The economics of the telethon: leadership, reciprocity and moral motivation

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Abstract

We run a series of experiments in which subjects have to choose their level of contribution to a pure public good. The design differs from the standard public good game with respect to the decision procedure. Instead of deciding simultaneously in each round, subjects are randomly ordered in a sequence which differs from round to round. We compare sessions in which subjects can observe the exact contributions from earlier decisions ("sequential treatment with information") to sessions in which subjects decide sequentially but cannot observe earlier contributions ("sequential treatment without information"). The results indicate that sequentiality increases the level of contribution to the public good when subjects are informed about the contribution levels of lower ranked subjects while sequentiality alone has no effect on contributions. Moreover, we observe that earlier players try to influence positively the contributions of subsequent decision makers in the sequence, by making a large contribution. Such behaviour is motivated by the belief that subsequent players will reciprocate by also making a large contribution. We also discuss the effect of group size on aggregate contributions. Finally, we conceptualize a model where agents' preferences incorporate a "weak" moral motivation element. The moral motivation is "weak" in the sense that contributors update their morally ideal level of contribution according to observed behaviours. This suggested qualification of rational contributors fits well with the patterns observed in the lab.

1. Introduction

Each year many telethons are organized across the world. Such fundraising events, broadcast on television, usually last for many hours with the purpose to collect money for popular worthy causes, such as charities, hospitals, children in need, victims of wars or catastrophic natural events... In essence, people sequentially contribute to a public good, with a tote board that continuously displays the amount of donations. Sequential contributions are actually used for a large variety of public goods: individual efforts in housework, ratification of international treaties about environmental issues, scientific research, etc… In these examples contributions are not necessarily in monetary terms but they share two important features: the amount of public good provided depends on the aggregate level of contributions, and later contributor in the sequence can observe, to some extent, previous contributions.

Surprisingly, the economic literature on sequential contributions is rather scarce, while an overwhelming bulk of knowledge has been been accumulated on simultaneous contributions environments. Other things being equal, should one expect a higher level of public good when contributions are sequential? Getting back to the telethon example, does the publicly released information about contributions affect donations during the campaign ?

Varian (1994) showed that a sequential contribution environment theoretically exacerbates the incentives to free-ride, compared to a simultaneous contribution environment. Instead of playing a Nash equilibrium as in the simultaneous contribution environment, in the sequential contribution environment agents play the Stackelberg equilibrium. In a two-player game with utility functions that are concave in the public good and linear in the private good, Varian (1994) shows that in the simultaneous contributions environment, the player who likes the public good most contributes

everything while the other player free rides. In contrast, in the sequential contributions environment, the first contributor has an incentive to free ride even if he likes the public good more than the other agent. Overall, the level of public good is therefore reduced compared to the level under simultaneous contributions. In sharp contrast with those predictions, the few experiments that studied sequential contributions show a positive effect of sequentiality in various contexts (Moxnes and van der Heijden, 2000 ;List and Lucking-Reiley, 2002; Shang and Croson, 2003; Güth et al., 2004). This raises a central question about the explanations for the increased level of contribution engendered by the presence of sequentiality. Indeed the logic of behaviors leading to a level of public good larger than the one under simultaneous contributions, has no place in the usual scenario where contributors maximize their self-centered utility.

The experimental literature suggests at least three reasons for larger contributions under sequentiality : *reciprocity*, *leadership* and *pure ordering*. First, according to the reciprocity motive an agent reacts to the observed contributions of lower ranked agents, even if he believes that he has no power on subsequent contributors (for a recent and comprehensive introduction to the economics of reciprocity, see Kolm, 2006). A growing experimental literature shows the importance of the reciprocity motive on contribution decisions. Such motive depends on the information available to the contributor, and is likely to be stronger as more information becomes available. Indeed information about individual contributions is well known in the literature to significantly influence the level of contribution (Sell and Wilson, 1991; Weimann, 1994; Croson, 2001; Duffy and Feltovich, 2002; Andreoni and Petries, 2004). Second, according to leadership, early contributors have a responsibility in setting the good example for other agents by making a large contribution, because they expect later contributors will positively react, for instance in accordance with the reciprocity motive. If sequentiality is endogenous, it is likely that the most generous contributors have a preference for acting

early in the sequence. The idea of leadership is that early contributors believe they have the power to influence positively later contributors, and that this power is stronger when the sequence is longer. Finally, even an agent who is unable to observe previous contributions and who believes that he cannot influence subsequent contributions, might be influenced by the knowledge of his ranking in the sequence. The so-called "pure-ordering" effect has been illustrated in common pool resource (CPR) experiments. A plausible explanation is that individuals have a moral motivation to contribute that is influenced by their position in the game. For example, in CPR experiments, first movers take a larger share than final movers, a fact that is commonly accepted and expected, as if subjects adhered to a social norm of taking.

In this paper we isolate experimentally the three effects of sequentiality in a pure public good game where subjects have to choose their level of contribution. We designed an experiment where subjects contribute sequentially under various information conditions. Our aim is threefold: first, we want to identify, experimentally, the variables that affect contributions in such a context, in particular how does a subject's rank in the sequence affect his contribution; second, we want to clearly separate the leadership effect from the ordering effect that was found in the experimental literature on sequential common pool resources games (Rapoport et al., 1993, Budescu et al., 1995, Suleiman et al., 1996, Rapoport, 1997). More generally, ordering effects may arise in contexts where subjects move sequentially, without being able to observe previous moves of other players. A substantial experimental literature addressed the issue, by trying to identify the conditions under which, a pure ordering effect might arise (Cooper et al., 1993, Weber and Camerer, 2004, Güth et al., 1998). Finally, because our data discard the pure ordering effect, we want to provide a plausible theoretical explanation that somehow combines the two other effects of leadership and reciprocity. To do so, we develop a model of sequential contributions to a public good with rational players who have a "weak moral motivation".

The assumption of weak moral motivation means that each player has an intrinsic motivation to contribute, but his motivation is externally influenced by his observations of others' contributions. A player's effective contribution is therefore the outcome of a revision process of his moral motivation to contribute.

In our experiment subjects contribute sequentially to a pure public good, with two information conditions : a treatment without information and a treatment with information. In the treatment without information, individuals decide sequentially but cannot observe earlier contributions. In the treatment with information, subjects observe the contributions of subjects who decided earlier in the sequence. The reference treatment is a simultaneous public good game (no sequential move and no information). Besides, we also investigate for the sequential treatment, whether the population size affects the average contribution. Increasing the size of the group of contributors may have conflicting effects : a positive effect because leaders can influence more players, and a negative effect because the temptation to free ride increases as the size of the provision increases. In the experiment we consider two population sizes : groups of 4 players and groups of 8 players.

Our main findings are as follows: *i)* in the sequential treatment with information, observed contributions decline with the order of play, and the average contribution is larger than in the simultaneous treatment; *ii)* sequentiality alone has no effect on contributions; *iii)* the size of the group has no significant impact on the average level of contributions, *iv)* we show that these results are compatible with the predictions of a model of sequential contributions incorporating a moral motivation function. Ex ante, each individual holds a morally ideal contribution, which he updates according to the observed contributions of earlier players. The model predicts that in a society of identical players who contribute sequentially in a linear public goods game, successive contributions decline. Furthermore,

the more sensitive players are to observed contributions, the larger the average contribution of the society's members.

The paper is organized as follows. Section 2 presents the related literature on the possible effects of sequentiality and highlights our differences. Section 3 presents the experimental design and section 4 provides the corresponding results. In section 5 we propose a model of moral motivation whose implications are consistent with our experimental data. Finally, we conclude in section 6 by drawing the implications of our analysis.

2. Related literature

While most experimental research on voluntary contributions to a public good, has focused on simultaneous contribution environments, there are a few recent experiments that studied a sequential contribution environment. As mentioned above, the results of these experiments are in sharp contrast with Varian's prediction.

2.1. Sequentiality with observation of previous moves

According to the experimental findings in sequential contribution environments, the first contributor tries to set the "good example" by making a large contribution in order to lead followers towards high contributions. In Güth et al. (2004), the leader's contribution is announced publicly before the followers decide simultaneously about their contribution. They found that such announcement significantly increases the average level of contributions to the public good, although followers contribute significantly less than the leader. Their interpretation is that followers condition their contribution on

the leader's contribution like in a repeated simultaneous contributions game, where subjects reciprocate previous period average contribution (Keser & Van Winden (2000)). Moxnes and van der Heijden (2000) run a similar experiment, but with a public bad : in each period one subject is called upon to act as a leader, i.e. his contribution is made public before the other members of the group decide simultaneously. Their results show that subjects invest 15% less in the public bad when there is a leader who sets the "good example" compared to the simultaneous move game. In the two-player game studied by Potters et al. (2004), one of the two players knows the "quality" of the public good, and players can decide to contribute either in a simultaneous move game or in a sequential move game, where the second mover can observe the contribution of the first mover. The authors found that the sequential move game is chosen more frequently with significantly larger contributions.

Several empirical studies also showed the importance of the leadership-effect in various contexts (List and Lucking-Reiley, 2002, Shang and Croson, 2003). Experimental and empirical studies suggest therefore that contributions are positively influenced by the informational context induced by sequentiality, even if the standard prediction is that there should be no effect, or worse, that the free-rider problem is exacerbated (Varian, 1994).

The positive leadership effect found in the experimental literature raises a central question about subjects' motivation to act as a leader : why do subjects in the position of the first contributor choose to make a larger contribution than they would make otherwise ? For example, Güth et al. (2004) showed that followers contribute less than the leader when they contribute simultaneously. This raises a further question about the leadership effect in a context where followers contribute also sequentially. Does the leadership vanish with the rank in the sequence of contributions?

2.2. Sequentiality without observation and ordering effect

According to standard game theory, a change in the timing of moves when no information is revealed to the players, should not affect their choice of actions. In other words, if agents' actions are unobservable, a game in which moves are sequential is strategically equivalent to a game in which moves are simultaneous.

However, in a series of papers, Rapoport and his colleagues (Rapoport et al., 1993, Budescu et al., 1995, Suleiman et al., 1996, Rapoport, 1997) exhibit a pure positional effect in common pool resource dilemma games. They showed that even in a situation without any information asymmetry (request disclosure), the first mover has a tendency to take a larger part, while later movers in the sequence, have a tendency to take less. In this game overexploitation of the common pool leads to null profits for all players. It is therefore likely that subjects rely on the tacit cue, commonly accepted, that the first served should take a larger amount than the followers. Typically, such cues can be used as a coordination device to facilitate equilibrium selection.

The implication of this result is that in a sequential contribution context, where previous contributions are observable, observed patterns can be attributed either to a pure ordering effect or to an information effect. For example, Güth et al. (2004) found that later contributions decrease when the first player's contribution in the sequence is announced. This negative effect might be simply caused by the ordering of moves as suggested by the experiment of Abele & Ehrhardt (2005). They found that average contributions are larger in a two-player simultaneous move game than in the sequential move game where contributions are not observable. Since contributions are not observable, neither under simultaneous moves, nor under sequential moves, the standard game-theoretic prediction is the same.

However, the authors found that subjects are more likely to cooperate in the simultaneous moves games, a fact that they attribute to a stronger "feeling of groupness" when contributions are simultaneous rather than sequential.

Cooper et al. (1993) also found a first mover advantage in the battle of sexes games. When the game is played sequentially without observability, the equilibrium which is more favourable to the first mover is played more frequently[1]. Overall, this literature suggests that when players can choose sequentially, but without disclosure, coordination is facilitated because equilibria where the first mover has an advantage become more salient.

To investigate further this idea, Weber and Camerer, (2004) manipulated the timing of moves in a weakest link coordination game. The aim of this experiment was to distinguish between the explanation based on "saliency of first mover advantage" and an alternative explanation based on the concept of "virtual observability" introduced by Amershi et al. (1989). According to the virtual observability theory in a sequential game without observability, players apply subgame perfection as if all moves were observable, provided that the selected equilibrium is also an equilibrium for the original game. The virtual observability prediction fits better their data on the sequential weakest-link coordination game, than the pure ordering prediction. Besides the leadership effect, this literature shows that sequentiality as such can generate other effects, either by affecting the saliency of some equilibria, or by affecting the players' reasoning, or simply the perception of the game.

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[1] In the two-players battle of sexes game, identifying one of the players as the "first player" and the other as the "second player" resulted in a significant increase of the frequency of the preferred equilibrium outcome by the first player (see Cooper et al., 1993). In this example, the timing effect can be attributed to a first mover advantage, or more generally to a positional advantage (Budescu et al., 1995). The same type of explanation applies to the case of a step-level public goods

However, all experiments which have studied order of play, with the exception of Güth et al. (1998), involved a coordination problem : common pool resource games, step-level public goods games, battle-of-sexes, … On the other hand, in Güth et al. (1998), where the first player has to play a dominated strategy in order to obtain a first mover advantage, the pure-ordering effect vanishes.

In the light of the literature about the timing of moves, it is therefore important to separate carefully the leadership and reciprocity effects induced by the observation of early contributions from the pure timing effect induced by sequentiality of contributions. In order to disentangle these effects, our experiment is based on a voluntary contribution game with a unique dominant strategy equilibrium in order to avoid any coordination problem for the players. According to Güth et al.'s (1988) results, subjects should not deviate from equilibrium play in this case, and therefore no pure ordering effect should be present. Furthermore, since there is a unique dominant strategy equilibrium, virtual observability does not make a different prediction.

3. Experimental design and standard theoretical predictions

The experiment consisted of 16 sessions of 15 periods each. Experimental sessions were conducted both at the University of Rennes[2] and at the university of Montpellier[3] in France. 252 subjects were recruited from undergraduate classes in business and economics at both sites. None of the subjects had previously participated in a public good experiment and none of them participated in more

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game or resource dilemma game. In each of these games, there are multiple equilibria in pure strategies, a situation which leads to a coordination problem.

2 CREM (Centre de recherche en Economie et Management) ,

[3] LAMETA (Laboratoire de Recherche en Economie Théorique et Appliquée)

than one session. The experiment was computerized using the Ztree program. On average, a session lasted about an hour and 20 minutes[4] including initial instructions and payment of subjects.

We set up an experimental design that allows us to investigate the effect of information accumulation on individual contributions in a sequential contribution environment. The reference treatment is a simultaneous voluntary contribution game. At the beginning of each period, each member of a group of n subjects is endowed with 10 tokens that he can invest in a private account and in a group account. Let x_i be the contribution of player i to the group account and x_{-i} the aggregate contribution of all other players - except i – to the group account. The function $u(x_i, x_{-i})$ is player i's payoff if he contributes x_i and the other players contribute x_{-i}. We assume that each account has a constant marginal return, which we set equal to 1 for the private account and 0.5 for the group account (equation (1)). Note that with our assumptions the marginal per capita return is also equal to 0.5. The unique dominant strategy equilibrium of the one-shot game is for each player to contribute $x_i = 0$. The constituent game was repeated exactly 15 periods. The unique subgame perfect equilibrium for the repeated game is for each player to contribute $x_i = 0$ each period. On the other hand, the group optimum is achieved if each player chooses to contribute his total endowment.

$$u(x_i, x_{-i}) = 10 - x_i + 0.5 \times \sum_{h=1}^{n} x_h \qquad (1)$$

In the reference treatment all subjects simultaneously select the amount of their endowment that they want to contribute to the group account. Subjects were instructed to indicate only their contribution to the group account, the remainder of their endowment being automatically invested in

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[4] The sequential treatments took slightly more time in large groups.

their private account. Tokens invested in the group account generate the same payoff for each member of the group.

Since we shall focus on the effects of differential information on individual contributions, we identify our treatments by the information available for the subjects. In the benchmark treatment, called "*simultaneous* treatment" subjects take their decisions simultaneously, and therefore none of the players has an informational advantage. In a second treatment called *sequential treatment without information,* decisions are taken sequentially. This is done by assigning in the beginning of each round each subject to a rank in the decision sequence. In this treatment, subjects know to which rank they are assigned but none of the subjects has an informational advantage. Indeed subjects are not informed about the individual contributions of each lower ranked subject. Since individuals cannot observe contributions in the sequential treatment without information, the standard game-theoretic prediction is the same as under the benchmark treatment. Finally, the third treatment is identical to the previous treatment except that each subject is informed about the individual contribution of each lower ranked subject. The least informed subject is the subject who is ranked first in the sequence whereas the most informed subject is the one who is ranked last in the sequence. The theoretical prediction remains unchanged compared to the benchmark treatment. Indeed, in this game, the agents play the Stackelberg equilibrium, contributing nothing to the public good.

The difference in contributions between the benchmark and the sequential treatment without information is a measure of the pure ordering effect on contributions. We hypothesize, based on the results of Güth et al. (1998) that simply knowing that one player moves first should not affect contributions. The difference in contributions between the sequential treatments with and without information is the joint outcome of leadership and reciprocity resulting from the information

13

asymmetry between players. We hypothesize that these two effects together affect positively the level of contributions. Indeed, we hypothesis that earlier players in the sequence should contribute more to influence later contributors (leadership effect) and that subsequent players should reciprocate previous observed contributions (reciprocity effect). Finally, the difference between the sequential treatment with information and the benchmark treatment measures both the effect of sequentiality and of information asymmetry. Note that our experimental design does not allow to separate reciprocity from leadership. A fundamental reason is that leadership is based on expected reciprocity. However, to some extent, it is possible to isolate *ex post* these two motives through a detailed analysis of the difference between intermediary positions and extreme positions. Indeed, the first player's contribution should not be influenced by "reciprocity" since no information about others' contributions is available to him. However, the first player could be influenced by leadership. At the other extreme, the last player in the sequence cannot be motivated by "leadership" since he can hardly influence anyone. However, his contribution might be motivated by reciprocity. Only players that have an intermediary position can be influenced both by "reciprocity" and "leadership".

While the information condition is our main treatment variable, we also study the impact of group size on the level of contribution in the sequential contribution environment. We compare treatments with 4 subjects, called *small groups* hereafter, to treatments with 8 subjects (called *large groups*). Increasing group size lengthens the sequence and therefore might have a positive or negative influence on individual contributions. Adding more players to the sequence might strengthen the leadership effect, since early players can influence more subsequent players. In particular the fourth player still has an influence in large groups in contrast to small groups. On the other hand, as the size of the group increases, the temptation to free ride for higher ranked subjects becomes stronger because the cumulated contribution can become larger. This would imply a negative effect of group size on the

average contribution. It is not obvious therefore what the effect of increasing the size of the group will be on aggregate.

We relied on the same presentation for all treatments[5]. At the end of each period, the computer screen displayed the subject's investment decision, the total group contribution and the earnings of the group account as well as the total earnings. Cumulated earnings since the beginning of the game, as well as the number of the period were also on display. After each period, subjects could see their detailed records since the beginning of the experiment. Table 1 provides a summary of our experimental design. The first four columns indicate the session number, the corresponding treatment, the number of groups and the number of subjects that took part in the session. The last column indicates the group size (4 or 8 members per group). A partner matching protocol was in effect for all sessions.

[Table 1: About Here]

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[5]To control for the existence of a possible "framing effect", we ran two sessions with a variant of the reference treatment, labeled " simultaneous treatment with framing". This control was required because the sequential version of the contribution game required a slight alteration of the usual presentation of the instructions. For this variant the investment in the group account is presented as an explicit addition of individual contributions which matches the presentation that was used for the sequential contribution treatments. The instructions pointed out that each subject's contribution would be identified by an index, e.g. subject i's contribution is noted I_i, and that the payoff of the group account would be given by $0.5 \times (I_1 + I_2 + ... + I_N)$. This point was described to the subjects in the following language :

"I_1 is member 1's investment to the collective account

I_2 is member 2's investment to the collective account

I_3 is member 3's investment to the collective account

This presentation, by making explicit the summation of individual contributions, could have influenced the subjects decisions in a non predictable way. However, the results indicate no significant difference at any level of significance in average contribution between the simultaneous treatments with and without framing.

4. Results

This section is organized as follows. Subsection 4.1 reports patterns in average contributions in the benchmark and the sequential treatments with and without information. We analyze the treatments in relation to each other and to the benchmark treatment, and evaluate the hypotheses stated in section two. In subsections 4.2 we study the determinants of the contribution behaviour separately for each treatment.

4.1. Average individual contribution

Figure 1 and figure 2 illustrate the time path of individual contributions by period respectively for small and large groups. The period number is shown on the horizontal axis and the average individual contribution on the vertical axis, where the maximum possible individual contribution is 10. These figures show the same pattern for all treatments : there is initially a positive level of contribution to the group account and the level of contribution declines with repetition (except for the sequential treatment with information in large groups, in which the average contribution level does not change appreciably as the game is repeated). This result is in line with several other experiments that have documented that the contributions tend to decline with repetition (Isaac et al. 1984, Isaac and Walker, 1988, Andreoni, 1988, Weimann, 1994, Keser, 1996).

[Figures 1, 2 and table 2 about here]

Result 1 summarizes our findings both about the informational effect and the order effect.

Result 1 : *Levels of contribution are higher under the sequential treatment with information than under the sequential treatment without information. Sequentiality without observability has no significant impact on the level of average contribution.*

Support for result 1 : Table 2 shows the average contribution for each treatment. The first three columns of table 2 indicate the average individual contribution for each small group. The last three columns contain the same data for each large group. Comparison of treatments suggests that sequentiality with information positively and significantly affects average contribution. Our results indicate that, for both small and large groups, average contribution levels in the sequential treatment with information are higher than contribution levels in the sequential treatment without information. A nonparametric Mann-Whitney rank-sum test[6] for small groups shows that the difference in average contributions between the sequential treatments with and without information is significant at the *p* < .10 level, (z = -1.678, two-tailed). A similar test of the difference between the sequential treatments with and without information for large groups also indicates a positive and significant effect of information (z = 2.082; two tailed test).

In order to isolate the pure effect of sequentiality, we compare the average level of contribution in the *simultaneous* treatment and in the *sequential* treatment *without information*. Our results indicate that for both small and large groups changing the timing of moves without changing the information condition has no significant effect on contributions (respectively z = - 0.145 for small groups and z = 1.601 for large groups). The comparison between the *simultaneous* treatment and the *sequential treatment with information* indicate that introducing both sequentiality and observability of previous contributions in the sequence increases the average contribution level in small groups (z = - 1.843). A

similar test for large groups indicates however, no significant difference between the two treatments (z = - 1.44; two tailed test). The insignificant difference between the baseline treatment and the sequential treatment with information for the case of large groups suggests that the positive effect of information is partly offset by the negative effect induced by sequentiality alone, though this effect is not significant. Finally, Mann-Whitney tests of the difference of contributions between each treatment according to group size indicate no significant effect for the size. A Mann-Whitney test of the differences between the simultaneous treatment with size 4 and the simultaneous treatment with size 8 yields an insignificant z = 0.307. Similar results are obtained for the sequential treatment without information (z = - 1.486 ; two-tailed) and for the sequential treatment with information (z = - 0.480; two tailed).

Table 3 provides formal evidence about the influence of sequentiality and information on contribution. The dependent variable is the amount of tokens contributed in the tth period. The independent variables are subjects' lagged contribution, the lagged average contribution of the other members of the group and several dummy variables including the variable "information", to control for the influence of information on contribution and the binary variable "sequentiality". The variable "information" takes value 1 if subjects are informed about previous contributions in the sequence and 0 otherwise. Finally, the variable "Sequentiality×information" takes value 1 if the treatment introduces both sequentiality and information and 0 otherwise. In addition we also introduced a counter variable beginning with value 1 in the 15th period and value 0 in the preceding periods.

[Tables 3 about here]

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[6] In all statistical tests reported in this paper, the unit of observation is the group.

The estimates summarized in table 3 confirm our previous findings. The specifications of the second and third columns reveal that individuals increase their contribution when they are informed about the contributions of each lower ranked subject. Table 3 also indicates that for both small and large groups, the coefficient associated with "sequentiality" is not significant, confirming that sequentiality without observability has no significant impact on the level of average contribution.

4.2. Determinants of contribution

We turn now to another central question of our experiment : how do sequentiality and information about other's contributions affect contributions ? Our answer to that question is stated in Result 2 and Result 3. Result 2 summarizes our findings about the relationship between the information, either sent or received, and the level of individual contributions. Our conjecture is that subjects are influenced both by the information received from the lower ranked subjects and by the information they "send" to higher ranked subjects through their own contribution. In result 3 we investigate in detail the dynamic of both the leadership and reciprocity effects over time in the sequence.

Result 2: *Consistent with a "reciprocity" effect, an individual's contribution in period t is higher (a) the higher the contributions of the other group members in period t-1 (in the simultaneous and the sequential treatment without observability), (b) the higher the contributions of the lower ranked players in the sequence in period t (in the sequential treatment with observability). Consistent with a "leadership" effect, individuals who decide first in the sequence, contribute significantly more than other group members in the sequential treatment with observability.*

Support for result 2 : Table 4 contains the estimates of regression model (2) for the simultaneous treatment:

$$x_i^t = \beta_0 + \beta_1 x_i^{t-1} + \beta_2 \overline{x}_{-i}^{t-1} \qquad\qquad (2)$$

For the sequential treatment without information we estimate equation (3):

$$x_i^t = \beta_0 + \beta_1 x_i^{t-1} + \beta_2 \overline{x}_{-i}^{t-1} + \beta_3 1^{st}\ position \quad (3)$$

For the sequential treatment with information we estimate equation (4):

$$x_i^t = \beta_0 + \beta_1 x_i^{t-1} + \beta_2 \overline{x}_{-i}^{t-1} + \beta_3 x_{-i}^{r\,\text{inf}\,t} + \beta_4 1^{st}\ position \qquad\qquad (4)$$

The independent variables are subject i's lagged contribution $\left(x_i^{t-1}\right)$, the lagged average contribution of the other members of the group $\left(\overline{x}_{-i}^{t-1}\right)$ and the average contribution of lower ranked subjects in the current period $\left(x_{-i}^{r\,\text{inf}\,t}\right)$. The latter two variables measure the influence of received information about previous players' contributions (reciprocity effect). In the simultaneous treatment and the sequential treatment without information, only information about past periods is available. In contrast, in the sequential treatment with information, subjects may be influenced both by the information received from previous periods and information from previous decisions in the sequence for the current period. Finally, we introduced a dummy variable for the fist position in the group. This variable indicates whether the first player in the sequence contributes more than other group members ("leadership" effect). It takes value 1 if subjects are in the first position in the sequence and 0 otherwise.

[Tables 4 about here]

If subjects choose their contribution on the basis of their contribution of the previous period, the coefficient associated with subject's lagged contribution will be positive and significant. But subjects may also choose their contribution by considering the lagged average contribution of other group members. In this case one should observe a positive and significant coefficient for this variable. Table 4 shows that in all treatments, subjects' own lagged contribution has a positive influence. This coefficient is significant at the 1% significance level for all treatments. It is not surprising that in all treatments, a subject's past contribution predicts his or her current contribution level. Thus, contributions exhibit some inertia in that individuals who make high contributions in one period are more likely to do so in the next period. In addition, table 4 indicates that "others lagged average contribution " has a positive and significant influence in the simultaneous treatment and the sequential treatment without information. High contributions on the part of the other group members are imitated or reciprocated by high individual contributions in these two treatments. Note that the corresponding coefficient is not significant for the treatment with information, while the coefficient associated to the variable "contribution of lowest ranked players" is positive and highly significant for that treatment. This result suggests that in the sequential treatment with information subjects tend to disregard information from the previous period to take into account the more relevant information from the current period. The coefficient associated with the variable "contribution of lowest ranked players is also significant for the data concerning the final position in the sequence (see estimates 7 and 8). This result shows the existence of a reciprocity effect, irrespective of any other effects such as leadership effect. Taken together, the above results support the idea that individuals reciprocate previous observed contributions, with one obvious exception for the first ranked player who cannot rely on any information generated within the sequence and only relies on the previous period average contribution observed in the group (significant at 1%)[7].

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[7] The results are available on request.

Turning to check whether our results also reflects a leadership effect, we find that the coefficient associated to the variable "first position" is positive and highly significant in the sequential treatment with information, indicating that subjects contribute more in first position (significant at 1%). The coefficient associated to this variable is not significant in the sequential treatments without information, indicating no pure timing effect. This result suggests that the pure ordering effect does not emerge in games that admit a unique equilibrium. Indeed, the ordering effect was essentially observed so far in games with multiple equilibria (e.g. step-level public goods games) raising thereby a coordination problem among subjects. We confirm thereby the conclusion of Güth et al. (1998) who found that if the ordering effect requires subjects to deviate from the unique equilibrium, it is less likely to emerge. Finally table 4 also reveals an end game effect in most of the treatments.

Result 3 indicates the dynamic in the sequence of both the leadership and reciprocity effects over time.

Result 3 : *Contributions remain unaffected by the position in the sequential treatment without information. In contrast, in the sequential treatment with information, the level of contribution declines with the position in the group. This result indicates that the leadership effect vanishes with the rank within a sequence because there are fewer agents who are likely to be influenced as the sequence moves towards the last player. On the contrary, the reciprocity effect is not influenced by the position in the group since subjects reciprocate previous contributions within the sequence, irrespective of their position in the group*

Support for result 3:

[Figures 3 and 4 about here]

Figure 3 shows the average contribution of small groups, by rank in the game, for the two sequential treatments. Figure 4 provides similar information for large groups. Both figures indicate that the average contribution in the sequential treatment with information decreases with the position in the game. In contrast, the average level of contribution in the sequential treatments without information remains stable with the position. Figures 3 and 4 also reveal that the average contribution of the early players in the sequence is higher than in the baseline whereas the opposite is true for higher ranked subjects in the sequence. Indeed, Figure 3 reveals that for small groups, the average contribution of the three first players in the sequence for the sequential treatment with information is larger than the average contribution in the simultaneous treatment. In contrast, the average contribution of the fourth player is lower than in the benchmark treatment, indicating a possible "end-sequence effect". Figure 4 indicates a similar pattern for large groups : the average contribution of the first six players in the sequence is larger than the average contribution in the simultaneous treatment whereas the average contribution of the last two players is lower than in the benchmark treatment.

[Tables 5 and 6 about here]

Further evidence about this leadership effect can be found in tables 5 and 6 which display the average contribution levels by position respectively for small and large groups. In both tables, the second and the fifth columns indicate the overall average individual contribution for each group, respectively for the sequential treatments with and without information. The third and sixth columns give the average individual contribution for the first position in the group. Finally, the fourth and

seventh columns provide similar information for the final position of the group. Our data clearly indicate that contributions in the sequential treatment with information are higher in the first position than in the last position. On the contrary, we do not observe differences between the first and the final position for the sequential treatment without information.

Why do contributions decrease over time within the sequence as shown in Figures 3- 4 and Tables 5-6? A potential explanation is that the leadership effect vanishes as fewer agents are likely to be influenced. However, one might also argue that reciprocity vanishes as the sequence proceeds, because the temptation to free ride becomes stronger. In order to identify these reasons, we estimated a model of the determinants of the contribution levels (Table 7), which both yields a measure of the reciprocity effect and of the leadership effect within the sequence.

[Table 7 : about here]

The dependent variable x_i is the individual contribution of player i. The independent variables are subject i's lagged contribution and the variable "contribution of lower ranked individuals". We added dummy variables for each position in the group. The variable "position 3" is 1 if the player is in third position in the sequence of the game and 0 otherwise. The construction of the other variables is identical. The results are interpreted in relation with the omitted category, i.e. the two first positions in the game. We also introduced several interaction variables to investigate whether the effect of observing previous contributions differs according to the position in the group. Table 7 indicates that both for small and large groups, the position in the game does not influence the average contribution in the sequential treatment without information (see estimates 1 and 5). In contrast, estimates (2) and (6) show that the level of contribution declines with the position in the sequence in the sequential treatment with information, for both group sizes. Notice the values of the coefficients are weaker for early positions than for later positions, indicating that the tendency to free ride increases with the position in

the sequence. Table 7 clearly indicates that the level of contribution is higher for earlier players in the sequence and is decreasing with the position in the sequence in the sequential treatment with information.

We are tempted to interpret the higher contributions of early players as a strong leadership effect indicating that they correctly anticipate to have a positive influence on subsequent contributors and that such influence is declining with the position in the sequence. However this result might also be due to the fact that individuals are less and less influenced by previous contributions of lower ranked individuals in the sequence. In order to isolate these two effects we include in column (3), (4) ,(7) and (8), the variable "Contribution of lower ranks"as well as the interaction variables "Contribution of lower ranked × position". Introducing these variables does not affect the significance of the decline of contributions with position. The coefficient associated with the variable "contribution of lower ranked individuals" is positive and significant, indicating that subjects are positively influenced by the observation of previous contributions in the sequence. However this effect remains constant over the sequence as indicated by the non-significance of the interaction variables. Put together, our results clearly show that the decrease of contribution levels with the position in the game is not due to a decreasing reciprocity effect but rather reflects a decline of the leadership effect. We show in the next section that the latter observation is compatible with a model of sequential contributions where early players in the sequence take into account their influence on subsequent decision makers by making a large contribution. As the decision sequence moves towards the last player, there are less and less agents who are likely to be influenced and therefore the leadership effect vanishes and as a consequence the contribution level declines.

5. Moral motivation in a sequential contribution environment

The standard game-theoretic model falls short of predicting our experimental results. Recently proposed models of behaviour, such as inequality aversion (Fehr & Schmidt, 2000), also fail to predict the pattern of contributions observed in our sequential treatment with information (see Appendix A). In this section, we suggest an alternative model of behaviours, with moral motivation, and show that most behavioural patterns observed in our experimental data are compatible with the predictions of this model. Our model draws on Brekke et al. (2003), in that preferences incorporate a concern for individual's self image as a socially responsible person. This concern is modelled in Brekke et al. (2003) as a loss function that penalizes any gap between the individual's contribution and his so-called "morally ideal action". But our approach differs in the specification of the morally ideal actions, which we allow to be updated according to the observed contribution of others. Before we expose our model, a few preliminary remarks are necessary in order to define more precisely the idea of moral motivation and to explain our qualification of this notion.

Fundamentally, a key assumption is that preferences are structured into several layers (Harsanyi, 1955, Sen, 1977), some with moral reasoning, the interplay of which finally explains actual decisions. For instance, suppose that individuals have two layers of preferences: self-interested preferences and social preferences. Upon deciding how much to contribute to a particular public good, any individual has in mind a *morally ideal level of contribution* (Nyborg, 2000, Brekke et al, 2003), which is derived under the assumption that he is able to judge matters from society's point of view, following a combination of the utilitarian philosophy and a version of Kant's Categorical Imperative: "how much should I

contribute to maximize social welfare, given that everybody else would act like me?" The answer ends up in a Paretian level of contribution; and any discrepancy between this morally ideal course of action and the actual decision incurs a loss of utility. Finally, an agent's actual contribution will be the result of a trade-off between his marginal utility of improving his self-image by making a large contribution, his marginal utility from enjoying more of the public good and his marginal utility of consuming more of the private good. In some sense people make intrapersonal comparisons between their utility layers.

Brekke et al (2003)'s approach of moral motivation, however interesting, also raises a few issues. Considering what should be the best plan for society, would individuals' answers be independent of the society in which they live? For instance, would they take a Pareto optimal allocation as an ethically valuable goal regardless of the fact that all other people free-ride? Or would they consider some societies more deserving than others? Answering no would be at odds with many experimental results supporting the idea that, for many people, reciprocity in public goods issues matters a lot, e.g. in a public good context, " I free-ride, not because it is my self interest, but because everybody else does". The answers to those questions are sufficiently unclear to call for an important qualification of Brekke et al (2003)'s theory of behaviors.

Our originality in this matter is to assume that individuals' moral responsibility is not only the result of some autonomous ethical reflection, as would do impartial outside observers, but it is also partly determined by their actual social environment. It is therefore affected by the observations of others' actions: an agent who observes other agents' contributions to the public good, will eventually revise his initial morally ideal behavior. Of course, in a more balanced perception of reality, some individuals might have a purely intrinsic motivation to contribute and therefore will always stick to it whatever the other agents contribute. Our intuition however, is that most individuals are amenable to reconsider their

morally ideal point according to the current social morality partly revealed by other members of their group. We suggest that the reciprocity hypothesis, a widespread argument to explain individual decisions in public good experiments, could be rooted in the updating of one's moral motivation. Such an updating arises naturally in a context where individual contributions to the public good are made sequentially.

Turning to formal matters, the cardinal representation of agents' preferences with moral motivation is given by:

$$U^i(x_i, x_{-i}) = w - x_i + \beta(x_i + x_{-i}) - v_i(x_i - \hat{x}_i), \quad i = 1, \ldots, n \tag{4}$$

where $\beta \in]0,1[$ is the marginal utility from consuming the public good $G = x_i + x_{-i}$.

The novel aspect of the above preferences comes from the moral motivation embodied in the function $v_i(.)$. If $\hat{x}_i$ stands for agent i's moral ideal, then his utility loss for any deviation from his moral ideal is $v_i(x_i - \hat{x}_i)$. There are two important remarks about the function $v_i(.)$. Firstly, in general the moral motivation function is specific to each individual. We shall however assume that all individuals suffer the same loss from a deviation from their moral motivation. Secondly, and more importantly, the moral ideal $\hat{x}_i$ is also specific to each individual even if all agents share the same loss function. In general $\hat{x}_i$ can take any value between 0 and w_i. This seems consistent with the experimental findings about over-contributions in public goods games. The average contribution in the first round is about half the endowment, and there is a large variance in individual contributions. Two natural assumptions about the loss function are as follows:

Assumption 5.1. $v(0) = 0$, $v(x_i - \hat{x}_i) > 0$ iff $x_i \neq \hat{x}_i$.

Assumption 5.2. $v'(.) \begin{Bmatrix} > \\ = \\ < \end{Bmatrix} 0 \Leftrightarrow x_i - \hat{x}_i \begin{Bmatrix} > \\ = \\ < \end{Bmatrix} 0$

The first assumption is obvious. The second assumption means that, starting from a situation where agent i contributes less (more) than her moral ideal, a marginal increase of x_i reduces (increases) her loss of utility.

As previously announced, we shall conceptualize the moral ideal of each agent as a function of two arguments. The first argument, noted x_i^*, captures an autonomous ethical logic, that we shall leave relatively unspecified for the purpose of this paper. It could be derived from a Kantian Categorical Imperative combined with an utilitarian philosophy, as in Brekke et al (2003), and would correspond in this case to a Pareto optimum level of contribution. In the framework with symmetric agents we consider, all those individual Pareto optimum levels are the same, i.e. $x_i^* = x^* = w$, $\forall i$. Note that from an experimental point of view x_i^* is not observable. The second argument/logic captures social influences on ethical thoughts *via* the observation of the average contribution of the previous agents in the sequence $\bar{x}_{i-1}$. The observation of others' contribution leads agents to revise their own moral ideal. We assume that $\hat{x}_i$, called the *effective moral ideal* from now on, is a convex combination of the autonomous moral obligation x_i^* and the observed average contribution of previous agents:

$$\hat{x}_i = (1 - \theta_i)x_i^* + \theta_i \bar{x}_{i-1} = x_i^* - \theta_i (x_i^* - \bar{x}_{i-1}), \quad \theta_i \in [0,1], \quad i = 2,3,\dots,n.$$

The case of the first contributor is sligtly different. Since he has no previous observation to update his ethical position, then his effective moral ideal is simply $\hat{x}_1 = x_1^*$.

Remember that actions are taken sequentially: agent 1 decides first, followed by agent 2, then agent 3 and so until agent n. In order to arrive at tractable solutions for the Stackelberg equilibrium, we restrict the model to the symmetric case. We do this by introducing two simplifying assumptions. First, we shall assume that all players have the same autonomous moral ideal, $x_i^* = x^*$ for all i, with $0 < x^* < w$. Second, we shall also assume that $\theta_i = \theta \in [0,1], \forall i$. Note that by our first assumption, we exclude the uninteresting case of no autonomous moral ideal ($x^* = 0$) - this would mean individuals have no personal ethical ideal - and the case where the autonomous moral ideal corresponds to the Pareto optimum contribution $(x^*= w)$. Even though the autonomous moral ideal could be arbitrarily close to w, this corner case is eliminated for two reasons. The possibility of corner decisions complicates substantially the analysis, because we would need to take into account of a sequence of discontinuous best replies functions to be anticipated by each leader. We discard this possibility to arrive at the phenomenon of interest as simply as possible. Secondly, there is no empirical reason to believe that subjects take the Pareto contribution as a reference for their autonomous moral ideal. Rather, the large available experimental evidence on voluntary contributions to a public good suggests that on average, in the first round, subjects have a moral motivation to contribute something to the public good, but far below the Pareto optimum level of contribution.

Under the previous restrictions the interior Stackelberg equilibrium turns out to be:

$$x_n = \hat{x}_n + v'^{-1}(-1+\beta),$$

$$x_{n-1} = \hat{x}_{n-1} + v'^{-1}\left(-1 + \beta + \frac{\beta\theta}{n-1}\right),$$

$$\ldots$$

$$x_{n-k} = \hat{x}_{n-k} + v'^{-1}\left(-1 + \beta + \beta\theta\sum_{h=1}^{k}(n-h)^{-1}\right)$$

$$\ldots$$

$$x_1 = x^* + v'^{-1}\left(-1 + \beta + \beta\theta\sum_{h=1}^{n-1}(n-h)^{-1}\right)$$

This equilibrium condition can be understood as follows: at equilibrium, agent $n\text{-}k$ chooses a level of contribution x_{n-k} which equalizes his marginal utility from deviating from his effective moral ideal to his marginal utility of contributing an additional unit to the public good $-1 + \beta + \beta\theta\sum_{h=1}^{k}(n-h)^{-1}$, where

$\beta\theta\sum_{h=1}^{k}(n-h)^{-1}$ captures the influence of his marginal contribution on the remaining subsequent players. Note that, because the last expression is always positive, early players can contribute more than their moral ideal.

Let us define

$$g(k) = \begin{cases} v'_{-1}(-1+\beta) & \text{for } k=0, \\[2ex] v'^{-1}\left(-1 + \beta + \beta\theta\sum_{h=1}^{k}(n-h)^{-1}\right), & \text{for } k \geq 1. \end{cases}$$

Notice that $g'(k) > 0$ for $k \geq 1$. By construction, $g(k)$ is agent k's optimal departure from his ideal level of contribution.

Using this definition, the Stackelberg equilibrium can be rewritten:

$$x_1 = x^* + g(n-1)$$

$$x_2 = \hat{x}_2 + g(n-2) = (1-\theta)x^* + \theta x_1 + g(n-2) = x^* + \theta g(n-1) + g(n-2)$$

$$x_3 = \hat{x}_2 + g(n-3) = (1-\theta)x^* + \theta \bar{x}_2 + g(n-3)$$

$$= (1-\theta)x^* + \theta x^* + \frac{\theta}{2}\big[(1+\theta)g(n-1) + g(n-2)\big] + g(n-3)$$

$$= x^* + \frac{\theta}{2}\big[(1+\theta)g(n-1) + g(n-2)\big] + g(n-3)$$

$$....$$

$$x_k = \hat{x}_k + g(n-k) = x^* + L_k\big[g(n-1), g(n-2), ..., g(n-k-1), g(n-k)\big]$$

where $L_k\big[g(n-1), g(n-2), ..., g(n-k-1), g(n-k)\big]$ is a linear combination, with positive coefficients, of

$g(n-1), g(n-2), ..., g(n-k-1), g(n-k)$.

Consider now the following assumption on the parameters:

Assumption 5.3. $\displaystyle\sum_{h=1}^{n-1}\frac{1}{n-h} \le \frac{1-\beta}{\beta\theta}$

Assumption 5.3 is easy to satisfy; for instance as the marginal utility of the public good tends to zero,

the right hand side of the inequality growths arbitrarily large. Note that Assumption 5.3 is equivalent to

assuming that the first contributor (agent 1) contributes less than his moral ideal, $x_1 < x^*$. If the latter

inequality is satisfied, by Assumption 5.2 we have $v'(x_1 - x^*) \le 0$ which means

$\left(-1 + \beta + \beta\theta\displaystyle\sum_{h=1}^{n-1}(n-h)^{-1}\right) \le 0$ (or equivalently Assumption 5.3).

Proposition 5.1. Under Assumption (5.3), successive contributions to the public good are decreasing:

$$x_1 > x_2 > ... > x_k > ... > x_n.$$

Proof : See Appendix B.1

This first property fits well with the pattern of contributions observed in the lab (and summarized in Result 3, Section 4.2).

Without Assumption 5.3, some agents can contribute to the public good above their moral ideal, as illustrated by the following example. Assume the moral obligation function is $v(x_i - \hat{x}_i) = \frac{v}{2}(x_i - \hat{x}_i)^2$ and let the parameters take the following values :

$$v = 0.1,\ \omega = 40,\ x^* = 20,\ \beta = \theta = 0.9 \text{ and } n = 3$$

Computing the Stackelberg equilibrium, one finds:

$$x_1 = 31.15,\ x_2 = 33.08,\ x_3 = 29.90.$$

This example illustrates the property that although early contributions may increase, they will eventually decrease at some point in the sequence. Actually, without Assumption 5.3 we have the following:

Proposition 5.2. *There exists an agent j ≤n such that, starting from that agent successive contributions to the public good are decreasing:*

$$x_j > x_{j+1} > \ldots > x_n.$$

Proof : See Appendix B.2

Another interesting property obtains when the parameter t has a positive impact on the first agent's optimal departure from his ideal contribution, hence on a positive effect on the ideal point of the second agent. Formally:

Assumption 5.4. $\frac{\partial}{\partial \theta}\left[\theta g(n-1)\right] = g(n-1) + \theta \frac{\partial}{\partial \theta} g(n-1) > 0$

Proposition 5.3. Under Assumption 5.4, the higher the importance of observed behaviours on agents' moral obligation (higher θ), the higher the contributions at a Stackelberg equilibrium.

Proof : See Appendix B.3

According to proposition 5.3 any average $\bar{x}_h$ is an increasing function of θ. When θ tends to zero, the Stackelberg equilibrium converges to the Nash equilibrium of a public good game with morally motivated contributors. Proposition 5.3 implies therefore that Nash contributions are lower than Stackelberg contributions, which is in accordance with our experimental findings (see Result 1, Section 4.1). Also, this particular case of moral motivation function boils down to Brekke et al (2003). With their model of preferences, the Nash and the Stackelberg equilbrium of the game with payoffs given by (4) are identical. Moral motivation per se is not sufficient to explain the regularities observed in the lab, except the tendency for agents to over-contribute, which is not predicted by standard Nash contributions without moral motivation.

Proposition 5.4 : $\bar{x}_n$ is increasing with n.

Proof : Recall that $g(n-k) = v'^{-1}\left(-1+\beta+\beta\theta\sum_{h=1}^{n-k}(n-h)^{-1}\right)$ is increasing with n-k. Since

$x_k = \hat{x}_k + g(n-k) = x^* + L_k[g(n-1), g(n-2),..., g(n-k-1), g(n-k)]$, *i.e.* contribution of player k is a linear

combination of $g(n-1), g(n-2),..., g(n-k-1), g(n-k)$ with positive coefficients, increasing n will increase

x_k.

Proposition 5.4 is intuitive: the larger the number of followers who can be induced to contribute, the stronger the marginal incentive for any leader to increase his own contribution. An equivalent interpretation is as follows: when more followers are to be influenced, increasing the level of public good by one unit can be done (indirectly) at a lower cost. Yet this "length" effect is not confirmed by our experimental results. One possible explanation might be the increased complexity of calculus when there are more agents. Or the other hand the intrinsic moral motivation might depend negatively on the number of agents in the population, so that the leadership effect might be counter-balanced by an increased perception of the free-riding problem. While our model fails to predict the neutral size effect found in our data, it is not sufficient to be rejected, since a positive experimental size effect might be found for larger population increases. Furthermore, our model nicely predicts the vanishing leadership effect found in our data and provides a nice explanation for declining contributions as the influence declines. Finally, our model explains our major finding, the fact that the average contribution is larger in the treatment with information, than in treatments without information.

5. Conclusion

We studied an experimental game of voluntary contributions to a public good, in which players move sequentially. In our test treatment later players can observe the contributions of previous players,

while in our control treatments, all players have to make their contribution without knowing the contributions of the other players. Our results show that sequentiality without observability does not significantly affect the average level of contribution, compared to the simultaneous contribution treatment. Our result contrast therefore with the literature on the positional order effect (Rapoport et al., 1993, Budescu et al., 1995, Suleiman et al., 1996, Rapoport, 1997). However, our voluntary contribution game has a unique equilibrium, avoiding therefore the type of coordination problem that arises in step-level public goods games or in common pool resources games, which are the type of games used to exhibit the positional order effect. Furthermore, our result is in accordance with Güth et al. (1998), who showed that in a game with a unique equilibrium, the positional order effect is seriously weakened.

Two major results have been obtained : i) the average level of contribution is significantly increased, when subjects contribute sequentially and have the opportunity to observe previous contributions, and ii) the average contribution declines with the position in the sequential contribution game because fewer subjects are likely to be influenced as the game proceeds and therefore the leadership effect vanishes over the sequence.

To explain those results, we have imagined a model of moral motivation with an updating process for the morally ideal behavior. Furthermore, as in our model, the experimental results suggest that contributions are not purely intrinsically motivated but are conditioned on observed contributions, in line with earlier findings on conditional cooperation in social dilemma games (Keser & van Winden, 2000). Our model of updating moral motivation provides a rational for conditional cooperation, based on mixing intrinsic motivation together with reciprocal behaviour. The model is also compatible with the so-called leadership effect, highlighted in several experiments on public goods provisions. Subjects who decide earlier in the sequence know that their contribution will affect positively the morally ideal

contributions of later decision makers; accordingly they will try to encourage them by making a large contribution. As the decision sequence moves toward the last player, implying that fewer players are likely to be influenced, the leadership effect vanishes, and the average contribution declines in the higher ranks of the game. This outcome is both observed in our data and predicted by our model. We also find that in the sequential treatment with observability, the level of contribution is not conditioned on the previous period average contribution as in the simultaneous treatment, but on contributions of earlier players in the sequence observed within the period. Finally, in contrast to the predictions of our model, we do not find that the size of the group has a significant impact on contributions.

While our model nicely explains the observed pattern of decreasing contributions by rank, it's main limitation is that it describes our results only on average. Nevertheless the model could be extended to a repeated game of sequential contributions, in order to explain the declining per period average contribution. This would require a more general rule for revising a player's moral motivation, by taking into account both the within period observed contributions and past contributions of previous periods. The model should explain why the average contribution declines both in the simultaneous and the sequential treatments (with or without information). There are some indications in our data why such a model would be promising. First, our analysis shows that there is an independent component in a subject's contribution, since past own contribution has a significant effect on the current contribution for all treatments. Second, our data clearly reveals that subjects choose their current contribution by taking into account the most recent information about previous contributions. In the simultaneous treatment and the sequential treatment without information, they rely on the average contribution of previous periods, while in the sequential treatment with information they tend to ignore this information and focus on the contributions of lower ranked players within the period. Finally, we also

showed that the first player in the sequence takes into account the average contribution of the previous period.

The fact that later contributors are influenced by the observed contributions of early players, can have important policy implications. Posting information on previous contributions might therefore be an efficient tool for increasing the level of contributions, suggesting that the design of public policies should take into account the leadership effect. For example, public announcements of previous efforts to reduce emissions might increase society's overall abatement effort. Clearly, the leadership effect alone is not sufficient to solve the social dilemma arising in voluntary contribution games. Fehr & Gächter (2000) showed that the introduction of costly punishment opportunities provides strong enough incentives to overcome the dilemma. Our results suggest that the same outcome can be reached with less demanding punishment opportunities. Introducing asymmetric punishment opportunities, *i.e.* early players can only punish later players, might provide enough incentives to increase the level of contributions to the socially optimal level.

Appendix A

We show, in the case of two players, that inequity aversion fails to predict the pattern of decreasing successive contributions observed in the lab.

Let y_j and y_i designate Player j and i's monetary payoff respectively. Player i's utility with inequity aversion à la Fehr and Schmidt (1999) is given by:

$$u_i = y_i - a \max(y_j - y_i, 0) - b \max(y_i - y_j, 0)$$

with $a > b \geq 0$, $b < 1$ and $y_i = w - x_i + \beta(x_i + x_j)$, $\beta < 1$. Therefore :

$$u_i = y_i - a \max(x_i - x_j, 0) - b \max(x_j - x_i, 0).$$

Let Player j be the first contributor and Player i the second contributor. We start with player i's best-reply. Note first that $x_i > x_j$ is impossible, since we would have

$$u_i = y_i - a(x_j - x_i) = w - x_i(1 - \beta + a) + x_j(\beta + a)$$

which is maximized for $x_i = 0$ since $1 - \beta + a > 0$. Therefore it remains to analyze the case $x_j \geq x_i$. Assuming $x_j \geq x_i$,

$$u_i = w - x_i(1 - \beta - b) + x_j(\beta - b).$$

If :

  i) $1 < b + \beta$, Player i maximises his utility by contributing $x_i^* = w$
  ii) $1 > b + \beta$, Player i maximises his utility by contributing $x_i^* = 0$

Assuming $\beta = 0.5$, as in the experiment, case i requires $b \geq 0.5$, i.e. an altruistic Player i. In the more likely case where $b < 0.5$, the model predicts $x_i^* = 0$.

Assuming $x_i^* = 0$, player j's utility becomes $u_j = w - x_j (1 - \beta - b)$, with $1 - \beta - b > 0$, and therefore $x_j^* = 0$.
Assuming $x_i^* = w$, player j's utility becomes $u_j = w - x_j (1 - \beta - b) + \omega (\beta - b)$, with $1 - \beta - b < 0$, and therefore $x_j^* = w$..

In any case, contributions are identical, a pattern refuted by experimental observations.

Appendix B

1.Proof of Proposition 5.1

Under Assumption 5.3, one has

$$-1+\beta+\beta\theta\sum_{h=1}^{k}(n-h)^{-1}\leq 0, \ \forall k \geq 1.$$

As a result $g(k)=v'_{-1}\left(-1+\beta+\beta\theta\sum_{h=1}^{k}(n-h)^{-1}\right)\leq 0$, due to the properties of function $v(.)$ explicited in Assumption 5.2.

The proof will be established recursively.

Note first that $x_1=x^*+g(n-1)\leq x^*$ because $g(n-1)\leq 0$. Then observe that $x_2=\hat{x}_2+g(n-2)\leq x_1$ because on one hand $\hat{x}_2\leq x_*$, as a convex combination of x^* and $\hat{x}_1\leq x_*$, and on the other hand $g(n-2)\leq g(n-1)\leq 0$ since $g(.)$ is an increasing function.

Now assume that the property $x_h\leq x_{h-1}$ holds for $h = 3,...,k$, for some k. To complete the proof, it must be established that $x_{k+1}\leq x_k$. If, as assumed, the property is true until $h = k$, then the sequence of averages $\overline{x}_h$ decreases with h until $h = k$. It follows that $\hat{x}_{k+1}$, a convex combination of x^* and $\overline{x}_k$, is lower than $\hat{x}_k$, a convex combination of x^* and $\overline{x}_{k-1}>\overline{x}_k$. To conclude,

$$x_{k+1}=\hat{x}_{k+1}+g(n-k-1)< x_k=\hat{x}_k+g(n-k),$$

because $\hat{x}_{k+1}< \hat{x}_k$ and $g(n-k-1)<g(n-k)$. QED.

2. Proof of Proposition 5.2

Without Assumption 5.3, the sign of

$$-1+\beta+\beta\theta\sum_{h=1}^{k}(n-h)^{-1}, \ \forall k \geq 1.$$

is ambiguous. Therefore $g(n-k)$ could be positive. However, as k increases it finally becomes negative, sing $g(.)$ is a monotonic function and $g(0) = v'^{-1}(-1+\beta)$. This means there is an agent $j \leq n$ such that $g(n-k) \leq 0$, for all $k \geq j$.

Starting with this agent j, there are two cases to be considered.

The first case is where the previous average is above the moral obligation, $\bar{x}_{k-1} > x^*$, $k \geq j$. Then $x_k = \hat{x}_k + g(n-k) < \bar{x}_{k-1}$, because on one hand $\hat{x}_k \leq \bar{x}_{k-1}$, as a convex combination of x^* and $\bar{x}_{k-1} > x^*$, and on the other hand $g(n-k) \leq 0$. To complete the proof, it is sufficient to observe that:

$$\hat{x}_{k+1} = (1-\theta)x^* + \theta \frac{1}{k}\left[(k-1)\bar{x}_{k-1} + x_k\right]$$

$$= (1-\theta)x^* + \theta \bar{x}_{k-1} - \theta \frac{1}{k}\bar{x}_{k-1} + \theta \frac{1}{k}x_k$$

$$= \hat{x}_k + \theta \frac{1}{k}\left[x_k - \bar{x}_{k-1}\right] < \hat{x}_k \text{ since } \bar{x}_{k-1} > x_k,$$

as established above. As soon as the average contribution declines, one can reproduce the recursive demonstration of the previous proposition to show that subsequent contributions are lower.

The second case, where $\bar{x}_{k-1} < x^*$, follows a similar logic. First, $x_k = \hat{x}_k + g(n-k) < \bar{x}_{k-1}$, because on one hand $\hat{x}_k \leq x^*$, as a convex combination of x^* and $\bar{x}_{k-1} < x^*$, and on the other hand $g(n-k) \leq 0$. Again the average contribution declines, so that the previous reasoning applies to complete the proof. QED.

3. Proof of Proposition 5.3

Here also, the proof is established recursively. It is readily checked that x_1 is an increasing function of θ. Under Assumption 5.4 this is also the case for x_2. Assume this property hold for x_h, $h = 3,...,k$ and let us show it holds also for x_{k+1}.

Because
$$x_h = x^* + L_h(g(n-1), g(n-2),...,g(n-k)), \quad \forall h,$$
it must be true that each function L_h, $h \leq k$, is an increasing function of θ.

Then, by construction
$$x_{k+1} = (1-\theta)x^* + \theta \bar{x}_k + g(n-k-1),$$

$$= (1-\theta)x^* + \theta \frac{1}{k}\left[kx^* + \sum_{h=1}^{k} L_h\right] + g(n-k-1),$$

$$= x^* + \theta \frac{1}{k}\sum_{h=1}^{k} L_h + g(n-k-1).$$

Observing the last line, the result simply follows from the property that each function L_h (.), $h \leq k$, is an increasing function of θ and $g(.)$ is also an increasing function of θ. QED.

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Figure 1. Average contribution level per period for N=4
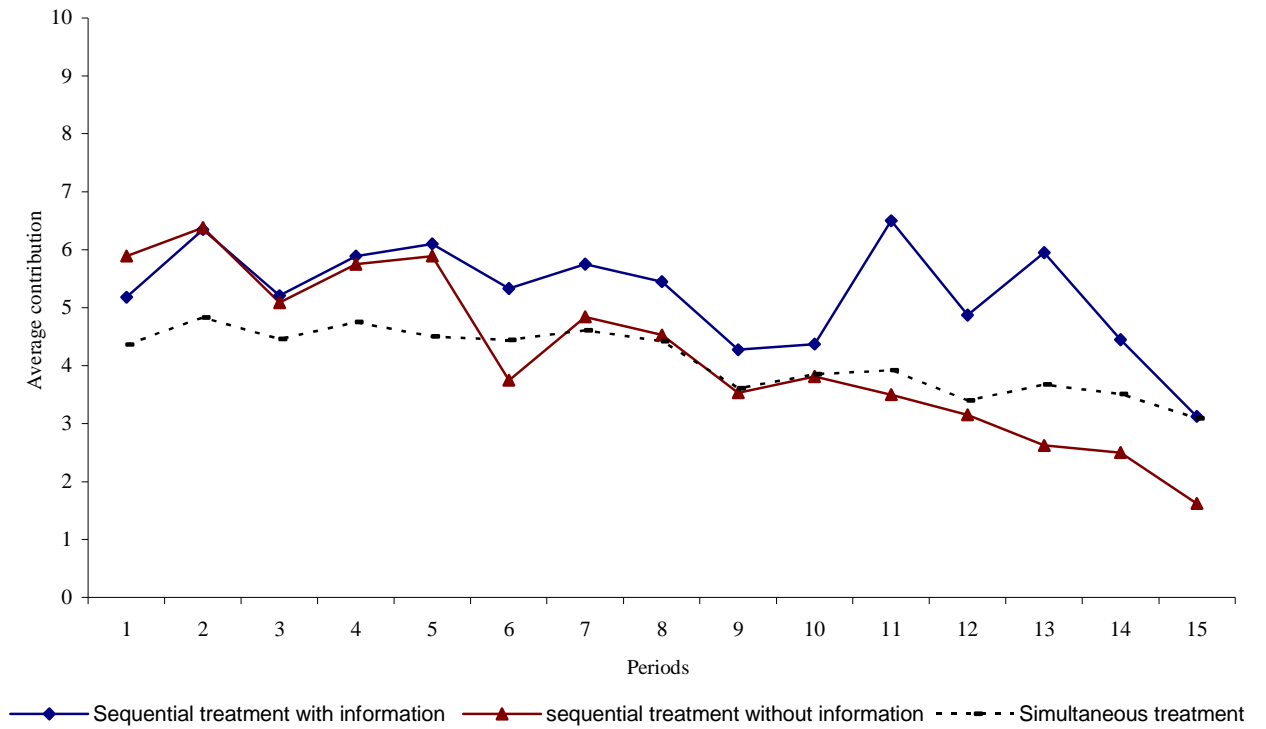
Figure 2. Average contribution level per period for N = 8
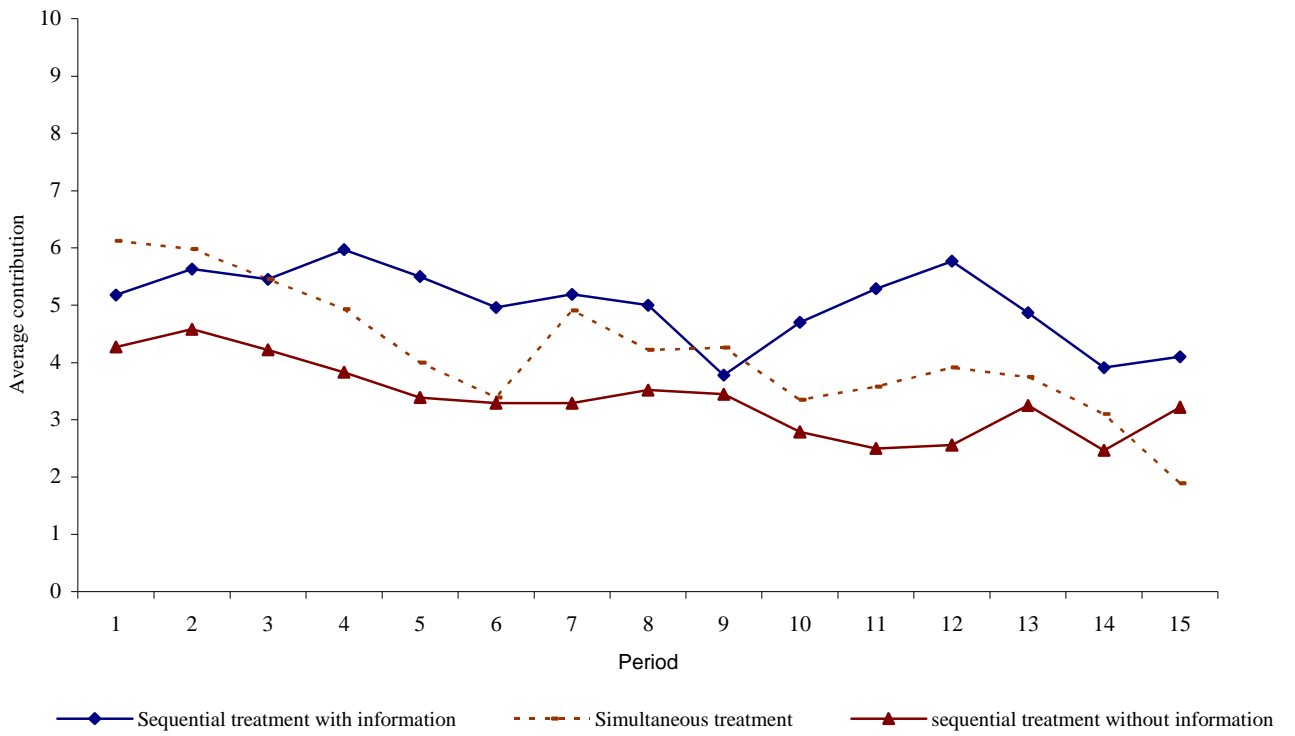
Figure 3. Average Contribution for each position in the game (size N=4)
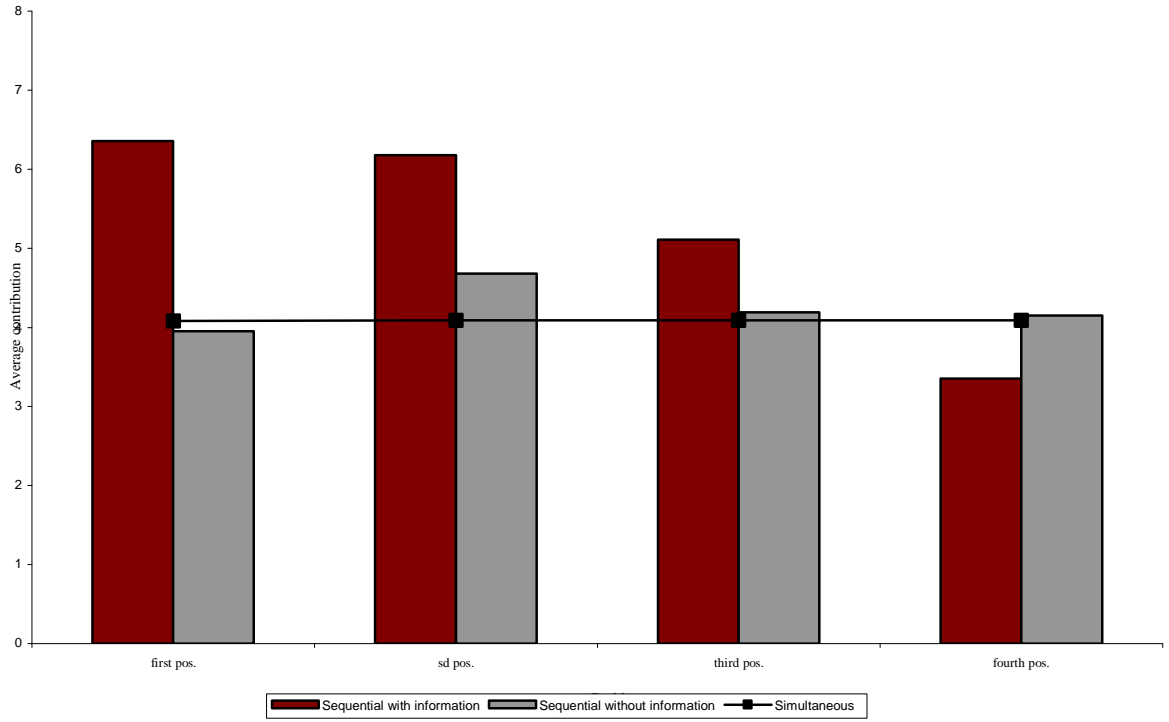
Figure 4 . Average Contribution for each position in the game (size N=8)
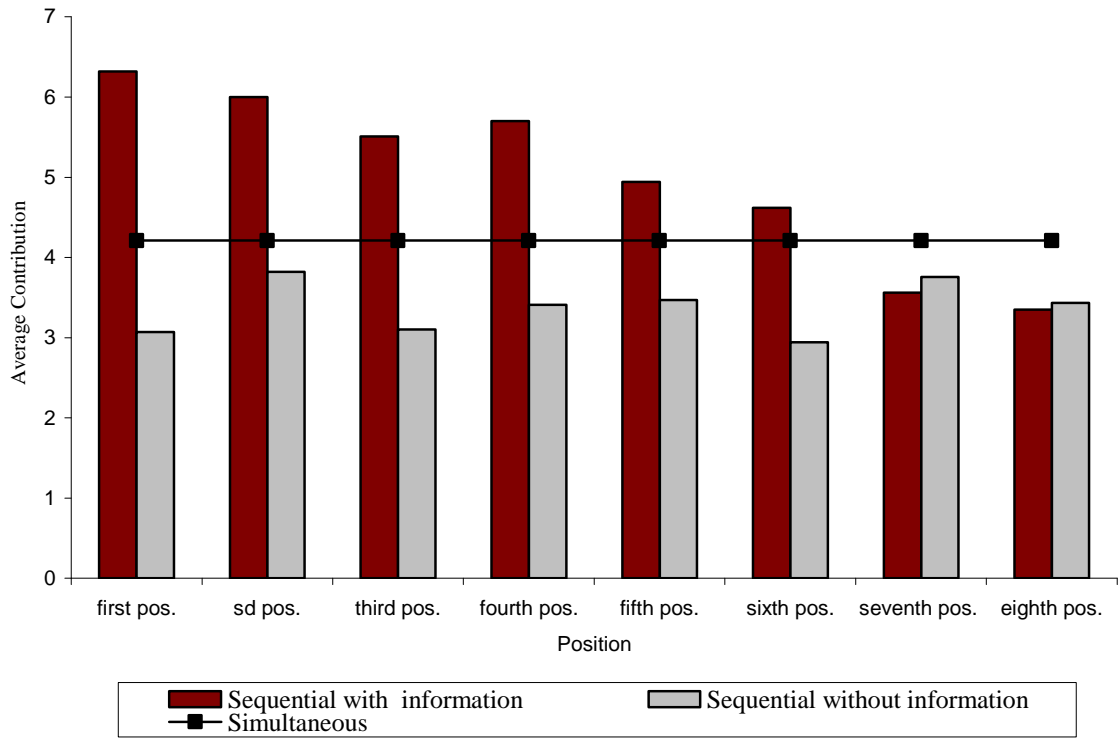
Table 1: Number of independent observations per cell

Session number	Treatment	Number of Groups	Number of subjects	Size of the group
1	Simultaneous game	5	20	4
2	Simultaneous game #	4	16	4
3	Simultaneous game #	4	16	4
4	Simultaneous game	2	16	8
5	Simultaneous game	2	16	8
6	Simultaneous game	2	16	8
7	Sequential game with info	3	12	4
8	Sequential game with info	3	12	4
9	Sequential game with info	2	16	8
10	Sequential game with info	2	16	8
11	Sequential game with info	2	16	8
12	Sequential game without info	4	16	4
13	Sequential game without info	4	16	4
14	Sequential game without info	2	16	8
15	Sequential game without info	2	16	8
16	Sequential game without info	2	16	8

simultaneous game with framing

Table 2. Group Average Contribution Levels

Group	N=4			N=8		
	Sim	Sequ without info	Sequ with info	Sim.	Sequ without info	Sequ with info
1	4.3#	5.4	4.58	4.84	2.65	3.85
	(2.94)	(4.57)	(3.67)	(3.44)	(3.43)	(3.08)
2	4.15#	4.7	6.23	4.95	2.7	3.88
	(2.83)	(3.17)	(3.11)	(3.38)	(2.5)	(3.85)
3	5.91#	4.28	5.15	3.48	3.22	6.025
	(2.33)	(4.72)	(2.99)	(3.44)	(2.43)	(3.08)
4	2.78#	5.93	5.53	5.26	4.28	5.50
	(3.26)	(3.06)	(3.31)	(3.34)	(2.91)	(4.03)
5	5.25#	4.21	5.35	3.52	4.05	4.24
	(2.93)	(3.12)	(3.30)	(3.61)	(3.04)	(2.22)
6	6.08#	4.1	4.68	3.18	3.34	6.53
	(2.52)	(3.05)	(3.11)	(3.35)	(2.72)	(4.28)
7	2.61#	2.28				
	(2.96)	(2.59)				
8	2.5#	3.05				
	(2.48)	(3.03)				
9	4.95					
	(1.92)					
10	2.05					
	(1.99)					
11	2.96					
	(3.17)					
12	5.25					
	(2.47)					
13	4.46					
	(3.13)					
	4.09	4.24	5.25	4.20	3.37	5.03
	(2.68)	(3.41)	(3.32)	(3.42)	(2.83)	(3.42)

The results show no significant difference at any level of significance in average contribution between the simultaneous treatments with and without framing. All simultaneous treatments with large groups were conducted with framing.

Table 3: Random-effects GLS regression of Individual Contribution: Information and Order Effects

	Sequ. treat. (sequ with and without info)		Treat without info. (simult and seq without info)		Simult treat and seq. treat with info	
	N=4	N=8	N=4	N=8	N=4	N=8
i's contribution (lagged)	0.210***	0.289***	0.412***	0.368***	0.426***	0.315***
	(0.035)	(0.027)	(0.027)	(0.026)	(0.029)	(0.027)
Others's average cbt (lagged)	0.290***	0.133**	0.287***	0.221***	0.161***	0.171***
	(0.052)	(0.057)	(0.040)	(0.057)	(0.043)	(0.054)
Information	0.654***	0.966***				
	(0.242)	(0.199)				
Sequentiality			-0.144	-0.175		
			(0.171)	(0.175)		
Seq*Information					0.454**	0.584***
					(0.190)	(0.191)
Period 15	-1.728***	-0.055	-0.841***	-0.526*	-0.981***	-1.014***
	(0.462)	(0.342)	(0.326)	(0.328)	(0.331)	(0.369)
Constant	2.028***	1.887***	1.227***	1.532***	1.701***	2.017***
	(0.295)	(0.238)	(0.209)	(0.288)	(0.218)	(0.279)
Observations	784	1344	1176	1344	1064	1344
R squared	0.15	0.14	0.25	0.17	0.24	0.14

Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: Determinants of contribution (Random-effects GLS regression)

Variable	Simult treat.		Seq treat. without info		Seq. Treat. with info All positions		Seq. Treat. with info Final position	
	N=4	N=8	N=4	N=8	N=4	N=8	N=4	N=8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i's contribution (lagged)	0.564*** (0.031)	0.377*** (0.036)	0.239*** (0.045)	0.348*** (0.037)	0.192*** (0.060)	0.234*** (0.040)	0.073 (0.115)	0.042 (0.102)
Others' average cbt (lagged)	0.191*** (0.047)	0.230*** (0.076)	0.390*** (0.067)	0.177** (0.089)	0.023 (0.091)	0.053 (0.080)	0.067 (0.164)	0.286 (0.200)
First position in the group			-0.247 (0.312)	-0.157 (0.244)	1.908*** (0.406)	1.296*** (0.405)		
Contribution of lower ranked indiv.					0.302*** (0.066)	0.221*** (0.040)	0.178* (0.11)	0.224*** (0.087)
Period 15	-0.531 (0.352)	-1.509*** (0.502)	-1.419** (0.624)	0.423 (0.421)	-1.802** (0.752)	-0.454 (0.555)	-1.985 (1.452)	-0.579 (1.08)
Constant	0.972*** (0.231)	1.518*** (0.368)	1.306*** (0.396)	1.461*** (0.350)	6.137*** (0.969)	1.981*** (0.457)	1.806* (1.119)	0.683 (1.224))
Observations	728	672	448	672	252	588	84	84
R2	0.36	0.19	0.18	0.12	0.26	0.14	0.08	0.06

Standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%

. **Table 5.** Group Average Contribution by position in the game (N = 4)

Group	Sequential treatment with info			Sequential treatment without info		
	All positions	First position	Last position	All positions	First position	Last position
1	4.58 (3.67)	6.33 (3.24)	2.26 (3.43)	5.4 (4.57)	5.13 (4.77)	6.2 (4.49)
2	6.23 (3.11)	7.33 (1.87)	4.33 (3.90)	4.7 (3.17)	3.8 (3.21)	4 (3.11)
3	5.15 (2.99)	6.86 (2.16)	3.4 (3.37)	4.28 (4.72)	4.33 (4.77)	4.73 (4.90)
4	5.53 (3.31)	6.33 (2.60)	3.13 (3.15)	5.93 (3.06)	5.46 (2.97)	4.93 (3.69)
5	5.35 (3.30)	6.93 (2.93)	2.86 (2.58)	4.21 (3.12)	3 (2.92)	3.66 (2.46)
6	4.68 (3.11)	4.4 (2.13)	4.13 (3.92)	4.1 (3.05)	5.33 (3.08)	4.13 (2.97)
7				2.28 (2.59)	1.53 (1.84)	1.8 (3.12)
8				3.05 (3.03)	3 (3.42)	3.8 (2.73)
	5.25 (3.32)	6.36 (2.64)	3.35 (3.40)	4.24 (3.41)	3.94 (3.37)	4.15 (3.43)

Table 6. Group Average Contribution by position in the game (N = 8)

Groups	Sequential treatment with info			Sequential treatment without info		
	All positions	First position	Last position	All position	First position	Last position
1	3.85	4.26	2	2.65	3.13	2.93
	(3.08)	(3.41)	(2.23)	(3.43)	(3.96)	(3.55)
2	3.88	6.33	.93	2.7	2.8	2.53
	(3.85)	(3.19)	(2.63)	(2.5)	(2.30)	(2.79)
3	6.025	8.26	6.2	3.22	3.46	3.2
	(3.08)	(1.83)	(3.91)	(2.43)	(2.41)	(1.89)
4	5.50	7.86	2.66	4.28	4.2	4.06
	(4.03)	(3.02)	(4.23)	(2.91)	(3.12)	(3.08)
5	4.24	4.6	2.8	4.05	2.46	5
	(2.22)	(2.55)	(2.54)	(3.04)	(2.19)	(3.31)
6	6.53	6.6	5.53	3.34	2.4	2.86
	(4.28)	(4.70)	(4.71)	(2.72)	(2.5)	(2.26)
Average	5.03	6.31	3.35	3.37	3.07	3.43
	(3.42)	(3.11)	(3.37)	(2.83)	(2.74)	(2.81)

Table 7: Random-effects GLS regression of contribution by position in the game

	N=4				N=8			
	Seq. without Information	Sequential with Information			Sequential without Information	Sequential with Information		
	(1)	(3)	(2)	(4)	(5)	(7)	(6)	(8)
i's contribution	0.305***	0.193***	0.195***	0.199***	0.354***	0.300***	0.264***	0.263***
(lagged)	(0.045)	(0.050)	(0.057)	(0.057)	(0.037)	(0.036)	(0.039)	(0.039)
Position 3	-0.358	-1.362***	-1.243***	-2.045*	-0.228	-0.912**	-0.566	-1.509
	(0.397)	(0.394)	(0.458)	(1.171)	(0.368)	(0.446)	(0.511)	(1.098)
Position 4	-0.193	-3.076***	-2.632***	-1.920*	-0.210	-0.518	-0.078	1.124
	(0.397)	(0.394)	(0.466)	(1.045)	(0.368)	(0.445)	(0.512)	(1.022)
Position 5					-0.050	-1.471***	-1.076**	-1.204
					(0.368)	(0.446)	(0.512)	(1.044)
Position 6					-0.434	-1.851***	-1.312**	-0.620
					(0.368)	(0.445)	(0.514)	(0.996)
Position 7					0.298	-3.363***	-2.694***	-2.014**
					(0.368)	(0.448)	(0.519)	(0.972)
Position 8					-0.317	-3.282***	-2.452***	-2.158**
					(0.368)	(0.446)	(0.526)	(0.912)
Cbt. of lower ranked			0.273***	0.293**			0.174***	0.224**
			(0.065)	(0.125)			(0.040)	(0.105)
Interaction variables								
Cbt. of lower ranked indiv**X** Pos. 3				0.128				0.155
				(0.169)				(0.155)
Cbt. of lower ranked indiv.**X** Pos. 4				-0.135				-0.209
				(0.157)				(0.147)
Cbt. of lower ranked indiv.**X** Pos. 5								0.027
								(0.148)
Cbt. of lower ranked indiv.**X** Pos. 6								-0.125
								(0.149)
Cbt. of lower ranked indiv.**X** Pos. 7								-0.130
								(0.149)
Cbt. of lower ranked indiv.**X** Pos. 8								-0.041
								(0.146)
period15	-2.074***	-2.104***	-1.895**	-1.839**	0.254	-0.583	-0.536	-0.534
	(0.636)	(0.626)	(0.738)	(0.737)	(0.414)	(0.501)	(0.534)	(0.535)
Constant	3.057***	5.476***	3.628***	3.475***	2.216***	4.938***	3.706***	3.385***
	(0.310)	(0.355)	(0.595)	(0.913)	(0.250)	(0.311)	(0.481)	(0.781)
Observations	448	336	252	252	672	672	588	588

Standard errors in parentheses* significant at 10%; ** significant at 5%; *** significant at 1%

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