Leading by example in a public goods experiment with heterogeneity and incomplete information*

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Abstract

We study the effects of leadership on the private provision of a public good when group members are heterogeneously endowed. Leadership is implemented as a sequential public goods game where one group member contributes first and all the others follow. Our results show that the presence of a leader increases average contribution levels, but less so than in case of homogeneous endowments. Leadership is almost ineffective, though, if subjects do not know the distribution of endowments. Granting the leaders exclusion power does not lead to significantly higher contributions.

Keywords: Public goods experiment, leadership, exclusion, heterogeneous endowments, incomplete information

JEL-classification: C72, C92, H41

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1 Introduction

Individuals often participate in organizations and groups in which they have to decide how much (effort or time) to contribute to activities that are beneficial for the organization or group. In many cases a conflict arises between one's own personal interest (e.g starting late to minimize effort) and the collective interest of the group (working hard and exerting a lot of effort). In such a social dilemma situation (Dawes, 1980) individuals typically benefit from all group activities, regardless of their own investment, i.e. they have an incentive to free ride. However, best outcomes are realized if all individuals pursue the collective interest by investing the maximum amount, i.e. by full cooperation. As the level of cooperation largely determines the functioning and wealth of groups, it is important to examine which factors may improve cooperative behavior and reduce free-riding behavior.

One factor that may foster cooperation is leadership, which has been an important topic in the political science and sociological literature for quite some time (e.g., Frohlich et al., 1971, Calvert, 1992, Yukl, 2001), but only recently has received some attention in the economics literature. Although leaders may differ in their capabilities (Bianco and Bates, 1990) or personalities (Rotemberg and Saloner, 1993), there is a rising consensus that leadership in all its forms helps increase cooperation and efficiency in social interactions, for instance in team work (Foss, 2001) or charitable fund-raising (Andreoni, 2005). Thus, leadership can be considered as a non-cooperative means to achieve (more) cooperation in social dilemma situations (Arce, 2001).

In this paper we experimentally examine the effects of leadership in a specific social dilemma situation, namely a public goods game. In spite of the long - mainly theoretical - tradition in political science and sociology, there is not much empirical evidence that identifies leadership as a possible solution to social dilemma problems. The lack of real life data may be one of the reaons. Experiments help generate data to study leadership because they allow for a higher degree of control of the *ceteris paribus* conditions than field data do. In the last decade some social psychological experiments and a few economic experiments have studied the effects of leadership on cooperation.

Experiments in the social psychological literature have mainly focused on factors that may affect leader's effectiveness in promoting cooperation. These influential factors include procedural fairness, perceived charisma (De Cremer and Van Knippenberg, 2002) and group commitment (De Cremer and Van Vugt, 2002). For instance, in a public goods game, De Cremer and Van Knippenberg (2002) find that the leader's perceived charisma or procedural fairness affect cooperation positively, but less so when they act simultaneously. De Cremer and Van Vugt (2002) show that highly committed group leaders are able to raise individuals' contribution, especially when group members identify strongly with their own group.

Economic experiments thus far have focused on one of the simplest forms of leadership, namely leading by example, where one subject decides first, and all the others follow (Hermalin, 1998). In these experiments leadership is typically implemented by random assignment of the leader role to one group member. The leader contributes first and, after observing his decision, the other group members decide on their contributions simultaneously. In such a setting, Moxnes and Van der Heijden (2003) find a small, but significant effect of leadership. Gächter and Renner (2004) observe higher average contributions with a leader than without, although the difference is not significant. Güth et al. (2004) report a rather large and significant increase in contributions in the presence of a leader. These results suggest that leadership in itself is beneficial for the private provision of public goods.[1]

To the best of our knowledge, all previous leadership experiments have considered situations with symmetric and commonly known endowments. It seems of great interest for the organization of groups and the institutional design of organizations to investigate whether the (positive) effects of leadership also prevail in more natural environments where subjects are heterogeneously endowed and do not know the others' endowments. By considering such more realistic environments, we can shed light on the circumstances under which leadership works and, thus, improve our insights into its functioning.

Investigation of behavior under asymmetric endowments links our paper to a strand of literature, initiated by Warr (1982, 1983), which considers how voluntary contributions to a public good depend on the income distribution. Warr's conjecture is that group contributions should be invariant under redistributions of income. Chan et al. (1996, 1999) actually find that "on average" this turns out to be true in a non-linear setting although, contrary to Warr's income-neutrality postulate, the rich tend to undercontribute and the poor to overcontribute relative to their endowments (see also Güth et al., 2002). In a linear public goods game, however, Cherry et al. (2005) show that average contributions are lower with asymmetric endowments than with symmetric endowments. In an asymmetric step-level public goods game Van Dijk and

[1] Note that in social psychological experiments individuals typically are led to believe that a (certain type of) leader makes decisions in their group whereas in economic experiments (and in ours) only 'real' decisions are made. In addition, the fact that we use real subjects as leaders enables us to study leader behavior too.

Wilke (1995) find that subjects with a twice as high endowment contributed almost twice as much as low endowed subjects, whereas Van Dijk and Grodzka (1992) observe no significant difference between subjects with high or low endowments.[2] In contrast, in a similar setting (but using a business scenario) Aquino et al. (1992) find strong support for the hypothesis that inequality leads to decreased cooperation. The evidence on the effect of asymmetric endowments on cooperation levels is thus far from being conclusive. Note, moreover, that all these papers are based on simultaneous decision making without any leadership structure. Therefore, the influence of heterogeneous endowments on the effectiveness of leadership is still an open question.

We address this issue by setting up three treatments: a control treatment, where we employ a standard simultaneous public goods game with asymmetric endowments, and two leadership treatments.[3] In the first ('normal') leadership treatment, the only difference between leader and followers is that the leader decides first. In the second ('strong') leadership treatment, leaders are granted exclusion power. That is, after observing all followers' contributions, leaders may exclude one group member from contributing to - and consuming - the public good in the next period. This means that not only the single excluded member but also the whole group may suffer from exclusion because a smaller group size implies possible efficiency losses.[4,5] The strong leadership treatment allows us also to investigate whether leading by example is sufficient for fostering contributions or whether it is necessary to back up the leader's voluntary example by the formal power to exclude misbehaving followers in order to achieve more efficient outcomes.

All three treatments are run under two different information conditions: one with complete information in which each subject knows the distribution of endowments, and the other with incomplete information in which each subject

[2] Unfortunately, neither study runs a similar design with symmetric endowments so that the overall effect of asymmetry cannot be derived.

[3] In this we follow Güth et al. (2004), which looks at the same three types of games in a situation with symmetric endowments and complete information.

[4] Note that our kind of punishment device is different from the punishment mechanisms used in most experimental studies. In other studies *all* group members can punish (or reward) each other (e.g., Fehr and Gächter, 2000, Ostrom et al., 1992). We believe that our punishment device mimics some real-life situations in a better way. Sanctions are typically imposed by one person (e.g., the manager in a firm or the judge in a trial or competition) rather than being mutually applicable.

[5] A few studies have looked at the effect of exclusion power in isolation, e.g., by granting exclusion power to some individual group member(s). In Cinyabuguma et al. (2005) members of a group are (permanently) expelled from the public good if at least half of the group members vote for expulsion, and in Masclet (2003) subjects could be excluded from 'social activities'. The main interest of the current paper lies in the combination of leadership and punishment.

only knows his own endowment and the total endowment of the group, but not the precise distribution of endowments. By these two information conditions we can verify how incomplete information interacts with the efficacy of leadership to raise average contributions.

By implementing two information conditions our paper is also connected to a (small) strand of literature that considers the effect of (incomplete) information about the level of endowments on cooperation in public good dilemmas. In an asymmetric step level public goods experiment Van Dijk and Grodzka (1992) find no difference in contribution levels between subjects who only know their own endowment and subjects who also know the endowments of their group members. In a similar vein Van Dijk et al. (1999) find that the overall (group) averages in the complete and partial information condition are very similar. Interestingly, however, they also discern an interaction effect between asymmetry and information: high endowed subjects contribute significantly more than low endowed subjects in the complete information condition whereas their contributions are not significantly different in the partial information condition. None of these studies looks at the effect of leadership though.

Besides considering the effects of leadership in asymmetric public goods dilemmas under different information conditions we are also interested in the selection process of leaders. In order to study if and whom subjects would elect as their leader, we split each treatment with leadership into two parts. In the first part the leader role is exogenously assigned in a rotating order to all group members. In the second part - after all group members have experienced leadership actively (by being a leader) as well as passively (by being a 'follower') - we allow subjects to vote on which group member they want to have as a leader. This feature of our experimental design will shed light on the frequency with which groups can agree on having a leader and whether the success or failure to appoint a leader has consequences for the contributions within a group.

In our companion paper (Güth et al., 2004), we have examined the effects of normal and strong leadership in case of complete information and symmetric endowments. We have found that leading by example increases contributions in comparison to a control treatment with simultaneous contributions and that strong leadership yields the highest contributions: leaders with exclusion power trigger average contributions which are almost twice as high as in the standard simultaneous game, and about 40% higher than in the case of normal leaders.

These unambiguously positive results of leadership can not be fully transferred to the case of asymmetric endowments and incomplete information. The main findings of this paper reveal, indeed, that leadership works less when people are asymmetrically endowed, especially so in case of incomplete information. Only if the endowments of the other group members are commonly known, average contributions in the leadership treatments are significantly higher than in the control treatment. Granting leaders exclusion power does not increase contributions, although strong leaders use their power to punish low contributors. Because leaders set a good example and contribute more than followers, they earn on average significantly less than followers in all leadership treatments. Furthermore, leaders' payoffs are in most cases lower and never significantly higher than the average payoff in the control treatment, implying that it does not pay off to be a leader. When endowments are known, followers earn significantly more than the average payoff in the control treatment. Finally, in the endogenous phases, groups that succeed to appoint a leader have significantly higher payoffs than unsuccessful groups. In spite of the obvious benefits of having a leader, only about one quarter of the groups is successful in appointing a powerless leader, whereas about 45% of groups manage to elect a leader with exclusion power.

The remainder of the paper is organized as follows. Sections 2 and 3 describe the public goods game and the experimental procedures. Section 4 presents the results. Section 5 offers a discussion of our results and section 6 concludes.

2 The public goods games

The basic game is the standard repeated linear voluntary contribution mechanism (hereafter, VCM) as introduced by Isaac et al. (1984). Let $I = \{1, \ldots, 4\}$ denote a group of 4 individuals $i = 1, \ldots, 4$ who interact for $t = 1, \ldots, T$ periods. In each period t, individual $i \in I$ is endowed with income $e_{i,t}$, which can be either privately consumed or invested in a public good. Individual endowments $e_{i,t}$ are asymmetric: in each 4-person group two individuals are relatively rich (i.e., $e_{i,t} = \bar{e}$ for $i = 1, 2$ for all t,) and two are relatively poor (i.e., $e_{i,t} = \underline{e}$ for $i = 3, 4$ for all t, with $\bar{e} > \underline{e} > 0$). Depending on the prevailing information condition, subjects know the others' individual endowment or not. If not, subjects only know the overall group endowment $\sum_{i=1}^{4} e_{i,t} = E$, but not how it is distributed.

Each individual's contribution at time t, $c_{i,t}$, must satisfy $0 \leq c_{i,t} \leq e_{i,t}$. Denoting by C_t the sum of individual contributions in t, i.e., $C_t = \sum_{i=1}^{4} c_{i,t}$, the monetary payoff of individual i in period t is linear in $c_{i,t}$ and C_t, and takes the following form:

$$u_{i,t}(c_{i,t}, C_t) = e_{i,t} - c_{i,t} + \beta C_t, \tag{1}$$

where $0 < \beta < 1 < 4\beta$. Due to $\beta < 1$, the dominant strategy for each player is to contribute nothing. If this is done by all, every individual i earns $u_{i,t} = e_{i,t}$. Since $4\beta > 1$, the socially efficient outcome (maximizing the sum of $u_{i,t}(\cdot)$ over $i \in I$) is, however, to contribute everything. This yields a payoff of $u_{i,t} = \beta E_t > e_{i,t}$ for all $i \in I$.

We study three types of this game under both information conditions: the standard-VCM, the VCM with leadership, and the VCM with strong leadership. The standard VCM, in which all four group members make their contribution decisions privately and simultaneously, is the control treatment. In the two leadership treatments, let $l \in I$ denote the group member in the leadership position. In each period $t = 1, \ldots, T$, the VCM with leadership has the following two decision stages:

(1) The *leader* l decides about his contribution $c_{l,t}$, which is announced to the other group members, the *followers*, j ($j \neq l$).
(2) All *followers* $j \in I$ decide privately and simultaneously about their contribution $c_{j,t}$.

Except for the last period, the VCM with strong leadership adds a third stage to the previous ones:

(3) After being informed about the followers' contributions in period t the leader may (but need not) exclude one other individual x ($\neq l$) from the group in the *next* period, $t+1$. The excluded individual x earns $u_{x,t+1} = e_{x,t+1}$ in period $t+1$ (i.e., he is excluded from contributing to, and consuming, the public good in the following period), and the remaining three group members play a 3-person public goods game (with $C_{t+1} = \sum_{i \neq x} c_{i,t+1}$).[6]

Assuming payoff-maximization and applying backward induction, the standard (game-)theoretical prediction for the VCM with leadership is the same as for the standard VCM. Since $\beta < 1$, the followers' dominant strategy in stage 2 is to contribute nothing. By anticipating this, a rational leader should contribute zero as well in stage 1. The same argument applies to the VCM with strong leadership. In the subgame-perfect equilibrium leaders are indifferent between excluding and not excluding a follower as all subjects should free-ride anyway. In sum, the standard game-theoretic prediction in all games is that all individuals, regardless of their role, contribute 0 and earn $u_{i,t} = e_{i,t}$, whereas the socially efficient outcome would require full contributions.

[6]Note that the traditional definition of pure public goods implies non-excludability, which would be at odds with the possibility to exclude other group members. What we have in mind here are *local* public goods. Furthermore, note that a player can never be excluded from the public good to which he may have contributed since the exclusion always applies to the *next* period.

3 Experimental procedures

The six experimental treatments form a 3×2 factorial design with the three different types of VCM and the two information conditions about the endowment distribution as treatment factors. The first factor, the presence and the type of leader (with or without exclusion power), allows us to investigate the effects of leadership in situations with asymmetric endowments. The second factor enables us to examine the effects of incomplete information about the distribution of endowments in each of the three VCM with asymmetric endowments.

In each period of the treatments with complete information subjects know that two "rich" group members are endowed with $\bar{e} = 30$ ECU (Experimental Currency Unit) and two "poor" group members with $\underline{e} = 20$ ECU. In the treatments with incomplete information subjects only know their own endowment, and that the total group endowment is $E = 100$ ECU, but are unaware of the distribution of endowments, which remains identical to that with complete information. The type of each subject (either rich or poor) is randomly assigned at the beginning of the experiment. Subjects know their own type, which is kept constant over an entire experimental session.

We will refer to the treatments as follows. With complete information we have the standard simultaneous VCM as control (henceforth treatment C), the VCM with leadership (treatment L), and the VCM with strong leadership (treatment S). The three treatments with incomplete information are called CI, LI, and SI, respectively.

For all treatments we have 14 independent observations (i.e., groups interacted in partner design), except for treatment C where we have 12 observations due to non show-up. In total 328 subjects participated in the experiment. Table 1 summarizes the treatments and their characteristics.

Table 1 about here

Each treatment was run for 24 periods, with payoff function (1) and $\beta = 0.4$. In the treatments with leadership, the experimental instructions (see Appendix) explained the two parts mentioned in the introduction: (1) an exogenous part (periods 1-16), and (2) an endogenous part (periods 17-24). In the exogenous part, each of the four group members is appointed as leader for four consecutive periods (that we call phase), where the sequence of taking turns as a leader is predetermined and commonly known.[7] Decision making in the

[7] Note that most of the literature on leadership considers the situation in which one (randomly selected) group member is assigned the leader role for all periods. In many organizations, however, leadership rotates among members, often according to a known and fixed

VCM with leadership and the VCM with strong leadership is based on the two- and three-stage procedure described above. Hence, the only difference between the L- and the S-treatment is that in the latter the leader can exclude one group member in the next period.[8] Regardless of the treatment, at the end of each period, participants get feedback on their private payoff and the individual contribution decisions of all group members. To allow participants to distinguish between contributions of rich and poor members in the treatments with complete information, the endowment of each group member is indicated next to his contribution decision.

Leadership in the endogenous part is determined as follows. Periods 17–24 are split into two 4-period phases. Before periods 17 and 21, there is a vote on leadership for periods 17–20 and 21–24, respectively. Subjects have to indicate for each group member (including themselves) whether they would accept that member as leader. If a single person is unanimously accepted, this person becomes the leader and stays in charge throughout the respective phase. If more than one person is unanimously accepted, one of these persons is randomly selected as leader. In all other cases, the group has no leader and all members contribute simultaneously to the public good like in the control treatments. Group members are informed about the other group members' contributions in the exogenous part before voting.

All sessions of the computerized experiment were conducted at the laboratory of the Max Planck Institute in Jena (Germany), using the software z-Tree (Fischbacher, 1999). Participants were undergraduate students from various disciplines at the University of Jena. After being seated at a computer terminal, participants received written instructions, which were also read aloud to establish common knowledge. Understanding of the rules was assured by a control questionnaire that subjects had to answer in order for the experiment to start. Sessions lasted on average less than 1.5 hours. In all treatments, only six periods were randomly chosen for payment (one period per phase). The average earnings per subject were about 12.50 euro (including a show-up fee of

scheme. For example, the Head of Department in academic institutions is usually selected from different research groups in a rotating order. Güth et al. (2004) and Gächter and Renner (2004) find that the way in which a leader is determined has no significant influence on contributions.

[8] In the strong leadership treatments (S and SI) we have restricted the leader's exclusion power in his final (i.e. fourth) period of leadership such that the leader cannot exclude anyone for the next period, because that might have caused problems in the next period in case the excluded person were the predetermined next leader. We have also restricted the leader's power to exclude only *one* other group member, because if the leader had excluded more than one other member, contributing to the public good would be inefficient even for the group as a whole (since $n\beta < 1$ if $n \leq 2$).

2.50 euro).

4 Results

The results are presented in two subsections. Section 4.1 focuses on the results of the exogenous part of the experiment (periods 1-16). First, we examine the effects of leadership by comparing average contributions in the leader treatments to those in the control treatment. We then take a closer look at leaders' and followers' behavior and at exclusion decisions. Section 4.2 discusses the endogenous selection of leaders (periods 17–24).

4.1 Leadership in the exogenous part

4.1.1 The effects of leadership

Table 2 summarizes the average contributions in the control and the two leadership treatments, separately for the situations with complete information (panel A) and with incomplete information (panel B). The average contributions are shown both for periods 1–16 (where we have exogenous leadership in the treatments with leaders) and, for the sake of completeness, over all periods. Standard deviations are indicated in parentheses.

Table 2 about here

When subjects have complete information about the distribution of endowments, average contributions in both leadership treatments (with a 'normal' and with a strong leader) are higher than in the control treatment. The differences are significant both for periods 1-16 and for all periods ($p = 0.02$ for C vs. L and $p < 0.01$ for C vs. S, two-sided non-parametric Mann-Whitney U-tests with group averages as independent observations).

In contrast, for the treatments with incomplete information, we cannot reject the hypothesis that average contributions without a leader are equal to average contributions with a leader ($p = 0.55$ for CI vs. LI and $p = 0.15$ for CI vs. SI). This gives our first result:

Result 1 *Installing a leader (with or without exclusion power) raises contributions to a public good, but only significantly so when initial endowments are commonly known.*

Table 2 also indicates that granting a leader exclusion power increases average contributions. However, both with complete and incomplete information the differences are not significant ($p = 0.60$ for L vs. S, and $p = 0.27$ for LI vs. SI, two-sided Mann-Whitney U-tests). This establishes our second result:

Result 2 *Leadership with exclusion power does not lead to significantly higher average contributions than leadership without exclusion power.*

These two results reveal that the previous experimental evidence on the positive effects of leadership has to be treated with caution. For the reader's convenience, we have included in panel C of Table 2 the main results of Güth et al. (2004) for the case of symmetric endowments and complete information. Denoting by c^k the average contributions in treatment k, the symmetric Güth et al. (2004)-design satisfies the order $c^S > c^L > c^C$ with significance $p < 0.05$. Our Results 1 and 2 show that leadership is still helpful in case of known asymmetry (yielding $c^S = c^L > c^C$, where a "=" indicates that contributions are not significantly different between the respective treatments), but its effect becomes insignificant when incomplete information is added (yielding $c^S = c^L = c^C$).

Looking at the influence of the information condition on average contributions, we see that, without a leader, contributions are higher when subjects do not know the others' endowment, albeit the difference is not significant ($p = 0.92$; two-sided Mann-Whitney U-test). With leadership, however, contributions are weakly significantly higher when information is complete rather than incomplete ($p = 0.06$ for L vs. LI; $p = 0.10$ for S vs. SI).[9] This result can be summarized by:

Result 3 *Incomplete information about endowments has no impact on average contributions without a leader. However, with leadership incomplete information yields lower contributions.*

The time paths of average contributions, aggregated for each of the six 4-period phases, are shown in Figure 1 (complete information condition) and Figure 2 (incomplete information condition). Focusing on the four phases with exogenous determination of leaders (periods 1-16), the time paths are nicely ordered in the complete information condition with average contributions being always the lowest in treatment C, and the highest in treatment S except for the first phase. In the treatments with incomplete information, contribution levels are the highest in treatment SI, whereas the graphs for treatments

[9] If we pool the two leadership treatments (i.e., combine the data from L and SL, and from LI and SI), which may be justified by Result 2, the difference becomes highly significant ($p = 0.01$), meaning that incomplete information leads to significantly lower contribution rates.

LI and CI frequently intersect. Note that the patterns in Figures 1 and 2 corroborate Results 1-3. Finally, notice that contributions in most treatments resemble the typical pattern of standard public goods experiments (Ledyard, 1995): contributions start at a level of about 50% and decline over time.

Figures 1 and 2 about here

4.1.2 Leaders' and followers' absolute and relative contributions

Table 3 presents the average absolute contributions of leaders and followers, averaged over the four phases with exogenous determination of leaders, as well as their average relative contributions (a subject's own contribution divided by his own endowment). Within each single treatment, leaders contribute significantly more than followers ($p < 0.01$ in any treatment; Wilcoxon matched-pairs signed-ranks test; $N = 14$ in any treatment). This holds both for the absolute and the relative contributions. The evidence can be summarized by:

Result 4 *Leaders contribute significantly more than followers in any treatment. Hence, leaders set a good example.*

Table 3 about here

Although followers contribute significantly less than leaders, leaders' and followers' contributions are highly correlated. For each of the leader treatments Figures 3 to 6 show the average contributions for leaders and followers, period by period. The graphs indicate that leaders' and followers' contributions develop similarly over time. In many cases the contributions move almost in parallel. The Spearman's rho correlation coefficients are significantly positive in all treatments (Spearman's rho is 0.92 in L, 0.74 in S, 0.87 in LI, and 0.79 in SI; $p < 0.01$ in all treatments). The correlation appears to be stronger when the leader has no exclusion power, whereas different information conditions have no effect on the strength of the correlation.[10] This leads us to our next result:

Result 5 *Followers follow their leaders closely, since their contributions are very highly correlated to the leaders' contributions.*

Figures 3 to 6 about here

Table 4 about here

[10] The differences are partly due to the fact that in the strong leadership treatments excluded players have zero contributions. If we consider the correlation between contributions by leaders and not excluded followers, Spearman's rho's increase to 0.84 in S ($p < 0.01$), and 0.85 in SU ($p < 0.01$), but they remain lower than in L and LI.

Taken together, Results 4 and 5 suggest that, although followers follow their leaders, they also exploit them by contributing significantly less. We can derive the extent to which this occurs by looking at the payoff consequences for leaders and followers. Table 4 displays the average profits for periods 1-16. First of all, it stands out clearly that followers earn more than leaders in all treatments with leadership ($p < 0.01$ in any treatment, Wilcoxon tests). Furthermore, they earn significantly more than the average payoff in the control treatment, although the difference is significant only under complete information ($p < 0.01$ for L vs. C, and $p = 0.01$ for S vs. C, whereas $p > 0.17$ for both comparisons under incomplete information, Mann-Whitney U-tests). The situation for leaders is almost the opposite: in treatment LI leaders' payoffs are significantly lower than the average payoff in the respective control treatment ($p < 0.02$) and in the other treatments we cannot reject the hypothesis of equality between leaders' payoff and average payoff in the control treatments ($p > 0.65$ for all three comparisons). This yields

Result 6 *Followers (and the total group payoffs) benefit from having a leader, but significantly so only when there is complete information. Being a leader is never beneficial.*

We conclude this subsection by looking at the question whether leaders' and followers' contributions depend on their endowment. In all treatments the rich (poor) group members are leaders in periods 1–8 (9-16). While Figures 3 to 6 show a gradual decline in the average level of contributions by leaders and followers, there is no clear "drop" after period 8 although the leaders' endowment declines by 50%. To consider the possible impact of endowments in more detail, Figures 7 and 8 show the evolution of the average *relative* contributions by leaders and followers. Table 5 displays the average absolute and relative contributions by leaders and followers in the first and last eight periods.[11]

Figures 7 and 8 about here
Table 5 about here

Relative contributions of leaders and followers are very similar in the first 8 periods: leaders and followers contribute on average about 65% of their endowment in treatments L and S, and about 55% in LI and SI. Then there

[11] Note that there may be a sequencing effect here because the order of rich and poor leaders is not changed in the experiment, and in public good experiments contributions typically decline over time. However, if we wanted to control for that we had to run twice as much sessions, which was not possible within our budget. Notice, moreover, that between-treatment comparisons are still valid as we use the same sequencing in all treatments.

is a substantial increase in leaders' relative contributions, indicating that poor leaders contribute a larger share of their endowment compared to rich leaders (namely on average about 79% (65%) with complete (uncomplete) information). The differences with respect to relative contributions in periods 1-8 and 9-16 are significant in all treatments except *LI* (Wilcoxon tests yield $p < 0.04$ for the other three treatments).

One would expect a smaller effect on followers because the percentage change in total follower income is smaller.[12] Nevertheless, the data unambiguously demonstrate that followers contribute less in periods 9-16 than in periods 1-8 in relative terms (namely on average about 51% (37%) with complete (incomplete) information). In all treatments this difference is significant (all $p < 0.02$, Wilcoxon tests).

Thus, while relative contributions of leaders and followers are about the same in periods 1-8, leaders contribute much more in relative terms than followers do in rounds 9-16.

Finally, Figures 6 and 7 illustrate that the development of the relative contributions in the two information conditions is rather similar. This is remarkable because in treatments *LI* and *SI* individuals do not know whether the leader is relatively rich or poor. Yet, relative contributions by leaders (followers) increase (fall) in periods 9-16, and in a similar way as in treatments *L* and *S*.[13]

4.1.3 Exclusion power

Although the results so far suggest that under asymmetric endowments leaders with exclusion power can induce, on average, higher contributions than leaders without such power, differences are not significant. This stands in contrast to what we observe under symmetric endowments (cf., Güth et al., 2004). The insignificant effect of strong leadership in our asymmetric environment may be due to the the fact that powerful leaders do not use their exclusion power as frequently as in the symmetric environment. Yet, this seems not to be the case. Focusing on periods 1–16, leaders exclude one other group member 52 times (31% of the possible periods) and 44 times (26%) in treatment *S* and *SI*, respectively.[14] The relative frequency of exclusion is thus on average even higher than the 24% exclusion rate observed by Güth et al. (2004). None of

[12] Total follower income changes from 70 in periods 1-8 to 80 in periods 9-16 (+14%), whereas leader income changes from 30 in periods 1-8 to 20 in periods 9-16 (-33%).

[13] The only exception is the very low average relative leaders' contributions in periods 11 and 12 in treatment *LI*.

[14] Exclusion follows the same pattern in both treatments. If a follower is excluded, it is in more than 85% of cases the one with the lowest contribution.

the differences is significant, though.[15]

A further reason for the relatively small impact of exclusion power with asymmetric endowments may be that followers react less strongly to exclusions than in the symmetric case, where we find a strong negative Spearman correlation coefficient ($r = -0.76$, $p < 0.01$) between the number of excluded group members and average followers' contributions. Although the correlation is less strong under asymmetry, it is clearly significant in both information conditions ($r = -0.61$ in S, $p = 0.02$, and $r = -0.58$ in SI, $p = 0.03$). This gives the following result:

Result 7 *There is a strong and significantly negative correlation between the followers' contributions and the number of times leaders execute their exclusion power.*

4.2 Leadership in the endogenous part - choosing a leader

In periods 17-24 of the treatments with a leader, group members can endogenously choose whether and whom they want to have as a leader in their group. Table 6 summarizes the relative frequency of successfully installing a leader, and the average contributions with and without a leader. Regardless of the information condition, the endogenous selection of a leader is successful in only about one quarter of the cases in the L- and LI-treatment, whereas it is more frequent (about 45%) with strong leaders in the S- and SI-treatment.[16] The difference in relative frequencies is only significant with complete information ($p = 0.04$ for L vs. S; $p = 0.23$ for LI vs. SI; Mann-Whitney U-tests). We find no evidence that the likelihood of successfully appointing a leader in the endogenous phases is significantly related to the level of contributions in the exogenous phases (periods 1–16). Furthermore, rich subjects and poor subjects are equally likely elected as leader.[17]

Table 6 about here

[15] Recall that a leader – who is appointed for 4 periods – can exclude another group member in the first three periods, but not in period 4 (subjects were informed about this). However, unfortunately in one session of treatment SI (7 groups) it was possible to exclude a group member in the last period of a phase due to an error in the software. It happened 5 times that a subject was unjustly expelled. The results seem not sensitive to this.

[16] Remarkably, the relative frequencies of successfully installing a leader in treatments LI and SI are exactly the same as the relative frequencies in the corresponding treatments with symmetric endowments and complete information (Güth et al., 2004).

[17] Note that in the treatments with incomplete information subjects do not know the others' endowment such that they cannot deliberately vote for a rich or a poor leader. However, contributions in the exogenous part may serve as informative signals. See also section 5.

Having a leader (with or without exclusion power) is clearly beneficial: in all leadership treatments except LI average contributions in the successful groups are about twice as high as the average contributions in the groups which fail to appoint a leader. Consequently, in these three treatments average payoffs are significantly higher if the group has a leader than if it has not ($p < 0.05$ in any treatment; Wilcoxon signed ranks test for those groups that experience both having and not having a leader). Apart from treatment LI, which has very low contributions in the endogenous phase both with and without a leader, average contributions with a leader are very similar to the average contributions in periods 1-16, and elected leaders in periods 17-24 behave similarly as exogenously appointed leaders in periods 1-16.

As these findings correspond very well to what has been found for symmetric endowments, we can conclude that the likelihood of successfully installing a leader is mainly determined by the leadership power, whereas the distribution of endowments and the information about it have very little influence on this likelihood and on the differences in contributions and payoffs between successful and unsuccessful groups.

We can sum up our major findings about the endogenous phases as:

Result 8 *Election of a leader is more likely when the leader has exclusion power. Incomplete information does not affect the frequency of appointing a leader. Groups with a leader earn significantly more than groups that fail to elect a leader.*

5 Discussion

Our results suggest that in the absence of a leader contributions are hardly affected by asymmetry and incomplete information (see Table 2). On the contrary, both factors appear to be important in case of leadership. Average contributions are higher with a 'normal' leader than without a leader as long as there is complete information. Strong leadership increases contributions even more, but only significantly so if endowments are symmetric and information is complete (see Güth et al., 2004). How are these findings related to previous ones?

When there is no leader, groups with asymmetric endowments do not have lower contributions than groups with symmetric endowments. This result is consistent with the income-neutrality theorem of Warr (1982, 1983). However, the experimental evidence is not unequivocal as far as the effects of heterogeneous endowments on overall average contributions are concerned. A short survey in Chan et al. (1999) reveals that the effects depend on the implemented public goods technology (linear, non-linear, step-level). Overall, the effects of heterogeneity seem to be rather small, though. A rather undisputed feature of experiments with heterogeneous endowments, however, seems to be that rich subjects typically contribute less in relative terms (comparing their contribution to their endowment) than poor subjects do. This stylized fact could be explained by a widespread norm that implies that all group members should contribute equally to the public good.[18]

When we move to our results with leaderhip, we find that average contributions are smaller under incomplete information than under complete information (see Result 3). We would like to argue that this is mainly due to the effect of the different information structure on the behavior of leaders. When information is complete, rich leaders contribute, on average, about 65% of their endowment, i.e., about 20 ECU. This is precisely the amount that poor followers can actually match given their endowment. Therefore, a leader's contribution of 20 ECU might serve as a signal to followers to match his conribution. We find that the rich leaders' modal contribution is, indeed, 20 ECU whereas only 18% (14%) of the time rich leaders contribute less than 12 ECU in treatments L or S. Poor leaders also set good and clear examples: almost 50% of the time they contribute the maximum amount of 20 ECU, and in only 11% (5%) of the cases poor leaders contribute less than 12 ECU in treatment L (S).[19]

Under incomplete information, leaders may find it much harder to send an unambiguous signal because they do not know which contribution the followers can afford. As a consequence, leaders' choices in treatments LI and SI are much more dispersed, especially in the first 8 periods. No clear modal (class of) contribution exists, and 42% (36%) of the time rich leaders contribute at most 12 ECU in treatment LI (SI). Poor leaders do not send very clear signals either, but they do manage to set somewhat better examples: although the maximal contribution is observed less frequently than in case of complete information, 20 ECU remains the modal contribution in both treatments (24% in LI vs. 37%

[18] This kind of equal contribution rule is sometimes contrasted with a proportionality rule that would prescribe that subjects contribute an equal share of their (unequal) endowments (see Van Dijk and Wilke, 1995, Van Dijk et al., 1999).

[19] As compared to the symmetric case, asymmetry in endowments does not trigger a different behavior in case of normal leadership, but it does so in case of strong leadership (see Güth et al., 2004 for more details). When all subjects are given the same endowment, strong leaders set very good examples by contributing on average 21.43. The examples are also clear as exactly 50% of the time they contribute the maximum amount of 25 and in only 6% of the cases they contribute 12 or less. Leaders typically exclude followers that contribute the least. As a consequence, followers contribute on average high amounts too, i.e. 17.98. Taken together this results in the high average cooperation level of 19.80 as shown in panel C of Table 2.

in SI).

Concerning the followers, they follow their leader to a degree which is only slightly different across treatments (cf., Result 5). Therefore, followers tend to base their decisions on a rule requiring them to contribute a certain share of the leader's contribution.[20]

To sum up, in all treatments our findings seem to be in line with earlier experiments indicating that rich subjects contribute more than poor subjects in absolute terms, but not in relative terms. Incomplete information about the others' endowment has no influence on cooperation levels in the simultaneous game, but it leads to less cooperation when a leader is present. We attribute this observation to the leaders' difficulty to send a signal about an appropriate contribution when others' endowments are unknown. The examples the leaders set are, indeed, worse and more ambiguous when information is incomplete.

6 Conclusion

We have investigated the effects of leadership on average contribution levels when subjects are heterogeneously endowed and may not know the distribution of endowments. We have considered situations in which leaders can merely lead by example and situations in which leaders not only move first, but have also some punishment power through the opportunity of excluding other group members.

Our results suggest that the effects of leadership depend substantially on the considered environment. Earlier studies - e.g., Moxnes and van der Heijden (2003), Gächter and Renner (2004) or Güth et al. (2004) - have focused on situations with complete information and homogeneous endowments. The earlier findings of leadership promoting higher contributions, particularly when leaders have exclusion power, do not fully carry over to the settings examined in this paper. In case of asymmetric endowments, in fact, leadership has just a small effect, which is significant only when information is complete. If subjects do not know the distribution of endowments, leadership is practically ineffective in rising the contribution levels observed in the control treatment with no leader. Furthermore, while granting the leader exclusion power fosters cooperation significantly when all subjects have the same endowment, this form of leadership does not result in significantly higher contributions in case of heterogeneous endowments, regardless of the information structure. Hence, the overall conclusion is that leading by example works very well in the symmetric case, less so

[20] For poor followers such a share is similar in all treatments. For rich followers it is also similar in all treatments, apart from LI where it is substantially lower.

in the asymmetric case and least when asymmetry is combined with incomplete information.

Unfortunately, the symmetric cases, where all subjects are equally endowed and full information prevails, seem to be the least realistic ones when we think of real-world examples like work groups in companies or clubs where members (have to) contribute to the common goal of the group or the club. Subjects in such groups are heterogeneous in many respects, of which individual capabilities (captured in the experiment by the endowments) are one important example. Likewise, group members may not be fully aware of the distribution of certain characteristics of group members. Rather, one often only learns through repeated interactions about the capabilities of other group members (as subjects may have learned about the endowments of other members in our incomplete information conditions). Given that leading by example has been shown to improve cooperation even in heterogeneous groups, provided that the heterogeneity is common knowledge, it should be in the interest of organizations that rely on work groups that group members have a fairly good knowledge about each other's task-related characteristics. In such circumstances, leading by example can work even in an heterogeneous environment.

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Appendix: Experimental Instructions

This appendix contains the instructions (originally in German) we used for the strong leader (S)-treatment with complete information. The instructions for the other treatments were adapted accordingly and are available upon request.

Welcome and thanks for participating in this experiment. You receive 2.50 for having shown up on time. If you read these instructions carefully, you can make good decision and earn more. The 2.50 and all additional amount of money will be paid out to you in cash immediately after the experiment.

During the experiment, amounts will be denoted by ECU (Experimental Currency Unit). ECU are converted to euros at the following exchange rate: 1 ECU = 0.06.

It is strictly forbidden to communicate with the other participants during the experiment. If you have any questions or concerns, please raise your hand. We will answer your questions individually. It is very important that you follow this rule. Otherwise we must exclude you from the experiment and from all payments.

Detailed information on the experiment

The experiment consists of 24 separate periods, in which you will interact with three other participants. The four of you form a group that will remain THE SAME in all 24 periods. You will never know which of the other participants are in your group. The group composition is secret for every participant.

What you have to do

At the beginning of the experiment, you will be randomly assigned to either of two types, either type A or type B. Subjects of type A will receive an amount of 30 ECU at the beginning of each period. Subjects of type B will receive 20 ECU per period. In the following, we shall refer to this amount as *your endowment*.

Your task (as well as the task of your group members) is to decide **how much of your endowment you want to contribute to a project.** Whatever you do not contribute, you keep for yourself ("ECU you keep").

In every period, your earnings are the sum of the following two parts:

1. the "ECU you keep";
2. the "income from the project".

The "*income from the project*" is determined by adding up the contributions of the four group members and multiplying the resulting sum by 0.4. That is:

Income from the project = [0.4 × (total group contribution)] ECU

Each ECU that you contribute to the project rises "income from the project" by 0.4 ECU. Since "income from the project" is the same for all four members of the group (i.e., all receive the same income from the project as this is determined by the total group contribution), each ECU that you contribute to the project rises YOUR period-earnings *as well as* the period-earnings of YOUR GROUP MEMBERS by 0.4 ECU. The same holds for the contributions of your group members: Each ECU that any of them contributes to the project increases "income from the project" (and therefore your earnings) by 0.4 ECU.

The "ECU you keep" are your endowment *minus* your contribution to the project. Each ECU that you keep for yourself raises "ECU you keep" and YOUR period-earnings by one ECU. Thus, each ECU that you keep yields money for YOU ALONE.

How you interact with your group members in each period

Within your group you are identified by a number between 1 and 4. This number will be assigned to you privately at the beginning of the experiment and will remain fixed.

Each period consists of the following three stages:

1. One group member first decides about his/her own contribution. In the following, we shall refer to the group member who decides first as the "*early contributor*".
2. Being informed about the decision of the early contributor, the other three group members decide simultaneously and privately about their own contribution.
3. The early contributor learns about the contribution of the others, and (s)he can decide to exclude at most one of them from the group *in the next period*.
   • If the early contributor DOES NOT EXCLUDE ANYONE, next period's "income from the project" and the earnings you are due in that period are determined as before.
   • If the early contributor EXCLUDES SOMEONE, in the following period the interacting group members will be three rather than four, and the "income from the project" is determined by adding up only their three contributions. Since the excluded group member stays out of the game, his (her) earnings in the subsequent period are merely equal to his/her endowment (i.e., either 20 ECU or 30 ECU).

Consider the following example: Member 1 is the early contributor in period 1 and contributes a certain amount. Knowing the contribution of the early contributor, the three other members of the group decide on their contribution, which is then communicated to the early contributor. If the early contributor decides, for instance, to exclude member 2, this means that member 2 is excluded from the group in the next period, i.e., in period 2. Hence, in period 2 only members 1, 3 and 4 interact with each other and their earnings in period 2 are as follows: "*ECU each keeps* + [0.4 × (sum of contributions of members 1, 3, and 4)]". Since member 2 does not participate in the interaction in period 2, (s)he just keeps his/her endowment. Note that member 2 will re-enter the group in period 3.

Each group member is appointed to be the "early contributor" for four consecutive periods, starting with member 1 and ending with member 4. In the following, we shall refer to the four consecutive periods in which the same group member is the early contributor as a "*phase*". Therefore:

- member 1 is the early contributor in phase 1 (i.e., in periods 1, 2, 3, and 4);
- member 2 is the early contributor in phase 2 (i.e., in periods 5, 6, 7, and 8);
- member 3 is the early contributor in phase 3 (i.e., in periods 9, 10, 11, and 12);
- member 4 is the early contributor in phase 4 (i.e., in periods 13, 14, 15, and 16).

In the last period of each 4-period phase (i.e., period 4 for member 1, period 8 for member 2, period 12 for member 3, and period 16 for member 4), the designated early contributor cannot exclude anyone. Therefore, in the first period of each phase (i.e., periods 1, 5, 9, 13) all four group members interact with each other.]

At the end of period 16, there will be two more phases (á four periods). In each of these two phases, group members will have the opportunity to choose themselves the person whom they want to be the early contributor in their group.

How you choose your preferred early contributor

In periods 17 and 21, you are requested to indicate whether you want a specific group member to become the early contributor. If you want a specific group member to be the early contributor, you must press the "Yes" button on the screen. Otherwise (i.e, if you do not want him/her to be the early contributor), you must press the "No" button. You have to decide on "Yes" or "No" for each single group member (including yourself). Please note that you can answer "Yes" for more than one group member.

- If there is a single person within your group who receives *four "Yes"*, this person will become the early contributor in the respective phase and the sequence of decisions is as described above.
- If two or more persons receive four "Yes", one of these persons will be randomly selected as the early contributor.
- Otherwise (i.e., if there is no person within your group who receives *four "Yes"*), there will be no early contributor, and you as well as your group members must make your contribution decisions simultaneously and privately. This, of course, also means that there will be no opportunity to exclude any group member in

this phase.]

The information you receive at the end of each period

At the end of each period, you will receive information about the number of ECU contributed by *each* of your group members as well as about your period-earnings.

Your final earnings

Your final earnings will be calculated as follows:

1. For each of the six phases of the experiment, one period will be randomly selected.
2. Your earnings in these 6 periods will be added up.
3. The resulting sum will be converted to euros and paid out to you in cash.

Before the experiment starts, we will run a control questionnaire to verify your understanding of the experiment.

Please remain seated quietly until the experiment starts. If you have any questions, please raise your hand now.

Tables and Figures

Table 1. Overview of the treatments

Treatment	leader	exclusion power	complete information	# groups (N)
C - Control	no	-	yes	12
L - Leadership	yes	no	yes	14
S - Strong leadership	yes	yes	yes	14
CI - Control	no	-	no	14
LI - Leadership	yes	no	no	14
SI - Strong leadership	yes	yes	no	14

Table 2. Average contributions by treatment

Treatment	Periods 1-16	Overall (Periods 1-24)
A) *Complete Information*		
C - Control	9.78 (4.17)	8.47 (4.15)
L - Leadership	14.38 (5.05)	12.35 (4.55)
S - Strong leadership	15.42 (3.64)	13.76 (3.93)
B) *Incomplete Information*		
CI - Control	10.42 (6.08)	8.95 (5.68)
LI - Leadership	10.86 (4.25)	9.03 (4.10)
SI - Strong leadership	12.90 (4.08)	11.69 (4.68)
C) *Symmetry**		
C - Control	10.04 (6.17)	8.35 (5.81)
L - Leadership	13.41 (6.46)	11.92 (6.44)
S - Strong leadership	19.80 (4.30)	18.26 (4.42)

Note: standard deviations in parentheses.

* Source: Güth et al. (2004).

Table 3. Absolute and relative contributions of leaders and followers in periods 1-16

	Absolute contributions		Relative contributions	
Treatment	Leaders	Followers	Leaders	Followers
Complete Information				
L - Leadership	17.29	13.41	0.70	0.59
S - Strong leadership	17.96	14.57	0.74	0.65
Incomplete Information				
LI - Leadership	13.99	12.14	0.57	0.41
SI - Strong leadership	15.19	14.06	0.62	0.50

Table 4. Average profits by treatment (Periods 1-16)

		Profits	
Treatment	Leaders	Followers	Average
Complete Information			
C - Control			30.87
L - Leadership	30.72	34.60	33.63
S - Strong leadership	31.68	33.58	34.25
Incomplete Information			
CI- Control			31.26
LI - Leadership	28.38	32.56	31.51
SI - Strong leadership	30.46	32.47	31.96

Table 5. Absolute and relative contributions of leaders and followers

	periods 1-8			
	Absolute contributions		Relative contributions	
Treatment	Leaders	Followers	Leaders	Followers
Complete Information				
L - Leadership	19.34	14.06	0.64	0.61
S - Strong leadership	19.45	15.19	0.65	0.66
Incomplete Information				
LI - Leadership	16.07	11.77	0.54	0.51
SI- Strong leadership	16.40	12.69	0.55	0.55
	periods 9-16			
Complete Information				
L - Leadership	15.25	12.76	0.76	0.48
S - Strong leadership	16.46	14.55	0.82	0.54
Incomplete Information				
LI - Leadership	11.91	7.86	0.60	0.30
SI- Strong leadership	13.97	11.59	0.70	0.44

Table 6. Leadership and contributions in the endogenous phases

Treatment	Leader appointed (relative frequency)	Contributions with leader	Contributions without leader
Complete Information			
L - Leadership	0.25	13.11	6.69
S - Strong leadership	0.46	14.97	6.84
Incomplete Information			
LI - Leadership	0.29	6.02	5.10
SI - Strong leadership	0.43	13.45	6.13

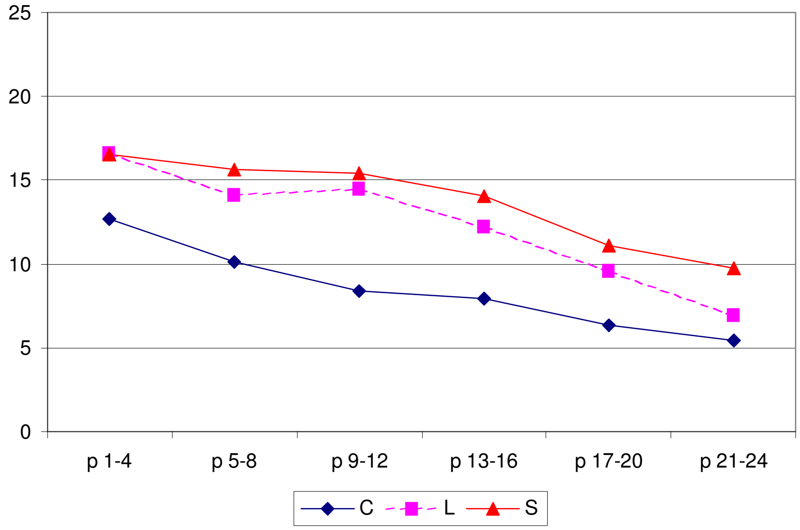

Figure 1: Total average contributions per phase (p) of four periods in the complete information condition

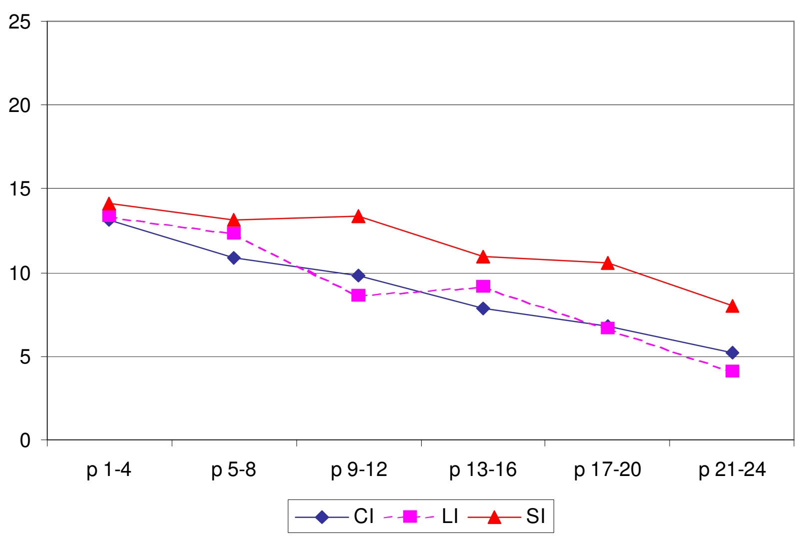

Figure 2: Total average contributions per phase (p) of four periods in the incomplete information condition

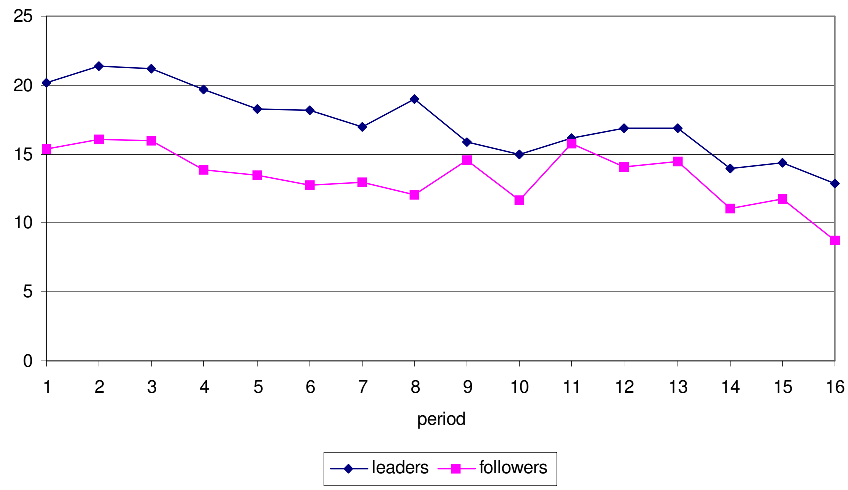

Figure 3: Leader and follower contributions in treatment L

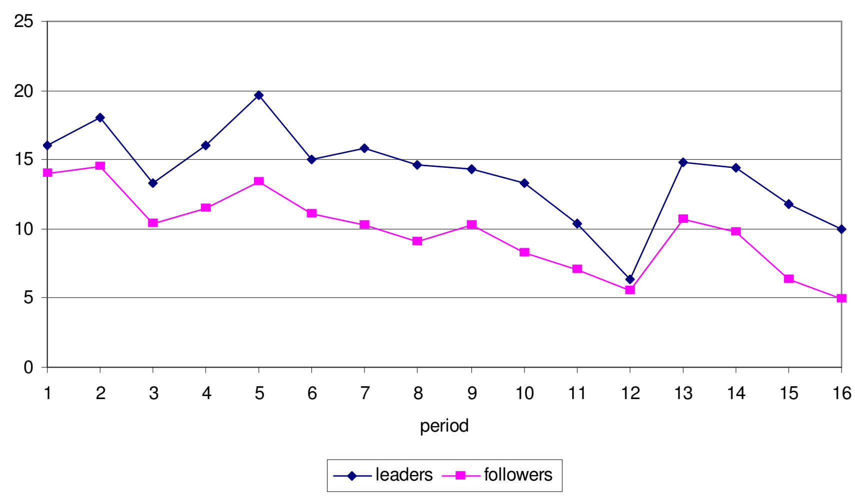

Figure 4: Leader and follower contributions in treatment LI

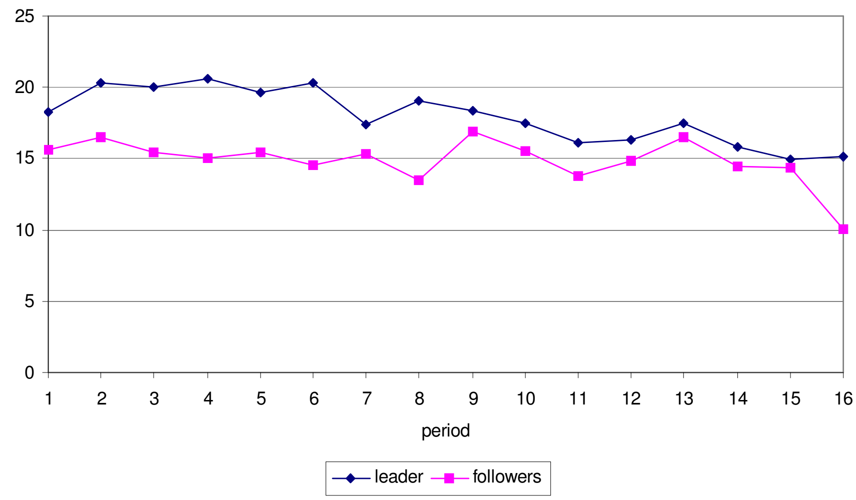

Figure 5: Leader and follower contributions in treatment S

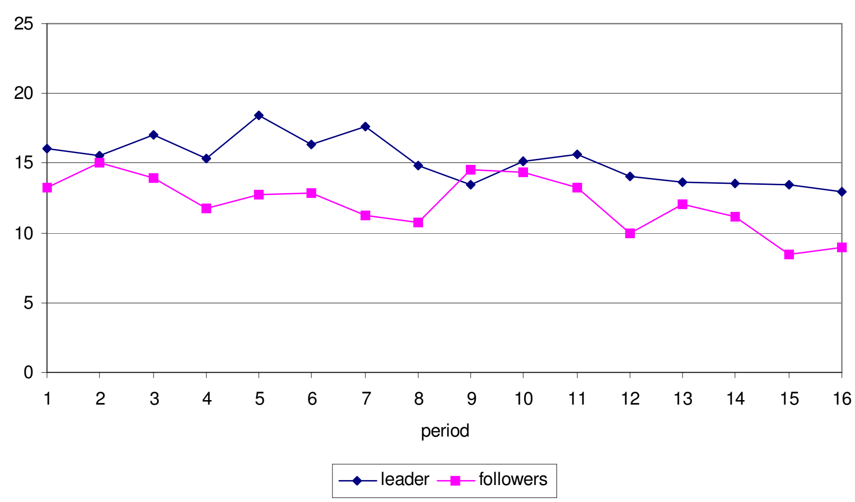

Figure 6: Leader and follower contributions in treatment SI

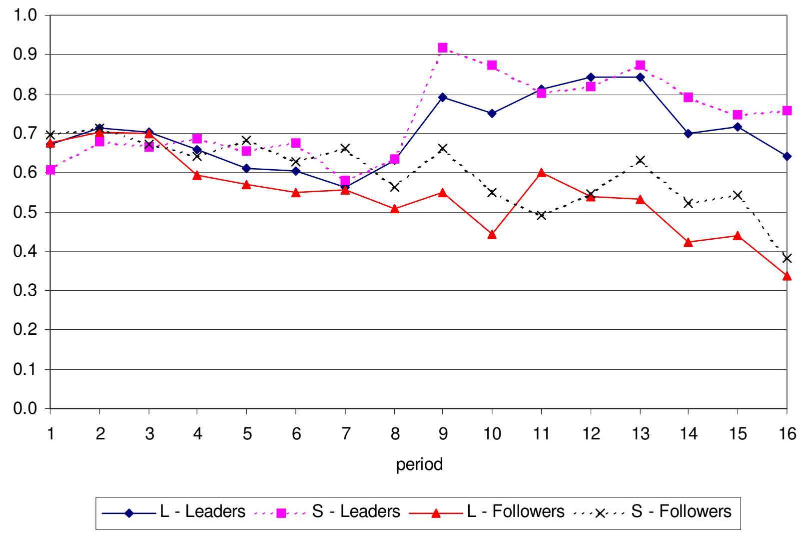

Figure 7: Relative leader and follower contributions in treatments L and S

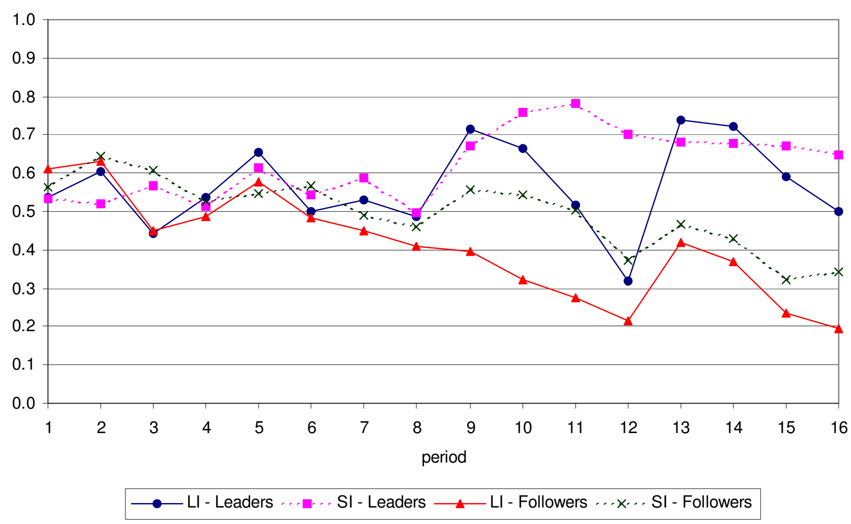

Figure 8: Relative leader and follower contributions in treatments LI and SI