Does contributing sequentially increase the level of cooperation in public good games? An experimental investigation

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Does Contributing Sequentially Increase the Level of Cooperation in Public Goods Games ? An Experimental Investigation

By

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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. Our 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"). Furthermore, we investigate the effect of group size on aggregate contributions. Our result indicate that contributing sequentially increases the level of contribution to the public good when subjects are informed about the contribution levels of lower ranked subjects. Moreover, we observe that earlier players in the sequence 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.

1. Introduction

In many situations agents' efforts to provide public goods are made sequentially. It is rare that all agents have to decide upon their level of contribution simultaneously. Sequentiality allows later contributers to observe earlier contributions, and condition their contribution on those observations. The Telethon is probably the best-known example. During some time range the amount of donations collected is on permanent display on popular medias, like television channels. At each point in time potential contributors are informed about cumulated donations since the beginning of the Telethon. Furthermore, information about specific individual contributions is provided from time to time. There are other examples where later contributors are informed about cumulated contributions of early donors, such as church contributions, contributions to public foundations or charities, countries' efforts to reduce greenhouse gas emissions, efforts to preserve natural areas, donations for helping populations suffering from natural catastrophes, … In contrast to the situation where contributions have to be made simultaneously, sequentiality is likely to affect positively individual contributions. The reason is that the provision of public information to followers about previous contributions can increase their contributions through a *leadership effect*. This may happen when early contributors make large contributions to lead by example. While several field studies support this idea (Silvermann et al., 1984, List & Lucking-Riley, 2002, Shang & Croson, 2003), they fail to isolate precisely the effect of available public information on the level of contributions. Furthermore, the effect may depend on the type and quantity of information that becomes available. For example, contributors could only observe the cumulative contributions of previous contributors, or their individual contributions. The size of the population of potential contributors might also affect the leadership effect, since with a larger population (or longer sequence), more individuals are likely to be influenced.

Most experimental research on voluntary contributions to public goods, has focused on simultaneous contribution environments. In the standard voluntary contribution experiment, subjects cannot observe the contributions of the other members of their group within a round. Individual contributions are therefore determined by the beliefs about all the other players' contributions. In contrast, when contributions are made sequentially, later players in the sequence observe the contributions of the earlier players, and beliefs concern only the contributions of the remaining players. Since this is commonly known to all the players, it affects their contribution whatever their position in the game, in spite of the asymmetric information structure that is generated by the game. In the Telethon example, donators usually know the cumulative donations of previous contributors. Later contributors who are better informed, are affected by the observation of early contributions, and early contributors are aware of their influence upon them. One reason for the influence of observed contributions is reciprocity. Agents who decide later and observe high levels of contribution might be encouraged to make a larger contribution than they would have done otherwise. On the other hand, if they observe low contributions they might also lower their expressed contribution compared to their intended contribution. Another reason is that agents who decide earlier and who expect that later decision makers will be influenced by the observed contributions, can be tempted to try to encourage them by deciding to make a high contribution. This is the so-called "leadership-effect" or "leading-by-example" effect, which has been investigated in previous experimental research by Potters et al. (2003) in the case of a public good and by Moxnes & van der Heijden (2000) in the case of a public bad. Potters et al. (2003) showed that contributions are larger in a (two-player) sequential move game than in a simultaneous move game, when the value of the public good is private knowledge. In the sequential contribution game, subjects came closer to the optimum level of contribution. In Moxnes and van der Heijden (2000) public bad experiment, one subject is called upon in each period 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. Empirical studies also showed the importance of the leadership-effect in various contexts (List & Lucking-Reiley, 2002, Shang & Croson, 2003). Experimental and empirical studies suggest therefore that contributions are influenced by the informational context induced by sequentiality, although the standard prediction is that there should be no effect.

There is however a question whether the observed effects are due to the information generated by sequential moves or by sequentiality as such, even if no information is provided to subsequent players in the decision making sequence. According to standard game theory, a change in the timing of moves has no effect on the agents' choice of actions, as long as the change in the order of moves does not reveal any further information. 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. In contrast to the standard prediction, a series of papers by Rapoport and 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 there is a first mover advantage, in that the first to decide has a tendency to take a larger part. Furthermore, for later decision-makers in the sequence, there is a tendency to take less, even in a situation with no information asymmetries (request disclosure). Cooper et al. (1993) also found a first mover advantage in battle of sexes games. When the game is played sequentially without observability, the equilibrium which is most favourable to the first mover is played more frequently[1]. In a recent study, Weber and Camerer, (2004) also showed that simply changing the timing of moves affects subjects' behavior in an ultimatum bargaining game and in a weak

[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 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.

link coordination game even if the same information set is used when moves are sequential or simultaneous. A theoretical justification of such observed differences might be found in the idea of "virtual observability" introduced by Amershi et al. (1989). In the light of the literature on timing of moves effects, it is important to separate carefully the leadership effect from any induced effect of the sequentiality of decisions[2]. To our knowledge, all the experiments which studied order of play, with the exception of Güth et al. (1998), involved a coordination problem. Common pool resource games and step-level public goods games both admit multiple Nash equilibria simply by permutating players. In contrast, our experimental game has a unique dominant strategy equilibrium for the one-shot game corresponding to the null contribution. According to Güth et al.'s (1988) we should not observe a higher frequency of deviations from equilibrium play in the positional order protocol than in the simultaneous play game.

In this paper we report the results of a public good experiment in which we try to dissociate the pure effect of sequentiality which was documented by many experiments, from the leadership effect. We designed an experiment in which subjects contribute sequentially, with two information conditions : a sequential game without information and a sequential game 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). Since the leadership effect might depend on the length of the sequence, we consider two different population sizes. We expect that early contributions might be larger in larger populations. Since we expect the leadership effect to vanish within a sequence, we should observe significant differences in contributions according to the rank of the subjects in the decision sequence, whatever the population size. Our data clearly indicate that sequentiality alone has no effect on contributions whereas the observation of previous contributions of lower ranked subjects increases the level of contribution to

[2] Coordination problems might be solved by generating some kind of asymmetry in the game, as suggested by Schelling (1960). An asymmetry in the game can be generated by simply labelling subjects according to priority of moves (first mover, second mover, …), so that some combinations of actions become more salient than others and lead therefore to equilibrium selection. Another way to solve the coordination problem is by "manipulating the Nash equilibrium" as proposed by Amershi et al., (1989). The underlying idea is that altering the game from simultaneous moves to positional order generates "virtual observability". Players are therefore likely to behave in the same way under non-observability than they would behave under observability as is the case in a standard sequential game. By relying on forward induction, a subgame perfect solution is thereby induced instead of the original Nash equilibrium. In simultaneous moves games with multiple Nash equilibria, the coordination problem would be (partly) solved by applying subgame perfection to a game with virtual observability, i.e. "players expect first movers to choose strategies as if subsequent players observe them perfectly and respond optimally" 'Weber and Camerer, 2004). The idea is that subgame perfection combined with virtual observability is used as a coordination device by selecting one of the Nash equilibria of the simultaneous moves game[2]. This idea is supported by Güth et al. (1998). On the basis of a two-player game, they showed that when virtual observability predicts a departure from equilibrium play (of the simultaneous moves game), by the first mover, subjects actually choose the various strategy combinations in the positional order protocol with the same frequencies than in the simultaneous moves game. Furthermore, they show that a deviation from equilibrium play becomes more likely when the associated outcome if more fair.

the public good. We also observe a decline of the level of contribution with the rank of the contributor when information is available to the subjects. Finally, we find that the length of the sequence has a negative impact on the level of contributions.

The paper is organized as follows. Section 2 presents the experimental design and section 3 provides the results of our study. In section 4 we discuss the results and conclude.

2. Experimental design

The experiment consisted of 16 sessions of 15 periods each. Experimental sessions were conducted both at the University of Rennes[3] and at the university of Montpellier[4] 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 than one session. The experiment was computerized using the Ztree program. On average, a session lasted about an hour and 20 minutes[5] including initial instruction 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 subjects is endowed with 10 tokens that he can invest in a private account and in a group account . Let c_i be the contribution of player i to the group account and c_{-i} the aggregate contribution of all other players - except i – to the group account. $u(c_i, c_{-i})$ is player i's payoff if he contributes c_i and the other players contribute c_{-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 $c_i = 0$. The constituent game was repeated exactly 15 periods. The unique subgame perfect equilibrium for the repeated game is for each player to contribute $c_i = 0$ each period. On the other hand, the group optimum is achieved if each player chooses to contribute the total endowment.

$$u(c_i, c_{-i}) = 10 - c_i + 0.5 \times \sum_{k=1}^{N} c_k \quad (1)$$

3 CREM (Centre de recherche en Economie et Management) ,
[4] LAMETA (Laboratoire de Recherche en Economie Théorique et Appliquée)
[5] The sequential treatments took slightly more time in large groups.

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 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 subject has an informational advantage. Indeed subjects are not informed about the individual contributions of each lower ranked subject. Finally, the third treatment is identical to the previous treatment except that each subject is informed about the individual contributions 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.

Therefore, the difference in contributions between the benchmark and the sequential treatment without information measure the pure effect of sequentiality on contributions. We hypothesize, based on the results of Budescu et al., 1995 and Weber and Camerer, 2004, that simply knowing that one player moves first might affect contributions. Indeed, Weber and Camerer, (2004) have shown that a change of the timing of moves affects behavior in the ultimatum bargaining game and the weak link coordination game even if the same information set is used when moves are sequential or simultaneous. The difference in contributions between the sequential treatments with and without information is interpreted as the effect of the information asymmetry. We hypothesize that the effect of information on contributions is positive. Finally, the difference between the sequential treatment with information and the Benchmark treatment measures the effects of both sequentiality and information asymmetry.

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 the group size lengthens the sequence and therefore might have a positive or negative influence on individual contributions. As the size of the contribution to the group account increases, the temptation to free ride in order to make a large payoff rises. This implies that the higher ranked subjects are likely to free ride more. This would imply a negative effect of group size on the average contribution. On the other hand, if subjects reciprocate earlier contributions in the sequence, the average contributions might become larger in larger groups. Furthermore, there might be a stronger 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. It is not obvious therefore what the effect of increasing the size of the group will be. The same presentation was used for all treatments[6]. 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]

3. Results

This section is organized as follows. Subsection 3.1 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 3.2 we study the determinants of the contribution behavior separately for each treatment.

3.1. 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

[6]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.

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 effects.

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[7] 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 indicate 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

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

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 contribution between each treatment according to group size indicate no significant effect of 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 sequentiality and information effects. The dependent variable is the amount of tokens contributed in the t^{th} period. The independent variables are subject's lagged contribution, the lagged average contribution of the other members of the group and several dummy variables including the variable "information" to control for a pure information effect and the variable "order" to isolate a potential sequential effect. 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 15^{th} period and value 0 in the preceding periods.

[Tables 3 about here]

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 "order alone" is not significant. 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. If the ordering effect requires subjects to deviate from the unique equilibrium, it is less likely to emerge (see Güth et al. , 1998). Finally, table 3 also indicates that the coefficients of the variables "own previous contribution" and "others average contribution in the previous period" are positive and highly significant. The interpretation of the latter results will be presented in the following sub-section

3.2. 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 their information about the individual contributions of the lower ranked subjects and by the information they "send" to higher ranked subjects trough their own contribution. In result 3 we present the effect of the rank in the group on the individual contribution level.

Results 2 :*For the simultaneous treatment and the sequential treatment without observability, the period t individual level of contribution is higher (a) the more he contributed in period t-1. and (b) the more other members of the group contributed in period t-1. For the sequential treatment with information, the period t individual level of contribution is higher (a) the more he contributed in period t-1, and (b) the more members in lower ranks contributed in period t.*

Support for result 2 : Table 4 contains the estimates of regression model (2) for the simultaneous treatment and the sequential treatment without information:

$$c^i_{\ t} = \beta_0 + \beta_1\left(c^i_{\ t-1}\right) + \beta_2\left(\overline{c}^{-i}_{t-1}\right) \qquad (2)$$

For the sequential treatment with information we estimate equation (3):

$$c^i_{\ t} = \beta_0 + \beta_1\left(c^i_{\ t-1}\right) + \beta_2\left(\overline{c}^{-i}_{t-1}\right) + \beta_3\left(c^{-i}_{r\inf\ t}\right) + \beta_4\left(position\right) \qquad (3)$$

The independent variables are subject's lagged contribution $\left(c^i_{\ t-1}\right)$, the lagged average contribution of the other members of the group $\left(\overline{c}^{-i}_{t-1}\right)$, the average contribution of lower ranked subjects in the current period $\left(c^{-i}_{r\inf\ t}\right)$ and a variable that controls for the position in the group. In the simultaneous treatment and the sequential treatment without information, subjects' contributions can only be influenced by information about past periods. 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.

[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 the variable for subjects' own previous contribution is positive. 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 the coefficient of the variable " others average contribution in the previous period" is also positive and significant for the simultaneous treatment and the sequential treatment without information. High contributions on the part of the other group members are imitated or reciprocated with high contributions in these two treatments. However this coefficient is not significant for the treatment with information. 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.

Table 4 clearly indicates that the level of contribution is decreasing with the position in the sequence in the sequential treatment with information. This result is a further indication of the existence of a "leadership effect". Indeed when contribution decisions are made sequentially, early players in the sequence may try to influence positively the contributions of subsequent decision makers in the sequence, by making a large contribution. However, 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. Such behaviour of early players is motivated by their belief that subsequent players will reciprocate by making also a large contribution. As indicated in table 4, subjects reciprocate contributions of low ranked members since we observe that the coefficient associated with the variable "contribution of the previous ranked member" is significant and positive in the sequential treatment with information. This result indicates that subjects also reciprocate contributions of members who are ranked earlier in the sequence. Indeed, high contribution on the part of other group members in lower ranks is reciprocated by high contributions.

Finally table 4 also reveals an end game effect in most of the treatments.

Result 3 indicates how the rank in the group affects the individual contribution level.

Result 3 : *The level of contribution declines with the position in the group in the sequential treatment with information whereas it remains unaffected by the position in the sequential treatment without information .*

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. Finally, figure 3 also 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. Figures 3 and 4 reveal that the average contribution of the early players in the sequence is higher than the baseline whereas the opposite is true for later players in the game.

[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. Statistical evidence for result 3 is provided in table 7 which summarizes the results of a regression of individual contributions on the position in the sequence.

[Table 7 about here]

The dependent variable c_i is the individual average contribution of player i. The variable "position 2" is 1 if the player is in second 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 first position in the game. Table 7 indicates that the position in the game does not influence the average contribution in the sequential treatment without information. However, the level of contribution shows a significant decline with the position in the sequence in the sequential treatment with information, for both group sizes. Notice that the coefficients are weaker for early positions than for later positions, revealing a stronger tendency to free ride for higher ranked subjects compared to lower ranked subjects.

4. Discussion and concluding comments

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 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.

Our main result is that the average level of contribution is significantly increased, when subjects contribute sequentially and have the opportunity to observe previous contributions. Observability influences both early contributors, through the leadership effect, and later contributors, who reciprocate observed contributions. First, our results reveal that individuals who decide later and observe high levels of contribution exhibit a tendency to reciprocate these decisions by making a high contribution as well. This result indicates that some part of the subject's contribution is not intrinsically motivated but is conditioned on observed contributions, in line with earlier findings on conditional cooperation (Keser & van Winden, 2000). However, under observability, the level of contribution is no longer conditioned on the previous period average contribution, but on the previous contributions observed within the period. Second, subjects who decide earlier in the sequence and who expect that later decision makers will be influenced by their contribution, try to encourage them by making a large contribution. This is what we called the leadership effect. However, as the decision sequence moves toward the last player, implying that fewer players are likely to be influenced, the leadership effect vanishes. As a consequence the average contribution declines in the higher ranks of the game.

From our experimental findings we conclude that with sequential contributions and observability the leadership effect increases the average level of contributions, independently of group size. Clearly, first movers do not exploit their position by making a low contribution, but in contrast make a large contribution. In some sense they act as if they felt moral obligation to lead by example, in order to increase group contributions. Such moral obligation is typically absent when contributions are made simultaneously or when contributions are made sequentially without observability.

The fact that later contributors are influenced by the observed contributions of early players, can have important policy implications. As already mentioned, our main result clearly demonstrates that intrinsic motivation is not the sole reason why agents contribute to the public good. Posting information on previous contributions might be enough to increase 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 contribution to the socially optimal level.

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Figure 1. Average contribution level per period for N=4

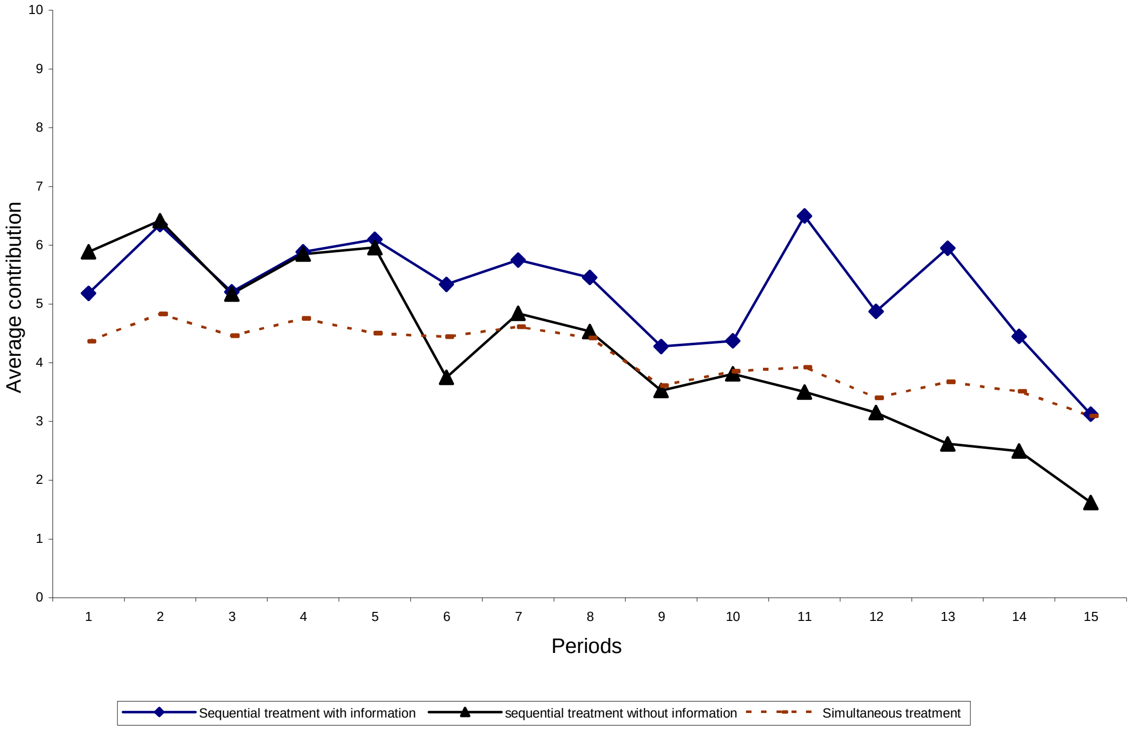

Figure 2. Average contribution level per period for N = 8

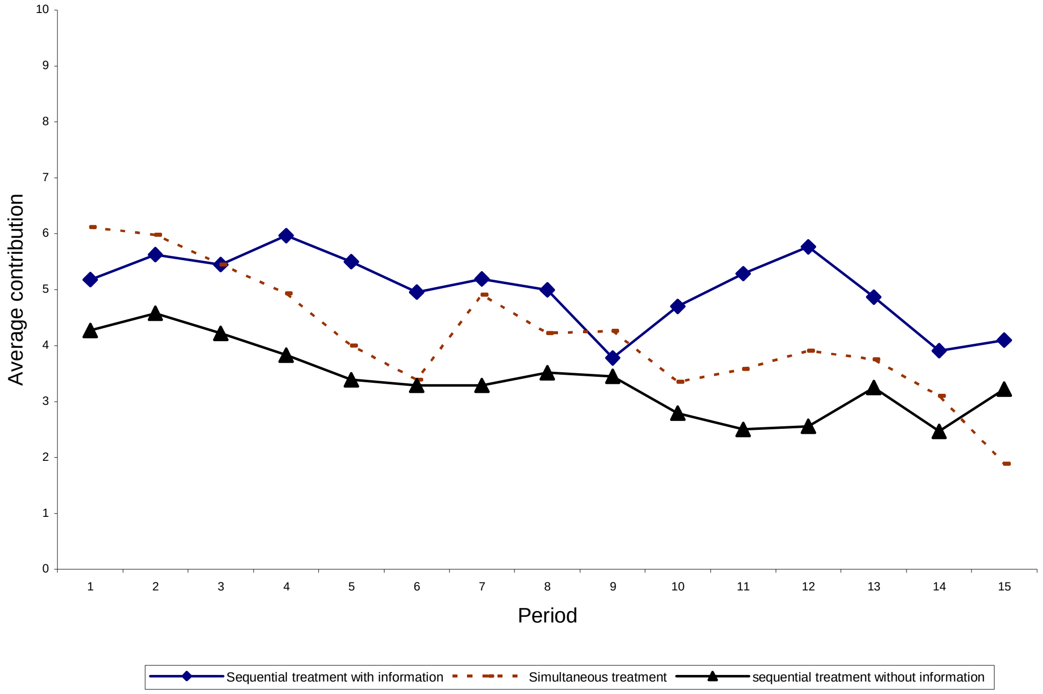

Figure 3. Average Contribution for each position in the game (size N=4)

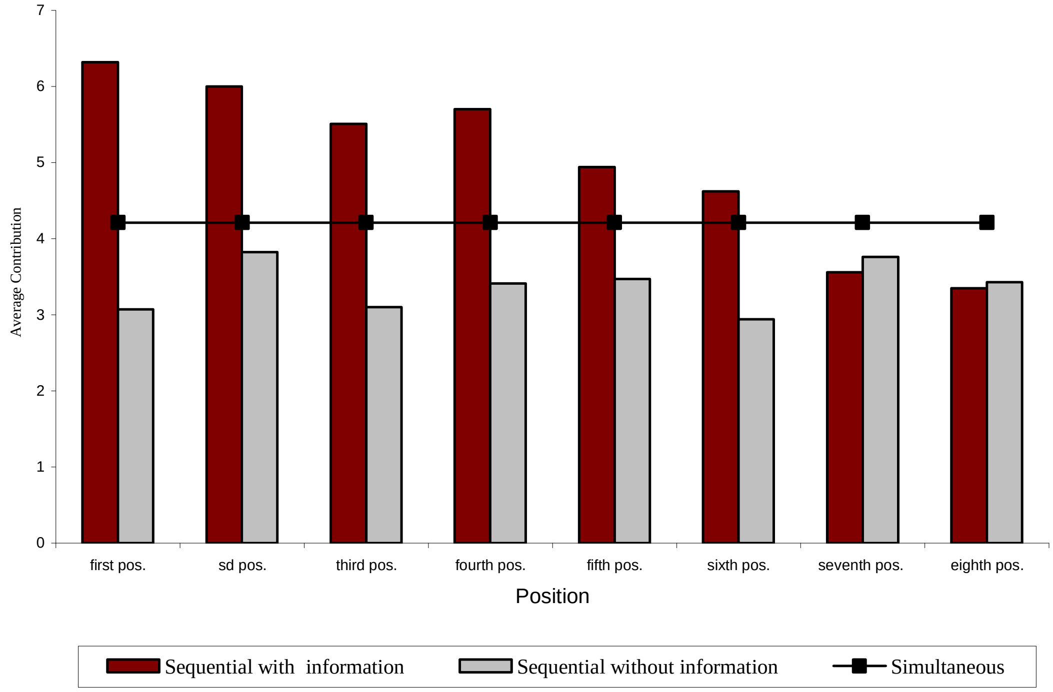

Figure 4 . Average Contribution for each position in the game (size N=8)

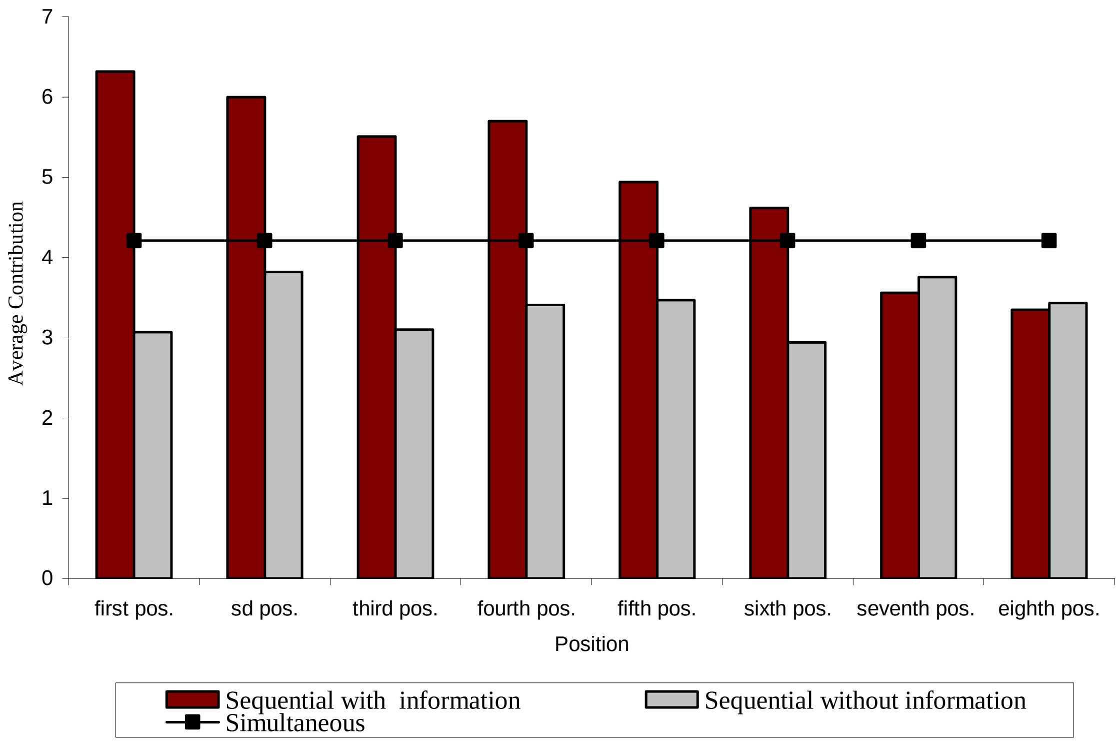

Table 1: Number of independent observations per cell

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		
	Null info	Order	Full info	Null info	Order	info
1	4.3# (2.94)	5.4 (4.57)	4.58 (3.67)	4.84 (3.44)	2.65 (3.43)	3.85 (3.08)
2	4.15# (2.83)	4.7 (3.17)	6.23 (3.11)	4.95 (3.38)	2.7 (2.5)	3.88 (3.85)
3	5.91# (2.33)	4.28 (4.72)	5.15 (2.99)	3.48 (3.44)	3.22 (2.43)	6.025 (3.08)
4	2.78# (3.26)	5.93 (3.06)	5.53 (3.31)	5.26 (3.34)	4.28 (2.91)	5.50 (4.03)
5	5.25# (2.93)	4.21 (3.12)	5.35 (3.30)	3.52 (3.61)	4.05 (3.04)	4.24 (2.22)
6	6.08# (2.52)	4.1 (3.05)	4.68 (3.11)	3.18 (3.35)	3.34 (2.72)	6.53 (4.28)
7	2.61# (2.96)	2.28 (2.59)				
8	2.5# (2.48)	3.05 (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 (2.68)	4.24 (3.41)	5.25 (3.32)	4.20 (3.42)	3.37 (2.83)	5.03 (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*** (0.035)	0.289*** (0.027)	0.412*** (0.027)	0.368*** (0.026)	0.426*** (0.029)	0.315*** (0.027)
Others's average cbt (lagged)	0.290*** (0.052)	0.133** (0.057)	0.287*** (0.040)	0.221*** (0.057)	0.161*** (0.043)	0.171*** (0.054)
Information effect	0.654*** (0.242)	0.966*** (0.199)				
Order effect			-0.144 (0.171)	-0.175 (0.175)		
Seq*Information					0.454** (0.190)	0.584*** (0.191)
Period 15	-1.728*** (0.462)	-0.055 (0.342)	-0.841*** (0.326)	-0.526* (0.328)	-0.981*** (0.331)	-1.014*** (0.369)
Constant	2.028*** (0.295)	1.887*** (0.238)	1.227*** (0.209)	1.532*** (0.288)	1.701*** (0.218)	2.017*** (0.279)
Observations	784	1344	1176	1344	1064	1344
Number of individu	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. (1) N=4	Simult treat. (2) N=8	Seq treat. without info (3) N=4	Seq treat. without info (4) N=8	Seq. Treat. with info (5) N=4	Seq. Treat. with info (6) N=8
i's contribution (lagged)	0.564***	0.377***	0.238***	0.349***	0.189***	0.246***
	(0.031)	(0.036)	(0.045)	(0.037)	(0.059)	(0.040)
Others' average cbt (lagged)	0.191***	0.230***	0.391***	0.177**	0.040	0.060
	(0.047)	(0.076)	(0.068)	(0.090)	(0.090)	(0.079)
Position in the group			-0.015	-0.004	-1.318***	-0.460***
			(0.140)	(0.046)	(0.233)	(0.071)
Contribution of previous rank					0.268***	0.169***
					(0.067)	(0.041)
Period 15	-0.531	-1.509***	-1.419**	0.423	-1.864**	-0.490
	(0.352)	(0.502)	(0.625)	(0.422)	(0.741)	(0.541)
Constant	0.972***	1.518***	1.469***	1.521***	6.137***	4.646***
	(0.231)	(0.368)	(0.506)	(0.403)	(0.969)	(0.594)
Observations	728	672	448	672	252	588
R2	0.36	0.19	0.18	0.12	0.26	0.18

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	6.33	2.26	5.4	5.13	6.2
	(3.67)	(3.24)	(3.43)	(4.57)	(4.77)	(4.49)
2	6.23	7.33	4.33	4.7	3.8	4
	(3.11)	(1.87)	(3.90)	(3.17)	(3.21)	(3.11)
3	5.15	6.86	3.4	4.28	4.33	4.73
	(2.99)	(2.16)	(3.37)	(4.72)	(4.77)	(4.90)
4	5.53	6.33	3.13	5.93	5.46	4.93
	(3.31)	(2.60)	(3.15)	(3.06)	(2.97)	(3.69)
5	5.35	6.93	2.86	4.21	3	3.66
	(3.30)	(2.93)	(2.58)	(3.12)	(2.92)	(2.46)
6	4.68	4.4	4.13	4.1	5.33	4.13
	(3.11)	(2.13)	(3.92)	(3.05)	(3.08)	(2.97)
7				2.28	1.53	1.8
				(2.59)	(1.84)	(3.12)
8				3.05	3	3.8
				(3.03)	(3.42)	(2.73)
	5.25	6.36	3.35	4.24	3.94	4.15
	(3.32)	(2.64)	(3.40)	(3.41)	(3.37)	(3.43)

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

	Sequential treatment with info			Sequential treatment without info		
	All positions	First position	Last position	All position	First position	Last position
G1	3.85	4.26	2	2.65	3.13	2.93
	(3.08)	(3.41)	(2.23)	(3.43)	(3.96)	(3.55)
G2	3.88	6.33	.93	2.7	2.8	2.53
	(3.85)	(3.19)	(2.63)	(2.5)	(2.30)	(2.79)
G3	6.025	8.26	6.2	3.22	3.46	3.2
	(3.08)	(1.83)	(3.91)	(2.43)	(2.41)	(1.89)
G4	5.50	7.86	2.66	4.28	4.2	4.06
	(4.03)	(3.02)	(4.23)	(2.91)	(3.12)	(3.08)
G5	4.24	4.6	2.8	4.05	2.46	5
	(2.22)	(2.55)	(2.54)	(3.04)	(2.19)	(3.31)
G6	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

	N=4		N=8	
	Sequential with Information	Sequential without information	Sequential with Information	Sequential without information
Position 2	-.29629	.69960	-.7589*	.4628
	(.4405)	(.4453)	(.4471)	(.3938)
Position 3	-1.2918***	.15924	1.148***	-.24422
	(.43902)	(.44604)	(.442)	(.39239)
Position 4	-3.096***	.30265	-1.058**	.3260
	(.44085)	(.4474)	(.443)	(.3958)
Position 5			-1.870***	.2673
			(.4551)	(.39465)
Position 6			-2.158***	-.24166
			(.4458)	(.3976)
Position 7			-3.470***	.4218
			(.44779)	(.3925)
Position 8			-3.58***	.0985
			(.447)	(.3941)
Constant	6.4266***	3.955***	6.760***	3.2428***
	(.3666)	(.3860)	(.4204)	(.3365)
sigma_u	.95514034	1.2634	1.936	1.308
sigma_e	2.9283759	3.4169	2.899	2.5716
Rho	.09615557	.12028	.3083	.20555
Observations	360	480	720	720

*** 1% significance level. ** 5% significance level. * 10% significance level. Standard error in parenthesis

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