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LEADERSHIP BY EXAMPLE IN THE WEAK-LINK GAME

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We investigate the effects of leadership in a four player weak-link game. A weak-link game is a coordination game with multiple Pareto-ranked Nash equilibria. Because the more efficient equilibria involve a degree of strategic uncertainty groups typically find it difficult to coordinate on more efficient equilibria. We wanted to see whether leadership by example, in the form of one player acting publicly before the rest of the group, could help groups do better. Our results suggest that leadership can increase efficiency but is far from being a guarantee of success. Specifically, in a significant number of groups we observed successful leadership and increased efficiency, but in most groups efficiency was low despite the efforts of leaders. We did not find any difference between voluntary leaders and leaders that are randomly assigned. (*JEL* C72, H41)

I. INTRODUCTION

The weak-link game was first introduced by Hirshleifer (1983) as a stylized way to capture the private provision of many public goods. As an illustration, Hirshleifer tells the story of Anarchia, a low lying island protected from flooding through a network of interconnected dikes. The crux of the story is that each citizen makes a private decision about how strong a dike to build on their land, yet the island will be flooded if the weakest dike breaks. Most relevant, therefore, is not the average or total contributions to the public good but the minimum contribution. The same could be said for the production of any good, public or private, where output is determined by the weakest component of production. Consequently, the weak link game is of much applied interest in understanding the performance of groups, organizations and nations (e.g., Brandts and Cooper 2006b; Knez and Camerer 1994). For example, it can help explain the high wage and productivity differentials between rich and poor countries (Kremer 1993).

Hirshleifer argued that production will be efficient in a weak link game. The basic reasoning is that a person cannot free-ride in the game and so there is an incentive to contribute an efficient amount to the public good. This hypothesis was confirmed in two player games (e.g., Harrison and Hirshleifer 1989), and also fares well in three player games (e.g., Knez and Camerer 1994; Weber, Camerer, and Knez 2004). It soon became clear, however, that in games with more than three players things are different (Isaac, Schmidtz, and Walker 1989; Van Huyck, Battalio, and Beil 1990). What we typically observe is considerable coordination failure with contributions rapidly falling to the minimum level (Camerer 2003).[1] The common explanation for this is that to contribute an efficient amount requires trust in others, because the low contribution of one player will make any high contribution redundant and costly for that

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1. There are some notable exceptions including Bortolotti, Devetag, and Ortmann (2009) who find higher effort levels in a real effort weak link game. See Devetag and Ortmann (2007) for a survey of the literature.

ABBREVIATIONS

CRT: Criterion-Referenced Test
GLS: Generalized Least Squares

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contributor, and in games with more than three players any trust quickly disappears (Yamagishi and Sato 1986).

How can such coordination failure be avoided? Various solutions have been considered in the literature (Devetag and Ortmann 2007). For instance, coordination failure is less following a temporary increase in the gains of coordinating (Brandts and Holt 2006), if there is pre-play communication (Blume and Ortmann 2007; Brandts and Cooper 2007; Chaudhuri, Schotter, and Sopher 2009), and if players opt in to play the game (Cachon and Camerer 1996). Generally speaking, however, these solutions may not always be practical. For example, pre-play communication may be unwieldy in large groups, and many of the solutions rely on the full distribution of contributions being known rather than just the minimum (a point taken up by Brandts and Cooper 2006a).[2]

The basic objective of this paper was to ask whether *leadership reduces coordination failure in the weak-link game*. Leadership evolved to solve coordination problems between individuals and is common in all social species (Van Vugt 2006; Van Vugt, Hogan, and Kaiser 2008). Our main hypothesis, therefore, is that leadership can help individuals coordinate in the weak link game. By leadership we shall mean that one player can lead by publicly choosing a contribution before all other players. Our focus is thus on *leadership by example*.[3] Various experimental studies have already demonstrated the positive effect of this kind of leadership on cooperative behavior in public good and public bad games (Güth et al. 2007; Pogrebna et al. 2008; Van der Heijden and Moxnes 2003).[4] It remains to be seen whether it also works in the weak link game.

Some evidence on the effectiveness of leadership by example in the weak link game is provided by Weber, Camerer, and Knez (2004) and Li (2007). They analyze a three player weak link game in which choices are made sequentially according to some exogenous order. The sequential nature of choice means that there is leadership but of a different form to the one we shall consider. It also means that the efficient Nash equilibrium is the unique sub game perfect Nash equilibrium of the game and so there are strong reasons to expect less coordination failure. Consistent with this both Weber, Camerer, and Knez (2004) and Li (2007) do find that coordination failure is less, even if some failure remains.[5] Leadership, therefore, partially worked. The interpretation of this result is not, however, clear cut because efficiency is relatively high in three player games even when there is not leadership. A bigger challenge is to avoid the extreme coordination failure typically observed in games with four or more players.

In order to see whether leadership by example can meet this challenge we first develop a simple model of behavior that allows us to distinguish different reasons why leadership may work. We then report on experiments with both exogenous and endogenous leadership in a repeated four-player weak link game. Overall our results are somewhat mixed. In some groups we observe successful leadership in which efficiency is high because leaders contribute a lot and followers respond to this. In other groups, however, leadership is less successful and efficiency is no better than we would expect without leadership. At the aggregate level, therefore, leadership does make a difference but considerable inefficiency still remains. We shall argue that it is primarily the fault of leaders rather than followers that leadership does not prove more successful.

Interestingly the absolute increase in efficiency we observe from leadership is very similar to that of Weber, Camerer, and Knez (2004) and Li (2007). Relatively speaking things look different because our benchmark of comparison is a four player game with relatively low and declining efficiency while theirs is a three player

2. To put these issues in some context: In the dike example, with which we began this paper, the full distribution of contributions would be observable (a person can just go around the island and look) but communication (e.g. each landowner saying how high a dike they plan to build) could be unwieldy. Next consider authors submitting articles to a special issue of a journal or contributed book. Here, only the minimum (i.e. slowest) contribution is likely to be observable and communication between authors may or may not be possible.

3. Different types of leadership have been studied in the weak link game and closely related turnaround game. Weber et al (2001) consider a setting where one player, the leader, reads out a prepared statement, after the second period, encouraging coordination. The speech was effective for groups of size 2 but not for groups of size 10. Cooper (2006) and Brandts and Cooper (2007) consider a setting where a manager can communicate a message to players while also changing the incentives to coordinate. Communication was relatively effective.

4. The public good literature has also shown that contributions may be lower if they are made sequentially rather than simultaneously (Varian 1994; Gächter et al. 2009).

5. Note that the focus of Weber et al. (2004) and Li (2007) was on virtual observability and not leadership.

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game with relatively high and stable efficiency. This is an important distinction, because escaping from the "trap" of low and declining efficiency in the weak link game is very difficult to achieve but crucial for the group (c.f. Chaudhuri, Schotter, and Sopher 2009; Crawford 2001). Our results suggest that leadership can help groups escape this trap, and that is an encouraging finding. Leadership proves, however, far from a panacea.

We proceed as follows, in Section II we introduce the weak-link game and in Section III we develop a simple model of leadership and state our hypotheses. Section IV describes our experimental design and Section V contains the results. Section VI concludes.

II. THE WEAK-LINK GAME

The weak-link game is a stylized representation of any situation where members of a group can contribute to some group project and the outcome depends on the contribution of the least contributing member. We adopt the standard payoff structure used by Van Huyck, Battalio, and Beil (1990). In this version n players simultaneously pick a whole number between 1 and 7 and the payoff of a player is given by the formula

$$u(k, m) = 0.6 + 0.2m - 0.1k$$

where k denotes the player's own choice and m denotes the minimum choice of all n players. Table 1 describes the payoff of a player for every potential combination of their own choice and the minimum choice.

Every outcome in which all players choose the same number is a Nash equilibrium. Clearly Nash equilibria on higher numbers are preferred to those over lower numbers, so the Pareto optimum is for every player to choose 7.[6] Note, however, that higher numbered Nash equilibria involve a degree of strategic uncertainty. Picking the highest number is the best strategy only if all other players also pick the highest number. This means that there are two notions of coordination in a weak-link game. We can think of players as coordinating if they all choose the same number

6. This makes the weak-link game a coordination game with Pareto-ranked equilibria. This class of coordination game can be distinguished from games with asymmetric players, such as the battle of sexes. Evidence on leadership in such games includes Cooper et al. (1989), Rapoport, Seale and Winter (2002), and Cartwright, Gillet and van Vugt (2009). See Camerer (2003) for a survey of the literature.

TABLE 1
Payoff Table

	Own choice						
Minimum Choice	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	0.7	0.6	0.5	0.4	0.3	0.2	0.1
2		0.8	0.7	0.6	0.5	0.4	0.3
3			0.9	0.8	0.7	0.6	0.5
4				1.0	0.9	0.8	0.7
5					1.1	1.0	0.9
6						1.2	1.1
7							1.3

and so are coordinating on a Nash equilibrium. Alternatively we can think of players as coordinating if they all choose high numbers and so are coordinating on the most efficient Nash equilibria. Throughout the following we shall focus on the later notion of coordination. We, thus, say that there is increased coordination and efficiency if the minimum number increases, and there is coordination failure and inefficiency if the minimum number chosen is low.

Our objective in this paper is to contrast the standard weak link game, in which all players choose simultaneously, with a version in which one individual, the leader, makes a choice before the remaining players. To do this, we shall distinguish three games, all sharing the payoffs given in Table 1, but differing in the dynamics of play:

Simultaneous game: All n players in the game simultaneously and independently of each other chose a number.

Exogenous leader game: The game consists of two stages. In the first stage, one of the $n$players is randomly selected to be a leader, and chooses a number. In the second stage, the choice of the leader is made public, and the remaining $n-1$ players simultaneously and independently of each other chose a number.

Endogenous leader game: The game consists of two stages. The first stage lasts at most T seconds and at any point during this time any of the n players can chose a number. As soon as one player has chosen a number the stage ends. We rule out the possibility that two players choose at the same time and the player who chooses first is called the leader. In the second stage, the choice of the leader is made public, and the remaining $n-1$ players simultaneously and independently of each other chose a number.

In both the exogenous and endogenous leader game there is one player, the leader, who chooses before the remaining players, the followers. The choice of the leader is known by the followers before they make their choice, resulting in leadership by example. In the exogenous leader game the leader is chosen randomly and thus exogenously. In the endogenous leader game the leader is the first player to choose a number and so is chosen endogenously.

III. HYPOTHESES ON LEADERSHIP

In the standard, simultaneous, weak link game we expect to see significant coordination failure. What difference will leadership make? By choosing a high number the leader can signal or communicate to others in the group that it is good to choose high numbers. The choice of the leader also provides a natural focal point around which others can coordinate. Our basic hypothesis, therefore, is that leadership can help groups avoid coordination failure. To develop this idea more formally we shall work through a simple but relatively general model of how leadership may affect a player's behavior. More specifically, we shall consider some player i and contrast what number player i will choose in a simultaneous game with that he will chose in a game with leadership.

We begin by focusing on a simultaneous game with n players. Suppose that player i believes every other player will independently choose number k with probability $f_i^n(k)$. We impose that $\sum_{h=1}^{7} f_i^n(h) = 1$ and, with a slight abuse of notation, shall denote by $F_i^n(k) = \sum_{h=k}^{7} f_i^n(h)$ the probability of a player choosing k or above. Of primary interest in the weak link game is the expected minimum choice of others. From beliefs f_i^n we can derive player i's inferred beliefs over what this minimum choice will be. For example, if the number of players is four, we get that

$$m_i^n(k) = f_i^n(k)^3 + 3 f_i^n(k) F_i^n(k) \times (F_i^n(k) - f_i^n(k))$$

is the probability with which player i should expect the minimum number chosen by others to be k. Let $M_i^n(k) = \sum_{h=k}^{7} m_i^n(h)$ be the probability with which he should expect the minimum number to be k or above.

Given his beliefs, the expected payoff of player i if he chooses k can be written

$$\pi_i^n(k) = 0.6 + 0.2\left(\sum_{h=1}^{k-1} h m_i^n(h) + k M_i^n(k)\right) - 0.1k.$$

We will assume that every player chooses k so as to maximize his payoff given his beliefs. Let $k_i^{S,n}$ denote the number that would be chosen by player i. For any k there is a set of beliefs such that it is optimal for a player to choose k.[7] What he does will, therefore, depend on his beliefs, and without imposing any more structure on these beliefs we cannot predict what the player will choose. This, however, is not a problem because we do empirically observe players choosing all the possible seven numbers. Of more interest to us is to question how leadership changes the incentives of the player.

A. *Leadership and Strategic Uncertainty*

In order to see how leadership changes incentives it is informative to first of all contrast a simultaneous game with n players to one with $n-1$ players. An informative way to do this is to compare the relative payoff gain (or loss) from choosing a number one higher. So, let $\Delta_i^n(k) = \pi_i^n(k) - \pi_i^n(k-1)$, for all $k > 1$, be the relative payoff gain in a simultaneous game with n players. Extending the notation introduced above in an obvious manner, let $\Delta_i^{n-1}(k) = \pi_i^{n-1}(k) - \pi_i^{n-1}(k-1)$, for all $k > 1$, be the relative payoff gain in a simultaneous game with $n-1$ players. It is simple to show that,[8]

$$\text{(1)} \qquad \Delta_i^{n-1}(k) - \Delta_i^n(k) = 0.2(M_i^{n-1}(k) - M_i^n(k))$$

for all k. The relative incentive to choose a number one higher will thus depend on player i's inferred beliefs on the likely minimum choice of others.

The crucial thing to now recognize is that a reduction in the number of players should make player i more optimistic about the minimum

7. For instance, if $f_i(k) \lesssim 1$ then it is optimal for player i to choose k.

8. To derive this it is useful to use that $\pi_i^n(k) = \pi_i^n(k-1) - 0.1 + 0.2M_i^n(k)$, and $\pi_i^{n-1}(k) = \pi_i^{n-1}(k-1) - 0.1 + 0.2M_i^{n-1}(k)$.

choice of others. This is because of reduced strategic uncertainty; player i is uncertain about the choices of only $n-2$ other players rather than $n-1$. For instance, even if player i's beliefs are the same in a game with n players as in a game with $n-1$ players, $f_i^n(k) = f_i^{n-1}(k)$ for all k, it will be the case that $M_i^{n-1}(k) \geq M_i^n(k)$ for all k. This motivates *assumption 1*, that

$$F_i^{n-1}(k) \geq F_i^n(k) \quad (2)$$

for all k. It immediately follows from Equation (1) and assumption 1 that

$$k_i^{S,n-1} \geq k_i^{S,n}.$$

Thus, player i would choose at least as high a number in a game with $n-1$ players as he would do in a game with n players. This effect has been observed experimentally (Camerer 2003; Van Huyck, Battalio, and Beil 1990; Van Huyck, Battalio, and Rankin 2007).

Consider now an exogenous leadership game, with n players, and suppose that player i is a follower. One would expect that the beliefs of followers will be conditional on the choice of leader. So, let L denote the choice of leader and let $f_i(k|L)$ and $F_i(k|L) = \sum_{h=k}^{7} f_i(h|L)$ denote the beliefs of player i given the leader's choice. There are two key things to now recognize. First, the choice of the leader reduces strategic uncertainty because player i is uncertainty about only $n-2$ other players rather than $n-1$. Second, the choice of the leader may serve as a focal point that influences others because of signaling or reciprocity. On this basis we suggest our main assumption, *assumption 2*, that

$$F_i(k|L) \geq F_i^{n-1}(k) \quad (3)$$

for all $k \leq L$ and any L. Assumption 2 complements assumption 1 by suggesting that followers in a leadership game will at least take account of the reduced strategic uncertainty caused by the leader's choice. This assumption appears relatively mild, particular given the evidence for signaling and reciprocity in public good and public bad games (Güth et al. 2007; Moxnes and Van der Heijden 2003).

Given the beliefs $f_i(k|L)$ we can derive inferred beliefs on the minimum choice of others $M_i(k|L)$ and expected payoff $\pi_i(k|L)$. With this we can compare incentives with and without leadership by letting $\Delta_i(k|L) = \pi_i(k|L) - \pi_i(k-1|L)$. It is simple to show, that if assumptions 1 and 2 hold,[9]

$$\Delta_i(k|L) - \Delta_i^n(k) = 0.2(M_i(k|L) - M_i^n(k)) \geq 0 \quad (4)$$

and

$$\Delta_i(k|L) - \Delta_i^{n-1}(k) = 0.2(M_i(k|L) - M_i^{n-1}(k)) \geq 0 \quad (5)$$

for all $k \leq L$. The incentives to choose a number one higher are, therefore, at least as great with leadership than without, and at least as great with leadership as with reduced strategic uncertainty.

To summarize what we have shown so far, let $k_i^F(L)$ denote the choice player i would make in a game with exogenous leadership if he is a follower and the leader has chosen L. The following result follows immediately from Equations (1), (4), and (5).

PROPOSITION 1. *Assumptions 1 and 2 imply that (i)* $k_i^F(L) \geq k_i^{S,n-1} \geq k_i^{S,n}$ *if* $k_i^{S,n-1} < L$, *and (ii)* $k_i^F(L) = L$ if $k_i^{S,n-1} \geq L$.

Player i could, therefore, choose more or less in a game with leadership compared to a simultaneous game. It depends on what the leader does. To progress further we need to think about what the leader may choose.

B. Hypotheses on Leadership

Suppose now that player i is the leader in an exogenous leadership game. It is likely that player i would expect the choice of others to depend on his choice. Let $f_i^D(k|L)$ and $F_i^D(k|L) = \sum_{h=k}^{7} f_i^D(h|L)$ denote the beliefs of player i if he leads and chooses L. It is very mild to assume, *assumption 3*, that

$$f_i^D(k|L) = f_i(k|L) \quad (6)$$

for all k and any L. All this assumption imposes is that followers are expected to react to the choice of the leader, and not his identity. Given f_i^D we can derive inferred beliefs on the minimum choice of others $M_i^D(k|L)$. The important thing to recognize here is that because player i leads he remains uncertain about the choices of

9. See footnote 8 for the derivation of the first equality. The reduction in strategic uncertainty implies that $M_i(k|L) \geq M_i^n(k)$ and assumption 2 implies that $M_i(k|L) \geq M_i^{n-1}(k)$.

$n-1$ other players. Recall, that when he is a follower he is uncertain about the choices of only $n-2$ players. Thus, player i should be more pessimistic about the minimum choice of others when he leads than when he is a follower. In particular, assumption 3 implies that $M_i^D(k|L) \leq M_i(k|L)$ for all k and L.

Let $\pi_i^D(k)$ denote the expected payoff of player i if he leads and chooses k and let $\Delta_i^D(k) = \pi_i^D(k) - \pi_i^D(k-1)$ be the incentive to choose a number one higher. Using the now familiar arguments, assumptions 1, 2, and 3, imply that $\Delta_i^D(k) - \Delta_i^n(k) = 0.2(M_i^D(k|k) - M_i^n(k)) \geq 0$ for all k. The incentives to choose a number one higher are, therefore, at least as high in a game with leadership as in a simultaneous game with n players. Assumptions 1, 2, and 3 are not, however, enough for us to say anything about

$$\Delta_i^D(k) - \Delta_i^{n-1}(k) = 0.2(M_i^D(k|k) - M_i^{n-1}(k)). \tag{7}$$

This is because the leader remains uncertain about the choices of $n-1$ players. Plausibly, therefore, one can get $M_i^D(k|k) \gtrless M_i^{n-1}(k)$ depending on whether reduced strategic uncertainty is expected to have a bigger or smaller effect than signaling and reciprocity.

To summarize what we have learnt about leader choice, let k_i^D denote the choice player i would make in a game with exogenous leadership if he is a leader.

PROPOSITION 2. *Assumptions 1, 2, and 3 imply that* $k_i^D \geq k_i^{S,n}$.

What we cannot say anything about, on the basis of assumptions 1, 2, and 3, is the relationship between k_i^D *and* $k_i^{S,n-1}$. *As just discussed, this will depend on the relative effects of reduced strategic uncertainty versus signaling and reciprocity. We have done enough, however, to motivate our first two hypotheses. Before stating these hypotheses we briefly note that assumptions 3 and 4, and proposition 2 can easily be rephrased in terms of a game with endogenous leadership (we shall discuss this issue in more detail shortly).*

> **Hypothesis 1**: There is less coordination failure in a weak link game with leadership than in a standard weak link game.

> **Hypothesis 2**: Coordination failure in a weak link game with leadership and n players is less than in a standard weak link game with $n-1$ players.

Hypothesis 1 follows directly from Propositions 1 and 2. Hypothesis 2 is more speculative and asks relatively a lot of leaders. In particular, Proposition 1 suggests that we can reasonably expect followers to choose higher numbers than they would have done in a simultaneous game with $n-1$ players *if* the leader chooses a high enough number. Less clear, as we have seen, are the incentives for the leader to choose a high enough number. Equation (7) suggests that the leader will only choose a high number if he expects it will cause others to choose an equally high number. It is an empirical question whether leaders do choose high numbers, and whether followers do reciprocate.

C. Endogenous Versus Exogenous Leadership

In the proceeding analysis we focused on an exogenous leadership game. This was appropriate given that we were asking what player i would do if he were a follower and what he would do if he were a leader. In an endogenous leadership game we need to look, in addition, at whether player i would want to lead or follow. This requires comparing his expected payoff if he leads to that if he follows.

For notational simplicity we shall assume that player i has the same beliefs in a game with endogenous leadership as with exogenous leadership.[10] We need to supplement this with player i's beliefs over the choice a leader would make, if the leader were not him. Suppose that he believes the probability that a leader will choose number L is $g_i(L)$ for all L. We can then compare the expected payoff of player i from leading and following. Player i will want to lead if and only if

$$\pi_i^D(k_i^D) \geq \sum_{L=1}^{7} g_i(L)\pi_i(k_i^F(L)|L). \tag{8}$$

Informally, there are two basic scenarios where this expression will be satisfied. If player i intends to choose the lowest number, $k_i^D = k_i^F(1) = \cdots = k_i^F(7) = 1$, then condition (8) is

10. If the decision to lead is not expected to be random then beliefs could be different in a game with endogenous leadership. Formally, one should also allow for the possibility that beliefs in an endogenous leadership game depend on the time spent waiting for someone to lead. A-priori, however, it is not clear in which way beliefs would differ in a game with endogenous or exogenous leadership, and so we focus on the more important issue of player i deciding whether or not to lead. Note also, that assumptions 2 and 3 remain appropriate with endogenous leadership.

trivially satisfied because his payoff will be 0.7 whether he leads or follows. Alternatively, if player i is confident that others will respond positively to a high leader choice but is not confident that another leader will choose a high number then condition (8) also satisfied. To illustrate this latter possibility, suppose that $k_i^D = 7$, $M_i^L(7|7) = 0.9$ and $g_i(1) = 0.9$. Then, player i's expected payoff from leading is at least 1.18, while his expected payoff from following is at most 0.76.

With this in mind we can now briefly compare endogenous and exogenous leadership. In the first scenario alluded to above, where player i intends to choose a low number, the minimum choice will be one in both cases and so there is coordination failure irrespective of whether leadership is endogenous or exogenous. In the second scenario, where player i intends to choose a high number, coordination failure should be no more in the game with endogenous leadership than exogenous leadership because of the high leader choice. This suggests that voluntary leadership may be more effective than exogenous leadership.

Hypothesis 3: Coordination failure in a weak link game with endogenous leadership is less than in a weak link game with exogenous leadership.

Empirical support for this hypothesis comes from the public good literature. For example, Van Vugt and De Cremer (1999) and Arbak and Villeval (2007) find that imposed leaders contribute less to a group than voluntary leaders. Similarly, Rivas and Sutter (2008) find a positive effect of leadership on cooperation but only with voluntary leaders. Gächter et al. (2010) also found that reciprocally oriented leaders contribute more.

IV. EXPERIMENTAL METHOD

To test our hypotheses we performed a laboratory experiment in which we compared four different versions of the weak link game: a simultaneous 3 player game (Sim3), a simultaneous 4 player game (Sim4), an exogenous 4 player leadership game (Exo), and an endogenous 4 player leadership game (End). In each case the payoff structure in Table 1 was used and the game was as described in Section II.

Each experimental session consisted of three distinct parts. In each part participants were grouped into groups of 3 or 4, as appropriate,

TABLE 2
Summary of Sessions

Session	Participants	Part 1	Part 2	Part 3
1	16	Exo	End	Sim4
2	16	End	Sim4	Exo
3	16	Sim4	Exo	End
4	16	Exo	Sim4	End
5	16	Sim4	End	Exo
6	16	End	Exo	Sim4
7	12	Sim3	Sim3	Sim3

and played 10 rounds of either Sim3, Sim4, Exo, or End. Note that within these 10 rounds the game and groups did not change. Between parts of the session the groups and possibly the game did change. We ran seven sessions in all, each with four groups. In one session participants played Sim3 in all three parts of the experiment.[11] In the other six sessions, participants played each of Sim4, Exo and End in varying order. That we had six sessions allowed us to consider all possible permutations of Sim4, Exo, and End as detailed in Table 2. To control for any potential order affects that may result from subjects playing three different games we shall, in the following: include part dummies in all regressions and provide statistical tests that use only data from part 1 of a session. We shall see, however, that there is no evidence of an order affect, and so we will group the data from all parts unless otherwise stated.

Participants were told at the start of the experiment that they would play "a number" of games (of 10 rounds each). Participants were only given the instructions to a particular game before they played that game. It was also emphasized to participants that they would be playing in a totally new group in each part of the experiment. For the conditions with a leader we deliberately avoided terms like "leaders" and "followers" and instead used more neutral descriptions like "the person choosing first" and "the other players". The instructions are available in the supporting information Appendix S1.

After each round participants were told their earnings and the minimum, and only the minimum, number chosen in the group. Announcing the full distribution of choices, rather than just the minimum, has been shown to make it

11. We did not combine Sim3 with any of the other treatments because the lab could not accommodate 24 subjects and 12 subjects is insufficient to maintain random matching between parts of a session.

FIGURE 1
The Average Minimum Choice by Treatment and Round

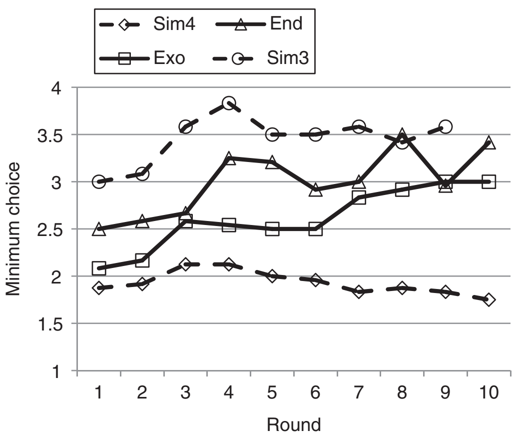
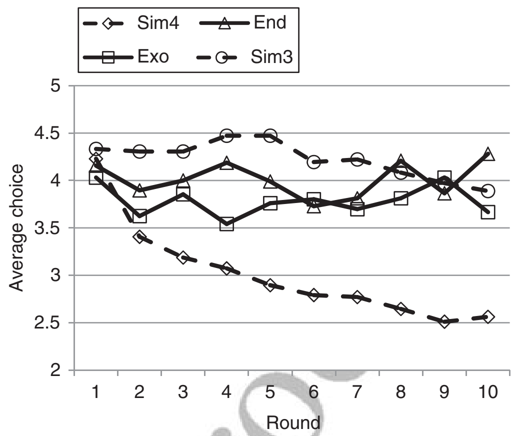


FIGURE 2
The Average Choice by Treatment and Round



easier to coordinate (Berninghaus and Ehrhart 2001; Brandts and Cooper 2006a).[12] We provide, therefore, a relatively tough test of leadership. This approach also allows us to more clearly distinguish how much the benefits of leadership are due solely to players seeing the choices of two others, the leader's choice and minimum choice, rather than seeing just one choice, as in a simultaneous game.

The experiment was programmed and conducted with the software Z-tree (Fischbacher 2007) and run at the University of Kent in 2009. Afterwards participants were paid the earnings of one randomly selected game. Participants were recruited via the university-wide research participation scheme and were randomly assigned to the different conditions and to their respective groups. In total 108 subjects participated, who earned on average £8.82. The experiment took about 45 min.

V. RESULTS

To give a first snapshot of the results Figure 1 plots the average minimum choice by group in each treatment and each round and Figure 2 plots the average choice. In the Sim4 treatment, as we would expect, we see large coordination failure with a minimum choice of 1 in over half the groups. Things are much better in the Sim3 treatment, illustrating how important group size can be, but significant coordination failure is still observed. The key question for us is whether leadership helped groups avoid such failure. We clearly see that leadership had at best a limited success. Coordination failure appears less in the leadership treatments than in Sim4 but remains high and as high as in the Sim3 treatment. Indeed, we find that in round 1 there is nothing to distinguish choices in the leadership conditions from those in Sim4 or Sim3 ($p = .91$, Kruskal-Wallis test). By round 10 we do find a significant difference in choices between the leadership conditions and Sim4 but not Sim3 ($p = .00$ all treatments, Kruskal-Wallis test, $p = .20$ excluding Sim4).[13]

The one positive sign in Figures 1 and 2 is a possible dynamic consequence of leadership. This does show up in simple trend terms: Choices decline in the Sim4 treatment (with coefficient of -0.15, $p = .00$) but remain relatively stable in the other treatments, including the leadership treatments (Sim3: -0.051, $p = .17$, Exo: -0.00, $p = .98$, End: $p = .90$). Furthermore, minimum choices are relatively stable in the simultaneous treatments (Sim4: -0.023, $p = .10$, Sim3: 0.03, $p = .35$) but increase in the leadership treatments (Exo: 0.10, $p = .02$, End: 0.08, $p = .07$). There is, therefore, some

12. Basically, if the distribution of choices is observed then players can signal through repeated interaction that higher numbers could be chosen to mutual benefit. Observed coordination failure is, thus, typically less. A similar effect is seen by Blume and Ortmann (2007) in a setting where only the minimum choice is made public but in a pre-play communication stage all players can send a signal of what they intend to do.

13. Pairwise Mann-Whitney tests by treatment give the same conclusion.

TABLE 3
Average Payoffs by Treatment

		overall	round 1	round 10
Overall	Sim4	0.69	0.55	0.69
	Sim3	0.87	0.77	0.89
	Exo	0.74	0.61	0.83
	End	0.80	0.68	0.86
Leaders	Exo	0.69	0.53	0.79
	End	0.76	0.65	0.80
Followers	Exo	0.76	0.64	0.85
	End	0.81	0.70	0.88

evidence of a dynamic benefit of leadership. The suggestion would still be, however, that efficiency is essentially catching up with that in Sim3.

This is also the picture we get from average payoffs, summarized in Table 3. We find no significant difference between the payoffs of leaders or followers across leadership treatments (e.g., leaders: $p = .53$ in round 1, $p = .27$ in round 10, Mann-Whitney test, followers: $p = .46$ and .43). We also find no significant difference between the payoffs of leaders and followers (e.g., $p = .36$ in round 1, $p = 1.00$ in round 10). Aggregating the data from the leadership treatments we find that subjects in the leadership treatments do earn significantly more than subjects in Sim4 in all rounds (e.g. $p = .00$ in round 1, $p = .00$ in round 10). When compared to Sim3 they earn less in round 1 but have caught up by round 10 ($p = .01$ in round 1, $p = .11$ in round 10).

We can begin to summarize our findings.

RESULT 1. *Overall efficiency is higher in the leadership treatments compared to the Sim4 treatment but not the Sim3 treatment. Initial choices in the leadership treatments appear similar to those in the simultaneous treatments. There is evidence of a dynamic improvement in efficiency in the leadership treatments but not the simultaneous treatments.*

This is supportive of Hypothesis 1 but not of hypotheses 2 or 3. To explore this further we shall look in more detail at the choices of followers and leaders, starting with the choice of followers.

A. Follower Choice

Figures 3 and 4 plot the average and minimum choice of followers as a function of the leader's choice (when averaging over all 10 rounds). We clearly see evidence that follower choice is positively correlated to leader choice. The Pearson correlation is 0.87 ($p < .001$) in the exogenous condition and 0.82 ($p < .001$) in the endogenous condition. We also see that followers pick a significantly lower number than the leader. The average difference between leader choice and (average) follower choice is 0.54 ($p = .001$) for exogenous leaders and 0.38 ($p = .001$) for endogenous leaders.

Of particular relevance to us is whether a high leader choice causes followers to choose higher numbers than those chosen in Sim3. This would be evidence that leadership has a benefit beyond reducing strategic uncertainty. Figures 3 and 4 suggest that it may. To pursue this in more detail Table 4 gives the average choice

FIGURE 3
The Average Choice of Followers Per Leader Choice. The Number of Observations Is Given in Brackets for the Exo [·] and End (·) Treatments

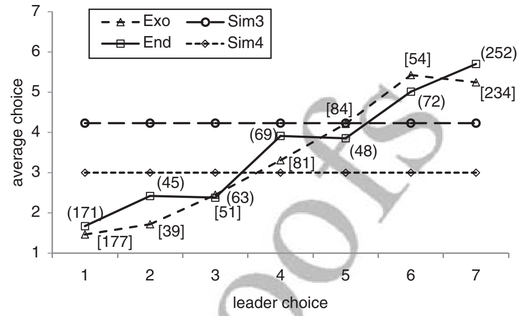


FIGURE 4
The Minimum Choice of Followers Per Leader Choice. The Number of Observations Is Given in Brackets for the Exo [·] and End (·) Treatments

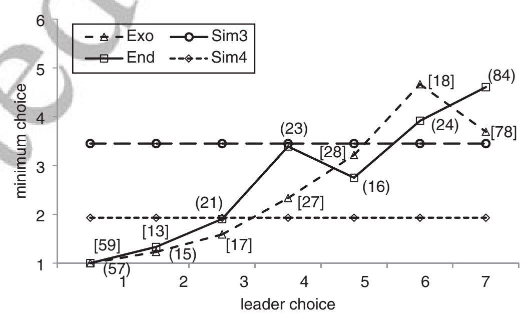


TABLE 4
The Average Choice of Subjects in the Sim4 and Sim3 Treatment Compared to Those Following a Leader Who Chose 7 in the Exo and End Treatments

		All parts		Part 1	
		all rounds	round 1	all rounds	round 1
No leader	Sim4	3.01 (960)	4.23 (96)	2.86 (320)	4.03 (32)
	Sim3	4.23 (360)	4.33 (36)	3.84 (120)	3.50 (12)
Leader chooses 7	Exo	5.24 (234)	4.81 (36)	4.77 (66)	4.40 (12)
	End	5.70 (252)	5.71 (24)	3.95 (57)	5.50 (6)
	Exo + End	5.48 (486)	5.17 (60)	4.39 (123)	4.78 (18)

Notes: The number of observations are given in brackets.

of followers if the leader chooses 7. In order to try and avoid any self selection bias (that may exist because only some leaders choose 7) we have included the averages for round 1 and for round 1 of part 1 of a session. We see in Table 4 that choices are consistently higher in the leadership treatments than in the Sim3 and Sim4 treatments if the leader chooses 7. These differences are statistically significant, even if we restrict attention to round 1 or round 1 of part 1 of a session. More specifically, we do not observe any difference in the Exo and End treatments in the average choice of followers in round 1 or round 1 of part 1 ($p = .14$ and .25, respectively, Mann-Whitney test). Pooling the data from the leadership treatments we do find a significant difference compared to Sim3 ($p = .02$ and .08) and Sim4 ($p = .00$ and .10). A similar story holds for all other rounds.

We do observe, therefore, subjects choosing higher numbers when following a leader who chooses 7 than they do in simultaneous games, even in round 1. This is consistent with Proposition 1 and evidence that leadership does more than reduce strategic uncertainty. To put all this in some context Table 5 presents the results of a random effects generalized least squares (GLS) regression and three ordered probit regressions with choice as the dependent variable. The regressions exclude the choice of leaders and so allow us to compare the behavior of followers with that of players in a simultaneous game. The Sim3 treatment is used as the comparator. Columns 1 and 2 focus on rounds 1 and 10, respectively, and include the choice of the leader and dummy variables to capture treatment and the order of the game in the session as independent variables.[14] Columns 3 and 4 report results using data from all rounds. To capture potential dynamic treatment effects we include as independent variables an interaction term between the round number and treatment. To capture potential dynamic choice effects we include the minimum choice in the previous round.[15] The 'threshold to choose x' parameter indicates the size of dependent variable required in order that a player is predicted to choose more than x. For example, the results in columns 1 and 2 imply that the average player in the Sim3 and Sim4 treatments is predicted to choose 4.

In comparing follower behavior in the leadership and simultaneous treatments we need to take account of the dummy variable together with leader choice. Doing so, we see that choices are expected to be higher in the leadership treatments than in Sim3 if and only if the leader chooses 6 or 7. For example, using the results in column 1, the net effect in the End treatment compared to the Sim3 treatment is $-1.69 + 0.34 \times L$, where L is the choice of the leader. Thus, followers are expected to choose high numbers if and only if the leader chooses more than 5. This fits exactly with the earlier analysis and leads to our second result.

14. To allow an easier comparison between the Exo and End treatments we use a leader treatment dummy (which takes value 1 for both the Exo and End treatments) and an Exo dummy (which takes value 1 for the Exo treatment). Differences between the Exo and End treatments and the Sim4 or Sim3 treatments should show up in the leader treatment dummy and differences between the Exo and End treatments in the Exo dummy.

15. In order to model all rounds it is necessary to try and capture dynamic effects. This, however, does create potential econometric concerns, particularly in regressing choice on the minimum choice in the previous round. The results are, however, robust to different specifications, such as only including subjects who chose more than the minimum choice in the previous round. Note that we also included, where relevant, the difference between the leader's choice and the minimum choice in the previous round. This, however, proved insignificant and so is omitted.

TABLE 5

Results of a GLS Random Effects Regression (3) and Ordered Probit Regressions (1), (2), and (4) with Choice as the Dependent Variable

	Round 1	Round 10	All Rounds	
Variable	**(1)**	**(2)**	**(3)**	**(4)**
Leadership treatment	−1.69** (0.32)	−1.96** (0.37)	−1.34** (0.34)	−1.01** (0.30)
Exo treatment	−0.24 (0.41)	−0.40 (0.40)	−0.05 (0.31)	0.11 (0.32)
Sim4 treatment	−0.07 (0.22)	−0.75* (0.24)	−0.19 (0.21)	−0.07 (0.12)
Round	—	—	−0.09** (0.02)	−0.07** (0.01)
Round × leader treatment	—	—	0.09** (0.02)	0.07** (0.02)
Round × Exo	—	—	−0.03 (0.03)	−0.03 (0.03)
Leaders choice	0.34** (0.06)	0.41** (0.06)	0.46** (0.05)	0.32** (0.05)
Leaders choice × Exo	−0.01 (0.08)	0.07 (0.08)	0.08 (0.05)	0.07 (0.04)
Min choice in last round	—	—	0.78** (0.05)	0.65** (0.05)
Min choice last round × leader	—	—	−0.43** (0.06)	−0.29** (0.06)
Min choice last round × exo	—	—	−0.04 (0.06)	−0.08 (0.04)
Round 1	—	—	2.34** (0.18)	1.83** (0.14)
Round 1 × leader treatment	—	—	−1.16** (0.33)	−0.69** (0.25)
Round 1 × exo	—	—	−0.78* (0.38)	−0.71* (0.29)
Part 2 of session	0.04 (0.14)	0.04 (0.14)	0.02 (0.09)	−0.04 (0.07)
Part 3 of session	0.13 (0.14)	0.17 (0.17)	0.05 (0.08)	−0.07 (0.06)
Constant	—	—	2.12** (0.27)	—
Threshold to choose 2	−1.11	−0.82	—	0.23
Threshold to choose 3	−0.85	−0.42	—	0.72
Threshold to choose 4	−0.31	−0.08	—	1.25
Threshold to choose 5	0.12	0.34	—	1.80
Threshold to choose 6	0.52	0.59	—	2.29
Threshold to choose 7	0.81	1.02	—	2.75
No of obs.	276	276	2760	2760

Notes: We include only the choices of subjects who were not leaders. The cluster corrected standard errors are given in brackets.

*Significant at 5%; **significant at 1%.

RESULT 2. *If the leader chooses 7 then followers choose higher numbers than can be explained solely by reduced strategic uncertainty. That is, they choose higher numbers than do subjects in the Sim3 treatment.*

Note that this result does not, in itself, imply that it is in the interest of leaders to choose 7. A point we return to in Section V.C.

B. Group Dynamics

In columns 3 and 4 of Table 5 we see a clear relationship between choice and what happened in the previous round. This is no surprise (Crawford 2001). The possibility we want to explore here is whether leadership can help groups overcome coordination failure. The dynamic benefit of leadership picked up in Result 1 suggests that it may, and this is an interesting possibility because escaping from the inefficient equilibrium typically proves impossible in the standard weak link game (e.g., Brandts and Cooper 2006a, 2007; Chaudhuri, Schotter, and Sopher 2009; Weber et al. 2001). The results in Table 5 predict that leadership can help a group to escape from coordination failure.[16] To back this up we can provide some direct evidence of leadership working.

The first thing we can do is look at specific group dynamics. We shall say that there was persistent coordination failure (CF) in a group if the minimum was 1 in all 10 rounds. By contrast, we shall say that there was a reversal of coordination failure to $x$if there was one round with a minimum of 1 and a later round with a minimum of x. Table 6 details how many groups fit into each category. As we would expect in the Sim3 and Sim4 conditions there is little evidence that groups can overcome coordination failure. In the leadership conditions we do get a more positive picture. For example, in none of the 26 groups without leadership did we see a minimum of 5 or more after there had been a round with a minimum of 1. In groups with leadership this happens in 12 of the 37 groups.[17]

16. For example, suppose the minimum choice is 1 in round 1 and a subsequent leader chooses 7. Applying the results from column (4) we get a prediction that the average choice with endogenous leadership will be 4 in round 2, 6 in round 3 and 7 in all subsequent rounds. With exogenous leadership the prediction is 5 in round 2 and 7 in all subsequent rounds.

17. There were 26 and 37 groups respectively where the minimum was 1 at some point. In all other groups the minimum choice was always above 1 and so there is no possibility to overcome coordination failure as we have defined it.

TABLE 6
Characterizing Group Dynamics by Leadership Condition

	R7	R6	R5	R4	CF
Exogenous ($n = 20$)	1	3	9	10	6
Endogenous ($n = 17$)	2	2	3	7	4
Sim4 ($n = 19$)	0	0	0	1	10
Sim3 ($n = 5$)	0	0	0	2	0

Notes: The number of groups that fit into each category is given in brackets.

TABLE 7
The Average Choice of Subjects in the Sim4 and Sim3 Treatment Compared to Followers in the Exo and End Treatments If There Had Been a Previous Round with a Minimum Choice of 1

		Round 2	Round 10
No leader	Sim4	2.68 (56)	1.94 (72)
	Sim3	2.67 (3)	2.60 (15)
Leader chooses 7	Exo	5.13 (15)	5.28 (18)
	End	3.89 (9)	4.33 (18)
	Exo + End	4.67 (24)	4.81 (36)

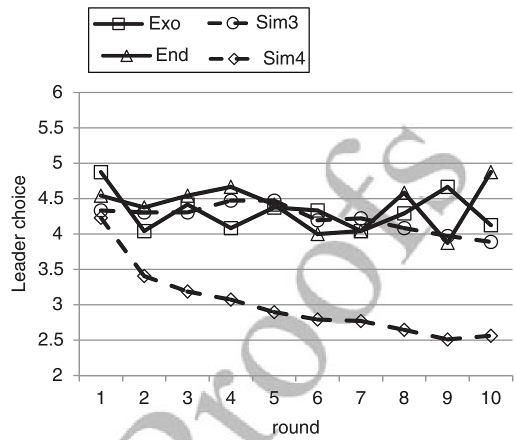
Notes: The number of observations are given in brackets.

In all the 12 groups where the minimum did increase to 5 it did so because a leader chose 6 or 7. This clearly fits with the idea that leaders can make a difference. To further back this up, table 7 looks at the average choice of followers if the leader chooses 7 and there has been a previous round with a minimum choice of 1. For illustration we have provided the data for rounds 2 and 10, but the picture is similar in all rounds. Round 2 is of particular note because we should avoid self selection issues (although there is a lack of data for the Sim3 treatment). We find no significant difference between choices in the leadership treatments ($p = .67$ in round 1, $p = .19$ in round 10, Mann-Whitney) but do find a significant difference between choices in the leadership and simultaneous treatments ($p = .00$ and $p = .14$ compared to Sim4 and Sim3 in round 1, $p = .00$ and $p = .00$ in round 10).

The key thing here is that we see evidence of followers responding to the leader choice even if there has been previous experience of coordination failure.

RESULT 3. *In simultaneous games one instance of coordination failure typically leads to persistent coordination failure. In games with leadership we see that coordination failure need not be persistent. In a significant number of groups leadership helped overcome coordination failure.*

FIGURE 5
The Average Leader Choice by Treatment and Round Compared to Average Choice in the Simultaneous Treatments



Results 2 and 3 suggest that followers do respond to leader choice. In reconciling this with the lack of success of leadership at the aggregate level it is natural to question the choices of leaders.

C. Leadership

Figure 5 plots the average choice of leaders in each round. Of interest to us, given Proposition 2, is whether leaders choose higher numbers than in the simultaneous treatments. For comparison we, therefore, plot average choices in the simultaneous treatments. The clear suggestion in Figure 5 is that leaders chose higher numbers than subjects in Sim4 but not those in Sim3. There is no evidence that leader choices in the Exo and End treatments differ (e.g., $p = .53$ in round 1, $p = .33$ in round 10, Mann-Whitney). There is also no evidence that leader choices in the leadership treatments differ from choices in the simultaneous treatments in round 1 whether using the data from all parts of a session ($p = .17$ compared to Sim4, $p = .32$ compared to Sim3) or only part 1 ($p = .18$ and .10). By round 10 there is evidence that leader choices differ from choices in Sim4 but not those in

Sim3 whether using all parts ($p = .00$ and .29) or only part 1 ($p = .00$ and .37).

Recall that Hypothesis 1 and Proposition 2 said that leaders should choose a number at least as high as they would have done in Sim4. The evidence is consistent with this. Hypothesis 2 reflected an expectation that leaders might choose higher numbers than would players in Sim3. The evidence suggests they do not.

RESULT 4. *In the early rounds we do not observe any significant difference between the choice of leaders in the leadership treatments and that of subjects in the simultaneous treatments. In the later rounds we do observe leaders choosing a higher number than subjects in the Sim4 treatment but find no difference compared to the Sim3 treatment.*

This, together with results 2 and 3, suggest that the overall lack of success of leadership comes more from the behavior of leaders than that of followers. Clearly, not all the blame should be put on leaders because there were groups with persistent coordination failure in which leaders chose 7 several times.[18] It seems, however, that leaders simply did not choose high enough numbers often enough in order that leadership would lead to a significant overall increase in efficiency beyond that obtained in the Sim3 treatment.

To understand why this happened we note that results 2 and 3, while showing a higher leader choice can lead to increased group efficiency, leave open the question of whether choosing a high number pays off for the leader. This is far from clear because a leader can guarantee a payoff of 0.7 by choosing 1 and needs the minimum choice of followers to be at least 4 in order to get a payoff of 0.7 if he chooses 7. Table 8 provides some aggregated data on whether choosing a high number did pay off for leaders. The payoffs of both leaders and followers are typically higher if the leader chooses a higher number. The increase, though, is small and arguably not enough to motivate giving up the sure payoff of 0.7. While choosing a high number can pay off for the group it does not, therefore, necessarily pay off for the leader. This was captured in the discussion of Proposition 2 and may explain why leaders did not choose high enough numbers often enough.

18. One should not necessarily read too much into this because there were also groups in the Sim4 treatment with persistent coordination failure despite some choosing 7.

D. Endogenous Versus Exogenous Leadership

One interesting consequence of Result 4 is that there is every opportunity for the distinction between endogenous and exogenous leadership to matter. You may already have noticed, however, that the type of leader appears to have little effect. We have already noted that there is no apparent difference in follower and leader choice in the two treatments. There is also no significant difference in minimum choice or the difference between leader and follower choices. Table 9 provides more evidence by giving the results of a random effects GLS regression and ordered probit regressions with leader choice as the dependent variable. The endogenous treatment is used as the comparator. In this, and Table 5, we see little consistent evidence that the distinction between exogenous and endogenous leadership matters.

RESULT 5. *We find no significant difference between the endogenous and exogenous leadership treatments.*

Result 5 is clearly contrary to Hypothesis 3. Recall, that Hypothesis 3 was motivated by the observation that a player will lead in an endogenous game if the player (1) is confident that others will respond positively to a high leader choice but (2) is not confident that another leader will choose a high number. Thus, a possible explanation for Result 5 is a lack of players satisfying these two criteria. In the Exo treatment we do see players that appear to satisfy criteria (1). This is evidenced by many leaders choosing high numbers and, in Table 9, the lack of any correlation between leader choice and what happened in the previous round in the Exo treatment. We see many exogenously determined leaders choosing a high number despite previous leaders choosing a low number, presumably because they think leadership by example can work.

In the End treatment a player satisfying criteria (1) and (2) will look to lead and choose a high number. This can only be good for the group. A player satisfying criteria (1) but not (2) will, however, wait for someone else to lead. They will prefer to wait and gain from the reduced strategic uncertainty, hopeful that someone else will lead and choose a high number. This is potentially not good for the group, if the eventual leader chooses a low number. In Table 9, we see much more persistence of leader choice in the End treatment. Overall, therefore,

TABLE 8
Average Payoffs of the Leader and Follower by Leader Choice

	Exo		End			
Leader's Choice	**Leader**	**Followers**	**Leader**	**Followers**	**Sim4**	**Sim3**
1	0.70 (59)	0.65 (177)	0.70 (57)	0.63 (171)	0.70 (344)	0.70 (37)
2	0.65 (13)	0.67 (39)	0.67 (15)	0.62 (45)	0.69 (125)	0.76 (45)
3	0.62 (17)	0.67 (51)	0.68 (21)	0.74 (63)	0.69 (116)	0.80 (80)
4	0.67 (27)	0.74 (81)	0.88 (23)	0.89 (69)	0.78 (144)	0.76 (39)
5	0.75 (28)	0.82 (84)	0.65 (16)	0.76 (48)	0.70 (94)	0.89 (38)
6	0.93 (18)	0.99 (54)	0.78 (24)	0.88 (72)	0.65 (60)	1.00 (39)
7	0.64 (78)	0.81 (234)	0.82 (84)	0.95 (252)	0.43 (77)	1.05 (82)
1–7	0.69 (240)	0.76 (720)	0.76 (240)	0.81 (720)	0.69 (960)	0.87 (360)

Notes: For comparison we give the average payoffs in Sim4 and Sim3 of subjects who choose the same number.

we suggest that the lack of difference between the End and Exo treatments can be explained by there being insufficient players who satisfied criteria (1) and (2). Many of those who think that leadership by example can work may prefer to wait for someone else to lead. In the Exo treatment they do not have such an opportunity, but in the End treatment they do. In other contexts we see people preferring to wait and see rather than lead (Nosenzo and Sefton 2009) and that appears to be the case here too.

VI. CONCLUSIONS

The provision of many public and private goods hinges on the actions of the weakest link, that is the lowest contributor (Camerer 2003; Hirshleifer 1983). The evidence suggests that in such cases the likely outcome is coordination failure. Our objective in this paper was to see whether leadership by example could help groups avoid such coordination failure.

We find that leadership had a positive but somewhat limited effect. We argue that the reason it was not more successful is due more to the actions of leaders than of followers. In particular we do see evidence of followers responding positively if the leader contributes a lot. We see, however, little evidence of leaders contributing a lot. So, in some groups there is successful leadership in which efficiency is high because leaders contribute a lot and followers respond to this, but in other groups leadership is less successful and efficiency no better than we would expect without leadership. Our main conclusion, therefore, is that leadership can work if leaders persistently set a good example. We found no discernible difference between voluntary and imposed leaders.

Our results add to a general literature on whether communication can make a difference in weak link games. Several studies have shown the benefits of both costless and costly communication (Blume and Ortmann 2007; Cahon and Camerer 1995; Cooper 2006; Cooper et al. 1992; Van Huyck et al. 1993). Costless communication has, however, proved less effective if only one player can communicate (Weber et al. 2001), primarily because signals are ignored.[19] Costly communication has also proved ineffective if players avoid the cost of signaling (Manzini, Sadrieh, and Vriend 2009). Our results are broadly consistent with the latter observation in that leaders may be unwilling to signal by choosing a high number. They are also consistent with findings in the public good literature that leaders may have little incentive to lead by example (Cartwright and Patel 2010).

To finish we can briefly revisit the comparison made in the introduction between our results and those of Weber, Camerer, and Knez (2004) and Li (2007). Recall that they compare sequential to simultaneous choice in a three player weak link game. There are clear similarities between our findings and theirs. They find no difference between sequential and simultaneous choice in round 1, but do find a difference over time that ultimately amounts to an increase of around one in average choice. This fits exactly with our findings. The key difference is the benchmark of comparison. We show that leadership can be of some benefit against a backdrop of low and declining efficiency while they do so against a backdrop of relative high and stable efficiency.

19. Costless communication has also proved less effective if there is not common knowledge what has been communicated (Chaudhuri, Schotter, and Sopher 2009).

TABLE 9

Results of a GLS Random Effects Regression (3) and Ordered Probit Regressions (1) (2) and (4) With Leader Choice as the Dependent Variable

Variable	(1)	(2)	(3)	(4)
Exo treatment	0.19 (0.32)	−0.36 (0.33)	0.86 (0.49)	0.82* (0.25)
Round	—	—	−0.02 (0.05)	−0.01 (0.03)
Round × Exo	—	—	−0.02 (0.07)	−0.02 (0.04)
Min choice in last round	—	—	0.60** (0.08)	0.48** (0.07)
Min choice last round × exo	—	—	−0.17 (0.09)	−0.18* (0.07)
Difference between leader choice and min in last round	—	—	0.09 (0.08)	0.14** (0.05)
Difference last round × exo	—	—	−0.12 (0.10)	−0.13* (0.06)
Round 1	—	—	1.86** (0.44)	1.59** (0.34)
Round 1 × exo	—	—	−0.58 (0.73)	−0.60 (0.46)
Part 2 of session	−0.05 (0.39)	0.33 (0.40)	0.04 (0.29)	−0.07 (0.17)
Part 3 of session	−0.19 (0.39)	0.00 (0.40)	−0.34 (0.29)	−0.25 (0.15)
Constant	—	—	2.78** (0.44)	—
Threshold to choose 2	−0.88	−0.58	—	0.52
Threshold to choose 3	−0.67	−0.46	—	0.76
Threshold to choose 4	−0.42	−0.40	—	1.04
Threshold to choose 5	−0.20	−0.30	—	1.38
Threshold to choose 6	0.06	−0.14	—	1.66
Threshold to choose 7	0.22	−0.08	—	1.94
No of obs.	48	48	480	480

Notes: The cluster corrected standard errors are given in brackets.

*Significant at 5%; **significant at 1%.

The consistency of these results is in contrast to results of on-going work by Coelho, Danilov, and Irlenbusch (2009). They consider a 10 player weak link game in which a leader, the person in the group with the highest criterion-referenced test (CRT) score, leads by example. The most significant differences with our approach are that the leader remains the same throughout the rounds and is selected on ability. They find that leadership leads to immediate and sustained efficiency if all players observe the minimum choice of previous rounds but immediate and declining efficiency if the minimum choice of previous rounds is not observed. These results suggest that more work on the consequences of leadership, and in particular the consequences of different types of leadership—appointed or elected, democratic or autocratic, selfish or servant—would be desirable (Gillet et al. 2009).

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Appendix S1. AQ4

Appendix S2.

Table S1. The minimum choice by round and group in the Sim3 condition.

Table S2. The minimum choice by round and group in the Sim4 condition.

Table S3. The leader choice and minimum choice by round and group in the Exo condition.

Table S4. The leader choice and minimum choice by round and group in the End condition.

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