The first follower effect in a public good game

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Abstract: A successful leader needs followers, and so the actions of the first follower can prove critical. We explore the role of first followers in a linear public good setting by contrasting four games that differ in the timing of investments. The standard leader and sequential games are compared with a first follower game, where the first follower acts as a bridge between the leader and subsequent followers, and a shared leader game, where there are two leaders. Theoretical results are provided detailing conditions under which expected investment is highest in the first follower game. We then provide the results of an experimental study where total investment is highest in the first follower game.

1. Introduction

Successful leadership is as much about followers as it is leaders. This point was powerfully made by Derek Sivers during a TED talk in 2013. He used the example of youngsters dancing at a music concert to illustrate how a 'lone nut', plus a first follower, and then a second follower becomes a movement. Without the first follower we merely have a lone nut; the first follower is critical to the success of the movement in showing others 'how to follow'. The notion that successful leadership is about more than leaders is now firmly established within the leadership literature (e.g. Bolden et al. 2011). Theories of shared and distributed leadership, for instance, see leadership as a dynamic process in which members of a group influence each other (e.g. Heenan and Bennis 1999, Pearce and Conger 2003, Pearce, Conger and Locke 2008).

A number of studies have looked at leadership in social dilemmas (e.g. Moxnes and Heijden 2003, Arbak and Villeval 2011, Rivas and Sutter 2011, Figuieres, Masclet and Willinger 2012, Cartwright, Gillet and van Vugt 2013). The focus of this literature, however, has almost exclusively been on *leadership by example*. In particular, attention has focused on a setting where one member of a group (the leader) makes a choice before others in the group (the followers) make theirs. If we view leadership as a dynamic group process then this focus on one particular organizational structure appears unduly constraining. Indeed, the first follower effect, described by Sivers, simply could not happen. It seems critical, therefore, to compare leadership by example with other possible leadership structures. That is the approach we take in this paper.

We focus on leadership in a linear public good game. This is the most common social dilemma used for studying leadership and so provides a natural starting point. The simplicity of the game also allows us to make precise theoretical predictions about behaviour. Our approach is to compare, theoretically and experimentally, four different types of organizational structure. Two of these structures have been studied before, namely, *leadership by example*, as previously described, and *sequential* choice, wherein group members choose in turn. The first alternative structure we consider will be called *first followership*; here one group member chooses first (the leader) then a second (the first follower) and then all others (the followers). The second alternative structure we consider will be called *shared leadership;* here two group members choose first (the shared leaders) and then all others (the followers).[1]

We would argue that the first followership structure can capture, in an admittedly stylized way, the first follower effect described by Sivers. This, therefore, is the structure about which we are particularly interested. A shared leadership structure is of interest in its own right. Our primary motivation| in considering this structure is, however, as the natural comparator to first followership. In particular, in both structures there are two group members who act before all others; the only difference is whether the two 'early movers' act at the same time (shared leadership) or in turn (first followership). Of interest is whether outcomes differ between first followership and shared leadership, despite this relatively subtle change.

[1] Figuries et al. (2012) mention the possibility of a public good game with two leaders.

Clearly it is also of interest to compare outcomes in these new structures with the two standard structures already familiar in the literature.

In Section 3 of the paper we work through a theoretical model of strategic leadership to compare the four organizational structures. Our results highlight two key determinants of predicted efficiency: (1) The structure itself can lead to different outcomes even if behaviour remains unchanged. Shared leadership, for instance, is particularly conducive to efficiency in this regard. This is essentially because shared leadership results in two chances for someone to set a 'good example'. (2) Behaviour, however, will likely *not* remain constant across structures. In particular, the incentives of first (and second) movers differ across structures. In this regard, leadership by example is particularly conducive to efficiency. This is essentially because the leader's pivotal role increases the incentive to set a good example.

Through a series of examples we shall show that the interplay between (1) and (2) means that no structure comes out as a clear winner. The relative efficiency of structures depend on parameters of the game, such as the number of players and return to the public good. We shall discuss in some detail the conditions under which first followership is best and argue that it is a relatively versatile structure. This versatility stems from the incentive for the leader to set a good example combined with the fact that two group members can influence others. Note that our analysis, see points (1) and (2), speak directly to the notion that successful leadership is about a group process and not just the actions of a leader. For instance, the shared leadership structure may be best even though the incentives for a leader to set a good example are relatively weak.

In Section 4 of the paper we report on an experimental study to compare efficiency and behaviour across the four organizational structures. We find that first followership results in the highest efficiency. Indeed, we find that outcomes are remarkably consistent with our theoretical model with one exception, namely, efficiency in the leadership by example is lower than predicted. This latter finding is of note because the prior evidence on leadership by example is mixed. In particular, a number of studies have found that contributions with an exogenous leader are no higher than in simultaneous games (e.g. Potters et al. 2007).[2] Our experimental results can offer insight on why exogenous leadership by example increases efficiency less than might be expected. We shall suggest the problem is a lack of strategic leadership.

In our study it was optimal for a (selfish) leader to invest in the public project in the leadership by example, first follower and sequential settings (but not the shared leadership setting). In the leadership by example setting, however, we saw little evidence of strategic leadership. One possible reason for this is the 'leaders curse' (Gächter and Renner 2014) whereby leaders earn lower payoffs than followers. If a leader invests in the project then he likely earns a higher payoff but also sees a gap between his payoff and that of others. In the leadership by example setting there is a sense in which the leader stands alone in making this 'sacrifice'. In the first follower and shared leadership settings, by contrast, this sacrifice may

[2] Leadership has proved more successful when endogenous (Haigner and Wakolbinger 2010, Rivas and Sutter 2011 and Arbak and Villeval 2013) or if leaders have additional information (Potters et al. 2007), there is asymmetry (Levati et al, 2007) or leaders have the power to exclude (Guth et al 2007).

seem shared. That, in turn, may increase willingness to invest. We expand on this discussion in Section 5.

2. Four organizational structures

We consider the standard linear public good setting. There are n players in a group, $N = \{1, \dots, n\}$. Each player is endowed with E units of a private good and has to decide how much of their endowment to invest into a public project. Let $x_i \in [0, E]$ denote the investment of player $i \in N$ and let $X = \sum_{i \in N} x_i$ denote total investment. Once all players in the group have invested, the total investment X is multiplied by factor $M > 0$ and split equally amongst all players. Let $m = M/n$ denote the MPCR (Marginal Per Capita Return) on the public project. The payoff to player $i \in N$ is given by

$$u_i(x_1, \dots, x_n) = E - x_i + mX.$$

Our main objective in the following is to compare and contrast games that differ in the timing of investment decisions. So, let $T = \{1,2, \dots, n\}$ be a set of time periods. For any player $i \in N$ there exists a unique time $t_i \in T$ at which player i must decide how much to invest. Note that we shall consider exogenous timing games and so a player i has not choice over t_i. For any player $i \in N$ let $B(i) = \{j \in N: t_j < t_i\}$ be the set of players who must choose to invest before player j. Similarly let $M(i) = \{j \in N\}: t_j = t_i\}$ and $A(i) = \{j \in N: t_j > t_i\}$ be the set of players that choose, respectively, at the same time and after player i. Crucially, we assume that player i invests knowing the investment of every player in set $B(i)$ (but not knowing the investment of any player in set $M(i)$ and $A(i)$). In other words, investments are publicly observed in real time.

We are now in a position to introduce four games that differ in the timing of investments. In a leader by example game (subsequently called **leader game**) player 1 invests first, $t_1 = 1$, and all other players subsequently invest simultaneously, $t_2 = \cdots = t_n = 2$. This game has been widely studied in the literature (e.g. Rivas and Sutter 2011). In a **sequential game** player i invests in time period i, $t_i = i$ for all $i \in N$, and so player's invest according to an exogenously given sequence. This game has also been studied in the public good literature (e.g. Coats et al. 2009).

As discussed in the introduction a particular objective of the current study is to consider a **first follower game**. In this game player 1 invests first, $t_1 = 1$, player 2 invests second, $t_2 = 2$, and then all others invest simultaneously, $t_3 = \cdots t_n = 3$. Note that this game differs from a leader game solely in the fact that player 2 chooses to invest before players 3 to n. Even so, this means that sets $B(i)$, $M(i)$ and $A(i)$ change for every player $i \neq 1$. As a comparator to the first follower game we shall consider a **shared leadership game**. In this game players 1 and 2 simultaneously invest in the first period, $t_1 = t_2 = 1$, and then all others invest simultaneously, $t_3 = \cdots t_n = 2$. Note that sets $B(i)$, $M(i)$ and $A(i)$ are identical in the first follower and shared leadership games for any player $i > 2$. The only difference, therefore, is the relative timing of player 1 and 2 investments.

Note that we shall follow the economic literature in using a positional definition of leader and follower. Hence, a player is viewed as a leader or follower depending on whether they move first, second, or so forth. Underlying our approach, however, is an interest in process leadership. In particular, we are interested in what makes someone a 'successful' leader, and how this depends on the organizational structure and behavior of followers.

3. Strategic Leadership

Standard game theoretic arguments lead to the simple prediction, in all four games, that every player $i \in N$ should invest zero. While these arguments are well rehearsed in the literature it will prove useful to briefly summarize them here. Consider, any player $i \in N$ that will move last, that is, a player for whom $|A(i)| = 0$. By construction, player i's investment cannot influence any other player. Thus, every unit he keeps in his private account will give payoff 1 and every unit invested in the group project will give payoff $m < 1$. Player i has a dominant strategy to invest zero.

Consider next, any player $i \in N$ that will move in the penultimate investment period. Player i knows that his investment will be observed by players in set $A(i)$. Thus, player i's investment could potentially influence others. We recall, however, that players in set $A(i)$ have a dominant strategy to invest zero. This would suggest that player i's investment should not actually influence others and so he should invest zero. More formally, iterated deletion of dominant strategies means that in any Nash equilibrium player i must invest zero.[3] The proceeding discussion is already enough to argue that the unique Nash equilibrium in a leader and shared leadership game is that all players invest zero. It is simple enough to extend the argument for the first follower and sequential game.

A Nash equilibrium of zero contributions stands in stark contrast to the experimental evidence. Numerous studies have shown that people are willing to invest to group projects. Particularly relevant for us is the strong evidence for conditional cooperation where a conditional cooperator is someone whose investment is increasing in the average investment of others (e.g. Fischbacher et al. 2001, Croson 2007). What happens if we take the evidence for conditional cooperation and insert it back into the earlier derivation of a Nash equilibrium? First, we see that a player who moves last may not contribute zero. Second, and crucially for our purposes, we see that a player who moves before last should take into account the effect their investment will have on subsequent players. Both of these observations follow directly from the fact that a conditional cooperator will positively reciprocate earlier investments. Conditional cooperation, therefore, gives rise to the potential for *strategic leadership*: a player may find it optimal to invest a positive amount if he believes that this will indirectly increase the investment of others (Potters et al. 2007, Cartwright and Patel 2010, see also Kreps et al. 1982).[4]

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[3] A Nash equilibrium is a profile of investments such that no player has an incentive to change his investment given the investment of others.

[4] Note that this argument for strategic leadership is distinct from the argument that more informed leaders can influence followers (e.g. Potters et al. 2005). In the first case strategic leadership is driven by the potential for conditional cooperation while in the second it is driven by signalling. Potters et al. (2007) considered a setting where both these possibilities could be directly compared

In order to make some specific predictions about strategic leadership we shall work through a simple model. The model is stylized but captures the essential features of interest. We assume that there are two types of player – conditional cooperators and strategists. We introduce each in turn. Conditional cooperators are 'automata' who invest an amount equal to the average investment of those before them. More specifically, for any $i \in N$ where $t_i > 1$ let

$$\acute{x}(i) = \frac{1}{|B(i)|} \sum_{j \in B(j)} x_j$$

denote the average investment of those who move before player i. If player i is a conditional cooperator then he will invest $x_i = \acute{x}(i)$. We emphasize that our objective in this paper is not to question the motives or origins of conditional cooperation. We simply take it as given that conditional cooperators exist. It is also worth emphasizing that the results to follow are not dependent on the specific form of conditional cooperation we have assumed. For example, the empirical evidence suggests that conditional cooperators often invest less than the average investment of others. It would be straightforward to extend our results to a more general setting where a conditional cooperator i invests $x_i = \alpha \acute{x}(i)$ for some constant α.[5]

A strategist is someone who acts to maximize his own material payoff. Crucially, we allow that a strategist may take into account the possibility for conditional cooperation. Specifically, if player i is a strategist then he has beliefs p_i where p_i is the probability he puts on a randomly selected player being a conditional cooperator (with $1 - p_i$ the probability they are a strategist). We shall allow for heterogeneity in beliefs. If $p_i = 0$ then player i does not expect any conditional cooperation. In this case (we shall formally show this below) he will invest zero. If $p_i > 0$ then player i does expect some conditional cooperation. This opens up the potential for strategic leadership. Our objective in the following is to solve for the optimal strategy of a strategist.

3.1 First Mover

Let us begin the analysis with first movers. To illustrate the ideas behind strategic leadership we shall work through the Leader game, which is easily the simplest of the four games to analyse. We then provide general results covering all four games.

Suppose the first mover, player 1, is a strategist and invests L. Each of the, $n-1$, second movers will invest L if they are a conditional cooperator and 0 if a strategist. The expected total investment of others is, therefore, $(n-1)p_1 L$. This means the expected payoff of player 1 if he invests L is given by

$$U(L) = E - L + mL(1 + (n-1)p_1).$$

Here we can clearly see a direct and indirect benefit of investing in the group project. The direct benefit of investing a unit in the group project is simply m. The indirect benefit is the

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and found that signalling was more important. There setting, however, was one with relatively little incentive to invest even if reciprocity was expected.

[5] We could also allow heterogeneity in conditional cooperation.

likely increase in the investment of others as given by $m(n-1)p_1$. Investing a positive amount is optimal if $m(1+(n-1)p_1) > 1$. This gives a critical value for p_1 of

$$p^L = \frac{1-m}{(n-1)m}.$$

If $p_1 > p^L$ then the first mover maximizes expected payoff by investing E. If $p_1 < p^L$ he does best to invest 0.

To put some context to this condition, consider a setting where $n = 4$ and $m = 0.4$. Then $p^L = 2/7$. Experimental evidence suggests that the proportion of conditional cooperators is around 50-70% (e.g. Fischbacher et al. 2001, Cartwright and Lovett 2014). If, therefore, the first mover has beliefs consistent with this evidence, say $p_1 = 0.5$, it would be optimal for her to invest E. Only if the first mover has relatively pessimistic beliefs with regard to the extent of conditional cooperation would it be optimal for her to invest zero. Clearly, p^L is a decreasing function of m and n. The intuition for these comparative statics is straightforward in that a higher MPCR and larger number of second movers increase both the direct and indirect benefits of investing in the group project.

In all of the four games we shall study there exists a critical value of p above which a first mover maximizes expected payoff by contributing E (and below which she maximizes expected payoff by contributing 0). Let p^{2L},p^{FF} and p^S denote this critical value in the shared leader, first follower and sequential games respectively. Our first result (proved in an appendix) details these critical values. Note that for the sequential game it is only possible to derive an implicit solution (Cartwright and Patel 2010).

Proposition 1: In the leader, shared leader, first follower and sequential game a strategic first mover, player i, will invest E if and only if $p_i > p^L, p^{2L}, p^{FF}, p^S$, respectively, (otherwise she invests 0) where

$$p^L = \frac{1-m}{(n-1)m}, p^{2L} = \frac{2(1-m)}{(n-2)m},$$

$$p^{FF} = \frac{\sqrt{n^2 - 8(n-2)\left(1-\frac{1}{m}\right)} - n}{2(n-2)}, \prod_{j=1}^{n-1} \frac{j}{p^S + j} = m.$$

To help with the interpretation of Proposition 1 we provide an immediate corollary. This corollary shows that a strategic first mover has 'more incentive' to invest in the leader game than in the first follower game, and more incentive in the first follower game than either the shared leader or sequential game.

Corollary 1: It must hold that $p^L < p^{FF} < p^{2L}, p^S$. Depending on the values of n and m it may be that $p^{2L} > p^S$ or $p^{2L} < p^S$.

The intuition behind Corollary 1 is relatively straightforward. In a leader game the first mover (i) can directly influence all n – 1 other players, and (ii) is the only player who can influence them. The first mover is, therefore, completely pivotal and this provides a strong incentive to invest and 'lead by example'. In the first follower game the first mover can still directly influence the n – 1 other players but she is not the only player who can do so. In particular the investment of the second mover inevitably dilutes the influence of the first mover. This reduces the incentive to invest; for instance, if the 'leader sets of a good example' this may be offset by a 'bad first follower'.

In the sequential game the influence of the first mover becomes even more diluted than in the first follower game because there is a third mover, fourth mover and so on. In a shared leadership game the influence of the first mover is diluted by their being two first movers. This, in itself, is similar to the first follower game. Note, though, that a first mover in the shared leadership game can have no influence on the other first mover (while the first mover in a first follower game can influence the second mover). In other words, a first mover can only influence $n-2$ other players as compared to $n-1$ in the other three games.

3.2 Second Mover

It is not only the first mover that may have an incentive to invest strategically. Before we explore the implications of Corollary 1 in more detail we, therefore, consider the second mover in the first follower game. Suppose the leader has invested L. If the second mover, player 2, invests K then the average investment observed by the other $n-2$ players will be $(L+K)/2$. So, if player 2 is a strategist his expected payoff can be written

$$U(K) = E - K + m\left(L + K + \frac{(n-2)p_2(X+K)}{2}\right).$$

Differentiating this with respect to K and setting equal to 0 gives a critical value of

$$p^{FF2} = \frac{2(1-m)}{(n-2)m}$$

If $p_2 > p^{FF2}$ then player 2 maximizes his expected payoff by investing E, while if $p_2 < p^{FF2}$ he maximizes his expected payoff by investing 0.

The incentives of the second mover in a sequential game were analyzed by Cartwright and Patel (2010). We can immediately, therefore, proceed to our second proposition and corollary.

Proposition 2: In the first follower and sequential game a strategic second mover, player i, will invest E if and only if $p_i > p^{FF2}, p^{S2}$, respectively, where

$$p^{FF2} = \frac{2(1-m)}{(n-2)m}, \prod_{j=2}^{n-1} \frac{j}{p^{S2}+j} = m.$$

Corollary 2: It must hold that $p^{FF2} = p^{2L} < p^{S2}$. Also $p^S < p^{S2}$.

The equivalence, $p^{FF2} = p^{2L}$ means that the incentives of a strategic second mover in a first follower game are identical to those of the first mover in a shared leadership game. This is more than a coincidence. In each case the strategist has to take as given the investment of one player and potentially influence that of $n-2$ others. The fact that the strategist knows the investment of this other player in the first follower game (but not in a shared leadership game) is irrelevant.

3.3 Total Investment

Having looked at the incentives of the first and second mover we can now turn our attention to expected total investments. In doing so, we need some further preliminaries. One thing we need to do is tie down the behavior of a conditional cooperator in the event she is a first mover. We shall assume that she would invest her total endowment E. This assumption appears relatively innocuous given the available evidence (e.g. Fischbacher and Gächter 2010) and can easily be relaxed. The other thing we need to tie down are the beliefs of strategists. Let p denote the actual proportion of conditional cooperators in the population. We then assume that there exists a cumulative distribution function G that captures the distribution of strategist beliefs. Specifically, $G(y)$ is the probability that a (randomly chosen) strategist i has beliefs $p_i \leq y$.

We are now in a position to make predictions on total investment to the group project. To illustrate, consider the leader game. With probability p the first mover, player 1, is a conditional cooperator and invests E. With probability $1-p$ the first mover is a strategist, in which case we need to take account of p^L and apply Proposition 1. With probability $G(p^L)$ the strategist will invest 0 because she does not believe a high investment will pay back. With probability $1 - G(p^L)$ she will invest E. If the first mover invests E then each of the, $n-1$, second movers will invest E if they are a conditional cooperator and 0 if a strategist. If the first mover invests 0 then all second movers will invest 0. So, expected total investment is

$$X^L(n,p,G,m) = \left(p + (1-p)\left(1 - G(p^L)\right)\right) E(1 + (n-1)p). \, (1)$$

Expected total investment can be similarly calculated for the other three games. Let X^{FF}, X^{2L} and X^S denote the respectively values. With these values to hand we can rank games in terms of the first best, the one that maximizes total investment (and, therefore, efficiency), second best, etc. Some simple examples (provided in an appendix) are enough to show that there is no unambiguous first best. For different beliefs and values of n, p and m the relative rank of the four different games can change considerably. Indeed, any organization structure can be most efficient.

To explore the reasons for this we shall look in more detail at how efficiency in the first follower game compares to that in other games. In particular, we provide a general statement detailing when expected investment is higher in the first follower game than shared leadership game and a less general, but still useful, statement regarding the leader and sequential games. (In the proof of the proposition we show that general statements are relatively easy to derive for the leader and sequential games but they are cumbersome and difficult to interpret. Our method of proof is also easily extended to other comparisons, such as that between leader and shared leader, but we omit details because of the large number of possible combinations.)

Proposition 3: (a) Expected total investment is weakly higher in the first follower game than the shared leadership game, $X^{FF} \geq X^{2L}$, if and only if

$$G(p^{FF})(1+p) \leq G(p^{2L}).$$

(b) If $G(p^{FF}) = 0$ then expected total investment is weakly higher in the first follower game than leader game, $X^{FF} \geq X^L$, if and only if

$$G(p^{2L}) \leq \frac{2}{2 + (n-2)p(1-p)}.$$

(c) If $G(p^{S2}) = 1$ then expected total investment is weakly higher in the first follower game than sequential game.

To put some context to Proposition 3 let us consider sufficient (not necessary) conditions under which the expected total investment in the first follower game is higher than in the other three games. Essentially we need $G(p^{FF})$ to be small, $G(p^{2L})$ to be large not too large and $G(p^{S2})$ to be large. For instance, if $n = 4$ and $p = 0.6$ then a simple application of Proposition 3 shows that the first follower game maximizes expected total investment if $G(p^{FF}) = 0, G(p^{2L} = 2/3) < 10/11$ and $G(p^{S2}) = 1$. The intuition behind this finding is relatively straightforward and gives general insight on the merits of different leadership structures. Let us consider, in turn, parts (a)-(c) of Proposition 3.

We know (Corollary 1) that there is more incentive for the leader to set a good example in the first follower than shared leadership game. The gap between $G(p^{FF})$ and $G(p^{2L})$ is one way to capture this, and the larger the gap the more likely it is that a player would invest E if leader in the first follower game but 0 in the shared leader game. Note, however, that it is not enough simply that $G(p^{FF}) > G(p^{2L})$. This is because in the shared leader structure there are shared leaders who could set a good example. The chance that *both* of these invest 0 may be low. So, the advantage of the first follower structure is that it increases the likelihood a particular leader will invest E, while the advantage of shared leadership is that it decreases the likelihood the average investment of leaders is 0.

We also know (Corollary 1) that there is more incentive for the leader to set a good example in the leader than first follower game. This is the main advantage of the leader structure. Part (b) of Proposition 3 makes clear, however, that this is not the only relevant factor. If $G(p^{FF}) = 0$ then leaders in both the leader and first follower game will invest E and yet still either structure could be more efficient. This comes down to the incentives of the first follower. If the first follower invests 0 then overall investment would be lower relative to what it would have been in the leader game. But a strategic first follower may have an incentive to invest E when he would invest 0 in the leader game. The lower is $G(p^{2L})$ the more likely is this latter scenario. This logic naturally extends to a comparison between the first follower and sequential structures. If the sequential game is to be more efficient then it must be because it incentivizes a strategic third, fourth mover and so on to invest E. This cannot happen if $G(p^{S2}) = 1$.

Proposition 3 and the proceeding discussion has focused on showing that the first follower game *can* be best in terms of maximizing expected investment. We remind, however, that any of the four games we have considered can be best depending on n, p and m. It is vital, therefore, to test whether the predictions of the model stand up to scrutiny. To this we now with a description of our experimental study.

4 Experiment Design

Our experimental study had four treatments corresponding to the four different games introduced above. For all treatments we set $m = 0.4, E = 5$ and$n = 5$. The parameters most commonly studied are the literature are $m = 0.4$ and $n = 4$. For consistency with prior studies we wanted to stay as close to this setting as possible. The problem with$n = 4$, however, is that there is little incentive for strategic leadership in any game other than the leader game. As the following discussion will illustrate things become more interesting when $n = 5$.

Table 1 reports the critical values of p when $m = 0.4$ and $n = 5$. Notice that in the shared leadership game a strategist should contribute 0 irrespective of her beliefs. By contrast, in the other three games a strategic leader may well have an incentive to invest E. Indeed, recall that realistic estimates of p are around 0.5-0.7; a strategist with beliefs in this range would be predicted to invest E. Finally, note that the incentives of a strategic leader and first follower are almost identical in the first follower and sequential games. These observations lead to some straightforward hypotheses. The first merely requires that $G(0.51) < 1$. The second that $G(0.25) < G(0.47)$.

Hypothesis 1: Leaders will contribute more in the leader, first follower and sequential treatments than the shared leader treatment.

Hypothesis 2: Leaders will contribute more in the leader than first follower and sequential treatments.

Table 1 Incentive for leaders and first followers to invest their endowment

Treatment/game	First mover	Second mover
Leader	$p^L = 0.25$	n/a
First Follower	$p^{FF} = 0.47$	$p^{2L} = 1$
Shared leader	$p^{2L} = 1$	n/a
Sequential	$p^{SS} = 0.51$	$p^{S2} = 1$

Consider next expected total investment. We know (see Proposition 3c and Table 1) that predicted investment is less in the sequential game than first follower game. We can also infer from Proposition 3b that predicted investment is likely to be lower in the first follower game than leader game. More specifically, even under the unrealistic assumption that $G(p^{FF}) = 0$, investment is predicted to be higher in the leader game if $p > 1/3$ and all the evidence suggests $p > 1/3$. With this we obtain our next hypothesis.

Hypothesis 3: Total investment will be higher in the leader game than first follower game, and higher in the first follower game than sequential game.

Tying down where the shared leadership game fits in terms of predicted investment is less straightforward. We know, (see Proposition 3a) that predicted investment is higher in the first follower than shared leadership game if and only if $G(p^{FF}) \leq 1/(1+p)$. But, for plausible values of p this appears a relatively borderline condition. For instance if $p = 0.5$ we would require a third of strategists to believe $p \geq 0.5$. Without more evidence it is difficult to judge whether this would hold or not.

In Table 2 we report predicted total investment under a variety of scenarios. Beliefs, G, are assumed to have a beta distribution with parameters α and β. (Note that the mean of the beta distribution is $\alpha/(\alpha+\beta)$ and the maximum possible investment is 25.) In the shared leadership game a strategic leader would always invest 0 and so predicted investment is entirely driven by the proportion of conditional cooperators, p. In the other games predicted investment is sensitive to the distribution of beliefs. The more 'optimistic' are strategists then the higher is predicted investment. Table 2 makes clear the difficulty in hypothesizing where the shared leadership game will come relative to the other three. In particular, the scenarios that a-priori seem most realistic are those with $\alpha = 2$ and we can see that predicted investment in the leader, first follower, and sequential games is very sensitive to the value of β in this case. If strategists are relatively optimistic, e.g. $\beta = 2$, then predicted investment is relatively low in the shared leadership game. If strategists are relatively pessimistic, e.g. $\beta = 5$, then investment is relatively high in the shared leadership game. Even so, the numbers in Table 2 justify our final hypothesis

Hypothesis 4: Total investment will be higher in the leader game than shared leadership game.

Table 2: Predicted total investment if beliefs are given by a beta distribution.

	Leader	First Follower	Shared leader	Sequential
$\alpha = 0.5, \beta = 0.5, p=0.5$	11.9	10.0	8.8	9.4
$\alpha = 5, \beta = 1, p=0.5$	14.9	13.0	8.8	12.2
$\alpha = 1, \beta = 3, p=0.5$	9.3	7.5	8.8	7.1
$\alpha = 2, \beta = 2, p=0.5$	12.6	10.2	8.8	9.5
$\alpha = 2, \beta = 5, p=0.5$	9.6	7.5	8.8	7.0
$\alpha = 0.5, \beta = 0.5, p=0.7$	16.6	14.9	14.4	14.2
$\alpha = 5, \beta = 1, p=0.7$	19.0	17.3	14.4	16.5
$\alpha = 1, \beta = 3, p=0.7$	14.7	13.0	14.4	12.4
$\alpha = 2, \beta = 2, p=0.7$	17.2	15.1	14.4	14.4
$\alpha = 2, \beta = 5, p=0.7$	14.9	12.9	14.4	12.3

We ran a total of 6 experimental sessions. At the beginning of each session the participants received instructions for their treatment only. The participants were randomly placed into groups of five and interacted over 20 rounds. In each round the group played the same type of game but with the timing sequence randomly determined a-fresh. Given that our main focus was on the two new games we had 8 groups play the first follower game, 9 the shared leadership game, 5 the leader game, and 4 the sequential game. This gives a total of 130 subjects who participated. The study was run at the University of Kent using the z-Tree program (Fischbacher 2007). A session lasted around 50 minutes.

5. Results

5.1 Total investment

We begin by looking at total investment in the public project. Figure 1 shows a moving average of group investment to the public project across the various treatments. Averaging across all rounds, total investment is highest in the first follower game (13.14), then the shared leader treatment (11.13), then the leader treatment (8.65) and finally the sequential treatment (8.14). Note that average investment is 61% higher in first follower than sequential treatment and so the differences are sizeable. The difference in investment between the first follower and shared leader treatments is not statistically significant ($p = 0.18$, Mann Whitney with the group as the unit of observation). Neither is the difference between the leader and sequential treatments ($p = 0.81$). The difference between the first follower and leader and sequential treatments is, however, marginally significant ($p = 0.06$). That between the shared leader and leader and sequential treatments is not ($p = 0.27$).

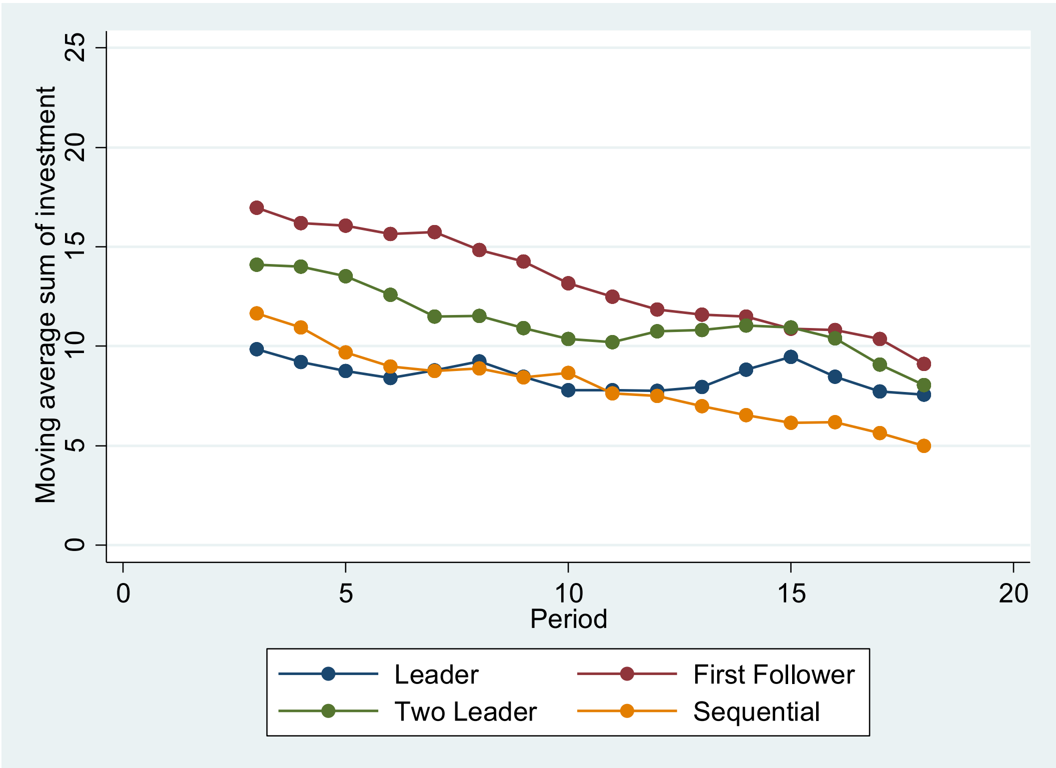

Figure 1 Moving average of total investment, averaging across 5 rounds

If we compare Figure 1 to hypotheses 3 and 4 and Table 2 the stand-out feature is the relatively low investment in the leader game. While investment in the first follower, shared leader and sequential games is broadly consistent with the predictions in Table 2, that in the leader game is not. Clearly, there is no support for our Hypothesis 4, that investment should be highest in the leader game. The only slight caveat is that investment remains steady over the 20 rounds in the leader treatment but falls in all other treatments. Even so, something is clearly missing from our model. In the following we shall investigate what this. Before doing so we reiterate the point made in the introduction that a lack of investment in the leader game is intriguing given the prior evidence that exogenous leadership does not lead to the increases in investment one might expect. Our results are consistent with this but also suggest that other types of leadership structure (namely first follower and shared leader) may work better. To explore this in more detail we look in turn at leader and follower behavior.

5.2 Leader behavior

Figure two plots the moving average of leader investment. The average leader investment in the first follower treatment (3.66) is consistently higher than the other treatments (2.89 in the shared leader, 2.71 in the leader and 2.4 in the sequential treatments). As expected (Hypothesis 1) the leader investment is significantly higher in the first follower than shared leader treatment ($p = 0.04$, Mann Whitney). It is also higher than in the sequential treatment ($p = 0.09$). While the differences between first follower and leader treatment are not significant ($p = 0.24$) it is still noticeable that leader investment in the leader treatment is not as high as we would have predicted. This clearly may contribute to the lower than expected total investment in the leader game.

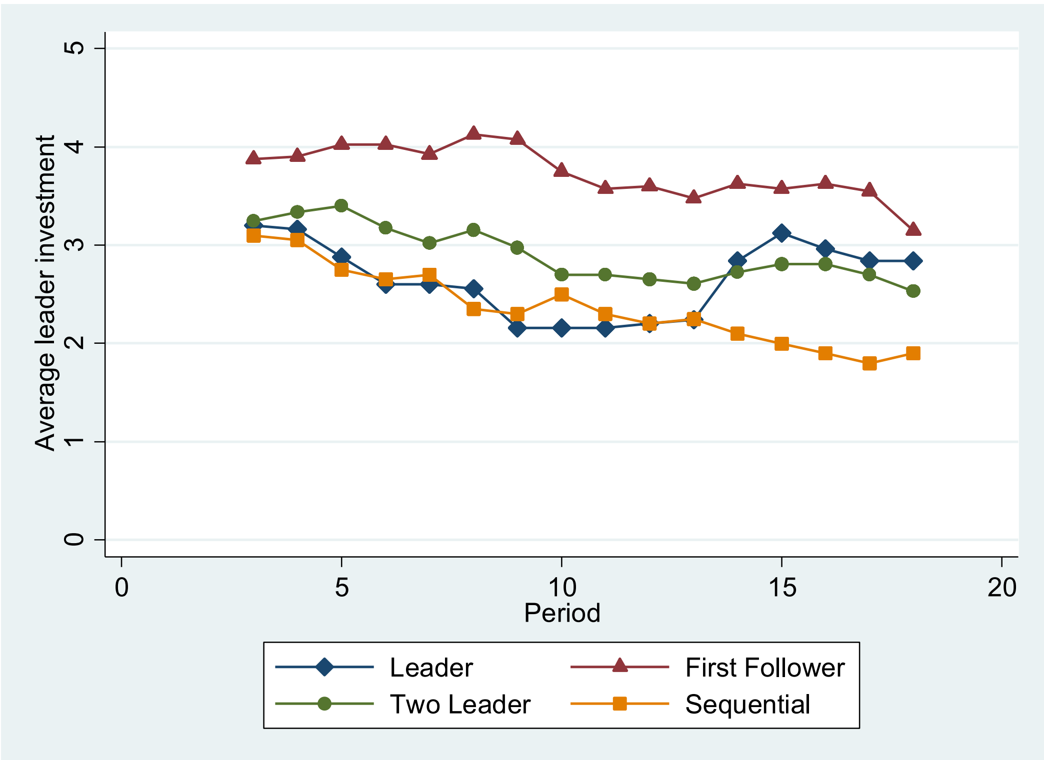

Figure 2 Moving average leader investment by treatment, averaging over 5 rounds

Table 3 provides the distribution of leader investments by treatment. Recall that our model predicts leader contributions of either 0 or 5. This is largely confirmed with 0 and 5 being the most common choices in all four treatments. Note, however, that the leader treatment sees a more extreme distribution with 80% of choices being 0 or 5. This compares to only 63% in the first follower treatment and 51% in the shared leader treatment. The split between 0 and 5 investments that we see in the leader game is broadly what we might expect if there is no strategic leadership. In the first follower game, however, there is evidence for strategic leadership with 76% of leader investments being 3 or above (which is significantly higher than any other treatment, $p \leq 0.01$, proportions test).

Table 3 Leader investment distributions

Investment	Leader	First Follower	Shared leader	Sequential
0	37.00 (37)	11.25 (18)	23.06 (83)	35.00 (28)
1	5.00 (5)	4.38 (7)	3.33 (12)	2.50 (2)
2	1.00 (1)	8.13 (13)	9.72 (35)	8.75 (7)
3	7.00 (7)	11.88 (19)	18.33 (66)	16.25 (13)
4	7.00 (7)	12.50 (20)	16.94 (61)	16.25 (13)
5	43.00 (43)	51.88 (83)	28.61 (103)	21.25 (17)

Note: The numbers in brackets state the number of instances of each outcome

5.3 Follower behaviour

In looking at follower behavior we need to be careful that we are comparing like with like given that games differ in the number of followers and the time at which they move. We shall begin, however, by looking at a broad brush measure of observed reciprocity. For each instance in which a participant does not move first we observe their investment, x_i, and the average investment of those before them, $\acute{x}(i)$. A simple measure of reciprocity is given by $x_i/\acute{x}(i)$. Clearly this can only be applied where $\acute{x}(i) > 0$. The average reciprocity we observed was 0.52, 0.61, 0.62 and 0.59 in the leader, first follower, shared leader and sequential treatments, respectively. While reciprocity is slightly lower in the leader game, none of these differences are significantly different ($p > 0.1$, Mann Whitney). Note that the observed reciprocity is in line with a p value of around 0.6. We return to this point below.

The broad measure of reciprocity discussed above suggests that follower behavior was similar across treatments. To reinforce this finding we shall look in more detail at some specific comparisons. We begin by comparing behavior in period 3 of the first follower treatment with that of period 2 in the shared leader treatment. Note that this is a like-for-like comparison because in each case there are two participants who have invested and three who are left to invest. Figure 3 depicts average investment as a function of previous investments. For comparison we have also included data on period 2 of the leader game and periods 3 to 5 of the sequential game.[6] As we would expect there is a strong positive relationship. There is also a clear similarity across treatments.

[6] These are not a like-for-like comparisons because in the leader game only one participant has invested and four are left to invest, while in the sequential game there are three left to invest but they will invest in sequence.

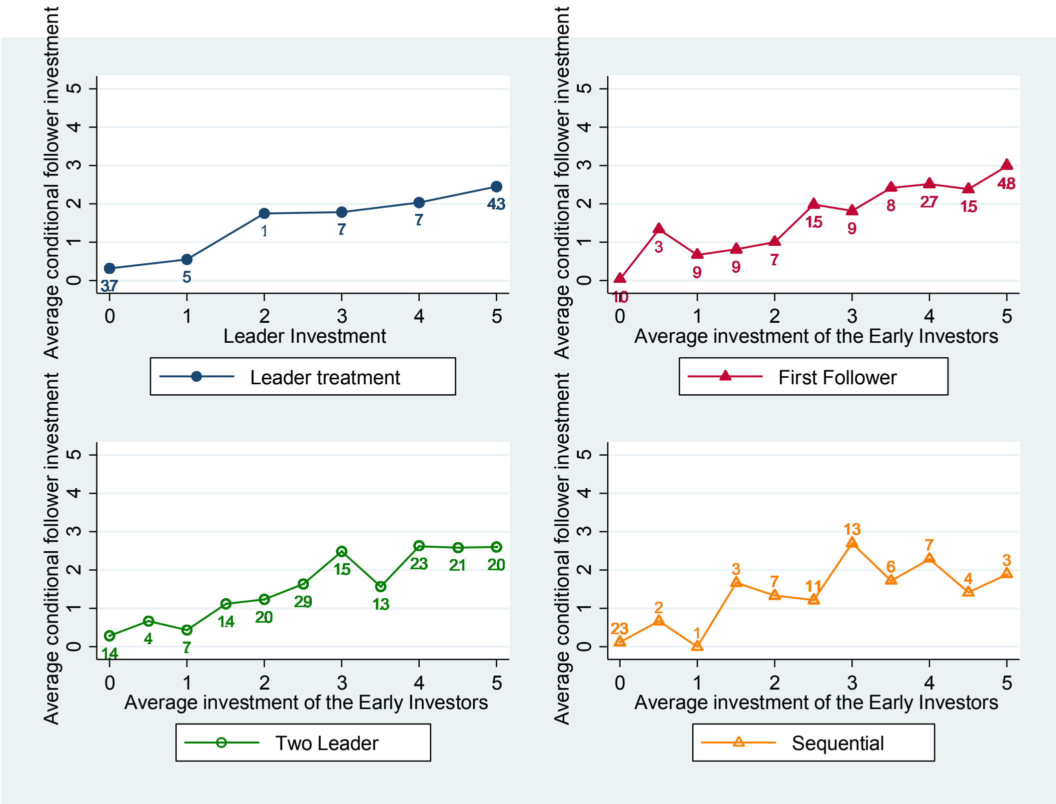

Figure 3 Average conditional follower investments across treatments. Comparing those that invest in period 2 in the leader and shared leader treatments, invest in period 3 in the first follower treatment and invest in periods 3 or later in the sequential treatment.

Consider next behavior in period 2 of the first follower and sequential games. This again is a like-for-like comparison because in each case there has been one previous investment and three will follow. Taking the average across all groups within a treatment, the first follower reciprocates 83% of the leader investment in the first follower treatment and 78% in the sequential treatment. As we would predict, this difference is not significant ($p = 0.17$, Mann-Whitney). A figure around 80% is, however, notably higher than the figure of 60% we obtained for other followers ($p < 0.01$, paired t-test). This would suggest first followers behave strategically to some extent. To illustrate this further, Figure 4 depicts the average first follower investment conditional on the leader investment. Note, focusing on the first follower treatment, how much closer the first follower relationship is to the 45° line than that we observed with other followers (see Figure 3). For example, if the leader contributes 5 the average investment of the first follower is around four. By contrast, if the leader and first follower both contribute 5 the average investment of subsequent followers is only around 3 (see Figure 3). This is clear evidence of strategic behavior by some first followers.

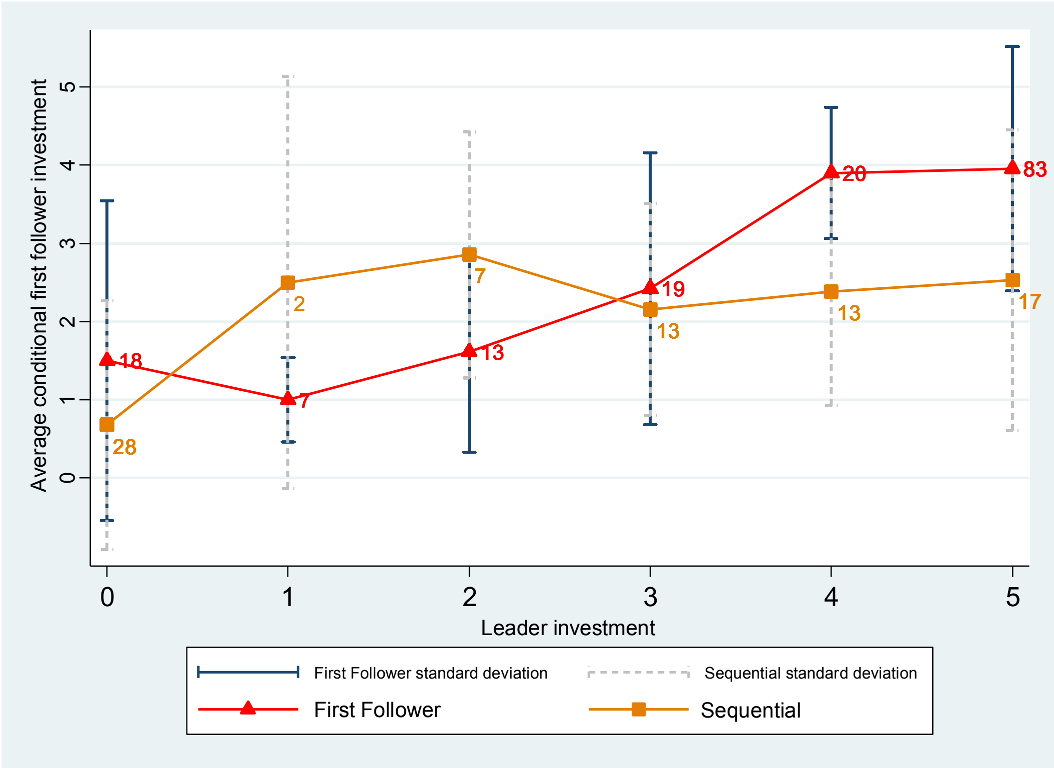

Figure 4 Average first follower investments conditional on leader investment

4.4 Leadership and fairness

Let us now return to the question of why investment was lower in the leader game than expected. We have seen that followers reciprocated earlier investments. Moreover, follower behavior was broadly consistent across treatments. It is, therefore, to leaders that we seemingly must look for an explanation.

As already discussed the evidence suggests less (if any) strategic leadership in the leader game than we might have expected. This makes it important to clarify that there was the potential for strategic leadership. Observed follower reciprocity would suggest a p value above 0.5. This is more than enough to imply (see Table 1) that a leader would maximize own material payoff by investing in the public project. For additional evidence we can compare the payoff of leaders who invested 0 with those who invested 5. In the leader treatment those investing 5 earned on average 7.6% *more* than those who invested 0. In the first follower treatment the gain was 4%. In the shared leader treatment, as expected, those investing 5 earned on average less (11%) than those investing 0. The only anomaly was the sequential game where we would expect those investing 5 to earn more but they actually earned less (6%).

If strategic leadership made sense and yet we saw little evidence for it in the leader treatment there seems two basic possibilities: (i) participants did not appreciate the possibility for strategic leadership, i.e. underestimated the extent of conditional cooperation, or (ii) were not willing to invest even if they did see the possibility for strategic leadership. There is undoubtedly evidence in the prior literature that would support point (i) (e.g. Potters et al.

2007, Gächter and Fischbacher 2010, Cartwright and Lovett 2014). We do, though, see evidence of strategic leadership (and strategic first followership) in the other treatments. This suggests to us that point (ii) must also play some role. So, why would someone be unwilling to strategically invest in the leader game?

One possibility is that of fairness. Table 4 details average per period payoff for each role respectively across each treatment. For all treatments, followers earn significantly more than leaders ($p < 0.05$, Mann Whitney). This result is consistent with the 'leader's curse' (Gatcher and Renner, 2014). This curse also extends to first followers with followers earning significantly more on average than the first followers in both the first follower and sequential treatments ($p < 0.01$). First followers in the first follower treatment earn significantly more than the leaders ($p = 0.02$) but not for the sequential treatment ($p = 0.11$).

The leader's curse may be a disincentive for a leader to set a good example. A leader who invests 0 is guaranteed to earn at least as much as every other player. By investing 5 a leader may increase his payoff but may also find himself at a disadvantage relative to others. Standard theories of fairness, whether it be inequality aversion, sequential reciprocity, or similar, suggest this may not appeal. In the leader game the leader is 'on his own' and so faces a relatively stark choice. He may prefer to invest 0 even if he expects some reciprocity from followers. In the other three organizational structures leaders do not face such a stark choice because there is at least one other player who can 'share some of the responsibility'. That we observe more strategic leadership from first followers in the first follower game than we do leaders in the leader game is consistent with this interpretation. For instance, if the leader invests 5 then a first follower who invests 5 knows for sure that at least one player will have the same payoff as him. This may reduce concerns about fairness and, therefore, incentivize investment.

Table 4 Average period payoffs by treatment and group member

Treatment	All members	Leader	First follower	Follower
Leader	33.65	5.75		6.98
First Follower	38.14	6.60	7.09	8.15
Shared leader	36.13	6.57		7.66
Sequential	33.14	5.86	6.43	6.95

5 Conclusion

In this paper we have compared four organizational structures that differ in the timing of decisions. Our motivation for doing so is the growing interest in studying leadership as a group process, rather than simply a process in which one person leads. We compared, theoretically and experimentally, leadership by example, sequential, first follower and shared leadership structures. Our theoretical results demonstrated that successful leadership is about more than the leader setting a good example. In particular, structures like shared leadership can be effective even if the incentives to set a good example are weak. Our experimental results showed that first followership maximized total investment. This appears consistent with a first follower effect.

Interestingly, we found that total investment in the leadership by example structure was less than we had predicted. This seemingly fits well with the prior evidence that exogenous leadership by example has less effect than might be conjectured. We suggest that leadership by example is relatively ineffective because it raises equity issues. In particular, the leader has to make a 'lone sacrifice' for the group and may be unwilling to do so. In other organizational structures like shared leadership the burden may appear shared (even if it is not). The crucial thing to note, however, is that our findings challenge the conventional way of studying leadership in social dilemmas. Prior studies have almost always imposed a leadership by example structure. This may provide a poor lens through which to study leadership if other forms of leadership structure, such as shared leadership, are more common and more successful. This is an issue that warrants further study.

Throughout this paper we have studied exogenous leadership. The advantage of studying exogenous leadership is that it gives us complete control over the decision making environment. That we observe significant differences with this control should convince that organizational structure matters. Clearly, however, it is also of interest to allow endogenous leadership. This can have two effects. First, it may influence the set of people who are leaders because those who chose to lead are not a random sample of the population (e.g. Gillet, Cartwright and van Vugt 2011). Second, it allows group members to endogenously choose the type of organizational structure they want. For instance, group members may choose shared leadership or first followership. In current work we are exploring such possibilities.

Appendix 1: Proofs of main theorems

Proof of Theorem 1: The leader game is treated in the main text and the sequential game by Cartwright and Patel (2010). Consider the shared leadership game. Suppose player 1 and player 2 are the first movers and player 1 is a strategist. Let L denote the investment of player 1 and K the investment of player 2. From the perspective of player 1, the expected investment of each second mover is $p_1\,(L+K)/2$. So the expected payoff of player 1 is

$$U(L) = E - L + m\left(L + K + \frac{(n-2)p_1(X+K)}{2}\right)$$

Differentiating U(L) with respect to L and setting equal to zero gives the advertised critical value of p_1.

Consider next the first follower game. Suppose that player 1 is first mover and a strategist. Let L denote the investment of player 1. If the second mover is a conditional cooperator she will invest L. If the second mover is a strategist she will (see Proposition 2 for a formal proof of this) invest an amount independent of L. Let K denote the amount player 1 expects a strategic first mover would invest. The expected payoff of player 1 can then be written

$$U(L) = E - L + m\left(L + p_1(1 + (n-2)p_1)L + (1-p_1)\left(K + \frac{(n-2)p_1(L+K)}{2}\right)\right).$$

Differentiating with respect to L gives

$$\frac{\partial U(L)}{\partial L} = -1 + m\left(1 + p_1(1 + (n-2)p_1) + (1-p_1)\frac{(n-2)p_1}{2}\right).$$

Setting this equal to 0 and simplifying gives

$$m = \frac{2}{(1+p^{FF})(2+(n-2)p^{FF})}.$$

Solving the quadratic formula gives the desired expression for p^{FF}.■

Proof of Theorem 3: There are various methods one could use to compare expected total investment in different organizational structures. In the following we use an approach that seems particularly informative and transparent. For completeness we shall go through the exercise in full even though there are clear redundancies we could exploit in order to prove theorem 3.

Consider the shared leader and first follower comparison. What we shall do is fix the type and beliefs of players 1 and 2 and compare expected investment in the first follower and leader game. With regard to player 1 there are four possibilities we need to consider: (i) Player 1 is a conditional cooperator (CC), (ii) player 1 is a strategist and has beliefs $p_1 < p^{FF}$, (iii) player 1 is a strategist and $p^{FF} \leq p_1 < p^{2L}$, and (iv) player 1 is a strategist and $p^{2L} \leq p_1$. With regard to player 2 there are three possibilities we need to consider: (i) Player 2 is a conditional cooperator (CC), (ii) player 2 is a strategist and has beliefs $p_2 < p^{2L}$, (iii) player 2 is a strategist and $p^{2L} \leq p_2$. In Table A1 we work through the resulting 12 combinations and detail the expected investment in the first follower and shared leadership games.

As you can see, in most instances there is no difference in expected investment. What we need to do is pick up the four cases where there is a difference and evaluate the probability of each case. For instance the probability that player 1 is a strategist with beliefs $p_1 < p^{FF}$ and player 2 is a conditional cooperator is given by $(1-p)G(p^{FF})p$. We, therefore, get that $X^{FF} \geq X^{2L}$ if and only if

$$G(p^{2L}) - G(p^{FF}) \geq (1-p)G(p^{FF})p.$$
$$(1-p)$$

This reduces to the expression given in Proposition 3(a).

Table A1: The difference in expected total investment between the first follower and shared leadership game conditional on the type and beliefs of players 1 and 2.

Player 1	Player 2	X^{FF}	X^{2L}	$X^{FF} - X^{2L}$
CC	CC	$E(2 + (n-2)p)$	$E(2 + (n-2)p)$	0
CC	$p_2 < p^{2L}$	$E\left(1 + \frac{(n-2)p}{2}\right)$	$E\left(1 + \frac{(n-2)p}{2}\right)$	0
CC	$p^{2L} \leq p_2$	$2 + (n-2)p$ E	$E(2 + (n-2)p)$	0
$p_1 < p^{FF}$	CC	0	$E\left(1 + \frac{(n-2)p}{2}\right)$	$-E\left(1 + \frac{(n-2)p}{2}\right)$
$p_1 < p^{FF}$	$p_2 < p^{2L}$	0	0	0
$p_1 < p^{FF}$	$p^{2L} \leq p_2$	$E\left(1 + \frac{(n-2)p}{2}\right)$	$E\left(1 + \frac{(n-2)p}{2}\right)$	0
$p^{FF} \leq p_1 < p^{2L}$	CC	$E(2 + (n-2)p)$	$E\left(1 + \frac{(n-2)p}{2}\right)$	$E\left(1 + \frac{(n-2)p}{2}\right)$
$p^{FF} \leq p_1 < p^{2L}$	$p_2 < p^{2L}$	$E\left(1 + \frac{(n-2)p}{2}\right)$	0	$E\left(1 + \frac{(n-2)p}{2}\right)$
$p^{FF} \leq p_1 < p^{2L}$	$p^{2L} \leq p_2$	$E(2 + (n-2)p)$	$E\left(1 + \frac{(n-2)p}{2}\right)$	$E\left(1 + \frac{(n-2)p}{2}\right)$
$p^{2L} \leq p_1$	CC	$E(2 + (n-2)p)$	$E(2 + (n-2)p)$	0
$p^{2L} \leq p_1$	$p_2 < p^{2L}$	$E\left(1 + \frac{(n-2)p}{2}\right)$	$E\left(1 + \frac{(n-2)p}{2}\right)$	0
$p^{2L} \leq p_1$	$p^{2L} \leq p_2$	$E(2 + (n-2)p)$	$E(2 + (n-2)p)$	0

Consider next the leader and first follower comparison. We can repeat the above exercise with a slight tweak to the possibilities that we need to consider with regard to player 1. In Table A2 we work through the relevant 12 combinations. As you can see, this comparison is more complicated than the shared leader one. If we proceed directly to write down an if and only if condition we get an expression that is very difficult to interpret. The assumption that $G(p^{FF}) = 0$ allows us to derive a simple expression. In particular we get that $X^{FF} \geq X^{L}$ if and only if

$$p(1-p)\left(1 - G(p^{2L})\right) + (1-p)^2\left(1 - G(p^{2L})\right) \geq \frac{(n-2)p}{2}(1-p)^2 G(p^{2L}).$$

This reduces to the expression given in Proposition 3(b). We can briefly comment on what happens if we relax the $G(p^{FF}) = 0$ assumption. This leads to several cases where the leader game maximizes investment and only one where the first follower game does. Moreover, the one case where the first follower game fares well requires the somewhat unlikely combination of $p_1 < p^{L}$ and $p_2 > p^{2L}$.

Table A2: The difference in expected total investment between the first follower and leader game conditional on the type and beliefs of players 1 and 2.

Player 1	Player 2	X^{FF}	X^{L}	$X^{FF} - X^{L}$
CC	CC	$E(2+(n-2)p)$	$E(2+(n-2)p)$	0
CC	$p_2 < p^{2L}$	$E(1+(n-2)p)$	$E(1+(n-2)p)$	0
CC	$p^{2L} \leq p_2$	$2+(n-2)p$ E	$E(1+(n-2)p)$	E
$p_1 < p^{L}$	CC	0	0	0
$p_1 < p^{L}$	$p_2 < p^{2L}$	0	0	0
$p_1 < p^{L}$	$p^{2L} \leq p_2$	$E\left(1+\frac{(n-2)p}{2}\right)$	0	$E\left(1+\frac{(n-2)p}{2}\right)$
$p^{L} \leq p_1 < p^{FF}$	CC	0	$E(2+(n-2)p)$	$-E(2+(n-2)p)$
$p^{L} \leq p_1 < p^{FF}$	$p_2 < p^{2L}$	0	$E(1+(n-2)p)$	$-E(1+(n-2)p)$
$p^{L} \leq p_1 < p^{FF}$	$p^{2L} \leq p_2$	$E\left(1+\frac{(n-2)p}{2}\right)$	$E(1+(n-2)p)$	$-E\frac{(n-2)p}{2}$
$p^{FF} \leq p_1$	CC	$E(2+(n-2)p)$	$E(2+(n-2)p)$	0
$p^{FF} \leq p_1$	$p_2 < p^{2L}$	$E\left(1+\frac{(n-2)p}{2}\right)$	$E(1+(n-2)p)$	$-E\frac{(n-2)p}{2}$
$p^{FF} \leq p_1$	$p^{2L} \leq p_2$	$E(2+(n-2)p)$	$E(1+(n-2)p)$	E

Finally, we can look at the first follower and sequential comparison. Recall that $p^{FF} < p^{S}$. This implies that the expected investment of the first mover is weakly higher in the first follower than sequential game. If $G(p^{S2}) = 1$ then the second mover in a sequential game will invest 0. So, the expected investment of the second mover is weakly higher in the first follower than sequential game. It follows immediately that expected investment is weakly higher in the first follower than sequential game. ■

Appendix 2: Examples of total investment

In this appendix we illustrate that the relative ranking of the different organizational structures in terms of predicted efficiency varies on the parameters n, m, p and G.

Example 1: Consider the case $n = 4$ and $m = 0.4$. Note that $p^{L} = 0.5$ and $p^{FF} = 0.58$. Suppose that every strategist has belief $\not{p}$ (and so $G(\not{p}) = 1$ while $G(y) = 0$ for any $y < \not{p}$). Suppose that where $p^{L} < \not{p} < p^{FF}$. In interpretation, only in the leader game does a strategic first mover have an incentive to invest. Finally, suppose that $p = 0.5$. We know (applying equation (1)) that $X^{L} = 5E/2$. What of the other games? In the shared leadership game there is a p^2 chance that both first movers are conditional cooperators who invest E, and there is a $2p(1-p)$ chance that one invests E. Thus,

$$X^{2L} = p^2 E(2+(n-2)p) + 2p(1-p)E\left(1+\frac{1}{2}(n-2)p\right) = \frac{3}{2}E.$$

The lack of strategic leadership results in $X^{2L} < X^{L}$. In the first follower game there is a p^2 chance that both first and second movers are conditional cooperators who invest E, and there is a $p(1-p)$ chance that the first mover is a conditional cooperator who invests E and the second mover a strategist who invests 0. Thus,

$$X^{FF} = p^2E(2+(n-2)p) + p(1-p)E\left(1+\frac{1}{2}(n-2)p\right) = \frac{9}{8}E.$$

Clearly $X^{FF} < X^{2L}$. The intuition for this result is that in the shared leadership game there are two independent chances for a conditional cooperator to 'set a good example' while in the first follower game everything depends on the first mover setting a good example. We will skip the details of the sequential game but it is possible to show that $X^S < X^{FF} < X^{2L} < X^L$. The leader game is, therefore, first best.

Example 2: Keep everything the same as in Example 1, suppose that $p^{FF} < \hat{p} < p^S$. (Note that $p^S = 1$ and $p^{2L} = 1$) In interpretation, only in the leader and first follower games does a strategic first mover have an incentive to invest. The only thing that we need to reconsider is X^{FF}. In this case we know that the first mover will invest E. There is a p chance that the second mover will too. Thus,

$$X^{FF} = pE(2+(n-2)p) + (1-p)E\left(1+\frac{1}{2}(n-2)p\right) = \frac{9}{4}E.$$

So, $X^S < X^{2L} < X^{FF} < X^L$ meaning that the first follower game jumps up to second best.

Example 3: Suppose that $n = 4$ and $p = 0.5$ as before but now $m = 0.8$. Note that $p^{2L} = 0.25$ and $p^{S2} = 0.28$. In the main text we only went as far as characterising the incentives of the second mover in the sequential game. We now need to look at the incentives of the third mover. If the third mover invests E (rather than 0) then there is probability p that the fourth mover will invest an extra $E/3$. So it is in the interests of a strategic player 3 to invest E if $m(1+p_3/3) > 1$. This rearranges to $p_3 > 0.75$.

Now suppose that every strategist has belief $\hat{p}$ where $p^{2L} < \hat{p} < 0.75$. In this case we know that the two first movers in the shared leadership game and the first and second mover in the first follower game will invest E. Thus,

$$X^{2L} = X^{FF} = E(2+(n-2)p) = 3E.$$

So, $X^L < X^{FF} = X^{2L}$. For completeness let us consider the sequential game. If $p^{S2} < \hat{p}$ then the first two movers in the sequential game will invest E. The third mover will invest E with probability p. The fourth mover will invest E with probability p^2 and $2E/3$ with probability $(1-p)p$. Thus,

$$X^S = E\left(2+p+p^2+\frac{2}{3}(1-p)p\right) = \frac{35}{12}E.$$

Overall, therefore, $X^L < X^S < X^{FF} = X^{2L}$. The shared leader and first follower game become first best while the leader game becomes worst. The intuition behind this result is that two players, not just one, have a strategic incentive to invest E.

Example 4: Keep everything the same as in the previous example except that $0.75 < \hat{p}$. (One could argue that this is an implausible belief given that $p = 0.5$ but the example would follow through with plausible beliefs for a higher value of m.) Now the first three movers in the sequential game will contribute E. Thus,

$$X^S = E(3+p) = \frac{7}{2}E.$$

So, $X^L < X^{FF} = X^{2L} < X^S$. The sequential game comes out first best because there is a strategic incentive for three players (rather than just two in the shared leader and first follower games or one in the leader game) to invest E.

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