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Leading by Example in a Public Goods Experiment with Heterogeneity and Incomplete Information

M. Vittoria Levati
Strategic Interaction Group
Max Planck Institute of Economics,
Jena, Germany and University of Bari, Italy
Matthias Sutter
Department of Economics
University of Innsbruck, Austria
Eline van der Heijden
Department of Economics and CentER
Tilburg University, Netherlands

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 participants 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*

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

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their own investment; that is, they have an incentive to free ride. However, best outcomes are realized if all individuals pursue the collective interest by investing the maximum amount, that is, by full cooperation. Since 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, Oppenheimer, and Young 1971; Calvert 1992; Yukl 2001)[1] but which has only recently 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 teamwork (Foss 2001) or charitable fund-raising (Andreoni 2006). Thus, leadership can be considered as a noncooperative means to achieve (more) cooperation in social dilemma situations (Arce 2001).

In this article, we experimentally explore the effects of leadership in a specific social dilemma situation, namely a public goods game. In spite of the long 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 reasons. 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.

Experiments in the social psychological literature have mainly focused on factors that may affect a leader's effectiveness in promoting cooperation. These influential factors include procedural fairness, perceived charisma (De Cremer and Van Knippenberg 2002), group commitment (De Cremer and Van Vugt 2002), and leadership style (Van Vugt et al. 2004). For instance, De Cremer and Van Knippenberg (2002) find that the leader's perceived charisma or procedural fairness has a positive influence on cooperation in a public goods game. De Cremer and Van Vugt (2002) show that highly committed group leaders are able to raise individuals' contributions, especially when group members identify strongly with their own group.

Economic experiments have concentrated on one of the simplest forms of leadership, namely leading by example. In these experiments, leadership is typically implemented by random assignment of the leader role to one group member. The leader contributes first, and after having observed 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. (2007) confirm these earlier findings and 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, even if a leader can only set an example.

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 participants 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.

The investigation of behavior under asymmetric endowments links our article 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 nonlinear setting, although, contrary to Warr's income-neutrality postulate, the rich tend to undercontribute and the poor to overcontribute relative to their endowments. In a linear public goods game, however, Cherry, Kroll, and Shogren (2005) show that average contributions are lower with asymmetric rather than symmetric endowments. In an asymmetric step-level public goods game, Van Dijk and Wilke (1995) find that participants with a twice as high endowment contributed almost twice as much as low endowed participants, whereas Van Dijk and Grodzka (1992) observe no significant difference between participants with high and low endowments. In contrast, in a similar setting (but using a business scenario), Aquino, Steisel, Kay (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 articles 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. In the "normal" leadership treatment, the only difference between leaders and followers is that the leader decides first. In the "strong" leadership treatment, leaders are granted exclusion power in addition. That is, after having observed 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.[2] 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 to achieve more efficient outcomes.

All three treatments are run under two different information conditions: one with complete information in which each participant knows the distribution of endowments and the other with incomplete information in which each participant 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 examine how incomplete information interacts with the efficacy of leadership to raise average contributions.

By implementing two information conditions, our article 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 participants who only know their own endowment and participants who also know the endowments of the others. In a similar vein, Van Dijk et al. (1999) find that the overall (group) averages in their complete and partial information condition are very similar. Interestingly, however, they also discern an interaction effect between asymmetry and information: high endowed participants contribute significantly more than low endowed participants 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 interested in the selection process of leaders. To study if and whom participants 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 participants 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 agree on having a leader and whether the success or failure to appoint a leader has consequences for the contributions within a group.

The remainder of the article is organized as follows. The next section outlines the public goods games and formulates the main hypotheses. The third section describes the experimental procedures. The fourth section presents the results. The fifth section offers a discussion of our results, and the sixth section concludes.

The Public Goods Games and Hypotheses

The basic game is the standard repeated linear voluntary contribution mechanism (hereafter, VCM). Let $I = \{1, \ldots, 4\}$ denote a group of four 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 four-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, participants know the others' individual endowment or not. If not, participants only know the overall group endowment $E_t = \sum_{j=1}^{4} e_{j,t}$ but not how it is distributed.

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

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

where $0 < \beta < 1 < 4\beta$. Because $\beta < 1$, the dominant strategy for a selfish, payoff-maximizing player is to contribute nothing. If this is done by all, every individual i earns $e_{i,t}$. 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, because this yields a payoff of $\beta E_t > e_{i,t}$ 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 our control treatment. The VCM with leadership has, in each period, 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 $f (f \in I)$.
2. All *followers* $f (\neq l)$ decide privately and simultaneously about their contribution $c_{f,t}$.

Except for the last period, the VCM with strong leadership includes a third stage:

3. After being informed about the followers' contributions in period t, the leader may (but need not) exclude one 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 $t + 1$ (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 three-person public goods game (with $C_{t+1} = \sum_{j \neq x} c_{j,t+1}$).[3]

Assuming general opportunism (i.e., own monetary 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 where, in the subgame-perfect equilibrium, leaders are indifferent between excluding and not excluding a follower as the equilibrium contribution of zero renders the leader's payoff independent of his exclusion decision. In sum, under the assumption of rational and strictly self-interested behavior, standard game theory predicts that in all three games, all individuals contribute zero, irrespective of their role.

However, numerous experimental studies have shown that individuals in social dilemma situations cooperate more than expected (see, e.g., Ledyard 1995, for an overview). Several explanations have been put forward to account for this behavior, most of which involve other-regarding preferences such as altruism (Becker 1976; Levine 1998), inequity aversion (Fehr and Schmidt 1999; Bolton and Ockenfels 2000), reciprocity (Rabin 1993; Dufwenberg and Kirchsteiger 2004), and conditional cooperation (Fischbacher, Gächter, and Fehr 2001).[4]

The same mechanisms that cause deviations from the standard prediction in public goods games with no leader may be important in the presence of a leader. For instance, fairness and inequity aversion may be stronger with than without a leader (on this issue, see, e.g., Samuelson and Messick 1995). Furthermore, a positive example by the leader may trigger more contributions by conditionally cooperative followers: if followers are willing to contribute to the public good if others do so and the leader anticipates this, it pays off for the group if the leader goes ahead with high contributions. Among the models designed to explain cooperative behavior, two prominent classes can be distinguished: outcome-based models that focus on distributional concerns (e.g., Fehr and Schmidt's [1999] and Bolton and Ockenfels's [2000] models of inequity aversion as well as Levine's [1998] model of altruism) and intention-based models that focus on the role of intentions that players attribute to one another (Dufwenberg and Kirchsteiger 2004; Falk and Fischbacher 2006). In our leadership experiments, where followers know (and can react to) the leader's contribution, intentions are superfluous for the followers but not for the leader, who must anticipate the willingness of his fellow members to cooperate. Experimental evidence of the relevance of conditional cooperation to increase contributions in public goods games with leadership is provided by Güth et al. (2007). Yet they do not allow for asymmetric endowments or incomplete information.

Besides being influenced by the above-mentioned individual attitudes, cooperation in the leadership treatments may depend on other aspects such as who leads, what leadership style is adopted, and how people perceive their leader. According to De Cremer and Van Vugt (2002), for instance, leaders are more effective in raising cooperation if they are able to fulfill both "instrumental" needs (i.e., to solve the free-riding problem) and "relational" needs (i.e., to shape group identity). Van Vugt and De Cremer (1999) observe that an instrumental leader who punishes noncooperating group members is more efficient in raising contributions than a relational leader.

Motivated by the importance of other-regarding preferences in social interactions and by the evidence concerning the enforcement of cooperation by leadership (see also the introductory section), we predict that, notwithstanding the asymmetry in endowments, other-regarding concerns will be equally important in all our contexts (at least, insofar as participants have complete information) and hypothesize a positive effect of leadership on cooperation, especially so when the leader has the option of excluding another group member. The rationale for the latter conjecture is twofold. From an instrumental perspective, followers are expected to cooperate more with strong than with normal leaders because they fear exclusion in case of noncooperation (in this sense, it is in their self-interest to cooperate). From a relational perspective, strong leaders should be more capable of strengthening people's affective ties with their group, thereby fostering their willingness to cooperate.

Understanding which "structural" characteristics of the environment are relevant for the eventual effect of leadership is a crucial and still open question. The information available to the actors may be a key variable affecting the effectiveness of leadership. For this reason, we explore whether and to what extent awareness of the distribution of endowments influences cooperation in the presence of a leader.

The effects of information conditions on cooperation with a leader are not easily predicted because two divergent forces may be at work. On one hand, if the presence of a leader is by itself beneficial to cooperation—as a relational perspective may claim—the different information conditions should not matter, and the presence of a leader should stimulate cooperation (as compared to the control treatment with no leader) regardless of the available information. On the other hand, one may argue that setting a (good) example or establishing cooperation as a norm is harder when endowments are not known and, consequently, the expected positive effect of leadership may be weakened under incomplete information. Economic theory offers little guidance about which of these two forces will prevail, and empirical evidence on the issue is lacking. Similarly, it is hard to conjecture whether granting the leader exclusion power has the same effect in the two information conditions. The fear of being excluded is present in both situations, but the exclusion decision may be more difficult if leaders do not know the individual endowments. Hence, rather than formulating a specific hypothesis, we prefer to be guided by data. In this sense, this aspect of our study is explorative.

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 address our first research question: will the acknowledged positive effects of leadership on cooperation endure in situations with asymmetric endowments? The second factor, the prevailing information condition, enables us to tackle our second research question: how does incomplete information about the distribution of endowments interact with the potential efficacy of leadership to raise contribution rates?

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

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. Table 1 summarizes the treatments and their characteristics.

In each period of the treatments with complete information, participants 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, participants know their own endowment and that the total group endowment is $E = 100$ ECU, but they are unaware of the distribution of endowments, which remains identical to that with complete information. The type of each participant (either rich or poor) is randomly assigned at the beginning of the experiment. Participants know their own type, which is kept constant over an entire experimental session.

Each treatment lasts twenty-four periods throughout which group composition never changes (partner design). Payoffs are determined via function (1) with $\beta = 0.4$. In the treatments with leadership, the experimental instructions introduce an exogenous part (periods 1 to 16) and an endogenous part (periods 17 to 24) of the experiment. In the exogenous part, each of the four group members is appointed as leader for four consecutive periods (which we call "phases"), where the sequence of taking turns as a leader is predetermined and commonly known.[5] Decision making in the 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.[6] 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 to 24 are split into two four-period phases. Before periods 17 and 21, there is a vote on leadership for periods 17 to 20 and 21 to 24, respectively. Participants 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 as in the control treatments. Group members are informed about the other group members' contributions in the exogenous part before voting.

In total, we ran twelve sessions (two per treatment). Except for treatment *C* where twenty-four participants showed up in each session, all other sessions involved twenty-eight participants. Because of the partner design, this yields fourteen independent observations for all treatments but *C* where we can rely on twelve observations. 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 [2007]). 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 before the experiment started. 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 participant were about 12.50 euros (including a show-up fee of 2.50 euros).

Results

The results are presented in two subsections. The first section focuses on the results of the exogenous part (periods 1 to 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. The second section discusses the endogenous selection of leaders (periods 17 to 24).

Leadership in the Exogenous Part

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 to 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
Average Contributions by Treatment

Treatment	Periods 1 to 16	Periods 1 to 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 (5.44)	8.35 (4.85)
L = Leadership	13.41 (4.62)	11.92 (4.60)
S = Strong leadership	19.80 (3.86)	18.26 (4.20)

*Source: Güth et al. (2007).
Note: Standard deviations are in parentheses.

As expected, the predictions of the subgame perfect equilibrium are clearly rejected: on average, all players, independently of the treatment, contribute positive amounts. Moreover, in accordance with our hypothesis about the efficacy of leadership, average contributions in the presence of a normal or strong leader are higher than in the control treatments. When participants have complete information about the distribution of endowments, the differences are significant both for periods 1 to 16 and for all periods ($p = 0.02$ for C vs. L and $p < 0.01$ for C vs. S, two-sided nonparametric 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: When initial endowments are commonly known, the installation of a leader increases contributions to the public good.

Our expectation that granting a leader exclusion power would increase contributions is also fulfilled on average, but 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.

Although somewhat in line with our predictions, these two results reveal that the previous theoretical studies and experimental evidence on the positive effects of leadership have 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. (2007) for the case of symmetric endowments and complete information. Denoting by c^k the average contributions in treatment k, the symmetric Güth et al. (2007) 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 $c^{SI} = c^{LI} = c^{CI}$).

Looking at the influence of the information condition on average contributions, we see that, without a leader, contributions are higher when participants 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*).[7] Thus, it seems that incomplete information weakens the capacity of leadership to increase contributions. 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 four-period phases, are shown in Figure 1 (panel A for the complete information condition and panel B for the incomplete information condition).

Focusing on the four phases with an exogenous determination of leaders (periods 1 to 16), the time paths are ordered according to our hypotheses in the complete information condition: average contributions are always the lowest in treatment *C* and the highest in treatment *S* except for the first phase. Under incomplete information, contribution levels are the highest in treatment *SI*, but the graphs for treatments *LI* and *CI* frequently intersect. Note that the patterns in Figure 1 corroborate Results 1 through 3. Finally, notice that contributions in all treatments resemble the typical pattern of standard public goods experiments (Ledyard 1995): contributions start at a level of about 50 percent and decline over time.

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 participant's own contribution divided by his own endowment).

Figure 1
Total Average Contributions per Phase of Four Periods

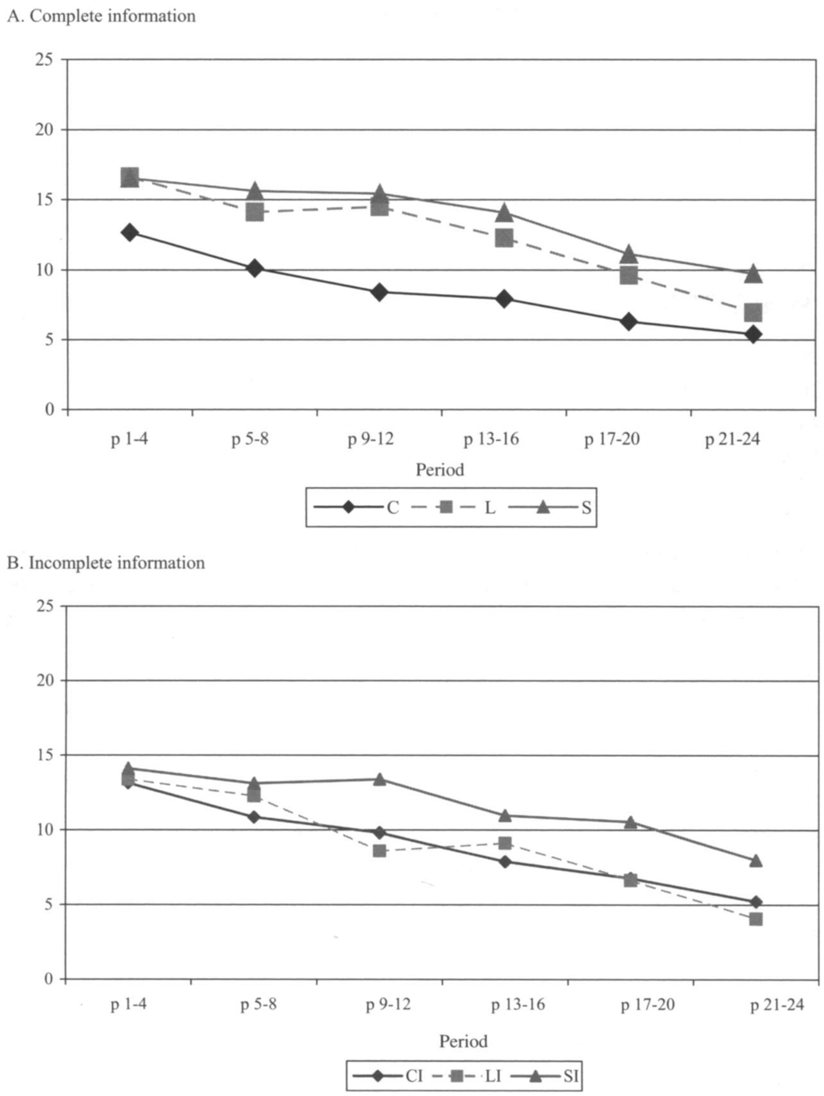


Table 3
Average Absolute and Relative Contributions of Leaders and Followers in Periods 1 to 16

	Absolute Contributions		Relative Contributions	
Treatment	Leaders	Followers	Leaders	Followers
Complete Information				
L = Leadership	17.29	13.41	0.70	0.55
S = Strong leadership	17.96	14.57	0.74	0.60
Incomplete Information				
LI = Leadership	13.99	9.81	0.57	0.41
SI = Strong leadership	15.19	12.14	0.62	0.50

Regardless of their power and whatever the information condition, leaders set a good example: in each treatment, they contribute significantly more than followers, both in absolute and relative terms ($p < 0.01$; two-sided Wilcoxon signed-rank tests; $N = 14$). Nevertheless, leaders' and followers' contributions turn out to be highly correlated. This becomes clear from Figures 2 and 3, which show the average contributions for leaders and followers.

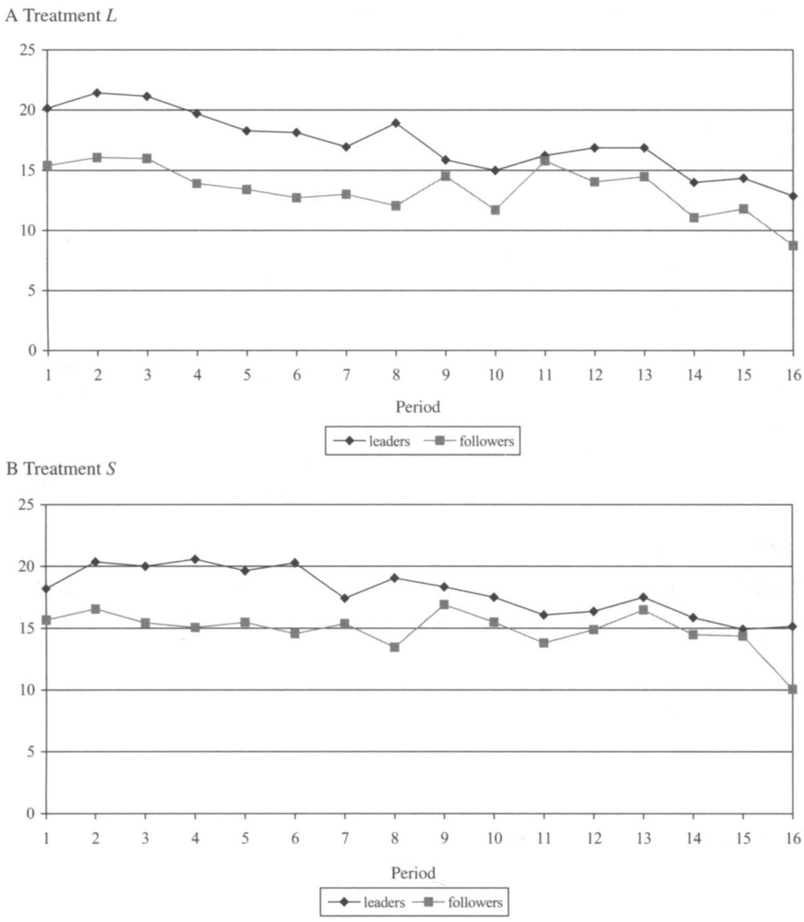
Leaders' and followers' contributions develop similarly over periods, and their contributions move almost in parallel in many cases. The Spearman's correlation coefficients are significantly positive in all treatments (Spearman's ρ is 0.92 in L, 0.74 in S, 0.87 in LI, and 0.79 in SI; $p < 0.01$ always). The correlation appears to be stronger when the leader has no exclusion power, whereas the information condition has no effect on the strength of the correlation.[8] This evidence is summarized in the next result:

Result 4: Followers follow their leaders closely in any treatment. However, they contribute significantly less than leaders.

Result 4 suggests that although followers follow their leaders, they also take advantage of them by contributing significantly less. We can derive the degree of exploitation by looking at payoffs. Table 4 displays the average profits for periods 1 to 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, two-sided Wilcoxon signed-rank tests). Furthermore, they earn 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, two-sided 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

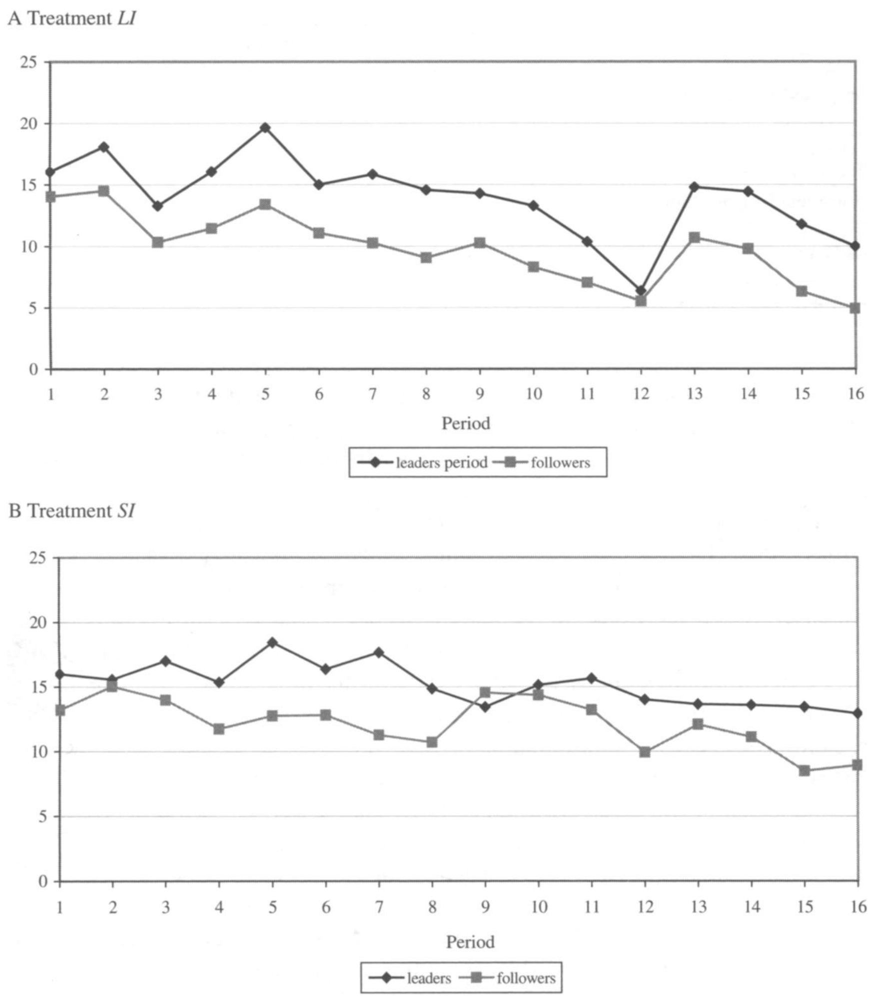
Figure 2
Complete Information and Contributions of Leaders and Followers



($p < 0.02$), and in the other three treatments, we cannot reject the hypothesis of equality between leaders' payoffs and the average payoff in the control treatments ($p > 0.65$ for all three comparisons). This yields

Result 5: Followers (and the total group payoffs) benefit from having a leader, but significantly so only under complete information. Being a leader is never beneficial.

Figure 3
Incomplete Information and Contributions of Leaders and Followers



We conclude this subsection by looking at the question of whether leaders' and followers' contributions depend on their endowment. In all treatments, the leader is rich (poor) in periods 1 to 8 (9 to 16). While Figures 2 and 3 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 percent. To

Table 4
Average Profits by Treatment (Periods 1 to 16)

Treatment	Profits		
	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

consider the possible impact of endowments in more detail, Figure 4 shows 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 of the exogenous part.[9]

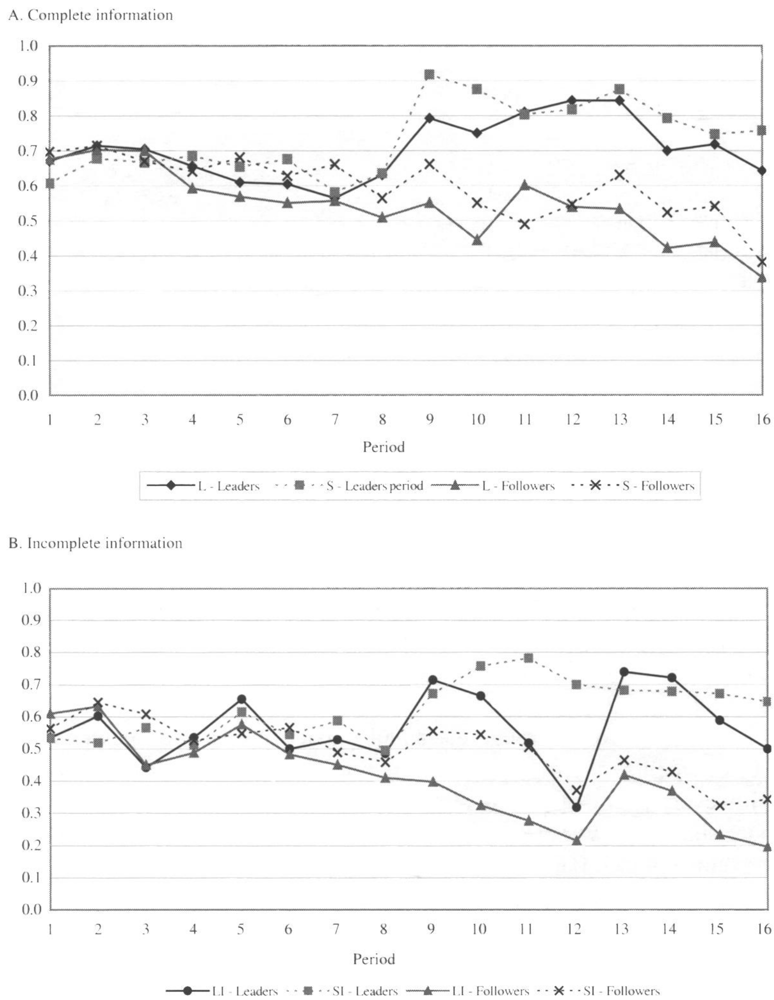
Relative contributions of leaders and followers are very similar in the first eight periods, after which we observe a substantial increase in leaders' relative contributions, indicating that poor leaders contribute a larger share of their endowment compared to rich ones. The differences in leaders' relative contributions between periods 1 to 8 and periods 9 to 16 are significant in all treatments except *LI* (two-sided Wilcoxon rank-sum tests yield $p < 0.04$ for the other three treatments).

Compared to leaders, one would expect a smaller effect of different endowments on followers because of the smaller percentage change in their total income.[10] However, the data unambiguously demonstrate that in all treatments, followers contribute significantly less in periods 9 to 16 than in periods 1 to 8 ($p < 0.02$, two-sided Wilcoxon tests). Thus, while relative contributions of leaders and followers are about the same in periods 1 to 8, leaders contribute much more in relative terms than followers do in rounds 9 to 16.

Finally, panels A and B of Figure 4 illustrate that the development of the relative contributions is hardly influenced by the information condition. 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 to 16 and follow similar patterns in all treatments, whatever the available information.

Exclusion power. So far, our results have shown that under asymmetric endowments, leaders with exclusion power engender higher average contributions than leaders without such power. Yet the two types of leadership do not imply significant

Figure 4
Relative Contributions of Leaders and Followers



differences in cooperation levels. This stands in contrast to the findings detected under symmetric endowments (cf. Güth et al. 2007). The insignificant effect of strong leadership in our asymmetric environment may be because of a scarce use of the exclusion option by powerful leaders. Yet this seems not to be the case. Focusing on periods 1 to 16, leaders exclude one other group member fifty-two

Table 5
Absolute and Relative Contributions of Leaders and Followers

	Periods 1 to 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 to 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

times (31 percent of the possible periods) and forty-four times (26 percent) in treatments S and SI, respectively. These frequencies are even higher than the 24 percent exclusion rate observed by Güth et al. (2007). None of the differences is significant, though. Furthermore, the exclusion pattern is the same in all treatments (including the symmetric ones): if a follower is excluded, it is in more than 85 percent of cases the one with the lowest contribution.

A further reason for the relatively small impact of exclusion power with asymmetric endowments may be that followers react less strongly or not at all to exclusion. However, this seems not to be the case either. Excluded participants contribute significantly more in the period after exclusion compared to the period before exclusion ($p < 0.01$, two-sided Wilcoxon rank-sum tests on group-level data), while nonexcluded participants and leaders do not alter their contributions significantly. Altogether, these observations give the following result:

Result 6: Leaders typically exclude the group member with the lowest contribution. Excluded followers react to exclusion by increasing their contributions significantly.

Leadership in the Endogenous Part—Choosing a Leader

In periods 17 to 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

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

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 treatments with a normal leader, whereas it is more frequent (about 45 percent) with a strong leader. 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; two-sided 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 to 16).[11] Furthermore, rich participants and poor participants are equally likely to be elected as leader.[12]

Agreeing on a leader is clearly beneficial, though. In all leadership treatments, except *LI*, average contributions in groups with a leader are about twice as high as average contributions in groups failing to appoint a leader. Consequently, average payoffs are significantly higher if the group has a leader than if it has not ($p < 0.05$ in *L*,*S*, and *SI*; two-sided Wilcoxon signed-rank 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 to 16, and elected leaders in periods 17 to 24 behave similarly as exogenously appointed leaders in periods 1 to 16.

Since these findings correspond very well to those for symmetric endowments, we conclude that the likelihood of successfully installing a leader is mainly determined by the leader's power. This likelihood as well as the differences in contributions and payoffs between successful and unsuccessful groups are not much affected by the distribution of endowments and the information about it.

Result 7: 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.

Discussion

Our results suggest that in the absence of a leader, contributions are hardly affected by asymmetric endowments and incomplete information about the asymmetry (see Table 2). However, both factors appear to be important in the presence 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 significantly so only in case of symmetric endowments and complete information (see Güth et al. 2007). Let us therefore investigate how these results relate to previous findings and how they can be explained.

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 on the effects of heterogeneous endowments on average contributions is not unequivocal. A short survey in Chan et al. (1999) reveals that the effects depend on the implemented public goods technology (linear, nonlinear, step-level). Overall, the effects of heterogeneity seem to be rather small, though. A rather undisputed feature of experiments with heterogeneous endowments seems to be that rich participants typically contribute less in relative terms than poor participants do. This stylized fact could be explained by a norm requiring all group members to contribute the same amount.[13] Our results for the no-leader treatments are consistent with these former studies. In addition, the observation that the level of cooperation in the no-leader treatments is independent of the information condition confirms earlier findings by Van Dijk and Grodzka (1992) and Van Dijk et al. (1999).

Turning to our results with leadership, we also observe that rich participants contribute more than poor participants in absolute terms but less in relative terms. Yet differently from the situation with no leader, we find that average contributions are smaller under incomplete information than under complete information (see result 3), and that leadership only increases cooperation when endowments are known (see result 2). We will argue that these findings may be because of the effect of information on leaders' behavior.

When information is complete, rich leaders contribute on average about 65 percent of their endowment, that is, about 20 ECU, which is the amount that poor followers can at most give because of their endowment constraint. Hence, a leader's contribution of 20 ECU may serve as a signal to followers to match his contribution. We find that the rich leaders' modal contribution is, indeed, 20 ECU, and only 18 percent (14 percent) of the time rich leaders contribute less than 12 ECU in treatments *L* (*S*). Poor leaders also set good and clear examples: almost 50 percent of the time, they contribute the maximum amount of 20 ECU, and in only 11 percent (5 percent) of the cases, poor leaders contribute less than 12 ECU in treatment *L* (*S*).

Although participants can figure out whether they are relatively rich or poor in the case of incomplete information, leaders may find it much harder to send an unambiguous signal because they do not know which contributions the followers can afford. Indeed, we observe that leaders' choices in treatments *LI* and *SI* are much more dispersed, especially in the first eight periods. No clear modal (class of) contribution exists, and 42 percent (36 percent) 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: 20 ECU is their modal contribution in both treatments (24 percent in *LI* vs. 37 percent in *SI*).

Concerning the followers, they follow their leader to a degree that 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, rather than contributing an equal share of (unequal) endowments, as would be predicted by equity theory (Adams 1965) or an equal amount as was observed in the control treatments.

Finally, when we compare normal and strong leadership, it turns out that giving power to the leader does not increase cooperation in a statistically significant way when participants have asymmetric endowments, although leaders use their power to discipline undercontributors, and followers seem sensitive to being punished.[14] This suggests that leaders' contribution decisions are more important than power and that the example needs to be good to succeed in establishing higher cooperation rates.

To sum up, in all treatments, our findings seem to be in line with earlier experiments indicating that rich participants contribute more than poor participants 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.

Conclusion

We have investigated the effects of leadership on average contribution levels when participants 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 also have some punishment power through the opportunity of excluding other group members. On the basis of previous theoretical and experimental studies indicating that leadership fosters cooperation, particularly when leaders have exclusion power, we predicted that the benefits of leadership would carry over to our settings with asymmetric endowments.

Our results suggest that the effects of leadership depend substantially on the considered environment. In case of asymmetric endowments, in fact, leadership has a significantly positive effect on average contributions only when information is complete. If participants do not know the distribution of endowments, leadership is practically ineffective in raising the contribution levels observed in the control treatment with no leader. Furthermore, while granting the leader exclusion power fosters cooperation significantly when all participants 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 in the asymmetric case, and least when asymmetry is combined with incomplete information.

Unfortunately, the symmetric cases, where all participants are equally endowed and full information prevails, seem to be the least realistic ones when we think of real-world examples such as work groups in companies or clubs where members (have to) contribute to the common goal of the group or the club. Participants 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 participants may have learned about the endowments of other members in our incomplete information condition). 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 a heterogeneous environment.

Notes

1. The social psychological literature distinguishes between individual and structural solutions to social dilemma situations (Messick and Brewer 1983). Leadership is a structural solution because it alters the dilemma's structure (Van Dijk, Wilke, and Wit 2003).

2. Note that our kind of punishment device is different from the punishment mechanisms used in most other studies where all group members can punish each other (e.g., Ostrom, Walker, and Gardner 1992; Fehr and Gächter 2000). We believe that our punishment device is more realistic since 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. Cinyabuguma, Page, and Putterman (2005) have studied the pure effects of exclusion power without combining it with leadership, though, as we do in this article.

3. Note that the traditional definition of pure public goods implies nonexcludability, which would be at odds with the possibility to exclude other group members. What we have in mind here are local public goods that allow for exclusion.

4. Kreps et al. (1982) or Fudenberg and Maskin (1986) have shown that incomplete information about other players' utility can suffice to sustain cooperation as an equilibrium in finitely repeated prisoner's dilemma games. In particular, cooperation can prevail if players expect others to be nonopportunistic with a small but strictly positive probability (depending on the number of repetitions). Incomplete information about the distribution of endowments differs from incomplete information about preferences, though. For this reason, it is not straightforward and beyond the scope of this article to apply Kreps et al.'s (1982) or Fudenberg and Maskin's (1986) equilibrium concepts here.

5. Most articles on leadership consider the situation where one (randomly selected) group member is assigned the leader role for all periods. We opted for a rotating scheme for three reasons. First, it resembles the structure of many real-life organizations where leadership rotates among members, often according to a known and fixed scheme. For example, the head of department in academic institutions is often selected from different research groups in a rotating order. Second, rotating leadership may be considered a fair procedure and thus be beneficial for group commitment and/or belongingness. Third, rotation makes the voting procedure more reasonable because all group members have acted as leaders in the exogenous part. Note that Gächter and Renner (2004) and Güth et al. (2007) find that the way in which a leader is determined has no significant influence on contributions.

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

7. If we pool the two leadership treatments (i.e., combine *L* and *S*, respectively, *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.

8. The differences are partly because of the fact that excluded players (in *S* or *SI*) have zero contributions in the next period. If we consider the correlation between contributions by leaders and nonexcluded followers, Spearman's coefficients increase to 0.84 in *S* ($p < 0.01$), and 0.85 in *SI* ($p < 0.01$), but they remain lower than in *L* and *LI*.

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

10. The follower's total income increases from 70 in periods 1 through 8 to 80 in periods 9 through 16 (+ 14 percent). The leader's income falls from 30 in periods 1 through 8 to 20 in periods 9 through 16 (–33 percent).

11. This contradicts the idea that people are more apt to bring about a structural change when they are dissatisfied with the status quo (Messick et al. 1983, Mulder et al. 2005). Yet it is in line with Samuelson and Messick's (1995) study showing that dissatisfaction with group outcomes is not a sufficient condition to induce structural changes.

12. Note that since participants in the treatments with incomplete information are not informed about the others' endowment, they cannot deliberately vote for a rich or a poor leader. Yet contributions in the exogenous part may have served as informative signals.

13. This equal contribution rule is sometimes contrasted with a proportionality rule, based on equity theory (Adams 1965), that would prescribe participants to contribute an equal share of their (unequal) endowments (see Van Dijk and Wilke 1995; Van Dijk et al. 1999).

14. There is a strong effect of exclusion power in the symmetric case, though (see Table 2 in this article and Güth et al. [2007] for details). Strong leaders set very good examples by contributing on average 21.43, inducing followers to contribute, on average, 17.98.

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