



Who are the voluntary leaders? Experimental evidence from a sequential contribution game

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« Who are the Voluntary Leaders?

Experimental Evidence from a Sequential
Contribution Game »

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Who are the Voluntary Leaders?

Experimental Evidence from a Sequential Contribution Game

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Abstract We show that the preference to act as a leader rather than as a follower is related to subjects' behavioral type. We rely on the methodology proposed by Fischbacher et al. (2001) and Fischbacher and Gächter (2010) in order to identify subjects' behavioral types. We then link the likelihood to act as a leader in a repeated public goods game to the elicited behavioral types. The leader in a group is defined as the subject who voluntarily decides in the first place about his contribution. The leader's contribution is then reported publicly to the remaining group members who are requested to take their contribution decisions simultaneously. Our main findings are that leaders emerge in almost all rounds and that conditional cooperators are more likely to act as leaders compared to free riders. We also find that voluntary leaders, irrespective of their behavioral type, contribute more than the followers. However leadership does not prevent the decay that is commonly observed in linear public goods experiments.

JEL-classification H41, C92

Keywords Public Goods, Experimental Economics, Voluntary Contribution Mechanism, Leadership.

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1 Introduction

In many real life situations that involve the provision of a public good, contribution decisions are taken sequentially rather than simultaneously. Examples include academic research, ratification of international treaties, Wikipedia articles, telethons, ... These examples have two features in common: (i) the amount of public good that is provided depends on some aggregation of individual contributions, and (ii) later contributors in a sequence can condition their contribution on previously observed contributions. In many cases the order in which agents take their contribution decisions is not given in advance but is determined endogenously. Some individuals prefer to choose their contribution before the others, while others prefer to wait in order to see what others contribute before deciding about their own contribution.

In this paper we provide experimental evidence about the issue of endogenous leadership in a simple game of voluntary contributions to a public good. Let us define the first mover as the *leader* and the later movers as the *followers*. Our main research question is the following: Why are some individuals willing to act as a leader and others prefer to act as followers in such games? An important reason is “*leading by example*”: some individuals want to show the “good example” by making a large contribution in the beginning of a repeated game in order to encourage others to reciprocate. In contrast, taste for conformity, risk-aversion, strategic reasoning can explain why some individuals prefer to “wait and see” before choosing their contribution. However there might be also intrinsic reasons that could explain subjects’ choices and that might be related to the individuals’ social preferences.

In order to analyze this issue, our experiment involves two stages. In the first stage, we elicit individuals’ behavioral types, according to their conditional contribution to a group project. We rely on the incentivized methodology proposed by Fischbacher et al. (2001) and Fischbacher and Gächter (2010) to categorize participants either as *free riders* (FR), *conditional cooperators* (CC), *triangle contributors* (TC) or *others* (O). In the second stage of the experiment, participants played a multiple rounds voluntary contribution game. Each round was organized as follows: in the first 60 seconds of each round each participant could decide about his group contribution that was publicly announced to the other group members. Only the leader’s contribution was observable for the other group members. Once the leader’s contribution was announced, the remaining group members (the followers) had to choose their contribution simultaneously. If after a 60 seconds time interval no-one had made a leading contribution, all group members had to take their contribution decisions simultaneously.

We rely on the data of our experiment to answer the following questions: (1) Is leadership frequent, or do most subjects *wait to see*? (2) Is there a relation between moving early and behavioral types? For instance, are CC individuals more likely to act as leaders than FR are? (3) Do leaders contribute larger amounts than followers, and do leaders’ and followers’ contributions depend on their behavioral type? We provide a positive answer to each of those three questions. We adopt the dynamic nonlinear panel data model proposed by Wooldridge (2005) which proposes a very flexible approach that is particularly suited to our data.

To what extent are our results pushing the knowledge frontier about leadership behavior? First, while there exist experimental evidence with respect to questions 1 and 3, there is almost no evidence with respect to question 2. Several laboratory experiments found that first movers tend to make larger contributions than later movers, and that later movers' contributions increase in first mover's contributions (Moxnes and van der Heijden (2003), Gächter and Renner (2003, 2007), Arbak and Villeval (2007), Güth et al. (2007), Levati et al. (2007), Potters et al. (2007), Pogrebna et al. (2009), Gächter et al. (2010), Rivas and Sutter (2011), Masclet et al. (2011), Kumru and Vesterlund (2012)). These results are also observed in field experiments (Shang and Croson (2009), Martin and Randal (2005)). Second, endogenous leadership in voluntary contribution games has been very parsimoniously studied, although it is a more common situation than exogenous leadership or simultaneous contributions. Haigner and Wakolbinger (2010) consider a treatment in which one randomly selected subject had the opportunity to choose either to lead or to follow, the 3 other group members having to decide simultaneously. Only 5 subjects out of the 18 randomly selected chose to lead.. Groups with voluntary leaders outperform groups with involuntary leaders where the role of leader was imposed to a randomly selected subject. Rivas and Sutter (2011) found similar results with an experimental design closer to ours: average group contributions are about 50 percent higher under voluntary leadership than without leadership and almost 80 percent higher under voluntary leadership than under forced leadership. In their endogenous leadership treatment they also observed a high frequency of leaders over time. These results suggest that “the most generous subjects are likely to volunteer as leaders” under voluntary leadership whereas under forced leadership “selfish could be randomly chosen to be the leader”. But another possibility is that “leaders anticipate that followers value the leader's contribution more — meaning that followers will reciprocate more — when leaders volunteer to be leaders than in the case where they are exogenously chosen to be leaders”. Because the leaders' type is unknown it is impossible to sort out between these two explanations.

There is only one paper (Gächter et al., forthcoming) that addressed the issue of leaders' profiles. The authors identified the leaders' motivation either as *cooperativeness* or *optimism*. Cooperative leaders are those who contribute large amounts when others do, *i.e.* they correspond to the CC type, while optimistic non-cooperators are more likely to be of the FR type. The experiment was based on the strategy method meaning that all subjects played both roles. The second mover's contribution can therefore be taken as a measure of (conditional) cooperativeness. After choosing their decision as first and second mover, subjects were also asked to predict the level of contribution of the second mover with whom they would be matched as a first mover. The expected level of contribution can be taken as a measure of optimism. As in other experiments, Gächter et al. (forthcoming) found that groups perform best when the leader is cooperatively inclined. They showed that this result is partly due to a false consensus effect: “cooperative leaders are more optimistic than non-cooperators about the cooperativeness of followers”.

The rest of the paper is structured as follows. In the next section we describe our experimental design. Section 3 presents standard and behavioral predictions. The results of our experiment are reported and analyzed in section 4. Section 5 concludes.

2 Experimental design

The voluntary contribution game was played in groups of four participants. Each group member was endowed with 20 tokens that he had to allocate between his private account and a collective account. Each token allocated to the private account provided a sure outcome of 1 point. Each token allocated to the collective account provided 0.5 points to each group member. The gain of group member i was therefore:

$$u_i(g_i) = 20 - g_i + 0.5(g_i + g_{-i})$$

where g_i is the contribution of player i to the collective account, and g_{-i} the total contribution of the other group members to the collective account.

The experiment was split into two stages. In stage 1 we relied on the contribution game to elicit behavioral types, and in stage 2 the contribution game was played over 20 rounds following a real-time procedure as explained below.

Stage 1: Elicitation of behavioral types

Stage 1 is a replication of the procedure of Fischbacher and Gächter (2010) which is intended to elicit each subject's behavioral type. Subjects were asked to make two types of decisions in the one shot contribution game: an “unconditional contribution” and a “conditional contribution”. First, each subject was asked to choose an unconditional contribution, i.e. the amount he wanted to contribute to the collective account. Second, each subject was asked to make a conditional contribution for each possible average contribution of the other members of his group, rounded to integer numbers, *i.e.*, for $0, 1, \dots, 20$. After all group members had decided about both types of contributions, one of the subjects, say subject i , was randomly chosen to be the conditional contributor, while the other group members were considered as unconditional contributors. Subject i 's gain was determined according to his conditional contribution with respect to the average unconditional contribution of the other members. Similarly, each other group member's payoff was determined according to his unconditional contribution and the other group members contributions. Each group member earned therefore a gain corresponding to his contribution decision and the contribution decisions of the other group members.

Following Fischbacher and Gächter (2010) we rely on each subject's response to classify him either as a free rider (FR), a conditional cooperator (CC), a triangle contributor (TC) or as other (O).

Stage 2: Repeated contribution game with endogenous leadership

In stage 2, group members played a *real time* contribution game according to the following rule: at the beginning of each round each group disposed of 60 seconds for making public the first decided contribution. If none of the group members had chosen a contribution within the 60 seconds time limit, all the group members had to choose their contribution level simultaneously. Otherwise, if a group member chose his contribution within the time limit, his

decision was announced to the other group members before they took simultaneously their own decision. In any case, individual contributions of all four members were displayed in a summary screen, along with the subject's earning before next round started. The game was repeated for 20 rounds. Each round followed the same procedure.

The experiment was conducted at the University of Montpellier in France in 2010. Subjects were recruited through the online recruitment system ORSEE. Two sessions composed of 5 groups of 4 subjects were organized. A total of 40 subjects participated to this experiment. Most of them were students from various disciplines. None of the subjects had previously participated in a public good experiment and none of them took part in more than one session.

Upon arrival, subjects were randomly seated at visually separated computer terminals. They received written instructions (see Appendix) describing the general framework of the contribution game that were read aloud by the experimenter after participants had read them once. Subjects had to answer 10 control questions before receiving the instructions for stage 1 (elicitation of types). Complete anonymity was granted to the participants. They were instructed, after completing the elicitation stage but before knowing their earnings for this first stage, that they would participate in a second stage and that their earnings from both stages would be added up and paid individually at the end of the experiment. The second stage of the experiment consisted in 20 rounds repetition of the contribution game. Group composition remained the same throughout the experiment. In both stages, subjects were asked to choose only their contribution to the group account, the remainder of their endowment being automatically invested in the private account.

On average, participants earned 16.99€ (5.68€ for stage 1 and 11.31€ for stage 2) plus a show up fee of 3€ or 8€ depending on whether the participant was a student of the site where the experiment took place or not. Each session lasted about 2 hours, including the completion of the post-experimental questionnaire and payment of the participants.

3 Predictions

3.1 Standard predictions

Under standard behavioral assumptions, i.e. selfish and rational players the Nash equilibrium of the simultaneous constituent game implies that each player contributes zero token to the group account. When the game is played sequentially, or in real time as in stage 2, timing is irrelevant since the best reply for any player is always to contribute zero, either as a first mover (leader) or as a second mover (follower), hence there is no issue of leadership. Under standard game-theoretic assumptions, we expect therefore to observe either a sequence of null contributions, or simultaneous null contributions, or a mixture of the two.

3.2 Behavioral predictions

With respect to our three questions ((1) Is leadership frequent? (2) Are CC subjects more likely to act as leaders? and (3) Do leaders contribute larger amounts?) and taking into account previous findings we expect the following.

First we expect to see frequent leadership since such behavior is frequent in real-life situations such as telethons, Wikipedia... Furthermore we expect first movers to make large contributions. As observed in Gächter et al. (forthcoming) the cooperative leaders are those who are the most optimistic about the followers' contributions. Therefore the most optimistic subjects should be also those who are the most likely to become leaders. In our sample we expect therefore that subjects who make a large unconditional contribution will act more frequently as leaders. There are two candidates for such a role: the CC subjects and the O subjects. CC subjects are more likely to believe that their group members are like-minded and will reciprocate (a false consensus effect). However, it could also be that CC subjects have a stronger preference for waiting to observe the leader's contribution before choosing their own contribution because of their conditional inclination. Some O subjects are unconditional contributor, which means that they contribute the same positive amount irrespective of what others do. If they are highly cooperative, they are therefore likely to lead by example in order to foster group cooperation. Our hypothesis is that the more a subject intends to make a large contribution, the more he is likely to move first to lead by example. Therefore, we also predict that FR subjects will seldom choose to be first movers.

4 Results

We split the presentation of the results as follows. In sub-section 4.1 we report the results about behavioral types. Subsection 4.2 provides estimates of the probability to act as a leader according to behavioral types. Finally in 4.3 we study the effects of endogenous leadership on contributions.

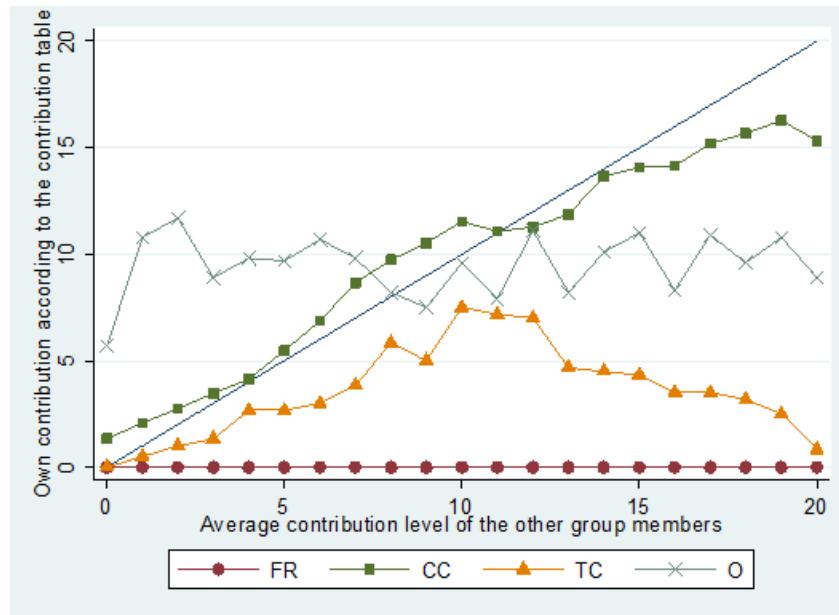
4.1 Behavioral types

The frequency of each behavioral type elicited in the first stage of our experiment is summarized in Table 1. Figure 1 shows the average contribution pattern for each behavioral type. The frequencies in table 1 are comparable to those found earlier by Fischbacher et al. (2001) and Fischbacher and Gächter (2010). Kocher et al. (2008) showed however that the distribution of player types may differ across countries: for instance they found that there are more conditional cooperators in their U.S location than in their Austrian and Japanese locations. We also find a significant difference in type frequencies between our sample and the Kocher et al.'s (2008) US sample which contains a higher frequency of conditional cooperators compared to our sample of French student subjects. However there is no significant difference in type frequencies between our sample and the Kocher et al. (2008) Austrian and Japanese samples (Chi-squared test with 3 degrees of freedom¹ at the 5% significance level). Furthermore, there is neither a significant difference in type frequencies between our sample and the Fischbacher et al. (2001) sample, nor between our sample and the Fischbacher and Gächter (2010) sample.

¹ The number of degrees of freedom is equal to $(r-1)(k-1)$ where r is the number of samples to compare and k the number of types.

Table 1 Distribution of behavioral types

Type	Number	Percent	Unconditional contribution	
			Mean	St.dev.
FR	9	22.5%	4.66	6.93
CC	15	37.5%	13.40	5.07
TC	6	15.0%	9.00	6.81
O	10	25.0%	9.70	4.74
Total	40	100%	9.85	6.35

**Figure 1** Average contribution pattern by types.

Since subjects were randomly matched into groups at the beginning of the experiment, we have 10 heterogeneous groups. Details on each group composition can be found in Table 2.

Table 2 Group composition

Group	Type				
	1	CC	FR1	FR2	O
2	CC	O1	O2	TC	
3	CC	FR	TC1	TC2	
4	CC	FR	O	TC	
5	CC	FR	O	TC	
6	CC1	CC2	O1	O2	
7	CC1	CC2	CC3	FR	
8	CC1	CC2	FR	O	
9	CC	FR1	FR2	TC	
10	CC1	CC2	O1	O2	

4.2 Probability of being leader according to type

Result 1: Leadership is frequently observed in all groups.

Support for result 1

Out of the 200 rounds (20 rounds×10 groups) there was no leader in only 9 of the rounds. In 95.5% of the rounds one of the 4 members announced publicly his contribution to the public good. In 6 groups out of 10 there was a leader in every round (see Table 3), in 2 groups there was no leader in a single round, in one group no leader was observed in 3 rounds and in one group there was no leader in 4 rounds. Failures of leadership occurred mostly towards the end of the repeated game (in rounds: 8, 14, 14, 16, 17, 18, 20, 20, 20). We measured also the leader's reaction time. On average, the leaders took their decision very quickly (the average time is less than 10 seconds).

Table 3 Identification of the leader if any (X) for each group in each round

Group	Round																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	CC	CC	FR1	CC	FR1	CC	CC	CC	O	CC	CC	CC	FR1	X	FR1	X	O	O	O	X
2	O2	TC	O1	O1	O2	CC	O1	TC	TC	O1	O2	TC	TC	O2	O1	TC	O1	O2	O2	O1
3	CC	TC1	TC1	FR	CC	TC1	FR	FR	CC	TC1	FR	FR	CC	FR	CC	CC	CC	FR	X	
4	TC	O	O	CC	CC	TC	TC	CC	O	O	CC	TC	FR	FR	TC	TC	CC	CC	FR	O
5	CC	FR	CC	CC	CC	FR	CC	CC	FR	CC	CC	CC	FR	FR	CC	CC	TC	FR	CC	CC
6	CC1	O2	O1	CC1	CC2	CC1	CC1	X	CC2	CC1	CC2	CC1	O2	X	O1	CC1	O2	X	CC1	X
7	CC3	CC3	CC3	CC3	CC1	CC3	CC3	CC2	FR	CC3	FR	CC3	CC3	CC1	CC3	CC1	X	CC3	CC3	CC3
8	O	O	CC2	CC1	O	O	CC2	CC1	O	CC2	CC1	CC2	CC2	CC1	O	CC2	O	O	O	FR
9	TC	FR2	CC	FR1	CC	TC	FR2	TC	CC	TC	CC	FR2	CC	CC	FR2	CC	TC	CC	FR2	CC
10	CC2	CC2	O1	CC2	CC1	O1	CC2	CC2	CC1	CC2	CC1	O1	CC2	CC2	CC1	O1	CC1	O1	O2	O2

Three subjects (1 FR, 1 TC and 1 O) out of 40 never acted as a leader. All CC however acted as leaders at least once. No subject was a permanent leader, i.e. for 20 rounds. At most two CC succeeded to lead in 13 rounds out of 20.

Result 2: Conditional cooperators are more likely to act as leaders than free riders.

Support for result 2

We observe that on average CC subjects were leaders in 6.5 rounds, whereas FR subjects leaded only in 3.2 rounds. Unexpectedly, FR subjects were rather frequently leaders. However no FR took the leadership in the first round, an observation that strengthens our finding that FR are less likely to lead than other behavioral types. Our data (see Figure 2) show that the frequency of being a leader is twice larger for a CC (0.32) than for a FR (0.16).

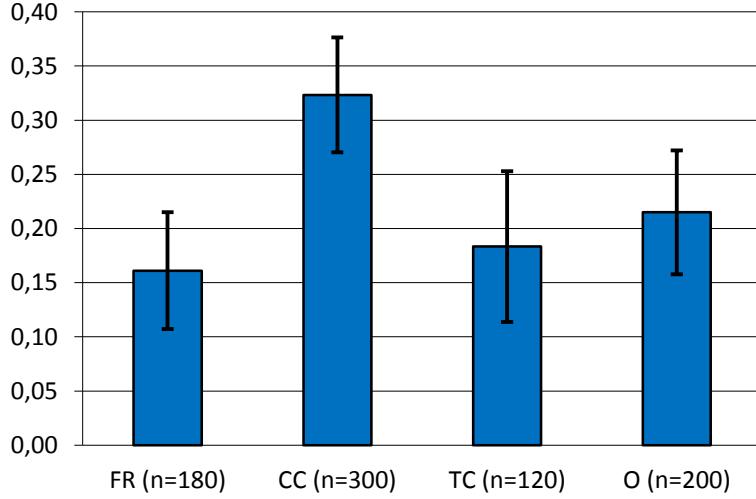


Figure 2 Frequency of acting as a leader by type.
Vertical lines represent the 95% confidence intervals.

We estimate the probability of being leader according to the behavioral types. Let y_{it} be the leader dummy variable, which is equal to 1 if i was a leader in round t and zero otherwise ($i = 1, 2, \dots, 40$ and $t = 1, \dots, 20$). We estimate the following model:

$$y_{it} = \begin{cases} 1 & \text{if } y_{it}^* > 0 \\ 0 & \text{if } y_{it}^* \leq 0 \end{cases}$$

where the latent variable y_{it}^* represents the utility difference for subject i if he chooses to act as a leader rather than as a follower. The latent equation is

$$y_{it}^* = \mathbf{z}'_{it}\boldsymbol{\gamma} + \mu_i + u_{it}$$

where bold characters stand for vectors; μ_i is the individual random effect ($\mu_i \sim N(0, \sigma_\mu^2)$). Note also that the regression error is idiosyncratic, i.e. $u_{it} \sim N(0, \sigma_u^2)$.

The probability of being leader is then estimated by:

$$P(y_{it} = 1 | y_{i,t-1}, \mathbf{z}_{it}, \mu_i) = \Phi(\rho y_{i,t-1} + \mathbf{z}'_{it}\boldsymbol{\gamma} + \mu_i)$$

The above model is a probit model generalized to the dynamic setting corresponding to our repeated game. The decision to lead may be affected by the subject's decisions in previous rounds. We rely on the method of Wooldridge (2005) to estimate the model. The method consists in specifying the density of μ_i conditionally on y_{i1} (the initial choice) and $\mathbf{z}_i (\equiv (\mathbf{z}_{i1}, \dots, \mathbf{z}_{iT}))$:

$$\mu_i | y_{i1}, \mathbf{z}_i \sim N(\alpha_0 + \alpha_1 y_{i1} + \mathbf{z}'_i \boldsymbol{\alpha}_2, \sigma_\mu^2).$$

Estimation of parameters of the model as well as the marginal effects of explanatory variables on the probability of being leader are summarized in Table 4. The probability for i to act as a leader in round t is higher if i was a leader in the first round and if he was not a leader at the previous round ($t - 1$). All other things being equal, being a CC type has a significantly positive effect (= 0.866) compared to a FR type (the reference type). Moreover, the marginal effect of type CC on the probability of acting as a leader is also significant and positive (=

0.236) whereas the marginal effects of other behavioral types are statistically insignificant. This finding corroborates the previous analysis based on Figure 2, i.e. CC types are more likely to act as a leader than FR types.

We included several control variables that are likely to influence the probability to act as a leader (gender, education, rank in siblings), independently of the behavioral type. Eldest appear to be more often leaders. On the contrary, graduate students are less often leaders than undergraduate students. We did not find evidence for a gender difference with respect to leadership in our data.

Our dynamic specification outperforms the static model according to a likelihood ratio test. Under the null hypothesis corresponding to the static model, $H_0: \rho = \alpha_0 = \alpha_1 = \alpha_2 = 0$, the test statistic follows a χ^2 distribution with 21 degrees of freedom. The computed statistic is 91.710 and the corresponding p-value is very close to 0, leading to the rejection of the static model in favor of our dynamic specification.

Table 4 Probability of being leader

Variable	Coefficient	(Std. Err.)	Marginal effect	(Std. Err.)
Leader in first round	1.227***	(0.274)	0.335***	(0.072)
Leader in previous round	-0.277**	(0.129)	-0.075**	(0.035)
Type CC	0.866**	(0.353)	0.236**	(0.095)
Type TC	0.069	(0.318)	0.019	(0.087)
Type O	0.171	(0.258)	0.047	(0.070)
Trend	-0.008	(0.010)	-0.002	(0.003)
Unconditional contribution	-0.046*	(0.028)	-0.013*	(0.007)
Female	-0.152	(0.195)	-0.042	(0.053)
Eldest	0.697**	(0.274)	0.190***	(0.074)
Number of brothers/sisters	0.101	(0.089)	0.028	(0.024)
Graduate student	-0.797***	(0.260)	-0.217***	(0.070)
Intercept	-0.778*	(0.405)		
$\ln \sigma_\mu^2$	-14.938	(29.129)		
LR $\chi^2(21)$	91.710***			
Log-likelihood	-370.144			
Number of individuals	40			
Number of observations	760			

Notes: Standard errors are in parentheses.

The likelihood ratio (LR) statistic compares the static model to the dynamic model.

Significant levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.3 Effects of endogenous leadership on contributions

Figure 3 shows that the decay, a stylized fact in voluntary contributions experiments, also arises under leadership: on average, group contributions are above the Nash contribution but decline with the repetition of the game. Furthermore group contributions are quite volatile across rounds as shown in Figure 4.

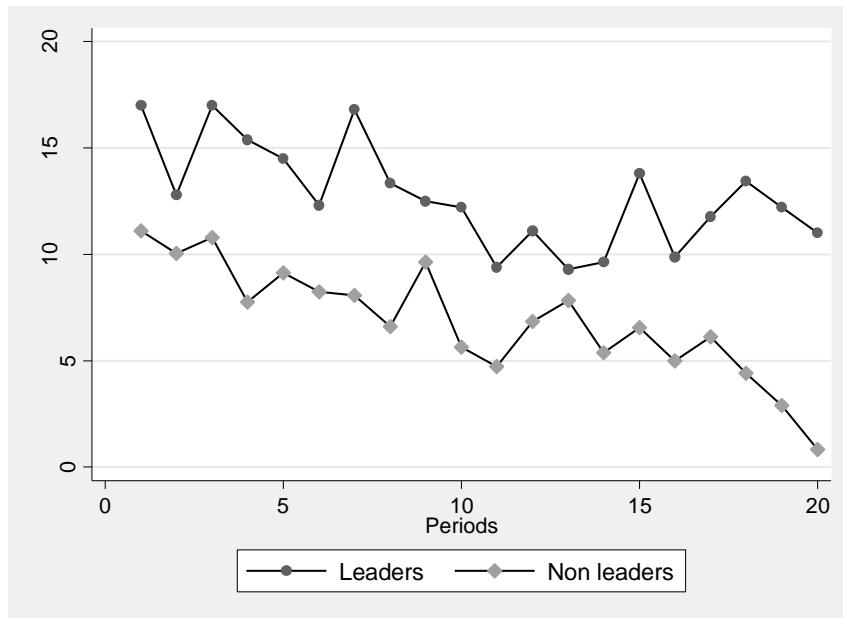


Figure 3 Average contribution for leaders and non-leaders

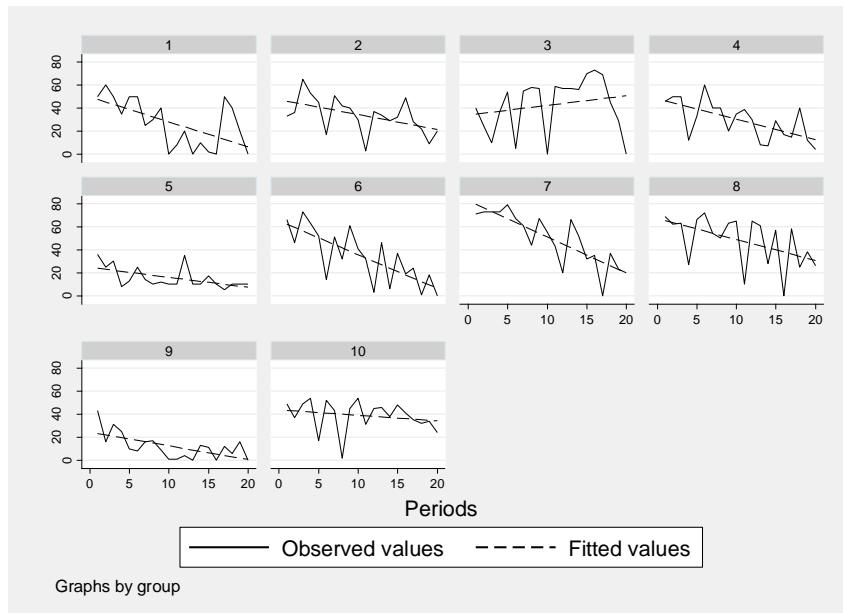


Figure 4 Group contribution by group

Result 3: Leaders contribute more than followers.

Support for result 3

Figure 3 shows that leaders' average contributions are much larger than those of non-leaders' across all rounds. Figure 5 shows the average contributions by status (leader, follower or simultaneous). Leaders contribute on average 12.84 tokens which is significantly more (Mann Whitney rank-sum test, 1%) than followers who contribute on average 7.18 tokens. This result

suggests that subjects who are willing to lead want also to give the “good example”. When there is no leader the average contribution collapses at a very low level close to the Nash contribution (1.36 tokens on average). The absence of a leader when subjects can volunteer to lead seems therefore to be a very bad signal that ruins cooperation among group members. The same issue was observed in Rivas and Sutter (2011).

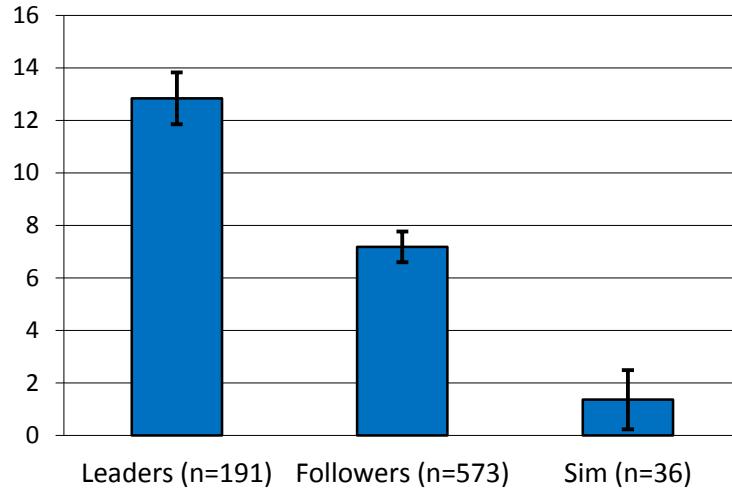


Figure 5 Mean contributions by status.
Vertical lines represent the 95% confidence intervals.

If we take the average contribution as an indicator the O types are the best leaders (see Figure 6) followed by the CC. Without surprise, the FR subjects are the worst leaders. On average CC followers contribute more than FR followers but slightly less than FR leaders.

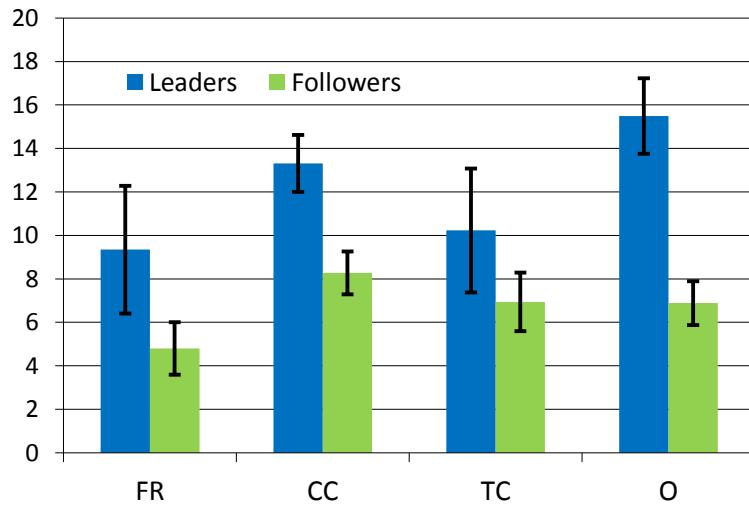


Figure 6 Average contribution by type and status.
Vertical lines represent the 95% confidence intervals.

We study the impact of various possible explanatory variables on the level of contribution. Let c_{it} be the contribution of subject i in round t ($i = 1, 2, \dots, 40$ and $t = 1, \dots, 20$). Because the contribution must be chosen within the set $\{0, \dots, 20\}$ we rely on a censored dynamic panel model:

$$c_{it} = \begin{cases} 0 & \text{if } c_{it}^* \leq 0 \\ c_{it}^* & \text{if } 0 < c_{it}^* < 20 \\ 20 & \text{if } c_{it}^* \geq 20 \end{cases}$$

with the latent model

$$c_{it}^* = \rho c_{i,t-1} + \mathbf{z}_{it}' \boldsymbol{\gamma} + \lambda_i + \nu_{it}$$

where bold characters correspond to vectors, λ_i represents a random individual effect, and ν_{it} is the standard regression error, $\nu_{it} \sim N(0, \sigma_v^2)$. Following Wooldridge (2005), the likelihood for each individual is

$$\prod_{t=1}^T f_t(c_{it} | z_{it}, c_{i,t-1}, \lambda_i; \boldsymbol{\theta})$$

where $\boldsymbol{\theta}$ includes the whole set of parameters to be estimated. To estimate the model we need to integrate the likelihood with respect to λ_i . We therefore require an additional assumption about the distribution of λ_i conditional on (c_{i1}, \mathbf{z}_i) , that is $h(\lambda_i | c_{i1}, \mathbf{z}_i; \boldsymbol{\delta})$ where $\boldsymbol{\delta}$ is the associated set of parameters and $\mathbf{z}_i \equiv (\mathbf{z}_{i1}, \dots, \mathbf{z}_{iT})$. Hence, the individual likelihood becomes

$$l_i(\boldsymbol{\theta}, \boldsymbol{\delta}) = \int \left(\prod_{t=1}^T f_t(c_{it} | \mathbf{z}_{it}, c_{i,t-1}, \lambda_i; \boldsymbol{\theta}) \right) h(\lambda_i | c_{i1}, \mathbf{z}_i; \boldsymbol{\delta}) \eta(d\lambda_i).$$

As in Wooldridge (2005), we assume the conditional density of λ_i as

$$\lambda_i | y_{i1}, z_i \sim N(\alpha_0 + \alpha_1 y_{i1} + \mathbf{z}_i' \boldsymbol{\alpha}_2, \sigma_\lambda^2).$$

We estimate separately the model for the leader's contribution (Table 5) and for the follower's contribution (Table 6).

Table 5 Effects on leader's contribution

Variable	Coefficient	(Std. Err.)
Leader in first round	-0.148	(0.400)
Leader in previous round	0.202*	(0.109)
Type CC	-0.011	(3.201)
Type TC	-11.899***	(3.864)
Type O	10.744**	(4.217)
Trend	-0.444***	(0.124)
Female	-12.412***	(3.806)
Eldest	-0.416	(3.376)
Number of brothers/sisters	-2.465	(1.624)
Graduate student	1.787	(3.531)
Intercept	-0.148	(0.400)
σ_λ	0.000	(0.686)
σ_v	7.344***	(0.560)
LR $\chi^2(21)$	104.122***	
Log-likelihood	-1185.267	
Number of individuals	37	
Number of observations	181	

Notes: Standard errors are in parentheses.

The likelihood ratio (LR) statistic compares the static model to the dynamic model.

Significant levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6 Effects on follower's contribution

Variable	Coefficient	(Std. Err.)
Leader in first round	0.991***	(0.171)
Leader in previous round	0.110*	(0.061)
Type CC	3.709***	(1.427)
Type TC	1.803	(2.093)
Type O	2.969*	(1.777)
Trend	-0.387***	(0.074)
Leader's contribution	0.613***	(0.069)
Female	-0.600	(1.559)
Eldest	2.509	(1.770)
Number of brothers/sisters	-2.378***	(0.757)
Graduate student	-3.560**	(1.592)
Intercept	-24.007***	(7.133)
σ_λ	0.000	(0.900)
σ_v	7.731***	(0.347)
LR $\chi^2(21)$	249.692***	
Log-likelihood	-408.017	
Number of individuals	40	
Number of observations	543	

Notes: Standard errors are in parentheses.

The likelihood ratio (LR) statistic compares the static model to the dynamic model.

Significant levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Leaders' and followers' contributions significantly decline over time (negative trend). As expected, the followers' contribution is significantly and positively affected by the leader's contribution. Thus, as observed in Figure 3, voluntary leadership does not prevent decay. Even if we control for the decline of leaders' contributions, followers also significantly decrease their contributions from round to round. As followers, CC types contribute

significantly more than FR, but as leaders there is no significant difference between CC and FR: only leaders of type O contribute significantly more than FR leaders. Apparently TC leaders contribute less than FR leaders, but this result is not robust and seems to be linked to the strong gender effect observed for the leader's contribution.

Indeed, our models include several demographic control variables (gender, ranks of siblings, education) that are likely to affect contributions. Demographic variables that have a significant impact on contributions are different for leaders and for followers. On the one hand female leaders contribute significantly less than male leaders, but there is no gender difference in contributions for followers. On the other hand, a larger number of siblings lowers the followers' contributions. Finally, graduate followers contribute less than undergraduate followers.

In tables 5 and 6 we report the results of the likelihood ratio test comparing our dynamic specification to the static model, for leader's contribution and follower's contribution respectively. The null hypothesis for the static model is $H_0: \rho = \alpha_0 = \alpha_1 = \alpha_2 = 0$ and the test statistic is a χ^2 distribution with 21 degrees of freedom. The computed statistics are equal to 104.122 and 249.692 for leaders' contribution and for followers' contribution, respectively. Both tests give a p-value very close to 0, implying that the static model is rejected in favor of our dynamic specification.

5 Conclusion

We designed a repeated real time public goods experiment in order to identify who are the leaders. In every round subjects were given the opportunity to voluntarily contribute before others to the public good and let their decision become common knowledge. We observed that leaders emerge in almost every round and that most subjects were willing to move first (at least once). Fewer than 5% of the rounds had no leader, a situation that happened mostly towards the end of the repeated game. Our key finding is that conditional cooperators are more likely to act as leaders than free riders. We showed this result by eliciting subjects' behavioral type and estimating the probability of acting as a leader based on a dynamic probit model with individual random effects.

Since contributions are constrained by the endowment we estimated leaders' and followers' contributions based on a censored dynamic panel model with random individual effects. We found that leaders contribute much more than followers, a fact that we interpret as attempts by leaders to set a good example. While the CC types are the most frequent leaders they are not the "best leaders" since the O types contribute significantly more as leaders than the other types. Our estimated models show that FR leaders do not contribute significantly less than CC and TC leaders, but as expected, FR followers contribute significantly less than followers of the three others behavioral types.

Our results contribute to a better understanding of leadership in voluntary contributions environments, a situation that is frequently encountered in real life. It is well known that variables such as the rank and number of siblings, gender or age, affect leadership behavior. We show that behavioral types have also a strong impact on leadership, both as a key

determinant of the probability to act as a leader and as a determinant of contributions of leaders versus followers.

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Appendix: Instructions for the experiment

Instructions for the elicitation phase

The elicitation phase, i.e. the strategy method used to elicit subjects' behavioural type, is based on the P-Experiment of Fishbacher and Gächter (2010). Instructions have been translated in French and slightly adapted. They are available upon request.

In French instructions we rather use the words "individual account" and "collective account" instead of "private account" and "project". We also replaced the verb "to invest" by "to put", which appears more neutral in French. For the same reasons we did not use the word "contribution". In addition, endowments are expressed in tokens and gains in points.

In order to make comparison with a previous experiment (Masclet et al., 2011), we fixed the marginal rate of the collective account to 0.5. This rate is 0.4 in Fishbacher and Gächter (2011).

Finally, in this first phase of the experiment, 1 point = 20 centimes of euros.

Control questions were the same.

Instructions for the rest of the experiment

We will now conduct another experiment. This experiment lasts 20 rounds. Each round, you and the 3 other members of your group will have to decide how many tokens, out of your 20 endowment tokens, you put in the collective account. The tokens left are automatically put on your individual account. The formation of the groups is the same than in the previous experiment and will not change until the end of the experiment. Your total income in each round is the sum of your income from your individual account and your income from the collective account. Your final gain for this experiment will be the sum of your incomes (in points) in the 20 rounds. The total of your cumulated points will be converted to euros at the following rate:

1 point = 2 centimes of euros

The sequence/procedure of a round

The decision

Each round, each member of your group (you included) must decide how many tokens to put in the collective account.

The first decision taken within the 60 first seconds is displayed in a table on your screen. As soon as a member of your group takes a decision, an informative window appears on your screen. Then you must click on the button "OK" to validate that you received the information. As soon as you validate, the informative window closes and the decision which has been taken is visible in the table. Only the first decision taken during the 60 seconds is displayed in

the table. A scroll bar displayed on your screen indicates the remaining time before the end of the 60 seconds. The decision screen which you will see in every round looks like Figure A1. As soon as a member of your group took a decision, or at the end of the 60 seconds, the scroll bar disappears and the members who did not took their decision must do it. Nevertheless, those decisions will not be visible in the table. If none of the group member took his decision within the 60 seconds, no information will be displayed on the screen. In that case all members of the group take their decision without information on the decision of others.

Note that once you validate your decision you cannot change it for the on-going round.

Summary of the round

When all the participants took their decision a summary will be displayed. Figure A2 shows how this summary looks like. It reminds you the allocation you decided between your individual account and the collective account. It informs you about the total number of tokens put in the collective account by your group, about the details of the decision of each member of your group and computes your income for the round. When all participants have clicked on the button “next round” of this screen, the next round starts.

Note that from the summary screen you can consult a historic of preceding rounds by clicking on the button “historic” at the up right of the screen. The historic screen looks like Figure A3.

When the 20th round is over, all the experiment is finished. Your total income for the experiment will be the sum of your income from the first experiment and the one of the second experiment. A screen will give your income in each of the two experiments and will convert your final gain in euros.

Période 3

Vous disposez de 20 jetons.

Ordre	Temps (en secondes)	Compte collectif
1	10	20

Saisissez le nombre de jetons que vous placez sur le compte collectif:

Figure A1 Decision screen

Période 3

Vous avez placé 8 jetons sur votre compte individuel, et 12 jetons sur le compte collectif.
Au total votre groupe a placé 54 jetons sur le compte collectif.

Ordre	Temps (en secondes)	Compte collectif
1	10	20
-	-	14
-	-	8
-	-	12

Votre gain pour la période est de 35.00 points.

Figure A2 Summary screen

Période 3 Fermer

Cliquer sur la ligne d'une période pour consulter le détail pour cette période.

Période	Compte individuel	Compte collectif	Total compte collectif	Gain période	Gain cumulé
1	16	6	44	37,00	37,00
2	12	6	18	20,00	57,00
3	8	12	54	35,00	92,00

Figure A3 Historic screen

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