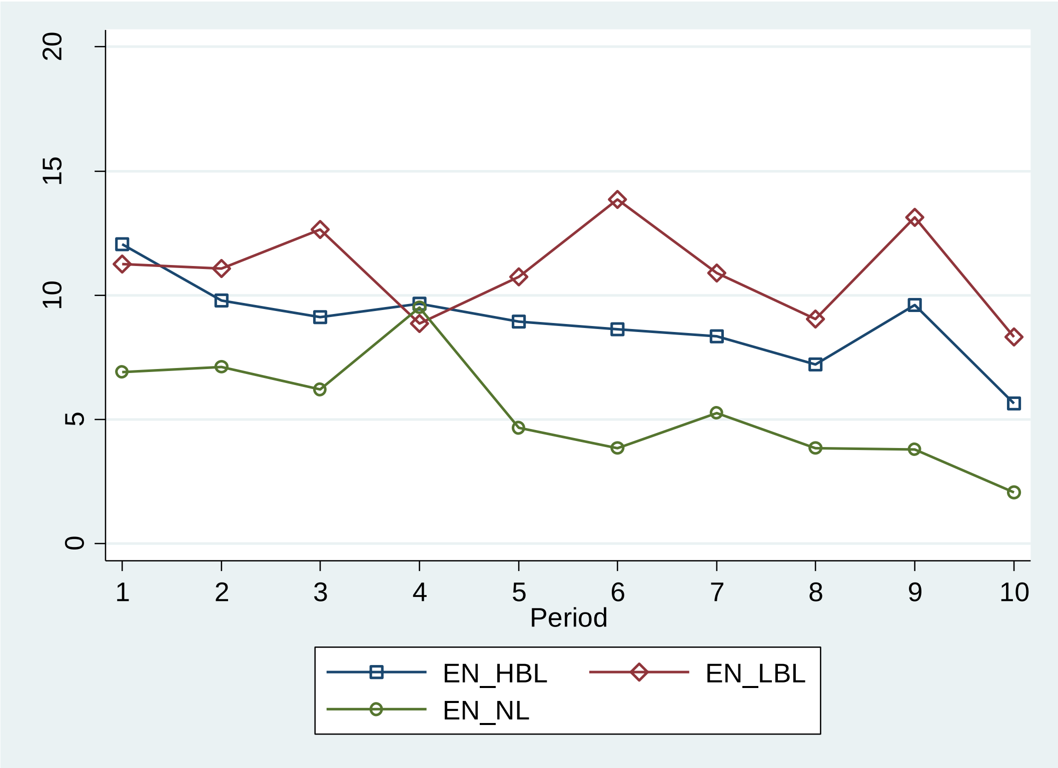


Figure 2.3: Average contributions in each situation of treatment EN



To sum up, when people decide by themselves whether or not to be the leader, low-benefit members being the leader could yield the highest average contributions, significantly higher than those in all other treatments except for HBL. When high-benefit members become the leader voluntarily, the average contributions are not significantly different from those in any other treatment. When nobody chooses to take the role of leader, the average contributions are the lowest and are also significantly lower than those in other treatments. We know from above that the most likely situation happening in treatment EN is EN_HBL, and the likelihoods of EN_LBL and EN_NL are pretty much the same. The highest contribution in EN_LBL is thus counteracted by the lowest contribution of EN_NL, which is why we do not see any significant overall differences between the treatment EN and other treatments. Hence, under benefit heterogeneity, how to increase the frequency of voluntary low-benefit leadership and decrease the frequency of no leadership is left for further studies.

Result 3: *Among the 3 situations in treatment EN, the contributions are highest in EN_LBL and lowest in EN_NL. The contributions in EN_LBL are significantly higher than those in almost all other treatments; the contributions in EN_NL are significantly lower than those in other treatments; whereas there is no obvious difference in contributions between EN_HBL and other treatments.*

2.3.2 Leaders' and followers' behavior

In this subsection we investigate the contribution behavior of leaders and followers respectively. Table 2.2 summarizes the average group level contributions by player type (separately for leaders and followers in leadership treatments and situations).

Table 2.2: Average contributions by player type (and identity) in each treatment and situation

	HM		LM	
BASE	10.23 (2.72)		4.16 (3.35)	
EN_NL	6.33 (5.04)		2.89 (2.67)	
	HL	HF	LF	
HBL	13.2 (5.36)	11.5 (5.62)	5.99 (4.97)	
EN_HBL	14.41 (4.14)	11.71 (5.95)	5.18 (3.70)	
	HF		LL	LF
LBL	10.25 (4.91)		7.06 (4.01)	5.27 (3.76)
EN_LBL	11.64 (3.80)		14.52 (4.77)	6.90 (5.64)

Notes: "HM(LM)" refers to high-benefit (low-benefit) members. "HL(HF)" refers to high-benefit leaders (high-benefit followers). "LL(LF)" refers to low-benefit leaders (low-benefit followers). Standard deviations in parentheses.

Our average data reveal a common leader's effect in each leadership treatment and situation: Compared to the average high-benefit members in treatment BASE, leaders in HBL and EN_HBL contribute significantly more ($p<0.05$ in the last 5 periods, HBL vs. BASE; $p<0.01$, EN_HBL vs. BASE); compared to low-benefit members in BASE, leaders in LBL and EN_LBL also contribute significantly more ($p<0.05$, LBL vs. BASE; $p<0.001$, EN_LBL vs. BASE)[32]. Interestingly, in EN_LBL, leaders' contributions even reach a stable level of about 14 points, which is sufficiently high for low-benefit members[33]. Concerning followers, in our study, there are two types of followers in each leadership treatment and situation. Hereafter, the follower who is of the same type as the leader will be referred to as the same-type follower and the followers who are of different type from the leader will be referred to as the different-type followers. Yet we do not find any significant difference when we compare the contributions of each type of follower to those of their respective counterparts in treatment BASE[34].

Result 4: *Irrespective of the way of imposing leadership or the type of the leader, those who play in the role of the leader contribute significantly more than their counterpart in BASE. Followers' contributions, however, are not promoted significantly by leadership.*

So how do followers make contribution decisions? Are their decisions correlated with leaders' contributions, as found in homogeneous populations? First, let us take a look at how people reciprocate in treatment BASE when there are no leaders. We find that in BASE, the group member's contributions are significantly correlated with his belief on the contribution of his group member of the same type (High-benefit members: Spearman's ρ is 0.77, $p=0.004$; Low-benefit members: Spearman's ρ is 0.92, $p=0.0000$). Moreover, we do not find any significant difference between the group member's contributions and this belief ($p=0.35$ for high-benefit members; $p=0.88$ for low-benefit members). Likewise, in all leadership treatments and situations, we find a significant positive correlation between leaders' contributions and the same-type followers' contributions (In HBL, Spearman's ρ is 0.86, $p=0.0006$; in LBL, Spearman's ρ is 0.90, $p=0.0001$; in EN_HBL, Spearman's ρ is 0.62, $p=0.001$; in EN_LBL, Spearman's ρ is 0.39, $p=0.08$)[35]. However, the same-type followers contribute significantly less than the leader ($p<0.05$ in HBL and EN_HBL; $p<0.005$ in LBL, $p<0.0005$ in EN_LBL), implying that the same-type followers exploit the leader to a significant extent. This result is consistent with the findings that in homogeneous population, followers not only follow the

[32] We also compare the average contributions between EN_NL and BASE for each type of player and find that the lowest contribution of EN_NL is mainly driven by the significant lower contribution of high-benefit members ($p<0.05$), since there is no significant difference in low-benefit members' contributions between the two cases ($p=0.31$). Figure B.2 displays the contribution dynamics by player type in these two cases.

[33] In EN_LBL, the leaders contribute 14.6 points in the first 5 periods and contribute 13.6 points in the last 5 periods.

[34] The comparison between HBL and BASE are additionally made for the last 5 periods considering the leaders' effect is found in the last 5 periods in HBL.

[35] Figure B.3 in the appendix displays the contribution dynamics of the leader and each type of follower in each leadership treatment and situation.

leader, but also undercut the good example set by the leader. Note that the correlation in EN_LBL is rather weak, which is different from those in other cases.

For followers who are of different type from the leader, we only find a marginally significant positive correlation between their average contributions and the leaders' contributions in HBL (In HBL, Spearman's ρ is 0.61, p=0.05; in LBL, Spearman's ρ is 0.29, p=0.35; in EN_HBL, Spearman's ρ is 0.26, p=0.21; in EN_LBL, Spearman's ρ is 0.16, p=0.48). This suggests that the good example of the leaders rarely has an effect on the contributions of the followers of different type. Rather, their contributions are highly correlated with their beliefs on the contributions of each other (In HBL and LBL, Spearman's ρ is 0.94, p=0.0000; in EN_HBL, Spearman's ρ is 0.91, p=0.0000; in EN_LBL, Spearman's ρ is 0.90, p=0.0000), just like their counterparts in BASE. This result is consistent with the previous finding of Keuschnigg & Schikora (2014) that the followers with a different religion from the leader do not follow the leader's good examples.

Another way of looking at the correlation between the leaders' contributions and followers' contributions is to compare the followers' behavior between those groups with higher leaders' contributions and those groups with lower leaders' contributions. For each leadership treatment and situation, we classify the groups into these two categories according to whether their leaders' contributions are above or below average. There are significant differences between the leaders' contributions in these two categories[36]. Will this cause a significant difference in the same-type followers' contributions between the two categories? It turns out that the same-type followers indeed contribute more with good leadership, although this difference is only significant in exogenous leadership treatments[37]. Moreover, in the groups with good leadership, leaders contribute highly significantly more than their counterparts of BASE[38]. Will the same-type followers in these groups contribute significantly more than their counterparts of BASE? We find this is indeed the case in all leadership treatments and situations except for EN_LBL[39]. The same-type followers' contributions seem not be influenced by leaders' contributions in EN_LBL. Considering the Spearman rank correlation between leaders' contributions and the same-type followers' contributions is rather weak in this situation, we claim that in EN_LBL, the same-type followers do not quite follow leaders.

We also do the same analysis for the different-type followers. The qualitative results are the same for all leadership treatments and situations: The different-type followers contribute similarly between the two categories; in the groups with good leadership, they do not contribute significantly more than

[36] OLS-regression with clustering of groups: p<0.001 in HBL, EN_HBL and EN_LBL; p<0.005 in LBL.
[37] OLS-regression with clustering of groups: p<0.005 in HBL and LBL; p=0.14 in EN_HBL; p=0.57 in EN_LBL.
[38] p<0.005, HBL (LBL) vs. BASE; p<0.0001, EN_HBL (EN_LBL) vs. BASE.
[39] p<0.01, HBL vs. BASE; p<0.05, LBL vs. BASE; p<0.005, EN_HBL vs. BASE; p=0.12, EN_LBL vs. BASE.

their counterparts of BASE either[40]. This picture is in line with what we have found above by using Spearman rank correlation, i.e. followers who are different from the leader in terms of the benefit from public goods probably do not follow the leader's good examples.

Result 5: *In EN_LBL, both types of followers do not quite follow the leader. In other leadership treatments and situation, it is mainly the same-type followers who follow the leader, whereas they also exploit the leader by contributing significantly less than them.*

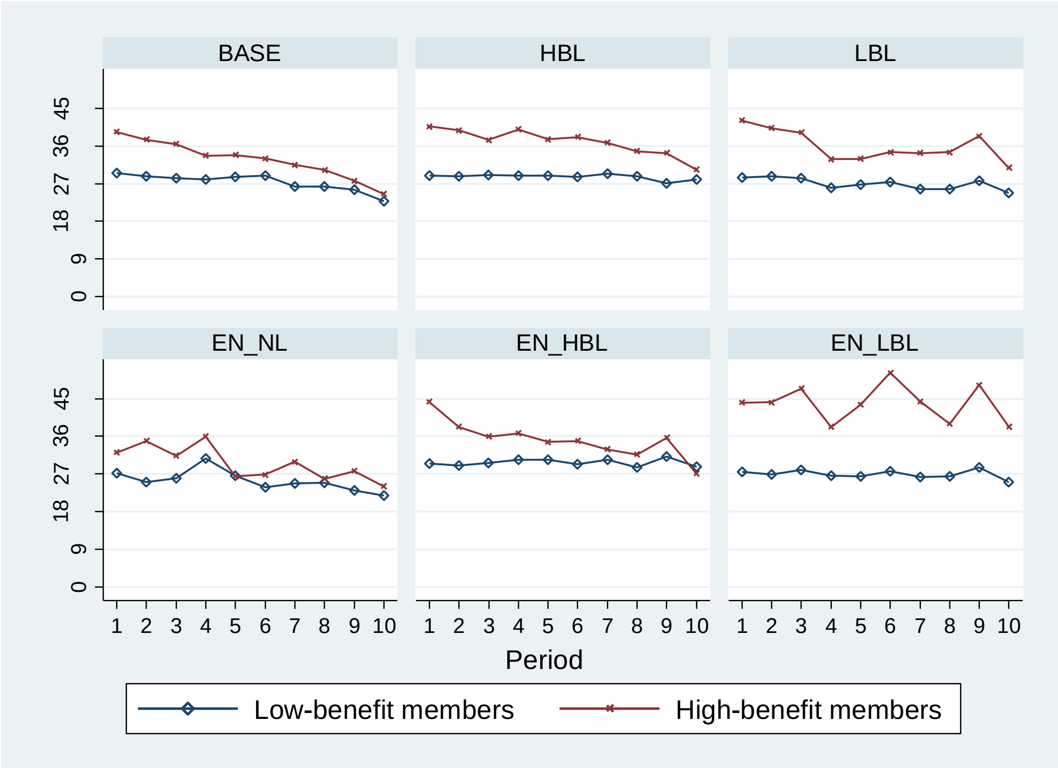
2.3.3 Efficiency and payoff distribution

Due to the linear nature of our game, there are no significant differences in the average group payoffs (excluding payoffs from the correct belief) across our 4 treatments[41]. However, it is worth to notice that the order in the sequential contribution mechanism might affect the payoff distribution between different types. Figure 2.4 shows the average earnings in each treatment and situation by player type. In all treatments and situations, high-benefit members earn significantly more than low-benefit members. Yet, the income disparities between high- and low-benefit members are significantly larger when low-benefit members are acting as the leaders than in treatment BASE ($p=0.06$ in LBL in the last 5 periods; $p<0.001$ in EN_LBL over all periods). In particular, compared to their respective counterparts, high-benefit members earn more and low-benefit members earn similarly.

Concerning the payoffs of leaders and followers, we find that leaders' earnings are not significantly different from those of the corresponding members in treatment BASE. The only exception is that leaders in EN_LBL earn significantly less than low-benefit members in BASE (27.35 in BASE vs. 23.36 in EN_LBL, $p<0.01$). This is consistent with the previous findings that being a leader is never beneficial compared to being the average member with an absent leader (Gächter & Renner, 2003; Levati et al., 2007; Güth et al., 2007). For high-benefit followers, we find that they earn significantly more in almost all leadership treatments and situations compared to high-benefit members in BASE ($p<0.1$ for BASE vs. HBL in the last 5 periods; $p<0.11$ for BASE vs. LBL in the last 5 periods; $p<0.05$ for BASE vs. EN_HBL; $p<0.001$ for BASE vs. EN_LBL). Low benefit followers, however, only earn significantly more than low-benefit members in BASE when leadership is implemented endogenously ($p<0.1$ for BASE vs. EN_HBL; $p<0.02$ for BASE vs. EN_LBL).

[40] OLS-regression with clustering of groups: $p=0.2$ in HBL; $p>0.2$ in other leadership treatment and situations. Comparing with their equivalent in BASE: $p>0.2$ in all cases.
[41] We also compare the average group payoff for each type of group member across the 4 treatments, and for neither type do we find a significant difference ($p=0.56$ for high-benefit members; $p=0.65$ for low-benefit members).

Figure 2.4: Average earnings of high- and low-benefit members in each treatment and situation



Result 6: *The income disparities between high- and low-benefit members are significantly larger when low-benefit members act as leaders than in treatment BASE. Leadership does not pay off for leaders, however, it yields higher earnings for high-benefit followers in all leadership treatments and low-benefit followers in endogenous leadership situations.*

2.4 Conclusion

In this paper, we have examined the effect of leading by example in heterogeneous benefit populations by using a repeated standard public goods game. We investigate both exogenous and endogenous leading by example.

The data analysis yields the following findings: Both exogenous and endogenous leading by example do not yield significantly higher contributions compared to the simultaneous contribution mechanism. In exogenous leadership treatments, the type of the leader does not affect significantly the average contributions. In the treatment that subjects are given the opportunity to choose to be the leader or not, a majority of people choose to be the leader at least once. High-benefit members volunteer to be the leader more frequently than low-benefit members. However, the group contributions are higher when the volunteer leaders are low-benefit members. When the volunteer leaders are high-benefit members, the group contributions do not differ from the baseline treatment. Overall, the highest contributions with a volunteer low-benefit leader are counteracted by the lowest contributions without a volunteer leader, leading to non-significance between the endogenous leadership treatment and the baseline treatment. Further studies are needed to explore how to increase the frequency of low-benefit members volunteering to be the leader in this heterogenous benefit populations. In sum, in comparison to the previous findings on the effect of leading by example in homogeneous populations, the positive effects of both exogenous and endogenous leading by example in heterogeneous benefit populations are much weaker.

Comparing leaders' and followers' contributions with the average contributions of their counterparts in the baseline treatment, we find that on average, leaders do set a good example by increasing their contributions, whereas each type of followers do not change their contributions significantly compared to their counterparts in BASE. As we explore this phenomenon in more detail, we find that followers whose type is different from the leader rarely follow the leader in all leadership treatments and situations. Rather, they are more prone to contribute conditional on their estimate about the contribution of each other. For followers of the same type with the leader, although in most cases they follow the leader, they also undercut the leader's contributions to a large extent.

In all, the effect of leading by example in increasing average contributions to public goods is limited within heterogeneous benefit groups. It reveals that in reality the circumstances in which leading by example is used to promote cooperation should be considered. When a public good brings people different benefits, leading by example may not foster followers' contributions, especially the contributions of those followers of different type from the leader.

Chapter 3
Asymmetric competition between a group and a single player[42]

3.1 Introduction

Inter-group or inter-person competition has been investigated in a large number of experimental studies (literature overviews are provided by Dechenaux et al. (2014) and Sheremeta (2015)). However, comparatively little attention has been devoted to the setting in which one competitor is a group of independent players and the other competitor is a single player or a delegate who could privately make the decision for his group. In reality, there are a lot of such competitions, e.g. unorganized workers striking against their single employer for benefits, an alliance composed of small companies competing against a single company for markets, or even people revolting against a dictator for rights. In such kind of competitions, the single player has complete control over his resource, which can be invested. Group members, however, face a coordination problem and a free-rider problem. This makes the result of the competition unpredictable when the total group owns more resources than the single player. On the one hand, the single opponent seems to be weaker in the competition; on the other hand, a weaker opponent might give rise to a serious within-group conflict, which causes the group to be at a disadvantage instead.

In this paper, we investigate a competition between a group of three players and a single player for a monetary prize. Each player has an endowment at his disposal and decides independently about his contribution to a project. The sum of the group members' contributions is compared to the single player's contribution. The party with the higher contribution level wins the competition and obtains the full prize. In case of tie, the prize will be shared by the group and the single player. Any prize obtained by the group will be shared by group members, irrespective of their individual contribution. Hence, the prize is regarded as a public good for the group. In the baseline treatment, we make the total endowment of both competitors equal. Then we keep the endowment of the group fixed, but reduce the endowment of the single player gradually. More specifically, we study the outcome of the competition and the contributing behavior in the competition in three settings: 1) the baseline treatment, when the total endowments of both competitors are equal; 2) under weak asymmetry when only the sum of all group members' endowments exceeds the single player's endowment; 3) under strong asymmetry when each group member owns as many endowments as the single player.

We find that after several periods of interactions, the group is at a slight disadvantage compared to the

[42] This chapter is joint work with Eva-Maria Steiger.

single player when they have equal total endowments at their disposal. The more the single player's endowment is reduced in the other two treatments, the lower are the group's contributions and the more free-riding behavior can be observed. Nonetheless, the group rarely contributes below the endowment of the single player and is able to outperform the single player in a majority of times. In effect, we find the inter-party competition works in solving within-group conflicts in these two asymmetric competition treatments. Interestingly, we find no significant difference in the outcome of the repeated competition between the two asymmetric treatments, although fewer group members have to contribute in one treatment than the other.

We also look at the consequence of asymmetry on the social efficiency loss and the welfare of each competitor. We find that the more the single player's endowment is reduced, the less the efficiency loss is for the society. The single player has highest net income in the symmetry treatment, while group members gain highest net income in the strong asymmetry treatment. Due to the similar net income of the single player between the two asymmetry treatments, the strong asymmetry treatment is a Pareto improvement over the weak asymmetry treatment.

Our paper relates to the literatures studying competitions between unequal-sized groups. Rapoport and Bornstein (1989) experimentally investigate a 3-player group competing with a 5-player group. Each group member has an endowment of 1 point and has to make a binary contribution decision. Contributions are not refundable. If they do not contribute, their endowment will be left in their private account directly. However, each group member could gain a prize if their group contributes more than its opponent and they could each gain half the prize if their group contributes equally as the opponent. They find that when the members make decisions independently and privately, almost all large groups dominates the small groups. Zhang (2012) investigates a similar contest game in a repeated setting; except that in her setting, the prize is fixed for both groups. She finds that even without any kinds of communication, the large group is more likely to win over the small group. Kugler et al. (2010) investigate a 3-person group competing with a 5-person group in a rent-seeking game setting. In the game, the probability of winning the game is the proportion of the competitor's contributions in the sum of contributions by both competitors. They also find that under equal sharing rules of the prize within the group, the individual contribution rate of the small group is more or less the same as that of the large group and the large group is thus more likely to win the competition.

It seems that when each group member has an equal competing endowment, the large group is at an advantage in the competition with the small group. However, in the competition between two groups, both groups face the collective action problem. Little research so far has been done on competitions between a group and a single player. The four exceptions we are aware of are Abbink et al. (2010), Ahn et al. (2011), Ke et al. (2013) and Kugler and Bornstein (2013). Their findings are mixed. The first three studies investigate the competition between a group and a single player in a rent-seeking game. Each player has the same endowment, so the total group has more endowments than the single player. Abbink et al. (2010) find that the group contributes more than the single player and is more likely to win the competition. Ahn et al. (2011) and Ke et al. (2013), however, find that the single player contributes even more than the total group and thus is more likely to win the competition. Kugler and Bornstein (2013) investigate a contest game between a group of players and a single player in which the total group and the single player have the same amount of endowments. They find that in this case the single player is at an advantage since in some groups, the group members fail to cooperate. Overall, to the best of our knowledge, no paper has systematically studied the effect of endowment differentials between the group and the single player on the outcome of the competition and the group coordination[43].

The remainder of the paper is organized as follows. Section 3.2 describes the experimental design, procedure and theoretical considerations. Section 3.3 reports the main findings. Section 3.4 concludes.

3.2 Experimental design, procedure and theoretical considerations

3.2.1 Experimental design

We implement a contest game similar to Kugler and Bornstein (2013). In our setting, one competitor is a single player and the other is a 3-member group. The two competitors form a fixed competing pair during the whole experiment which lasts for 30 periods. Subjects' roles (also the group members' identification number), which are randomly assigned before the experiment begins, remain constant throughout the whole experiment. In each period, each of the 3 group members receives an endowment of 1 experiment point, which can be either kept privately or contributed to a project. Depending on the treatment, the single player receives some amount of endowment in each period, from which he could decide on his contribution to a project. In each period the sum of the 3 group members' contributions is compared with the contribution of the matched single player. The competitor with a higher contribution wins the competition and obtains the full prize, whereas the losing competitor gets no prize. If the two competitors contribute equally, the prize is equally split between them. Contributions of each player are not refunded. When the group wins or ties the competition, the gained prize is shared equally among the 3 group members irrespective of their

[43] Very few studies investigate asymmetry between the competitors in inter-group competitions, e.g., Bhattacharya (2015) explores inter-group competitions in which the competitors differ in their probabilities of winning or their contribution costs; Hargreaves-Heap et al. (2015) examine contests between groups with unequal endowments.

individual contributions[44].

The period earning for each player is the prize he gained, plus the part of endowment which he does not contribute to the project. All decisions are made independently and privately, since no communication of any kind is allowed during the experiment. We run 3 treatments with a between-subject design. The 3 treatments only differ in the single player's endowment: In our baseline treatment (T3), the single player owns an endowment of 3 points, which is equal to the total endowments of the group; in treatment T2, the single player owns an endowment of 2 points; whereas in T1, the single player only has an endowment of 1 point, just like each group member. The prize is set to be 9 points, so that a rational player will definitely contribute once his contribution is critical for tying or winning the competition[45]. Table 3.1 summarizes our treatment settings.

Table 3.1: Summary of experiment design

Treatment	Endowment of the single player	Endowment of the total group	Independent Observations
T3	3 points	3 points	18
T2	2 points	3 points	18
T1	1 point	3 points	17

At the end of each period, subjects get detailed feedback including which competitor wins, the period contributions and earnings of each player in his competing pair. All 30 periods of interactions count towards final earnings.

3.2.2 Procedure

The experiment was conducted in the MELESSA laboratory at the University of Munich in September and October of 2015. A total number of 212 students (58.49% are female) with various academic backgrounds were recruited via ORSEE (Greiner, 2015). Subjects remained anonymous throughout the experiment. The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007). For each of the 3 treatments, we ran 3 sessions with 6 groups each, yielding 18 independent observations per treatment[46]. At the beginning of each session, the instruction was read

[44] In our setting, the rates at which experimental earnings are converted into payment are equal for all players, such that each group member is paid less from winning or tying than the single player. This is different from Kugler and Bornstein (2013), who set different conversion rates, such that the single player and each group member are paid the same amount from winning or tying. Both settings have their advantages and disadvantages. We choose this setting considering that many real world competitions have fixed prizes, regardless of whether the winner is a group or a single player. For instance, when a group of unorganized workers fights with their employer for a pay rise, the prize of the contest are the total sum of workers' additional salaries. If the workers fail to push through their demands, the prize will remain with the employer and increase his profit.

[45] When the contributing of a group member is critical for preventing his group to lose the competition, the group member could get a prize of 1.5 points, which is still larger than his contributed endowment.

[46] One exception is in T1, there are only 17 independent observations due to no show-ups.

aloud to the participants. In order to test the understanding of the game mechanisms and the incentive structure, subjects were provided the opportunity to make the contribution decisions of all 4 players of a competing pair and got to see the corresponding payoffs for each player. This trial phase lasted 8 minutes. Then the experiment began. All treatments ended with a short post-experimental questionnaire, in which subjects filled out their gender, major, age etc. and typed their motivations for contribution decisions. After the questionnaire they learnt their total earnings of the experiment and were paid individually. Each session lasted on average about one hour (including the time for the payment), and subjects earned an average of 13.4 Euro (including a 4-Euro show up fee), with a minimum of 7.2 Euro and a maximum of 34.2 Euro.

3.2.3 Theoretical considerations

Based on purely selfish preferences, there is a unique pure strategy Nash equilibrium in the stage game of T3, namely, all group members contribute to the project and the single player also contributes all his endowment. Apparently, no player has an incentive to deviate from the full contribution strategy given that the other 3 players fully contribute. However, there is no pure strategy Nash equilibrium for the stage game of T2 and T1. In T2, the group members could guarantee themselves to win the competition by fully contributing. Anticipating this, the single player will contribute nothing in order to save his endowment. The group members, then, would have an incentive not to contribute to avoid unnecessary resource waste. But this gives the single player an incentive to increase contributions in order to win or tie the competition. Anticipating this, all group members would contribute again. This loop is the same in treatment T1.

In this study, the competition is repeated by the same players for 30 periods. In repeated interactions, the set of equilibria is larger. For instance, in T3, the state that all players contributing nothing, could be supported by Nash equilibrium with a sufficiently large discount factor. This collusion state could make the highest social efficiency and is a Pareto improvement over the stage-game Nash equilibrium. In treatments T2 and T1, people can also mix their strategies over time to reach some equilibria. In this paper, we refrain from characterizing all potential equilibria of the repeated game in detail since this is a difficult theoretical problem. In our game, the social optimal state is all players contributing nothing. In the next section our data from the experiment will shed light on the outcomes.

3.3 Results

Our experimental results are presented as follows. First, we present the contributions and winning probabilities of both competitors. Then we analyze group members' contribution behavior in detail. Lastly, we report the welfare effect of the competition. Unless specified differently, we use two-sided Mann-Whitney rank sum tests for comparisons between treatments and two-sided Wilcoxon signed-rank tests for within-treatment comparisons.

3.3.1 Contributions and winning probabilities

Figure 3.1 depicts the average contributions of both competitors over the whole 30 periods. As shown in Figure 3.1, the contributions of the single player never show a declining trend over time. Instead, we find an increasing trend in treatments T1 and T3 (Sperman's rho=0.43, p<0.05 in T1; Spearman's rho=0.64, p<0.0005 in T3). Over all 30 periods, the average contribution levels of the single player are 2.56 points in T3, 1.15 points in T2 and 0.58 points in T1 (p<0.0001 for T3 vs. T2 and T2 vs. T1). Hence, the single player's contribution level significantly decreases as the single player's endowment is reduced gradually. This suggests that as the endowment of the single player is gradually reduced, the group members have a reduced incentive to contribute. In fact we observe that the group indeed significantly decreases its contributions when the endowment of the single player is gradually reduced. On average, over all 30 periods, the group contributes 2.54 points in T3, 2.23 points in T2 and 1.49 points in T1 (p<0.05 for T3 vs. T2; p<0.0001 for T2 vs. T1). This finding confirms the existence of a discouragement effect, which is a common finding in those studies on inter-person competitions with asymmetric players[47]. Moreover, we find that the weaker the single player is, the more variation exists among group members' contributions (average standard deviation of group members' average contributions: 0.07 in T3; 0.14 in T2; 0.21 in T1, p<0.05 for both T3 vs. T2 and T2 vs. T1). In other words, the weaker the opponent is, the more free-riding behavior exists within the group.

Interestingly, as shown in the left panel of Figure 3.1, in T2 and T1 with a severer free-riding problem within the group, we do not detect a declining time trend in the group's average contributions (Spearman's rho=0.24, p=0.2 in T2; Spearman's rho=0.02, p=0.9 in T1). In contrast, in treatment T3 with a less free-riding incentive within the group, we see a decreasing trend in the group's contributions (Spearman's rho=-0.77, p<0.0001 in T3). Throughout all 30 periods, the group contributes similarly as the single player in T3 (p=0.79); yet it contributes significantly more than the single player in T2 and T (p<0.0005 for both comparisons) and even more than the endowment of the single player (p<0.05 in T2, p<0.001 in T1).

To allow for learning effect and convergence, in the following of this subsection we focus on looking at the outcomes in the last 10 periods. The average contribution rates and winning probabilities of both competitors in the last 10 periods are summarized in Table 3.2[48]. Considering that the single

[47] Previous experimental studies have found a common discouragement effect in competitions between asymmetric players, i.e., the weak player cuts back on his contributions into the competition considering it unprofitable to try to beat the strong player. As a consequence, the strong player decreases his contributions into the competition as compared to when he competes against a player of similar strength. Hence, the asymmetry could reduce both players' contributions. (see section 3.2 in Dechenaux et al. (2014)).

[48] Table C.1 in Appendix C displays the same data in the first 20 periods.

player has different endowments across treatments, we list the relative contribution rates and absolute contribution values separately.

The discouragement effect still exists in the last 10 periods. As shown in Table 3.2, the single player's average absolute contributions are highest in T3 and lowest in T1 ($p<0.0001$ for all comparisons). In T3, the single player's average relative contribution reaches nearly 90%. In T2 and T1, the single player reduces his relative contribution to a similar level of 60% ($p<0.005$ for T1 vs. T3; $p<0.0001$ for T2 vs. T3; $p=0.52$ for T1 vs. T2). For the group, we find that in the last 10 periods, the average contributions in T3 are only marginally higher than those in T2 ($p<0.1$ for T3 vs. T2), while the difference between T2 and T1 is still highly significant ($p<0.0001$ for T2 vs. T1).

Figure 3.1: The average contributions of both competitors over time

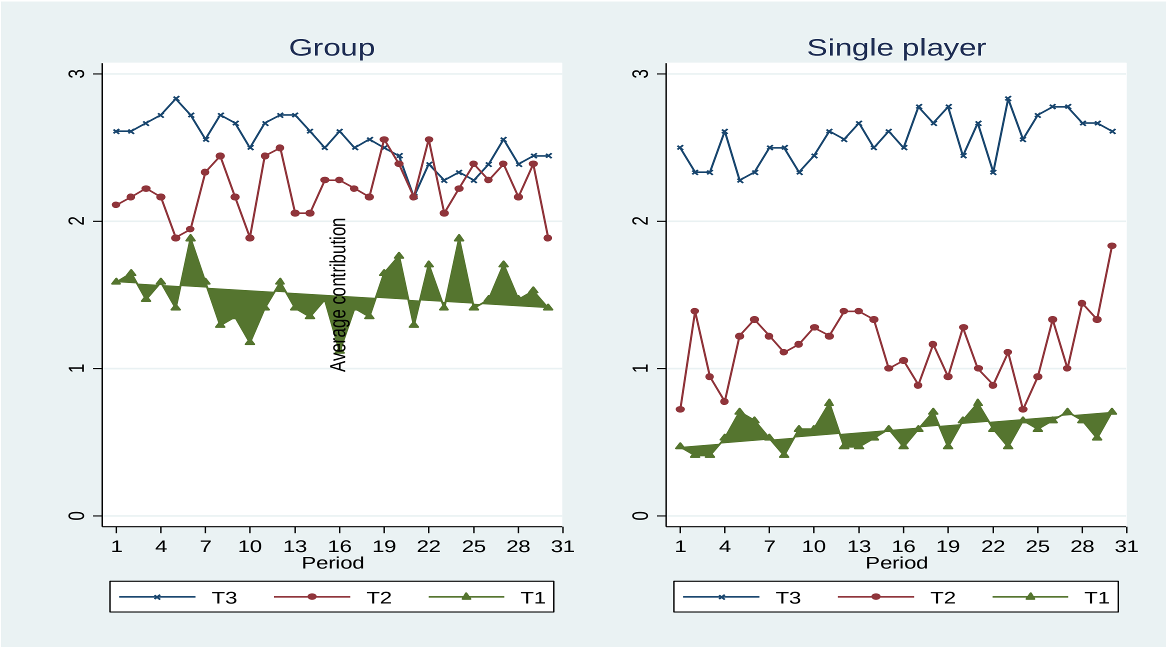


Table 3.2: Relative/Absolute contributions and winning probabilities in the last 10 periods

Treatments	Relative contribution rate		Absolute contribution value		P(GW)	P(T)	P(SW)
	Group	Single	Group	Single			
T3	79%	89%	2.37	2.66	7.8%	68.3%	23.9%
T2	75%	58%	2.25	1.16	65%	23.3%	11.7%
T1	51%	63%	1.53	0.63	68.8%	25.9%	5.3%

Notes: P(GW) refers to the percentage of the group winning the competition; P(T) refers to the percentage of the competition draw; P(SW) is the percentage of the single player winning the competition.

If we compare the contribution levels of both competitors in the last 10 periods, we find that in T3 the group contributes less than the single player, albeit insignificantly ($p=0.16$). In T2 and T1, the group contributes significantly more than the single player ($p<0.001$ for both treatments) and also more than the endowment of the single player ($p<0.05$ in T2; $p<0.001$ in T1).

The distribution of the three possible outcomes of the competition in the last 10 periods is listed in the last three columns of Table 3.2 for each treatment. In T3, the most common result is a competition draw, which accounts for 68.3%. Of these, in 93.5% of the cases do we see the full contribution of both competitors. Apart from the competition draw, the group wins the competition in 7.8% of the cases, but the single player wins the competition in 23.9% of the cases. It confirms that after repeated interactions, the group is less competitive relative to a single player with equal endowments. In both T2 and T1, the most common result is the group winning over the single player, which makes up 65% in T2 and 68.8% in T1; while the single player rarely wins the competition. This suggests that after repeated interactions, the group is at an advantage relative to a weaker single player. The chi-square test rejects the null hypothesis of no difference in the distributions of the three potential outcomes between T3 and each of the other two treatments ($p<0.001$ for both) clearly. However, there is no significant difference in the distributions between T2 and T1 ($p>0.1$, T2 vs. T1)[49]. This is interesting since the group has more endowments than the single player in T1 compared to in T2, however, we do not observe a difference in the outcome of the competition.

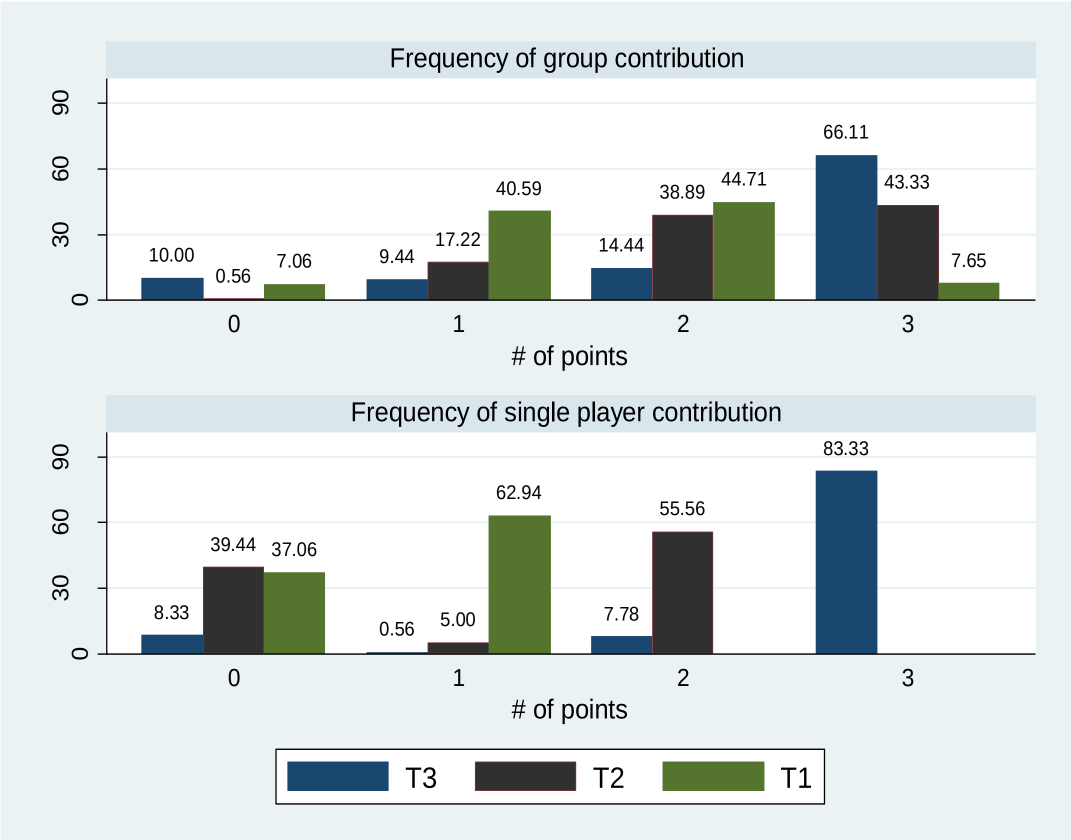
We reach a similar conclusion when observing the outcomes in each competing pair[50]. In treatment T3, most competing pairs reach the steady state of fully contributing in the last 10 periods. However, there are also some exceptions: In 5 out of 18 groups (11, 13, 14, 16 and 18), group members are not able to coordinate, causing the group to lose the competition for at least 50% of the last 10 periods; whereas there is only one competing pair in which the single player always contributes nothing and loses the competition mostly. Although the social efficiency state is a Pareto improvement over the Nash equilibrium in this treatment, in no competing pairs do we find a stable state of social efficiency in the last 10 periods. In treatments T2 and T1, only in few competing pairs do find the group not in advantage in the last 10 periods (2 pairs in T2 and 3 pairs in T1)[51].

Figure 3.2 shows the distribution of both competitors' contributions in the last 10 periods[52]. In treatment T3, the single player contributes fully for about 83%, whereas the group does so less frequently (66%). In treatment T2, the single player rarely contributes 1 point, namely, he contributes either fully or nothing, whereas the group's distribution is bimodal with two peak values 2 points and

[49] This result also holds in the first 20 periods ($p=0.23$ for T2 vs. T1, $p<0.0001$ for other two comparisons). We also use the proportional test to examine if there is any difference between treatments in the propensity of each competitor to win the competition. The qualitative results are basicly similar.
[50] The contributions of both competitors by competing pair are provided in Figure C.1-C.3 in Appendix C.
[51] The group being at an advantage is defined as the group winning over the single player at least 50% of the time and being dominated by the single player less than 50% of the time.
[52] The two-way relative frequencies are provided in Table C.2-C.4 in Appendix C.

3 points, each making up about 40%. In treatment T1, the single player's behavior is similar to that in T2, but the group focuses on contributing 1 point and 2 points at the frequency of around 40% respectively. The group seems to adjust its contribution according to the endowment of the opposing single player, but it rarely contributes below the single player's endowment in asymmetric competitions[53].

Figure 3.2: The distribution of contributions for both competitors in the last 10 periods



Result 1: *After repeated interactions, the group wins the competition less often than the single player in T3; however, in both T2 and T1, the group wins the competition about 65% of the time and the single player rarely wins. Moreover, the winning probabilities of both competitors are similar between T2 and T1.*

Result 2: *As the endowment of the single player decreases, the contribution of the group decreases monotonically and group members free ride more on others. However, in both T2 and T1, the group rarely contributes below the single player's endowment and keeps being competitive over time.*

[53] In the first 20 periods, the group also rarely contributes below the single player's endowment in both T2 and T1 (below the single player's endowment 17.5% of the time in T2 and 13.5% of the time in T1).

3.3.2 Explaining the group's contribution behavior

In this subsection we want to provide deeper insights into the group's contribution behavior by investigating its dynamics. Let us first consider the group as a whole to see how its contributions change across periods. Table 3.3 displays the percentage of the group contribution that decreased, increased, or remained the same from one period to the next, as a function of whether the group won, tied or lost the competition in the previous period. As seen from Table 3.3, in T3 the group does not change contributions across periods in most cases, irrespective of the lagged outcome. In treatments T2 and T1, however, the group mostly increases its contributions when the group did not win the competition in the previous period (tying plus losing). Moreover, in T2 and T1 a win also has the effect of decreasing contributions. A closer look at the data reveals that the group rarely decreases its contribution in the next period when it wins the competition with a contribution level equal to or below the single player's endowment. When the group contributes more than the single player's endowment, the group has an inclination to decrease its contribution in the next period, mostly until the level of the single player's endowment. In treatment T2, the group decreases its contribution in about 50% of the cases when the group's lagged contribution is 3 points. In T1, the group decreases its contribution in about 48% of the cases when the group's lagged contribution is 2 points and in about 87% of the cases when the group's lagged contribution is 3 points.

Table 3.3: Changes of the group's contributions across two periods

Result in the last period	Changes of contribution from previous period	T3	T2	T1
Win	Increase	5.48%	12.64%	18.51%
	Unchanged	<u>75.34%</u>	<u>48.85%</u>	<u>37.61%</u>
	Decrease	19.18%	<u>38.51%</u>	<u>43.88%</u>
Tie	Increase	1.22%	<u>52.14%</u>	<u>54.4%</u>
	Unchanged	<u>90.58%</u>	36.75%	35.2%
	Decrease	8.21%	11.11%	10.4%
Lose	Increase	34.17%	<u>64.91%</u>	<u>75.76%</u>
	Unchanged	<u>54.17%</u>	29.82%	24.24%
	Decrease	11.67%	5.26%	-

Note: Underlined numbers indicating (1) the highest frequency of change within specific case if the highest frequency is at least 50%; (2) the peak frequencies of change within specific case if the highest frequency is less than 50%.

Table 3.4 reports an OLS regression on the contribution dynamics of group members. The dependent variable is the changes of group members' contributions across two periods. As predictors, we include the deviation of own group's lagged contribution from the single player's lagged contribution ($ß_1$ and $ß_2$), and the deviation of the subject's lagged contribution from the lagged average contribution of other two group members (ß$_3$ and ß$_4$). We distinguish between positive and negative deviations to see if they have any different effects. A time trend (ß$_5$) is also controlled for. As shown in the regression table, both coefficients ß$_1$ and ß$_2$ are significant in treatments T1 and T2, but insignificant in T3, indicating a similar result as what we have found in Table 3.3. That is, in treatment T3, group members do not significantly change their contributions, irrespective of the inter-party contribution deviations in the previous period. However, this deviation is an important determinant of group members' contributions in T2 and T1. In these two treatments, group members do not want their group to lose the competition, but also decrease their contributions to some extent in case of winning the competition in the previous period. In case of winning, the negative reaction of group members (ß$_1$) is larger in T1 than in T2 ($p<0.0001$, chow-test).

Table 3.4: Contribution dynamics of group members over all 30 periods (OLS regression)

Dependent variable: changes of contributions from t-1 to t	T3	T2	T1
ß$_1$: Inter-party positive deviation in t-1	-0.011	-0.053***	-0.213***
	(0.006)	(0.014)	(0.022)
ß$_2$: Inter-party negative deviation in t-1	0.050	0.170***	0.184**
	(0.034)	(0.055)	(0.079)
ß$_3$: Intra-group positive deviation in t-1	-0.504***	-0.290***	-0.616***
	(0.109)	(0.059)	(0.081)
ß$_4$: Intra-group negative deviation in t-1	0.579***	0.850***	0.611***
	(0.056)	(0.064)	(0.089)
ß$_5$: Period	-0.001	0.000	-0.001
	(0.000)	(0.001)	(0.002)
ß$_6$: Constant	-0.011	-0.066**	0.210***
	(0.010)	(0.025)	(0.045)
R^2	0.334	0.403	0.418
N	1566	1566	1479

Notes: *** 1% significance level, ** 5% significance level, *10% significance level. Robust standard errors in parentheses (clustered on group level). "Inter-party positive (negative) deviation in t-1" measures the amount the group's contribution exceeds (falls short of) that of the single player in the previous period. "Intra-group positive (negative) deviation in t-1" measures the amount own contribution exceeds (falls short of) the average contribution of the other two members in the previous period.

In addition, group members' contributions are also affected by their comparisons with other members. ß$_3$ and ß$_4$ are highly significant in all treatments, which shows that in all treatments, there is indeed conditional cooperation behavior within the group. That is, group members decrease contributions when they contribute more than the average of the other two, and increase contributions when they contribute less than the average of the other two. It is worth noting that the coefficients of either $ß_3$ or $ß_4$ are not similar between T2 and T1. The positive reaction to the negative deviations from other members' average contribution in t-1 is weaker in T1 than in T2 ($p<0.05$, chow-test), whereas the negative reaction to the positive deviations in the previous period is stronger in T1 ($p<0.005$, chow-test). This, from the perspective of within-group conditional cooperation, also explains why we see a lower contribution rate of the group in treatment T1 and a similar outcome of the competition between T2 and T1.

Result 3: *In T3, group members do not react significantly to inter-party contribution deviations in the previous period. However, in both T2 and T1, group members' contribution decisions are significantly affected by the inter-party contribution deviations in t-1.*

Result 4: *Compared with those in T2, group members in T1 lower their contributions to a larger extent in case of either intra-group or inter-party positive deviations, but raise their contributions to a smaller extent in case of intra-group negative deviations.*

3.3.3 Efficiency

Recall that in our setting, the social optimum is reached when all players contribute nothing. This is true in real life when the competition between competitors is social waste. Over all 30 periods, the contribution level of the whole competing pair is highest in treatment T3 (85% of the whole endowment of the pair) and lowest in treatment T1 (52% of the whole endowment of the pair). All pair-wise comparisons are highly significant ($p<0.0005$), indicating that the social efficiency loss decreases as the gap between the two competitors' endowment increases. This is intuitive since the waste into the conflict is usually quite big when the two competitors are equally strong, whereas in asymmetric competitions where some competitor is relatively weak, the waste in the conflict could be reduced.

We also compare the net income (the earning minus the endowment) of each competitor across treatments. For the group, its net income increase monotonically as the endowment of the single player decreases ($p<0.001$ for T1 vs. T2; $p<0.0001$ for T2 vs. T3). Since the free-riding amount within the group is also increasing, one may wonder whether the group member who is free-ridden on by other members also benefits from the increasing asymmetry. We further rank group members according to their average contributions throughout the experiment. There are few groups in which some or all group members contribute the same over all periods. We rank them according to their rank in the last 10 periods.[54] We then compare the net income of each type of group member between T1 and T2, and find that each type of group member earns significantly more in T1 than in T2 ($p<0.005$ for high- and middle contributors; $p<0.0005$ for low contributors). We also compare the net income of each type of group member in T1 with the average net income of the group members in T3, and find that each type of group member also earns significantly more than the average group member in T3 ($p<0.005$ for high contributors; $p<0.001$ for middle contributors; $p<0.0001$ for low contributors). Thus, in terms of efficiency, the group could get the highest net income under strong asymmetry, both for the group as a whole and for group members.

The single player's net income is highest in T3 ($p<0.005$ for T1 versus T3; $p<0.0005$ for T2 versus T3). This is not surprising since the single player is at an advantage relative to the group in T3, but loses his advantageous role in T2 and T1. Interestingly, the single player's net income is similar between T2 and T1 ($p=0.23$). This suggests that when a single player competes with a strong group of players, it does not matter how much stronger the group is. This, also indicates that the strong asymmetry treatment T1 Pareto dominates the weak asymmetry treatment T2. All significant results in this subsection also holds in the last 10 periods of the game.

Result 5: *Social efficiency loss is biggest in T3 and smallest in T1. Among all treatments, group members get the highest net income in T1 and the single player get the highest net income in T3. T1 is a Pareto improvement over T2 in terms of all players' net income.*

3.4 Conclusion

In this paper, we explore the competition between a group of players and a single player when the total group owns a higher endowment than the single player that can be contributed towards the competition. In the baseline treatment we assign an equal endowment to both competitors. We find that in this treatment, the group contributes a high amount into the competition, but its average contribution is less than that of the single player after repeated interactions (albeit insignificantly). As the endowment of the single player decreases, the group's contributions decrease significantly and group members free-ride more on others. However, the group's contributions are significantly larger than that of the single player and even larger than the corresponding endowment of the single player. As a consequence, the group changes from a slightly disadvantageous position in symmetric competitions to a dominating position over the single player in asymmetric competitions. However, when the group owns more endowments than the single player, the asymmetry level hardly has any effect on the outcome of the competition.

[54] Table C.5 and C.6 provide the average contribution of each group member over all 30 periods by group in T2 and T1. In group 5 of T2, we could only rank the group members after the period 23.

When exploring group members’ contribution changes across periods, we find that in symmetric competitions group members do not react significantly to the group’s lagged contribution deviations from the single player. However, in asymmetric competitions, the inter-party contribution deviation affects significantly group members’ contribution decisions. Group members increase contributions when the contribution of the group fell short of that of the single player in the previous period, and also decreases contributions when the group contributed more than the single player in t-1. Ceteris paribus, the amount of deviations positively affect subjects’ contribution changes. Group members’ contribution changes are also affected by the conditional cooperation within the group. Comparing the two asymmetric treatments, we find that, as compared to T2, in T1 group members decrease their contributions to a larger extent either when they contributed more than the average of others or when the group won the competition in the previous period. They also increase their contributions to a smaller extent when they contributed less than the average of others in t-1. All of these, from an ex post perspective, explain the different contribution behavior of the group across treatments.

Our findings have implications for real-life conflicts between a group of players and a single player. For example, in the conflict between unorganized workers and their single employer, our results imply that the workers have an advantage if they as a whole have more resources that could be invested in the conflict than the single employer, even if they make decisions independently. Our result also indicates that the asymmetry level do not necessarily affect the outcome of the conflict, but a strong asymmetry between the two parties yields lower wastes into the conflict and is a Pareto improvement over a weak asymmetry.

Our paper suggests many ways for future research. First, in our study, the prize is shared equally by the group members irrespective of their contributions. It would be interesting to introduce other intragroup profit sharing rules within the group. For example, one could study how the competitions evolve when the prize is shared proportionally within the group. Second, intragroup communication is not allowed in our setting. However, in reality, non-binding communication within an alliance sometimes is possible. Studies on whether within-group communication could further help to mitigate the mis-coordinations within the group are also needed[55]. Lastly, the group only includes three members in our setting. A natural extension is to investigate whether the group is still at an advantage in the asymmetric competitions when the group size increases.

[55] Bornstein and Gilula (2003) investigates the effect of communication on the competition resolution in inter-group chicken and assurance game; Zhang(2012) also explores the effect of communication in inter-group competitions.

Appendix A

Providing global public goods: Electoral delegation and cooperation

A.1 Proofs of predictions

A.1.1 Proof of Hypothesis 1(c): voting

We prove that in equilibrium everyone has the same probability to be elected as the delegate. Each player A, B, C has six pure strategies: (1, 2, 3), (1, 3, 2),…, which give points to candidate (A, B, C), respectively.

It is straightforward to show that the only weakly undominated strategy for each player is to assign the most favorable rank (in this case 1) to herself. For instance, assume that A chooses (**2**, 1, 3) and B and C choose (3, 1, 2) and (2, 3, 1), respectively, so that the total ranks are 7, 5, and 6 for the three candidates. In this situation, A loses outright. If A chooses (**1**, 2, 3) instead, the total ranks will be 6, 6, and 6 points for the three candidates—a three-way tie in which A has a strictly higher probability of winning. A similar analysis can be applied to other ranking combinations.

Given that players assign the most favorable rank to themselves, the question becomes how they allocate ranks 2 and 3 to the other two candidates. We analyze the following reduced game. The payoffs which are defined as the probability of winning the election and normalized to 1 for convenience are displayed in the order A, B, C. We define choosing a player by "assigning rank 2 to this player and rank 3 to the third player".

Pl. C (columns), ***Pl. B*** (rows), ***Pl. A*** (matrices)

Pl. A: B

Pl. B \ Pl. C	A	B
A	$\underline{1}$,0,$\underline{0}$	0,$\underline{1}$,$\underline{0}$
C	$\frac{1}{3},\frac{1}{3},\frac{1}{3}$	$\underline{0}$,$\underline{1}$,0

Pl. A: C

Pl. B \ Pl. C	A	B
A	$\underline{1}$,$\underline{0}$,0	$\frac{1}{3},\frac{1}{3},\frac{1}{3}$
C	0,$\underline{0}$,$\underline{1}$	$\underline{0}$,0,$\underline{1}$

Based on the payoff matrix, there are two pure strategy equilibria in this game: {A: (1,2,3), B: (3,1,2), C: (2,3,1)} and {A: (1,3,2), B: (2,1,3), C: (3,2,1)}.

Now consider mixed strategy equilibria. Define p_i^j as the probability that player *i* chooses player *j* (assigning rank 2 to player *j*). In our game, player A chooses player B if player A's expected payoff (probability of winning) is at least as large as for choosing C (she is indifferent if the expected payoffs are the same):

$$\mathrm{E}[\pi_A|B] = p_B^A p_C^A + \frac{1}{3}(1 - p_B^A)p_C^A \geq p_B^A p_C^A + \frac{1}{3}p_B^A(1 - p_C^A) = \mathrm{E}[\pi_A|C]$$

The left- and right-hand sides give A's expected payoffs for choosing B and C, respectively. The parameters p_B^A and p_C^A give the probabilities that B and C choose A. Rearranging yields $p_C^A \geq p_B^A$.

Since the game is symmetric, player B will mix between choosing A and C only if $p_C^B = p_A^B$, while player C will mix between choosing A and B only if $p_A^C = p_B^C$. Thus, the mixed strategy equilibria should be $p_B^A = p_C^A = p_C^B = p_A^B = p_A^C = p_B^C =$0.5. Each player is indifferent between choosing the other two members. The mixed-strategy Nash equilibrium payoff for each player is 1/3, implying everyone has the same probability to be elected as the delegate.

A.1.2 Inequity aversion following Fehr and Schmidt (1999)

In this section, we relax the self-interest assumption by considering a popular outcome-based other-regarding preference model: the inequity-aversion model by Fehr and Schmidt (1999). Fehr and Schmidt (1999) model fairness as a dislike of inequitable outcomes. Specifically, an inequity-averse player gains utility from her own payoff π_i, but suffers a utility loss if her own payoff differs from those of the other members in her reference group. The specific utility function is the following:

$$U_i(\pi) = \pi_i - \alpha_i \frac{1}{n-1}\sum_{j\neq i} max\{\pi_j - \pi_i, 0\} - \beta_i \frac{1}{n-1}\sum_{j\neq i} max\{\pi_i - \pi_j, 0\}, \quad (3)$$

where the disadvantageous inequity-aversion parameter α_i and the advantageous inequity aversion parameter β_i need to satisfy the following conditions: $\beta_i \leq \alpha_i$ and $0 \leq \beta_i < 1$.

Table A.1 gives an overview of the parameter conditions required for the existence of cooperative equilibria using Fehr-Schmidt-preferences in the stage game of our experiment. The conditions assume common knowledge of the preferences, rationality and risk-neutrality.

Table A.1: Predictions for contributions in the stage game with inequity-averse preferences

	Baseline	*Delegation*
Part 3	[A] $c_i = 0$, if $\exists\ \beta_i < 0.5$, or [B] $c_i = c \in [0, 20]$, if $\forall \beta_i \geq 0.5$	
Part 4 *three-person reference group*	[A] $c_i = 0$, if $\exists\ \beta_i < 0.83$, or [B] $c_i = c \in [0, 20]$ if $\forall\ \beta_i \geq 0.83$	[A] $c_o = 20$, and $c_D = 0$ if $\beta_D < 0.33$, or [B] $c_o = c_D = 0$ if $\beta_D \geq 0.33$
Part 4 *nine-person reference group*	[A] $c_i = 0$, if $\exists\ \beta_i < 0.83$, or [B] $c_i = c \in [0, 20]$ if $\forall\ \beta_i \geq 0.83$	[A] $c_o = 20$, and $c_D = 0$ if $\exists\ \beta_D < 0.83$, or [B] $c_o = c_D = 20$ if $\forall\ \beta_D \geq 0.83$

Notes: i… group member *i*, with three or nine members in the group, depending on the size of the reference group.
o… ordinary group member (i.e. other group members); *D*… delegate.

Hypothesis 2(a) for Baseline: *Part 3 predictions and Part 4 predictions for Baseline are identical. A cut-off-level of β for all group members determines whether cooperative equilibria exist.*

Proof of Hypothesis 2 (a) for *Baseline* contributions (stage game):

Part 3

In a three-person linear public goods game, the contributions of all group members must be equal in any equilibrium. Otherwise, the member with the highest contribution is always better-off by reducing her contribution. Now suppose $c_1 = c_2 = c_3$. For any member c_i, a unilateral deviation by one point increases her monetary earnings by 0.5 points (1- 0.5), but increases her advantageous disutility by $\frac{1}{2}2\beta_i$ within the group. It is straightforward that this group member chooses not to decrease her contribution when $\beta_i \geq 0.5$. Assume that the distribution of β parameters among delegates is common knowledge. Under this assumption, only when all members are sufficiently advantageously inequity-averse (i.e., $\beta_i \geq 0.5\ \forall$ i), there exist multiple Pareto-ranked equilibria, each of which implies the same level of weakly positive contributions for all group members, $c_i = c \in [0, 20]$. If one group member satisfies $\beta_i < 0.5$, complete free-riding ($c_i = 0\ \forall$ i) is the unique equilibrium outcome.

Part 4 (Case 1): Three-person reference group

The analysis in this case is similar to that of Part 3, since the only aspect that changes is the marginal per capita return (MPCR) of the public account. For any member c_i, withdrawing one contribution point increases her monetary earnings by 0.83 points (1- 1.5/9), instead of 0.5 points as in Part 3. At the same time, disutility from payoff inequity increases by $\frac{1}{2} \times 2\beta_i$ if the player completely ignores earnings of out-group members. Obviously, for contributing to become optimal, the monetary gain should not exceed the disutility from earning more than the other group members. This gives the condition $\beta_i \geq 0.83$ that has to be fulfilled for the equal contribution equilibrium $c_i = c \in [0, 20]$.

Otherwise, complete free-riding ($c_i = 0 \; \forall$ i) is the unique equilibrium outcome. A stronger sensitivity from advantageous inequity compared to Part 3 is required in the larger group, because defecting become monetarily more profitable.

Part 4 (Case 2): Nine-person reference group

A change in the reference group does not alter equilibrium outcome for Baseline, due to the fact that 1) the return of the public good is linear and in proportion of the contributions, and 2) an in-group member is not treated differently from an out-group member. In this case, the disutility increases by $\frac{1}{8} \times 8\beta_i$ if a member tries to undercut her contribution by one point, which is exactly the same as in Case 1. Therefore, the equilibrium outcome remains the same: $c_i = c \in [0, 20]$ if $\forall \; \beta_i \geq 0.83$; otherwise, $c_i = 0$ if $\exists \; \beta_i < 0.83$.

Hypothesis 2(b) for Delegation: *Only three potential equilibria are sustainable:* $c_D = c_o = 20$, $c_D = c_o = 0$, *and* $c_D = 0 / c_o = 20$. *Which one applies, depends on the specific assumptions regarding the size of the reference group and* β*-parameters of either the single delegate or all delegates in the super-group.*

<u>**Proof of Hypothesis 2 (b) for Delegation contributions (stage game):**</u>

Part 4 (Case 1): Three-person reference group

Denote contribution for delegates as c_D, and the contributions of the other two members as c_o. In *Delegation*, delegates play a three-person public goods game, subject to a utility maximization constraint regarding payoff distributions among three members. Note that in any solution, it is not possible that $c_D > c_o$, since the delegate could always be better off by decreasing her own contribution. When $\beta_D < 0.33$, the equilibrium assignment will be $c_D = 0$ and $c_o = 20$. Otherwise, if $\beta_D \geq 0.33$, a delegate will assign $c_D = c_o = 0$ for every member. The intuition behind these equilibria is that, when delegates do not care much about earnings for the other two members, they act selfishly by forcing them to contribute fully. When she sufficiently cares about earnings of her group member (but not about out-group members), the optimal strategy is to always equalize everyone's contribution in the group and free ride on other groups by contributing zero.

Suppose $\beta_D < 0.33$ for all delegates. The proposition is that $c_D = 0$ and $c_o = 20$ is an equilibrium. In such an equilibrium, a delegate has no incentive to increase her own contribution, since the reduction in her advantageous disutility ($\frac{1}{2} \times 2\beta_D$) is strictly smaller than her monetary gain of 0.83 points $(1 - \frac{1.5}{9})$. Similarly, she has no incentives to decrease others' contributions, since her gain in utility from decreasing the advantageous position ($\frac{1}{2}\times\beta_D$) will be smaller than her monetary loss from doing so ($\frac{1}{6}$).

Suppose $\beta_D \geq 0.33$ for all delegates. The proposition is that $c_D = c_o = 0$ is the unique equilibrium. In this case, a unit increase in a group member's contribution leads to a $\frac{1}{6}$-points increase in the delegate's monetary payoff, which is smaller than the inequity gap of $\frac{1}{2}\times\beta_D$. Hence, it is better to equalize the payoffs between herself and the other group members than not. Note that any other positive contribution is not an equilibrium, since a delegate could increase her utility by assigning zero contributions for every member in her group and free-ride on the other groups (that are not in the utility function by definition).

Now suppose one delegate exhibits $\beta_D \geq 0.33$, and the other two $\beta_D < 0.33$. Then, contribution vectors will be (0, 0, 0) for the group with the inequity-averse delegate and (0, 20, 20) for the other two. Since the reference group is the three-person group and public good provision is linear, contributions in other groups neither affect the marginal gain/loss analysis nor how incomes within groups are compared.

Part 4 (Case 2): Nine-person reference group

When the advantageous inequity parameters of all three delegates are larger or equal to 0.83, then the contribution vector $c_i = c = 20$ constitutes an equilibrium. A unilateral unit decrease for a delegate leads to 0.83 points of monetary gain, but $\frac{1}{8}\times 8\beta_D$ units of utility loss. Since $\beta_D \geq 0.83$, the loss is larger than the gain. However, if there exists a delegate with $\beta_D < 0.83$, then the unique equilibrium is that every delegate assigns $c_D = 0$ for herself and $c_o = 20$ for the other group members. There is no incentive for any delegate to deviate, since a unit increase in her own contribution decreases her monetary benefit by 0.83 points and also her advantageous utility by $\frac{1}{8}\times 2\alpha_D$. Her utility gain compared to the other members who are forced to contribute fully, on the other hand, is strictly smaller ($\frac{1}{8}\times 6\beta_D$).

A.2 Supplementary tables and figures

The delegation mechanism significantly increases public goods provision compared to the baseline. Table A.2 outlines the results from random effect regressions. The dependent variable is the proportion of total endowment contributed to the public good in a group in Part 4. In both *Baseline* and *Delegation*, a group with higher average contributions in Part 3 is also more likely to contribute more in Part 4 (β_2). Nonetheless, even after controlling for that, the delegation mechanism still brings in higher contributions (β_1). This result is robust when controlling for time trend (β_3) and the interactions between treatments and time (β_4).

Table A.2: Random effects regression analysis of group contributions in Part 4

Dependent variable: contributions at the group level (percentage)	(1)	(2)	(3)
β_1: Delegation (1 for "treatment Delegation")	0.387***	0.379***	0.368***
	(0.039)	(0.037)	(0.057)
β_2: Part 3 average contribution in group (percentage)		0.198**	0.198**
		(0.078)	(0.078)
β_3: Period			-0.014***
			(0.002)
β_4: Delegation × Period			0.001
			(0.004)
β_5: Constant	0.096***	0.033	0.167***
	(0.013)	(0.023)	(0.033)
R^2 overall	0.424	0.449	0.506
N	756	756	756

Notes: * $p < .1$, ** $p < .05$, *** $p < .01$. Robust standard errors (clustered at the super-group level) are reported in parentheses.

Table A.3: Random effects regression analysis of group contributions in *Delegation*

Dependent variable: Average contributions in a group (percentage)	
Period	-0.011***
	(0.003)
Part 3 average contribution in a group (percentage)	0.292**
	(0.145)
Delegate being the high contributor in Part 3	0.095**
	(0.037)
Delegate being the low contributor in Part 3	0.002
	(0.048)
Constant	0.435***
	(0.072)
R^2 overall	0.167
N	432
Groups	24

Notes: * $p < .1$, ** $p < .05$, *** $p < .01$. Robust standard errors (clustered at the super-group level) are reported in parentheses. A delegate is a "high contributor" if her average contributions in Part 3 is the highest in her group. Likewise, a delegate is a "low contributor" if her contribution in Part 3 is the lowest in her group.

Table A.4: Determinants of election in the first period (Probit model)

Dependent variable: Whether a subject is elected in the first period (1 means yes)

	(1)	(2)	(3)	(4)	(5)
Part 3 rank within group	-1.218***	-1.349***	-1.197***	-1.164***	-1.238***
(1 means the high contributor and 3 means the low contributor)	(0.394)	(0.397)	(0.405)	(0.392)	(0.394)
Part 1 unconditional contribution		-0.037			
		(0.028)			
Part 1 free rider			-0.103		
			(0.396)		
Part 1 hump-shaped/others			-0.387		
			(0.867)		
Part 2 fully exploit				-0.304	
				(0.393)	
Part 2 self-serving				-0.096	
				(0.363)	
Part 3 individual average contribution					-0.008
					(0.010)
Constant	1.794***	2.347***	1.804***	1.863***	1.896***
	(0.652)	(0.750)	(0.625)	(0.660)	(0.661)
Log-likelihood	-30.89	-30.26	-30.71	-30.24	-30.87
N	72	72	72	69	72

Notes: * $p < .1$, ** $p < .05$, *** $p < .01$. Robust standard errors (clustered at the sub-group level) are reported in parentheses. The variable "Part 1 free rider" and "Part 1 hump-shaped/others" represent the two conditional contribution preferences in the one-shot public goods game based on Fischbacher et al. (2001), with the baseline being the conditional cooperators. The baseline distributional preference in the Part 2 is equal contributions across three members; while "Part 2 fully exploit" means assigning full contributions for the other two players but zero to him/herself. The variable "Part 2 self-serving" represents a lighter degree of exploitation by asking others to contribute more than herself.

Table A.5: Determinants of election in the last election period (Probit model)

Dependent variable: Whether a subject is elected in the last election period (1 means yes)

	(1)	(2)	(3)	(4)
Incumbent delegate (=1 if yes)	3.577***	3.627***	3.674**	3.783***
	(1.332)	(1.371)	(1.429)	(1.307)
Part 3 rank within group	-0.129	-0.207	-0.063	-0.040
	(0.311)	(0.350)	(0.424)	(0.328)
Incumbent delegate × Part 3 rank within group	-1.209**	-1.285**	-1.321**	-1.309**
	(0.605)	(0.612)	(0.611)	(0.572)
Positive deviations from the super-group averages	0.090	0.056	0.082	0.106
	(0.163)	(0.154)	(0.189)	(0.181)
Incumbent delegate × Positive deviations from the super-group averages	-0.857*	-0. 731	-0.723	-0.881**
	(0.445)	(0.467)	(0.442)	(0.443)
Negative deviation from the super-group averages	-0.084	-0.086	-0.031	-0.100
	(0.124)	(0.123)	(0.128)	(0.141)
Incumbent delegate × Negative deviations from the super-group averages	0.288	0.258	0.473	0.268
	(0.280)	(0.283)	(0.472)	(0.284)
Part 1 unconditional contribution		-0.036		
		(0.033)		
Part 1 free rider			1.284**	
			(0.534)	
Part 2 fully exploit				-0.046
				(0.483)
Part 2 self-serving				-0.319
				(0.561)
Constant	-0.523	-0.073	-0.832	-0.677
	(0.613)	(0.804)	(0.804)	(0.616)
Log-likelihood	-35.62	-34.95	-29.60	-33.11
N	70	70	61	67

Notes: * $p < .1$, ** $p < .05$, *** $p < .01$. Robust standard errors (clustered at the sub-group level) are reported in parentheses. There are only 2 observations in which the variable "Incumbent delegate × The average extent of exploiting both" equals nonzero and the delegates are both kicked out of office, so this variable is automatically dropped in the regression. The variables "Part 1 hump shaped/others" and "Part 2 altruistic", "Part 2 others" are also automatically dropped because of the same reason.

Table A.6: Ranking analysis in the first election (Ordered logit model)

Dependent variable: voter *i*'s ranking to candidate *j* (1-3)

	High contributor	*Middle contributor*	*Low contributor*	*Aggregate data*
Part 3 candidate's rank within group	2.947***	0.997***	0.006	1.206***
	(0.766)	(0.341)	(0.354)	(0.251)
Part 3 candidate's average contribution	-0.030	0.041**	0.003	0.006
	(0.019)	(0.019)	(0.018)	(0.011)
Candidate is the voter herself (=1 if yes)	-	-	-	-2.336***
				(0.439)
Log-likelihood	-47.40	-76.83	-75.80	-190.36
N	72	75	69	216

Notes: * p < .1, ** p < .05, *** p < .01. Robust standard errors (clustered on individual voters) are reported in parentheses. All variables here are referring to candidates.

Table A.7: Ranking analysis in the last election (Ordered logit model)

Dependent variable: voter *i*'s ranking to candidate *j* (1-3)

	High contributor	*Middle contributor*	*Low contributor*	*Aggregate data*
Incumbent delegate (= 1 if yes)	0.238	-0.539	0.711	-1.486
	(0.897)	(1.769)	(1.968)	(1.112)
Part 3 candidate's rank within group	2.127***	0.696*	-1.804***	0.171
	(0.512)	(0.387)	(0.592)	(0.242)
Incumbent delegate ×Part 3 candidate's rank within group	a	-0.341	-0.299	0.634
		(0.898)	(0.764)	(0.448)
Positive deviation from the super-group average	-0.369	-0.456**	0.475**	-0.080
	(0.249)	(0.213)	(0.205)	(0.199)
Incumbent delegate × Positive deviation from the super-group average	1.150	1.325*	-1.624**	0.491
	(0.755)	(0.730)	(0.683)	(0.698)
Negative deviation from the super-group average	0.264**	0.090	0.125	0.160**
	(0.124)	(0.083)	(0.091)	(0.070)
Incumbent delegate × Negative deviation from the super-group average	-0.677*	-0.187	-0.602**	-0.490**
	(0.378)	(0.338)	(0.305)	(0.227)
Average extent of exploiting both	0.023	0.003	-0.052	-0.019
	(0.028)	(0.026)	(0.033)	(0.031)
Incumbent delegate × Average extent of exploiting both	9.585***	0.113	0.102	0.001
	(0.660)	(0.123)	(0.124)	(0.114)
Candidate is the voter herself (=1 if yes)	-	-	-	-2.590***
				(0.476)
Log-likelihood	-58.45	-75.52	-59.50	-195.59
N	72	75	69	216

Notes: * $p < .1$, ** $p < .05$, *** $p < .01$. Robust standard errors (clustered on individual voters) are reported in parentheses. Variables are defined analogously to Table 1.6.

[a]: The variable is dropped from the regression due to convergence failure.

Table A.8: Contribution dynamics conditional on the performance of the super-groups

Dependent variable: Changes of contributions across periods	*Failed super-groups (No. 1,2,4)*	*Other super-groups (No. 3, 5, 6,7,8)*	*Aggregate data (All super-groups)*
β_1: Changes apply to the other two members (=1 if yes)	-0.581	-0.393	-0.442
	(0.450)	(0.405)	(0.305)
β_2: Positive deviation from the super-group average (t-1)	-1.079***	-0.783***	-0.855***
	(0.269)	(0.217)	(0.148)
β_3: Negative deviation from the super-group average (t-1)	0.448	0.489***	0.557***
	(0.310)	(0.113)	(0.139)
β_4: Changes apply to the other two members × Positive deviation from super-group average (t-1)	0.261***	0.365	0.304
	(0.093)	(0.396)	(0.214)
β_5: Changes apply to the other two members × Negative deviation from super-group average (t-1)	-0.030	0.074	0.017
	(0.102)	(0.111)	(0.075)
β_6: Period	0.077	-0.189**	-0.098
	(0.112)	(0.075)	(0.067)
β_7:Constant	-1.208	0.600	-0.186
	(1.384)	(0.579)	(0.632)
R^2 overall	0.177	0.130	0.141
No. of observations	216	360	576

Notes: * p < .1, ** p < .05, *** p < .01. Robust standard errors (clustered at the sub-group level) are reported in parentheses. Variables are defined analogously to Table 1.2.

Table A.9: Election analysis in later periods for failed and other super-groups (Probit model)

Dependent variable: whether a subject is elected	*Failed super-groups (No. 1,2,4)*	*Other super-groups (No. 3,5,6,7,8)*	*Aggregate data (All super-groups)*
β_1: Incumbent delegate (= 1 if yes)	2.725**	2.154***	2.345***
	(1.222)	(0.648)	(0.575)
β_2: Part 3 rank within group	-0.053	-0.102	-0.086
	(0.292)	(0.174)	(0.149)
β_3: Incumbent delegate × Part 3 rank within group	-0.368	-0.187	-0.277
	(0.340)	(0.238)	(0.196)
β_4: Positive deviation from super-group average	0.207	0.105	0.123
	(0.181)	(0.093)	(0.082)
β_5: Incumbent delegate × Positive deviation from the super-group average	-0.524	-0.312	-0.372*
	(0.415)	(0.229)	(0.194)
β_6: Negative deviation from the super-group average	0.224	0.023	0.076
	(0.161)	(0.079)	(0.082)
β_7: Incumbent delegate × Negative deviation from the super-group average	-0.438	-0.057	-0.160
	(0.411)	(0.179)	(0.185)
β_8: Average extent of exploiting both	0.393	0.051***	0.051***
	(0.244)	(0.014)	(0.017)
β_9: Incumbent delegate × Average extent of exploiting both	-0.960*	-	-0.754***
	(0.575)		(0.133)
β_{10}: Re-election period	0.019	-0.002	0.010
	(0.013)	(0.015)	(0.011)
β_{11}: Constant	-1.252*	-0.923**	-1.007***
	(0.759)	(0.373)	(0.347)
Log-likelihood	-66.86	-105.19	-173.87
No. of observations	135	223	360

Notes: * $p < .1$, ** $p < .05$, *** $p < .01$. Robust standard errors (clustered at the sub-group level) are reported in parentheses. Variables are defined analogously to Table 1.5. There are not enough observations for "Incumbent delegate × Average extent of exploiting both" for successful super-groups. We do not report marginal effects instead of regression coefficients, because the former make little sense for interaction terms.

A.3 Experiment instructions (Delegation treatment)

Welcome to the experiment and thank you for participating!

Please do not talk to other participants.

General

This is an experiment on decision making. You receive €4.00 for showing up on time. If you read these instructions carefully, you can make good decisions and earn a considerable amount of money that will be paid out to you in cash at the end of the experiment.

The experiment will last approximately two hours. If you have any questions, please raise your hand, and one of the experimenters will come to you and answer your questions privately. During the experiment, your earnings will be calculated in experimental **points**. At the end of the experiment, all points that you earn will be converted into Euro at the exchange rate announced at the beginning of each part.

Anonymity

You will learn neither during nor after the experiment, with whom you interact(ed) in the experiment. The other participants will neither during nor after the experiment learn, how much you earn(ed). We never link names and data from experiments. At the end of the experiment you will be asked to sign a receipt regarding your earnings which serves only as a proof for our sponsor. The latter does not receive any other data from the experiment.

Means of help

You will find a pen at your table which we ask that you, please, leave on the table when the experiment is over. While you make your decisions, a clock at the top of your computer screen will run down. This clock will inform you regarding how long we think that the maximum decision time will be. However, if you need more time, you may exceed the limit. The input screens will not be dismissed once time runs out. However, the output/information screens (here you do not have to make any decisions) will be dismissed after time is up.

Experiment

The experiment consists of four parts. You will receive instructions for each part after the previous part has ended. These instructions will be read to you aloud. Then you will have an opportunity to study them on your own and to ask questions privately.

Part 1

Exchange rate

Any point earned in Part 1 will be converted into Euro at the following exchange rate: **10 points = 1 EURO**

The basic decision situation

The basic decision situation will be explained to you in the following. Afterwards you will find control questions on the screen that will help you better understand the decision making environment.

You will be a member of a group consisting of **3 members**. Each group member has to decide on the allocation of 20 points. You can put these 20 points into your **private account** or you can put them **fully or partially** into a **group account**. Each point you do not put into the group account will automatically remain in your private account.

Your income from the private account:

You will earn one point for each point you put into your private account. For example, if you put 20 points into your private account (and therefore do not put anything into the group account) your income will amount to exactly 20 points out of your private account. If you put 6 points into your private account, your income from this account will be 6 points. No one except you earns something from your private account.

Your income from the group account:

Each group member will profit equally from the amount you put into the group account. On the other hand, you will also get a payoff from the other group members' contributions into the group account. The individual income for each group member out of the group account will be determined as follows:

Individual income from group account =

Sum of all group members' contributions to the group account $\times$ *0.5*

If, for example, the sum of all group members' contributions to the group account is 60 points, then you and the other members of your group each earn 60×0.5=30 points out of the group account. If the three group members contribute a total of 10 points to the group account, you and the other members of your group each earn 10×0.5=5 points out of the group account.

Total income:

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

Income from your private account (= 20 – contribution to group account)

+ Income from group account (= 0.5 $\times$ *sum of contributions to group account)*

= Your total income

Before we proceed, please try to solve the control questions on your screen. If you want to compute something, you can use the Windows calculator by clicking on the calculation symbol on your screen.

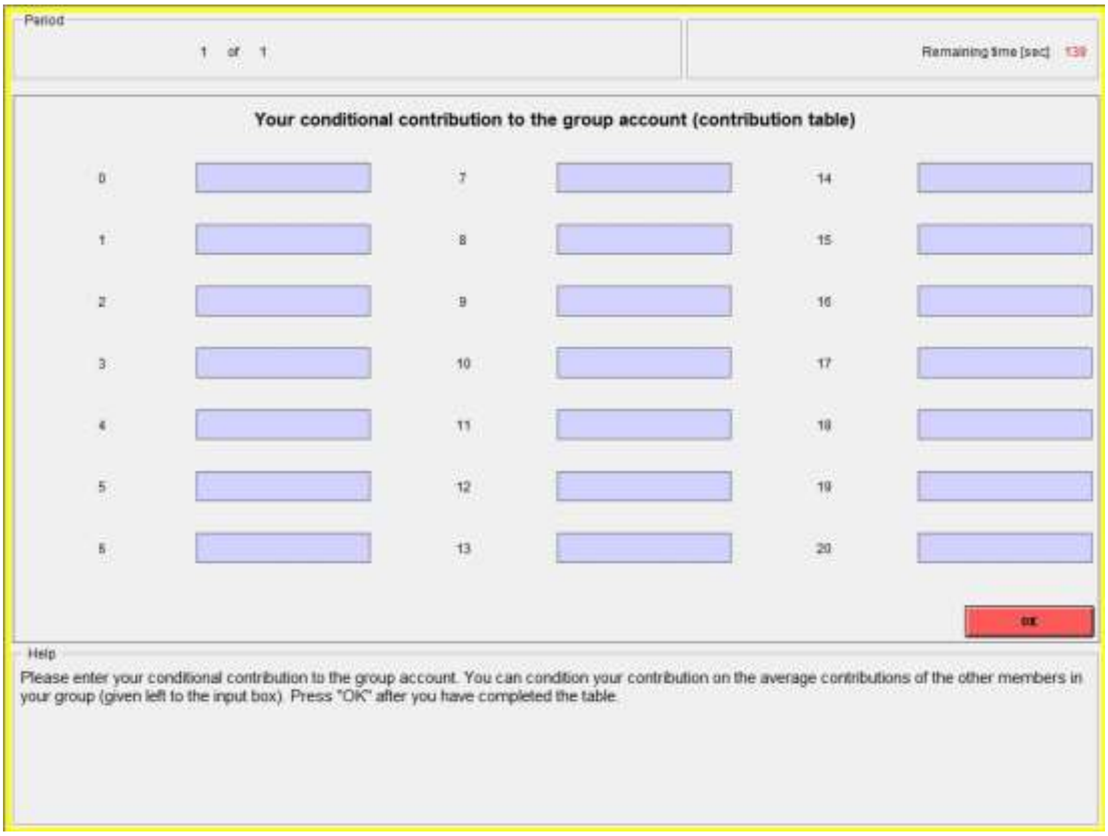
Procedure of Part 1

Part 1 includes the decision situation just described to you. The decisions in Part 1 will only be made **once**.

On the first screen you will be informed about your group membership number. As you know, you will have 20 points at your disposal. You can put them into your private account or you can put them into the group account. Each group member has to make **two types** of contribution decisions which we will refer to below as the **unconditional contribution** and the **contribution table**.

- In the **unconditional contribution** case, you decide how many of the 20 points you want to put into the group account. Please insert your unconditional contribution in the respective box on your screen. You can insert integers only (e.g., numbers like 0, 1, 2…). Your contribution to the private account is determined automatically by the difference between 20 and your contribution to the group account. After you have chosen your unconditional contribution, please click "OK".

- On the next screen you are asked to fill in a **contribution table**. In the contribution table you indicate **how much <u>you</u> want to contribute to the group account for each possible average contribution of the <u>other</u> group members** (rounded up to the next integer). Thus, you can condition your contribution on the other group members' average contributions. The contribution table looks as follows:



The numbers in each of the left columns are the possible (rounded) average contributions of the **other** group members to the group account. This means, they represent the average amounts of the other group members' contributions into the group account. You simply have to insert into the input boxes how many points you want to contribute to the group account – conditional on the indicated average contributions. **You have to make an entry into each input box**. For example, you will have to indicate how much you contribute to the group account if the others contribute 0 point to the group account on average, how much you contribute if the others contribute 1, 2, or 3 points on average, etc. You can insert any whole number from 0 to 20 into each input box. You can of course insert the same number more than once. Once you have made an entry into each input box, please click "OK".

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

Example 1: Assume that **the random mechanism selects you. This implies that your relevant decision will be your contribution table**. The unconditional contribution is the relevant decision for the other two group members. Assume they made unconditional contributions of 0 and 2 points. The average rounded contribution of these two group members, therefore, is 1 point ((0+2)/2=1). ab

- If you indicated in your contribution table that you will contribute 1 point to the group account if the others contribute 1 point on average, then the total contribution to the group account is given by 0+2+1=3 points. All group members, therefore, earn 0.5×3=1.5 points out of the group account plus their respective income from the private account. You would then earn in total (20–1) +1.5 =20.5 points (the sum of your income from your private and the group account).

- If, instead, you indicated in your contribution table that you would contribute 19 points if the others contribute 1 point on average, then the total contribution to the group account is given by 0+2+19=21 points. All group members therefore earn 0.5×21=10.5 points out of the group account plus their respective income from the private account. You would then earn in total (20–19) +10.5=11.5 points (the sum of your income from your private and the group account).

<u>**Example 2:**</u> Assume that **the random mechanism did not select you,** implying that **the unconditional contribution is taken as the payoff-relevant decision** for you and the other group member. Assume that your unconditional contribution to the group account is 16 points and that of the other group member is 18 points. The average unconditional contribution of you and the other group member, therefore, is 17 points (= (16+18)/2).

- If the group member whom the random mechanism selected indicates in her contribution table that he/she will contribute 1 point to the group account if the other two group members contribute, on average, 17 points, then the total contribution to the group account is given by 16+18+1=35 points. All group members will therefore earn 0.5×35=17.5 points out of the group account plus their respective income from the private account. You would then earn in total (20-16) +17.5= 21.5 points (the sum of your income from your private and the group account).

- If, instead, the randomly selected group member indicates in her contribution table that he/she will contribute 19 points to the group account if the others contribute, on average, 17 points, then the total contribution to the group account is given by 16+18+19=53 points. All group members will therefore earn 0.5×53=26.5 points out of the group account plus their respective income from the private account. You would then earn in total (20-16) +26.5= 30.5 points (the sum of your income from your private and the group account).

The random selection of the participants will be implemented as follows: The computer will randomly select a number – 1, 2 or 3 – **after** all participants have made their unconditional contributions and have filled in their contribution tables. The randomly selected number will then be compared with the group membership number, which was shown to you on the first screen. If the randomly selected number equals your group membership number, then your contribution table is payoff-relevant for you and the unconditional contribution is payoff-relevant for the other two group members. Otherwise, your unconditional contribution is the relevant decision for you.

You will make all your decisions only once. After the end of Part 1 you will get the instructions for Part 2. How much you have earned in Part 1 will be revealed at the end of the experiment.

Part 2

Exchange rate

Any point earned in Part 2 will be converted into Euro at the following exchange rate: **10 points = 1 EURO**

The basic decision situation

You will be a member of a group consisting of **3 members**. You are randomly matched **anew** into a group of 3 at the beginning of this part. Each group member receives a random identification number from 1 to 3. In Part 1, you were asked to allocate 20 points between your private account and the group account. *In this part, you need to decide how to allocate the 20 points for every group member (including yourself) between the two accounts.* Specifically, for each group member, you need to decide how many points to put into the group account, with the remainder automatically stays in the private account of that group member. You may put in any number of points between and including 0 and 20 points to the group account, and you may select different allocations for each individual.

Individual income from Part 2

The total income of each member is determined in the same way as in Part 1:

Individual income from one's private account (= 20 – allocation to group account)
+ Income from group account (= 0.5 × sum of total allocations to group account)

= Your total income

Example: Assume that you decide to allocate 12 points to the group account for yourself, 6 points to the group account for the second member and 0 point for the third member. In this case, the group account collects 12+6+0=18 points. This means that each member in your group receives 18×0.5=9 points from the group account.

Your total income: (20-12)+0.5×18=17 points;

The total income of the second group member: (20-6)+0.5×18=23 points;

The total income of the third group member: (20-0)+0.5×18=29 points.

After you have made the allocation decisions for all group members, the program will randomly select one member from your group and implement her allocation decisions for payment. Each of the three members in your group is equally likely to be chosen. If you are chosen, your decisions are payoff-relevant for you in Part 2. If another group member is chosen, her or her decisions are payoff-relevant for you in Part 2. How much you have earned in Part 2 will be revealed at the end of the experiment.

The decisions in Part 2 will only be made **once**. After the end of Part 2 you will get the instructions for Part 3. Before we start you have to answer the control questions.

Part 3

Exchange rate

Any point earned in Part 3 will be converted into Euro at the following exchange rate:

50 points = 1 EURO

Periods

The third part of the experiment will last 8 periods. The 8 periods follow exactly the same procedure. You are randomly matched **anew** into a group of 3 at the beginning of this part. The group composition does not change over the 8 periods. That means your group consists of the same people in all 8 periods. Each group member receives a random identification number from 1 to 3. This number will remain fixed.

The basic decision situation

The basic decision situation is the same as the one described in the instructions for the previous parts. In every period, each member of the group has to decide upon the allocation of the 20 points. You can put these 20 points into your private account or you can put them fully or partially into a group account. Each point you do not put into the group account automatically stays in your private account. *The only difference to the first part is that you can only provide an unconditional contribution. There is no contribution table in this part.* Every member's total income in each period depends on all members' unconditional contribution decisions.

Your income from the private account:

As in Part 1, you will earn one point for each point you put into your private account. No one except you earns something from your private account.

Your income from the group account:

The individual income for each group member from the group account will also be determined in the same way as in Part 1:

Individual income from group account =   *Sum of all group members' contributions to the group account* $\times 0.5$

Total income:

Your total income is determined in the same way as in Part 1:

Income from your private account (= 20 – contribution to group account)

+ Income from group account (= 0,5 × sum of contributions to group account)

= Your total income

The decision screen, which you will see in every period, looks like this:

There is no conditional contribution table. You only need to decide on your unconditional contribution in every period. At the end of every period, each experiment participant receives feedback on the results of the period, including the individual contributions of each group member and every member’s income from that period.

Your earnings from Part 3 will be the sum of your total income from the 8 periods of Part 3, and it will be paid out in cash to you at the end of the experiment. After the end of Part 3 you will get instructions for Part 4.

Part 4

Exchange rate

Any point earned in Part 4 will be converted into Euro at the following exchange rate: **50 points = 1 EURO**

Periods

Part 4 consists of 18 periods in which participants remain in the same groups and receive the same identification numbers (ID numbers) as in Part 3.

Super-group

In Part 4, your group and two other groups will be randomly matched to a super-group of 9 members. You are asked to vote for one member in your group to allocate the 20 points between the private account and the super-group account on your behalf. We will call the elected member *allocator*. Your earnings in this part will be determined by the decisions of the allocator selected from your group as well as the decisions of the allocators from the other two groups. The following sections describe the election, allocation and payoff calculation in turn.

Election

Election will take place at the beginning of every third period. During the election stage, you will see the average contributions of all three members in your group from Part 3 of the experiment and all decisions from the previous three periods of Part 4 (in the first vote, you only see the average contributions from Part 3). During the election, you can express your preferences for the allocator in your group. In particular, you are asked to rank the three members in your group (including yourself). The highest or most favorable rank is "1", and your least favorable rank is "3". Ties are not allowed – that is, you cannot give the same rank to more than one candidate.

After every group member has completed their rankings, the computer will sum up the ranks of all candidates. The member who has the lowest sum of ranks will be the allocator of her group in the following three periods. In case of ties, one person will be randomly selected (with equal probability) from those who received the lowest ranks.

After the election, you will see the ID number of the allocator. You will not see the total ranks for each member. The tenure of an allocator ends after three periods, and there will be a new election at the beginning of the fourth period, the seventh period, the tenth period, the thirteenth period and the sixteenth period. The same allocator can be elected more than once.

Allocation

The allocator will decide how to allocate the points of her or her own-group members' between their private accounts and the super-group account in each of the three periods. Hence, there are three allocation decisions.

Specifically, for each own group member, the allocator will decide how many points to put into the super-group account, with the remainder automatically stays in that member's private account. The allocator may assign any whole number of points between and including 0 and 20 to allocate to the super-group account for each member in the group (including him- or herself). The allocator may select different allocations for each individual.

Payoff calculation

Similar to Part 3, your final income is the sum of your income from your private account and the return from the super-group account. The super-group account collects the sum of all contributions of the 9 super-group members (where the decisions on the individual contributions to the super-group account are taken by the three allocators). Define C_N^K as the contribution of member N in group K determined by the allocator of group K. The sum of contributions to the super-group account is then:

$$C = C_1^1 + C_2^1 + C_3^1 + C_1^2 + C_2^2 + C_3^2 + C_1^3 + C_2^3 + C_3^3.$$

The three C_N^1 are determined by the allocator of group 1, the three C_N^2 are determined by the allocator of group 2, and the three C_N^3 are determined by the allocator of group 3. The amount C is multiplied by 1.5 and the resulting amount of 1.5×C is distributed equally to the three groups. Each group thus receives 0.5×C. Within the group, the amount is also divided equally: Each member thus receives (0.5×C)/3.

The following examples illustrate how your income is calculated.

Example 1: Assume that the allocator of your group decides to allocate 14 points to the super-group account for you, 6 points to the super-group account for the other group member and 0 point to the super-group account for him- or herself. In this case, the total contribution of your group to the super-group account is 20 points. Now further assume that the total contributions of the other two groups are 40 and 60 points. In that case, the total contribution to the super-group account will be 20+40+60=120 points. Your group *as a whole* (and each other group) gets 0.5×120=60 points as return from the super-group account. Then the 60 points are equally shared by the three group members. This means each member in your group receives 60/3=20 points from the super-group account.

Your total income: 20-14+(0.5×(20+40+60))/3=26 points;

The total income of the other group member: 20-6+(0.5×(20+40+60))/3=34 points;

The total income of the allocator: 20-0+(0.5×(20+40+60))/3=40 points.

Example 2: Assume that the allocator of your group decides to allocate 5 points to the super-group account for you, 10 points to the super-group account for the other group member and 15 points to the super-group account for him- or herself. In this case, the total contribution of your group to the super-group account is 30 points. Now further assume that the total contributions of the other two groups are 0 and 60 points. In that case, the total contribution to the super-group account will be 0+30+60=90 points. Your group *as a whole* (and each other group) gets 0.5×90=45 points as return from the super-group account. Then the 45 points are equally shared by the three group members. This means each member in your group receives 45/3=15 points from the super-group account.

Your total income: 20-5+(0.5×(0+30+60))/3=30 points;

The total income of the other group member: 20-10+(0.5×(0+30+60))/3=25 points;

The total income of the allocator: 20-15+(0.5×(0+30+60))/3=20 points.

Example 3: Assume that the allocator of your group decides to allocate 20 points to the super-group account for every group member. Now suppose that the total contributions of the other two groups are both 0 points. In that case, the total contribution to the super-group account will be 60+0+0=60 points. Your group as a whole (and each other group) gets 0.5×60=30 points as return from the super-group account. Then the 30 points are equally shared by three group members. This means each member in your group receives 30/3=10 points from the super-group account.

Since the allocator of your group lets every member contribute the same to the super-group account, the total income of every member is: (20-20) + (0.5× (60+0+0))/3=10 points.

The purpose of the above examples is to clarify the payoff calculations, rather than to provide advice on how to act. You should make decisions as you wish.

Feedback

At the end of every period, every member will receive an information screen regarding the ID number of the allocator, the allocated contribution and income of every member, and the total contributions of each of the three groups.

Your earnings from Part 4 will be the sum of your total income from the 18 periods of Part 4. After the 18 periods, you will be asked to complete a short questionnaire. This will conclude the experiment. You will receive information on your income for Parts 1 and 2, and we will pay you your earnings in private.

Appendix B

Leading by example in public goods games with benefit heterogeneity

B.1 Supplementary tables and figures

Table B.1: Random effects regression of contributions in all treatments

	(1) Periods 1-5	(2) Periods 6-10	(3) Periods 1-10	(4) Periods 1-10
HBL	1.126	2.814*	1.970	-0.019
	(1.437)	(1.657)	(1.480)	(1.536)
LBL	0.108	1.917	1.012	-0.808
	(0.863)	(1.453)	(1.061)	(1.118)
EN	0.827	1.537	1.182	0.396
	(0.841)	(1.040)	(0.832)	(1.102)
Period				-0.736***
				(0.123)
HBL × Period				0.362**
				(0.177)
LBL × Period				0.331
				(0.207)
EN × Period				0.143
				(0.171)
Constant	8.888***	5.504***	7.196***	11.244***
	(0.417)	(0.753)	(0.534)	(0.599)
R^2 overall	0.004	0.015	0.007	0.057
N	1180	1180	2360	2360

Note: Standard errors in parentheses * $p < .1$, ** $p < .05$, *** $p < .01$, clustered on the group level, treatment BASE is the reference category. Wald test between any two treatment variables are not significant.

Figure B.1: The distribution of the 3 situations in treatment EN by group

Figure B.2: The average contributions by player type in the non-leadership treatment and situation

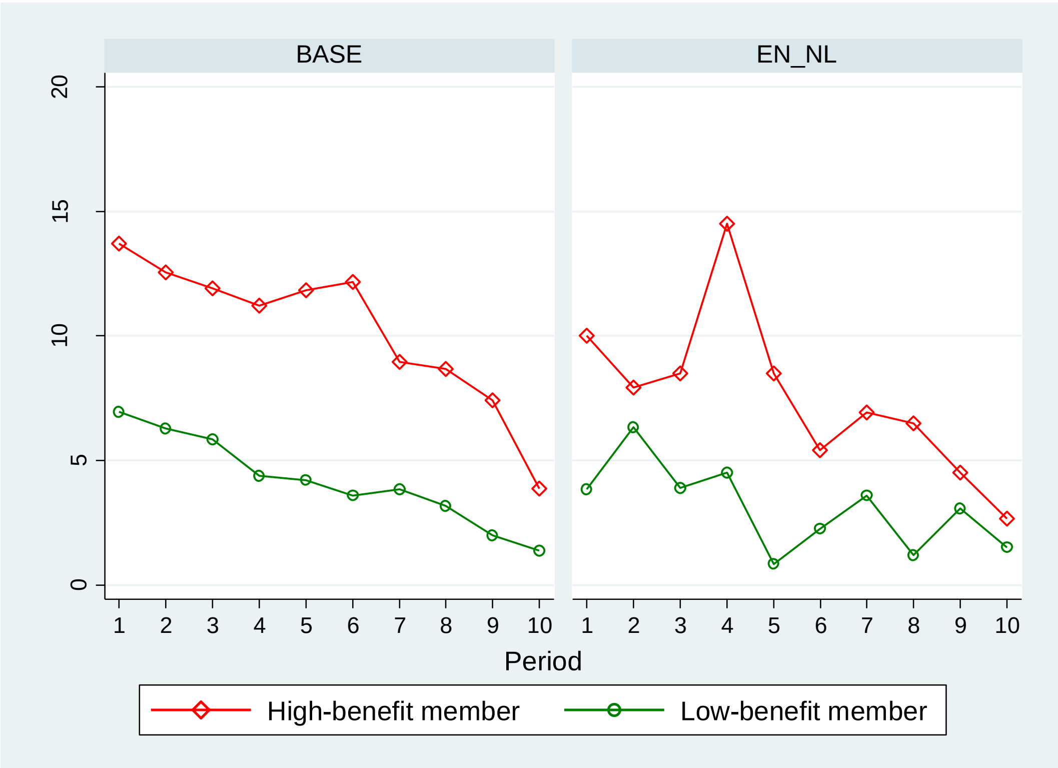
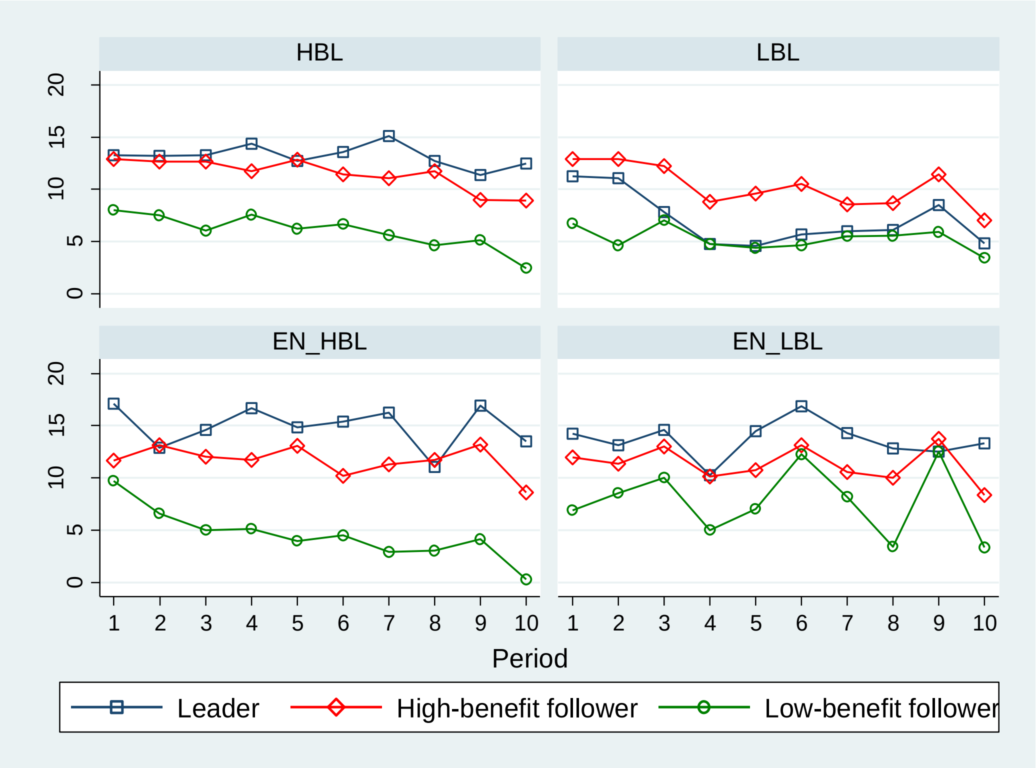


Figure B.3: The average contributions by identity and player type in leadership treatments and situations



B.2 Experiment instructions (HBL treatment)

Welcome to this experiment! Thank you very much for participating!

Please do not talk to other participants from now on!

General

This is an experiment on decision making. You receive €4.00 for showing up on time. If you read these instructions carefully, you can make good decisions and earn a considerable amount of money that will be paid out to you in cash at the end of the experiment.

The experiment will last approximately 1 hour. If you have any questions, please raise your hand, and an experimenter will come to you and answer your questions privately. During the experiment, your earnings will be calculated in experimental **points**. At the end of the experiment, all points that you earn will be converted into Euro at the exchange rate announced at the beginning of each part.

In the interest of clarity, we will only use male terms in the experiment. They should be interpreted as being gender-neutral.

Anonymity

You will learn neither during nor after the experiment, with whom you interact(ed) in the experiment. The other participants will neither during nor after the experiment learn, how much you earn(ed). We never link names and data from experiments. At the end of the experiment you will be asked to sign a receipt regarding your earnings which serves only as a proof for our sponsor. The latter does not receive any other data from the experiment.

Means of help

You will find a pen at your table which we kindly ask that you, please, leave on the table when the experiment is over. While you make your decisions, a clock at the top of your computer screen will run down. This clock will inform you regarding how long we think that the maximum decision time will be. However, if you need more time, you may exceed the limit. The input screens will not be dismissed once time runs out. However, the output/information screens (here you do not have to make any decisions) will be dismissed after time is up.

Experiment

The experiment consists of two parts. You will receive instructions for the second part after the first part has ended. These instructions will be read to you aloud. Then you will have an opportunity to study them on your own and to ask questions privately.

Your total earnings in this experiment will be the sum of your earnings in parts 1 and 2. The two parts of the experiment are completely independent, i.e. decisions in part 1 have no consequences for your earnings in part 2.

Part 1

Exchange rate

Any point earned in Part 1 will be converted into Euro at the following exchange rate:

1 Point=0.02 Euro (50 Points = 1 Euro).

The basic decision situation

This part consists of **10 identical periods**. You are randomly assigned into a group of **four** at the beginning of this part. The group composition **does not** change over the 10 periods. That means your group consists of the same people in all 10 periods. Before the first period starts, two group members are randomly selected to be of type A and the remaining two members will be of type B. The meanings of type A and type B will be explained below. You will be informed of your type at the beginning of the first period and your type remains **unchanged** during this entire part. Additionally, each group member receives a random identification number (ID) from 1 to 4. This number will remain **fixed** during this entire part.

In every period, each group member has to decide on the allocation of 20 points. You can keep these 20 points in your **private account** or you can contribute them **fully or partially** to a **group account**. Each point you do not contribute to the group account will **automatically** remain in your private account. Saving points for a later period is therefore not possible.

Your income from the private account:

You will earn one point for each point you keep in your private account. For example, if you keep 20 points in your private account (and therefore do not contribute anything to the group account) your income will amount to exactly 20 points out of your private account. If you keep 6 points in your private account (and therefore contribute 14 points to the group account), your income from this account will be 6 points. No one except you earns something from your private account.

Individual income from your private account =

20 – Your contribution to the group account

Your income from the group account:

Each group member will profit from the amount you contribute to the group account. On the other hand, you will also get a payoff from the other group members' contributions to the group account. The individual income for each group member out of the group account will be determined as follows:

Individual income from the group account =

*Sum of all group members' contributions to the group account × **type-factor***

If you are of **type A**, your type-factor is **0.4**. If you are of **type B**, your type-factor is **0.8**. That is, for each point contributed by all group members to the group account, you receive 0.4 points if you are of type A and you receive 0.8 points if you are of type B.

Total income:

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

Income from your private account (= 20 – Contribution to the group account)

*+ Income from the group account (= Sum of contributions to the group account× **type-factor**)*

= Your total income

Example: Suppose you contribute 8 points to the group account and the other three members contribute 20 points to the group account altogether. Then your income from the private account will be 12 points (20-8=12). Your income from the group account will be 11.2 points (0.4× (20+8) =11.2) if you are of type A and 22.4 points (0.8× (20+8) =22.4) if you are of type B. Hence, your total income will be 12+11.2=23.2 points if you are of type A and 12+22.4=34.4 points if you are of type B.

How you interact with your group members

At the beginning of each period, the computer will randomly assign the role of "**First mover**" to one of the two members of **type B** in your group. The **three** remaining members in the group will be assigned the role of "**Second mover**".

Each period consists of the following two stages:

1. First mover decides about his own contribution to the group account before the other second movers.

2. Being informed about the ID and contribution decision of the first mover, the other three second movers decide simultaneously and privately about their own contributions. This means no second mover will be informed about the contribution decision of another second mover before he makes his decision.

Which member of type B goes first is determined randomly for each period.

Procedure of Part 1

At the beginning of this part you will be informed about your **type and ID**. After checking them, please click "Continue". Then a screen will show you **whether you are the first mover or a second mover**. Please click "Continue" to proceed.

- If you are the **first mover**, you have to **decide how many of the 20 points you contribute to the group account before the other three group members**. The other three group members are second movers and would make their contribution decisions **simultaneously and privately** after seeing your type, ID and contribution. Please insert your contribution in the box on your screen. You can insert integers only (e.g., numbers like 0, 1, 2…20). The difference between 20 and your contribution to the group account is automatically the amount you keep in your private account. After you have chosen your contribution, please click "OK". You cannot change your decision after you have pressed "OK". After clicking "OK", a waiting screen will appear. The experiment continues after all second movers have made their decisions.

- If you are a **second mover**, you will be asked to wait patiently. After the first mover has made his decision, a screen will show you his **type, ID, and contribution to the group account**. In the lower part of that screen, you have to **decide how many of the 20 points you contribute to the group account**. You can insert integers only (e.g., numbers like 0, 1, 2…20). The difference between 20 and your contribution to the group account is automatically the amount you keep in your private account. Please click "OK" if you are ready to continue. A waiting screen will appear until all second movers have pressed "OK".

At the end of the period, every group member will receive an information screen regarding the type, ID, moving position (First mover or not) and contribution of each group member, as well as every member's income from that period. After receiving feedback, the next period starts. After 10 periods, Part 1 of the experiment ends.

Your earnings from Part 1 will be the sum of your total income from the 10 periods, and it will be paid out in cash to you at the end of the experiment. After the end of Part 1 you will get instructions for Part 2.

Before we proceed, please try to solve the control questions on your screen. If you want to compute something, you can use the Windows calculator by clicking on the calculation symbol on your screen.

Part 2

You are randomly assigned into a group of **two** at the beginning of this part. You have to answer 24 questions, in which you can choose one of two options A or B. Every option results in a positive or negative payoff for you and the other person in your group. The other person answers exactly the same questions. Your payoff in part 2 depends on your decision and the decision of the other person in your group.

A decision example:

	Option A	Option B
Your payoff	10.00	7.00
Other's payoff	-5.00	4.00

- If you choose option A, you receive 10 points, and the other person loses 5 points. If the other person also chooses option A, he, too, receives 10 points and you lose 5 points. In total, you therefore earn 5 points (10 points from your choice minus 5 points from the other person's choice). The other person earns 5 points (10 points – 5 points), too.

- If you choose option B and the other person chooses option A, you earn 2 points (7 points from your own choice minus 5 points from the other person's choice). The other person would earn 14 points (10 points + 4 points).

- The remaining combinations (you choose A and the other person chooses B, or you both choose B) are analogous to these two examples.

Overall you take 24 decisions like the one described above. Your total payoff is computed as follows: The 24 values for "your payoff" are summed up over your decisions. The 24 values for "Other's payoff" are summed up over the other person's decisions. The sum of these two sums determines your total payoff from this part and is converted into Euro at the following exchange rate:

1 Point=0.10 Euro (10 Points = 1 Euro).

Note that you are not receiving information on each single decision taken by the other person in your group. Rather, you will find out only the sum of your decisions for "your payoff", the sum of the other person's decisions for "Other's payoff" and your total payoff from Part 2.

If there are any questions, please raise your hand now. We will come to you and answer your questions privately.

After Part 2, you will be asked to complete two short questionnaires. This will conclude the experiment. You will receive information on your respective income for Parts 1 and 2, and we will pay you your earnings in private.

Appendix C

Asymmetric competition between a group and a single player

C.1 Supplementary tables and figures

Table C.1: Relative/Absolute contributions and winning probabilities in the first 20 periods

Treatments	Relative contribution rate		Absolute contribution value		P(GW)	P(T)	P(SW)
	Group	Single	Group	Single			
T3	87%	83%	2.61	2.5	16.9%	60.8%	22.2%
T2	74%	58%	2.22	1.15	65.6%	23.1%	11.4%
T1	49%	55%	1.47	0.55	67.4%	25.0%	7.7%

Notes: P(GW) refers to the percentage of the group winning the competition; P(T) refers to the percentage of the competition draw; P(SW) is the percentage of the single player winning the competition.

Table C.2: Relative frequencies of the contributions in T3 in the last 10 periods (in %)

Group \ Single	0	1	2	3	Total
0	1.67	-	1.11	7.22	10.00
1	2.78	-	3.33	3.33	9.44
2	2.22	0.56	2.78	8.89	14.44
3	1.67	-	0.56	63.89	66.11
Total	8.33	0.56	7.78	83.33	100

Table C.3: Relative frequencies of the contributions in T2 in the last 10 periods (in %)

Group \ Single	0	1	2	Total
0	-	-	0.56	0.56
1	4.44	1.67	11.11	17.22
2	16.11	1.11	21.67	38.89
3	18.89	2.22	22.22	43.33
Total	39.44	5.00	55.56	100.00

Table C.4: Relative frequencies of the contributions in T1 in the last 10 periods (in %)

Group \ Single	0	1	Total
0	1.76	5.29	7.06
1	16.47	24.12	40.59
2	17.06	27.65	44.71
3	1.76	5.88	7.65
Total	37.06	62.94	100.00

Table C.5: Average contribution of each group member over all 30 periods by group in T2

Group	Member	Mean con.	Group	Member	Mean con.	Group	Member	Mean con.
1	1	0.87	7	1	0.50	13	1	0.67
	2	0.93		2	0.50		2	0.80
	3	0.53		3	0.90		3	0.93
2	1	0.80	8	1	0.73	14	1	0.67
	2	0.70		2	1.00		2	0.87
	3	0.87		3	0.50		3	0.90
3	1	0.67	9	1	0.33	15	1	0.90
	2	1.00		2	0.57		2	0.17
	3	0.50		3	0.43		3	0.90
4	1	0.77	10	1	0.60	16	1	0.80
	2	0.83		2	0.67		2	0.70
	3	0.80		3	0.63		3	0.50
5	1	0.90	11	1	0.90	17	1	0.93
	2	0.90		2	0.73		2	0.83
	3	0.90		3	0.80		3	0.80
6	1	0.60	12	1	0.70	18	1	0.87
	2	0.90		2	0.73		2	0.97
	3	0.63		3	0.77		3	0.77

Table C.6: Average contribution of each group member over all 30 periods by group in T1

Group	Member	Mean con.	Group	Member	Mean con.	Group	Member	Mean con.
1	1	0.70	7	1	0.50	13	1	0.50
	2	0.70		2	0.30		2	0.47
	3	0.10		3	0.47		3	0.77
2	1	0.00	8	1	0.70	14	1	0.37
	2	0.87		2	0.50		2	0.33
	3	0.63		3	0.63		3	0.03
3	1	0.30	9	1	0.53	15	1	0.33
	2	0.87		2	0.37		2	0.43
	3	0.77		3	0.67		3	0.97
4	1	0.53	10	1	0.57	16	1	0.53
	2	0.67		2	0.57		2	0.37
	3	0.37		3	0.27		3	0.47
5	1	0.57	11	1	0.60	17	1	0.20
	2	0.63		2	0.43		2	0.57
	3	0.53		3	0.13		3	0.50
6	1	0.53	12	1	0.40	18	1	-
	2	0.50		2	0.13		2	-
	3	0.90		3	0.63		3	-

Figure C.1: The average contributions of both competitors for each pair in T3

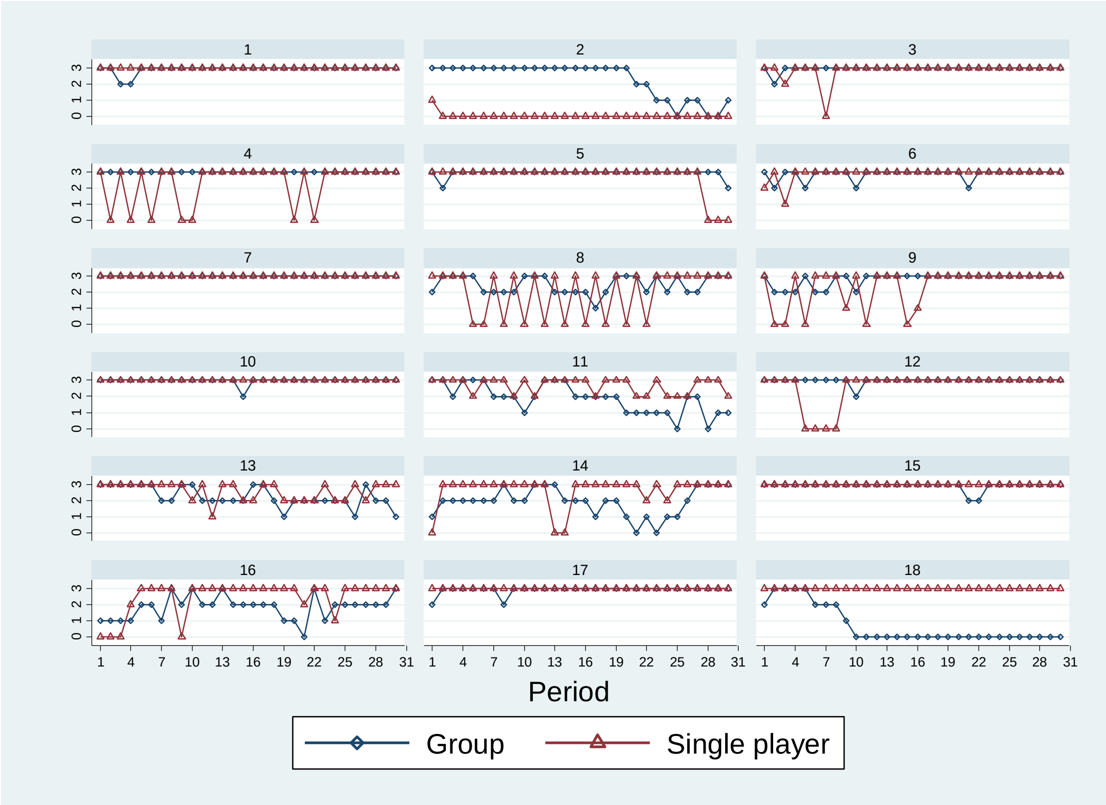


Figure C.2: The average contributions of both competitors for each pair in T2

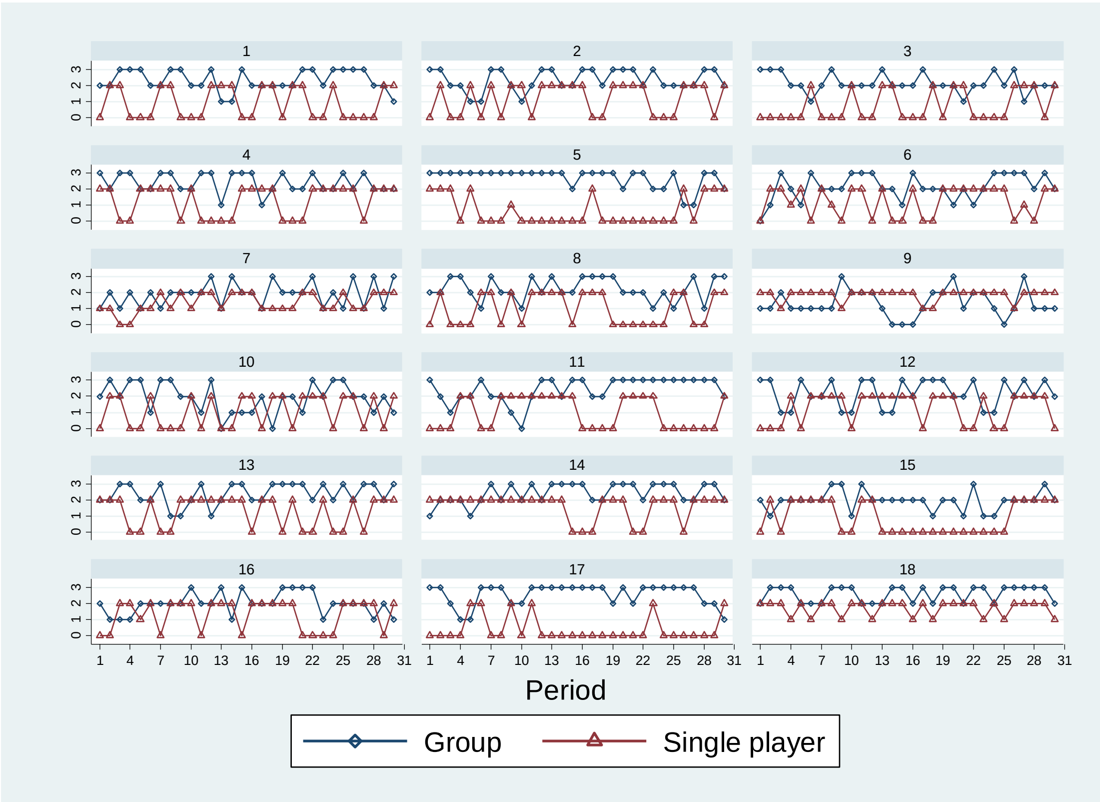
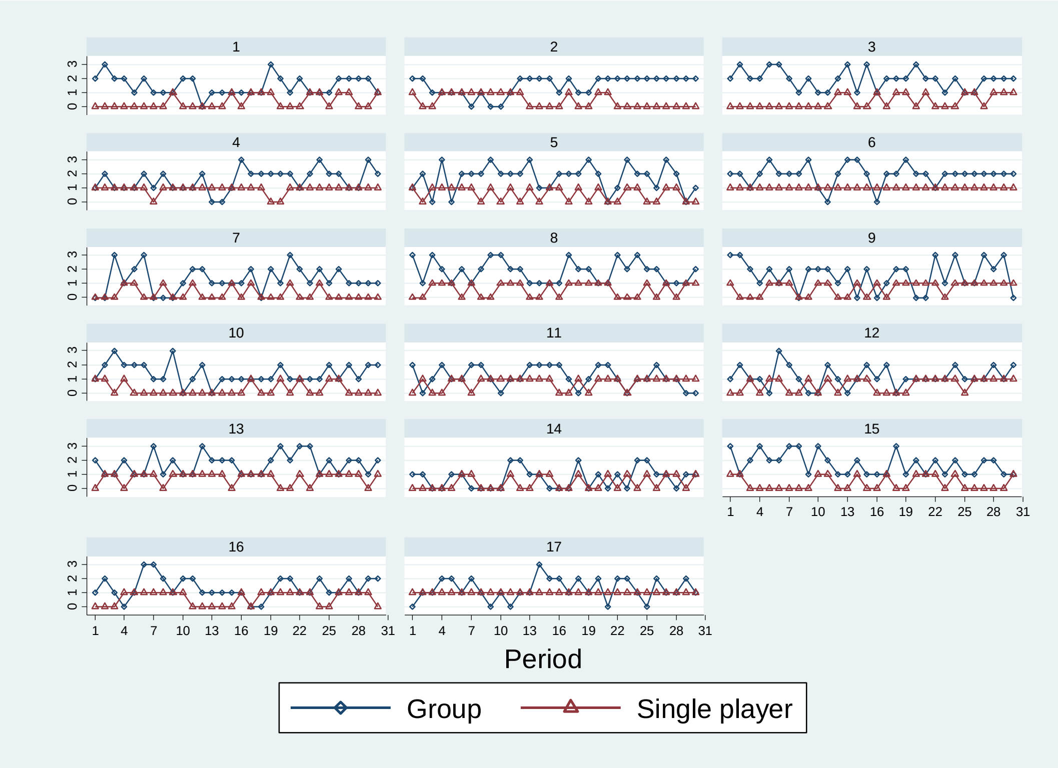


Figure C.3: The average contributions of both competitors for each pair in T1



C.2 Experiment instructions (treatment T2)

Welcome to the experiment and thank you for participating!

Please do not talk to other participants and switch off your cell phone

General

This is an experiment on decision making. You receive €4.00 for showing up on time. If you read the instructions carefully, you can make good decisions and earn a considerable amount of money that will be paid out to you in cash at the end of the experiment. The instructions are identical for all participants.

It is very important that you keep silent and do not talk to other participants. If you have any questions, please press F11 (the red button on the keyboard), then one of the experimenters will come to you and answer your questions privately. If you talk, laugh, exclaim out loud, etc., you will be asked to leave and you will not be paid.

Anonymity

You will learn neither during nor after the experiment, with whom you interact(ed) in the experiment. The other participants will neither during nor after the experiment learn, how much you earn(ed). We never link names and data from experiments. At the end of the experiment you will be asked to sign a receipt regarding your earnings which serves only as a proof for our sponsor. The sponsor does not receive any other data from the experiment.

Means of help

You will find a pen at your table. Please leave that on the table when the experiment is over. While you make your decisions, a clock at the top of your computer screen will run down. This clock will inform you regarding how long we think that the maximum decision time will be. The output/information screens (here you **do not have to** make any decisions) will be turned off when time has run out. However, the input screens (here you **have to** make any decisions) will **not** be turned off when time has run out. If you need more time to make your decision, you are allowed to exceed the limit.

Experiment

The experiment consists of **30** decision-making periods. Your earnings will be the sum of your income from all these **30** periods. Before we start, you will be randomly assigned a role of either **an individual player** or **a member of a 3-person group**. Each individual player will be matched with a group to form a set of **4** participants. The compositions of the **3-person groups** and the **4-person sets** will remain the same across the whole experiment. That means the group consists of **the same people** in all **30** periods and the individual player your group is paired with is also **the same person** in all **30** periods. Each of the 3 group members receives a random identification number from 1 to 3. This number will also remain fixed.

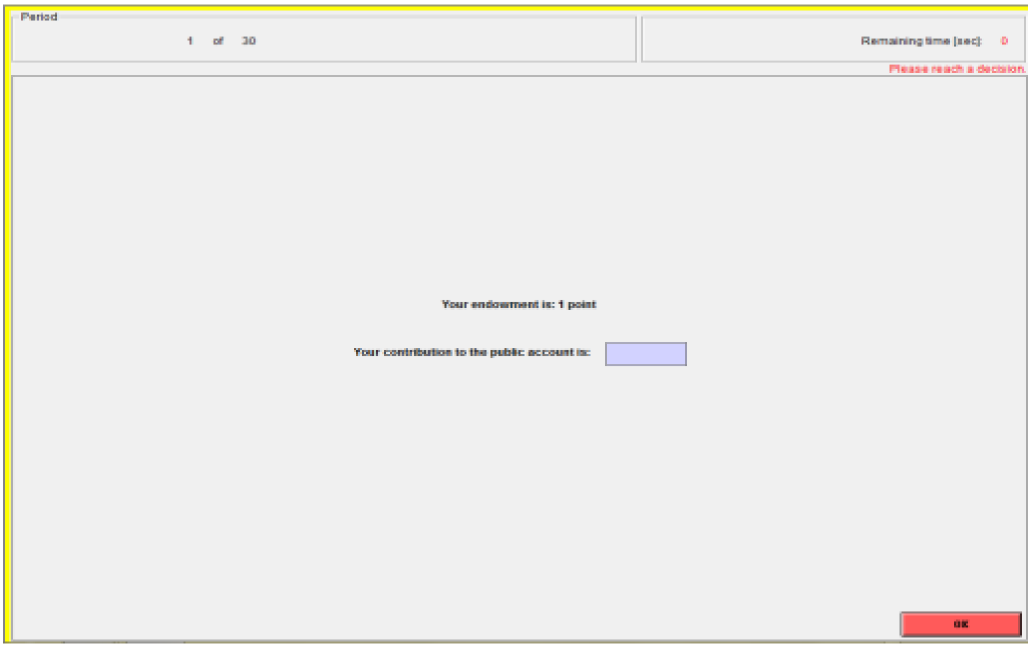
Exchange rate:

During the experiment, your earnings will be calculated in experimental points, which will be converted into Euro at the end of the experiment. Any point earned will be converted into Euro at the following exchange rate: **1 point = 0.12 EURO**

Your decision:

If you are **an individual player**, EACH period you will be given an endowment of **2** points. If you are in the **3-person group**, EACH period you will be given an endowment of **1** point. You will be asked to decide **how many** points out of your endowment to be allocated to a public account in each period. You can insert integers only (e.g., numbers like 0, 1, 2 for the individual player; numbers like 0, 1 for each group member). Saving points for later periods is **not** possible. Decisions of all players are made independently and simultaneously.

The decision screen, which each group member will see in every period, looks like this:



Your income:

The contribution to the public account of the individual player will be **compared** with the TOTAL contribution to the public account of the 3-person group. The side with the **higher** contribution will earn a prize of **9** points and the other side with the **lower** contribution will get **nothing**. In case of **tie** each side will earn half of the prize, i.e. **4.5** points. The prize earned by the group is furthermore shared **equally** by all 3 group members, i.e. each group member will earn a prize of **3** points when the group contribute **higher** than the individual player; each group member will earn a prize of **1.5** points in case of **tie** and will earn **nothing** if the group contribute **less** than the corresponding individual player. Note that the points allocated to the public account are NOT refundable even if your side gets a prize of **0** point.

Your period earnings are the prize you earn **plus** any endowed points that are NOT allocated to the public account. The following examples illustrate how your period earnings are calculated.

Example 1:

The sum of all **3 group members**' contributions to the public account is **2** points, and the contribution to the public account of the **individual player** is **1** point (please see Table 1 below). The number of points allocated to the public account of the **3-person group** exceeds the number of points put in the public account of the **individual player**, thus EACH group member earn a prize of **9/3=3** points and the individual player earns **nothing**. Each player's period earnings are the sum of the earned prize and any endowed points that are NOT allocated to the public account.

Table 1

	Points in the Public account	**Endowed points left**	**Prize earned**	**Earnings**
Group member 1	0	1	9/3=3	1+3=4
Group member 2	1	0	9/3=3	0+3=3
Group member 3	1	0	9/3=3	0+3=3
Individual Player	1	1	0	1+0=1

Example 2:

The sum of all **3 group members**' contributions to the public account is **2** points, and the contribution to the public account of the **individual player** is also **2** points (please see Table 2 below). The two sides contribute **equally**, thus the individual player will earn a prize of **4.5** points and EACH group member earns a prize of **4.5/3=1.5** points. Each player's period earnings are the sum of the earned prize and any endowed points that are NOT allocated to the public account.

Table 2

	Points in the Public account	**Endowed points left**	**Prize earned**	**Earnings**
Group member 1	0	1	4.5/3=1.5	1+1.5=2.5
Group member 2	1	0	4.5/3=1.5	0+1.5=1.5
Group member 3	1	0	4.5/3=1.5	0+1.5=1.5
Individual Player	2	0	4.5	0+4.5=4.5

Example 3:

The sum of all **3 group members**' contributions to the public account is **1** point, and the contribution to the public account of the **individual player** is **2** points (please see Table 3 below). The number of points allocated to the public account of the **individual player** exceeds the number of points put in the public account of the **3-**

person group, thus EACH group member earns **nothing** and the individual player earns a prize of **9** points. Again, each player's period earnings are the sum of the earned prize and any endowed points that are NOT allocated to the public account.

Table 3

	Points in the Public account	Endowed points left	Prize earned	Earnings
Group member 1	0	1	0	1+0=**1**
Group member 2	0	1	0	1+0=**1**
Group member 3	1	0	0	0+0=**0**
Individual Player	2	0	9	0+9=**9**

Feedback

At the end of each period, every participant will receive an information screen regarding the contribution decision and earning of each player in your set (including the 3 group members and the individual player) for this period. After all **30** decision-making periods, you will be asked to complete a short questionnaire. This will conclude the experiment. You will receive information on your total earnings, and we will pay you your earnings in private.

Before we proceed, you will have the opportunity to familiarize yourself with the software and the rules of the experiment for **10** minutes. Here you will be acting in all player roles in a set and seeing the corresponding payoff for each player. No other participants will be able to observe what you are doing. This phase is for you to better understand the decision making environment and thus not for payment. After the ten-minute phase the experiment starts.

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