Groups in economics

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Chapter 4

Leadership in a Weak-Link Game

4.1 Introduction[40]

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 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. This applies to the production of any good, public or private, where output is determined by the weakest component of production. The weak link game is thus of much applied interest and can prove useful in understanding such things as the performance of organizations and nations (e.g. Knez and Camerer 1994 and Brandts and Cooper 2006b) or the high wage and productivity differentials between rich and poor countries (Kremer 1993), for example.

Hirshleifer argued that production will be efficient in a weak link game. The basic reasoning is that a person cannot free-ride in a weak link game and so there is an incentive to contribute an efficient amount to the public good. This hypothesis was confirmed in two player games (Harrison and Hirshleifer 1989), but Isaac *et al.* (1989), Van Huyck *et al.* (1990) and subsequent studies provide little support for this hypothesis when there are more than two players. Basically, while it is a Nash equilibrium to contribute an efficient amount this requires coordination and trust, because a low contribution of one player will make any high contribution redundant and costly for that contributor (Yamagishi and Sato 1986). What we typically observe, therefore, is considerable coordination failure with contributions rapidly falling to the minimum level (Camerer 2003).[41]

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 Cooper 2006b), if there is pre-play communication (Blume and Ortmann 2007, Brandts and Cooper

[40] This chapter is based on Cartwright, Gillet and Van Vugt (2011)

[41] There are some notable exceptions including Bortolotti, Devetag & 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.

2007 and Chaudhuri *et al*. 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).[42]

The basic objective of this chapter is 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 *et al*. 2008a; Van Vugt *et al*. 2008b). Our main hypothesis is that leadership significantly reduces coordination failure compared to when all players contribute simultaneously. By leadership we shall mean that *one player can lead by publicly choosing a contribution before all other players*. Various experimental studies have already demonstrated the positive effect of this kind of leadership on cooperative behavior in public good and public bad games (Van Der Heijden & Moxnes 2003, Güth *et al*. 2007 and Pogrebna *et al*. 2008). It remains to be seen whether leadership also works in the weak-link games.

To test the consequences of leadership we ran a laboratory experiment with both exogenous and endogenous leadership in a repeated four-player weak link game. Overall our results are somewhat mixed. It is clear that leadership does make a difference, and in some groups we do observe successful leadership whereby efficiency is increased because leaders contribute a lot and followers respond to this. In other groups, however, leadership was less successful and efficiency no better than we would expect without leadership. In interpreting these results we reiterate the well known difficulty in overcoming coordination failure in a weak link game (*cf*. Crawford 2001 and Chaudhuri *et al*. 2009). That leadership can help overcome this coordination failure some of the time is good. That it does not work all the time is possibly to be expected.

We proceed as follows, in section 4.2 we introduce the weak-link game and in section 4.3 we discuss leadership, related literature, and state our hypotheses. Section 4.4 contains the results, Section 4.5 concludes and additional materials are provided in the appendices.

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[42] To put these issues in some context: In the dike example, with which we began this chapter, 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 given anonymity.

4.2 The Weak-Link Game

In a standard weak-link game participants simultaneously pick a number. The earnings of a particular player depend on the number they chose and on the lowest number chosen. The lower is the lowest number chosen then the lower are earnings. Earnings are also negatively correlated with the distance between own choice and the lowest choice. A weak-link game is a representation of any situation where the group output depends on the contribution (or effort) of the least contributing member and contributing is costly.

We adopt the standard payoff structure used by Van Huyck *et al.* (1990). In this version of the game participants pick a *whole* number between 1 and 7 and their earnings depend on the choices made according to the following formula:

0.60 + 0.10 [minimum choice] - 0.10 [own choice - minimum choice]

Table 4.1 describes the earnings for participants for every potential combination of their own choice and the lowest choice.

Choice:	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Min = 1	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Min = 2		0.8	0.7	0.6	0.5	0.4	0.3
Min = 3			0.9	0.8	0.7	0.6	0.5
Min = 4				1.0	0.9	0.8	0.7
Min = 5					1.1	1.0	0.9
Min = 6						1.2	1.1
Min = 7							1.3

Table 4.1: Payoff table

Every outcome where all participants 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. 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.

It is worth clarifying 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 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, with the brief exception of figure 4.3, we shall focus on the latter 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.

4.3. Leadership

We contrast the standard weak link game in which all players choose simultaneously with a game in which one individual, the leader, makes a choice before the remaining players. In a standard weak link game we expect to see significant coordination failure. What difference will leadership make? Our main hypothesis is that it reduces coordination failure.

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

It is useful to decompose Hypothesis 1 into two parts: (a) leaders choose higher numbers than would players in a standard weak link game, and (b) followers respond by also choosing higher numbers. For leadership to work we require both (a) and (b). We suggest three reasons why both may hold – signaling, reciprocity and reduced strategic uncertainty.

In a weak link game with leadership a leader can, by choosing a high number, send a costly signal, or communicate to others, that it is good to choose a high number.[43] This is the overriding reason we suggest Hypothesis 1 and several studies have shown the benefits of both costless and costly communication in weak-link games (e.g. Cooper *et al*. 1992, Van Huyck *et al*. 1993, Cachon and Camerer 1995, Cooper 2006 and Blume & Ortmann 2007). We note, however, that costless communication has proved less effective if only one player can communicate (Weber *et al*. 2001), primarily because signals are ignored.[44] Costly communication has also proved ineffective if players avoid the cost of signaling (Manzini *et al.* 2009). Together, this casts doubt on both (a) and (b). Weber *et al.* (2004) seemingly confirm this by finding significant coordination failure in a sequential weak-link game. In this case choosing the highest number is the unique sub game perfect Nash equilibrium and so there should be no coordination failure. In fact, significant coordination failure was still observed, which the authors put down to an unwillingness of some leaders to bet on the

[43] The signal is costly because choice is non-reversible.
[44] When the message promoting cooperation is not entirely clear costless coordination has also proved less effective if it's not common knowledge that the message is common knowledge (Chaudhuri *et al*. 2009).

levels of iterated rationality of others. That leadership will work is, therefore, an open empirical question.

The public good literature provides more reason to be optimistic about the effects of leadership. There leading by example has been shown to have a positive effect on contributions because high leader contributions are reciprocated by followers (Moxnes and Van Der Heijden 2003; Güth *et al*. 2007). Extrapolating this finding to a weak link game means that if a leader chooses a high number (which is a relatively risky thing to do) then followers would reciprocate by also choosing a high number. In a linear public good game (and other settings where it is typical to talk of reciprocity) reciprocity is not consistent with Nash equilibrium and so leadership proves effective only because of followers social preferences (Fehr and Gächter 2000). In a weak link game reciprocation can be consistent with Nash equilibrium and should, therefore, reinforce signaling. The public good literature has also highlighted, however, that a leader may not want to gamble on follower reciprocation (Cartwright and Patel 2010). This is consistent with Fernanda Rivas & Sutter (2011) who find a positive effect of leadership on cooperation but only with voluntary leaders.

The discussion so far suggests that while there are good, intuitive reasons that leadership could increase efficiency, because of signaling and/or reciprocity, there are also reasons it may not. This suggests comparing voluntary (endogenous) leadership versus imposed (exogenous) leadership. Our second hypothesis is that voluntary leadership is more effective than exogenous leadership.

Hypothesis 2: Coordination failure in a weak link game with endogenous leadership is less than in a weak link game with exogenous leadership.

This hypothesis is motivated by the idea that (a) voluntary leaders will be more willing to gamble by choosing a high number, and (b) followers may be more willing to reciprocate a voluntary leader. Support for this 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, while Gächter *et al*. (2008) found that reciprocally oriented leaders contribute more[45].

A final important consideration is that outcomes in the weak-link game are sensitive to group size. The more people there are to coordinate the greater is coordination failure

[45] One related question here is what kind of person chooses to lead. As part of this experiment we also ran some personality questionnaires. The findings are discussed in Appendix 4D.

(Van Huyck *et al*. 1990 and Van Huyck *et al*. 2007). Given that the choice of the leader is known before followers make their choices, followers face less strategic uncertainty in a game with leadership than without. This means that leadership should improve coordination merely by reducing strategic uncertainty. Our final hypothesis is that leadership, because of signaling and reciprocity, does more than this. To test that we need to compare what happens in an *n* player game with leadership to an *n – 1* player game without leadership.

Hypothesis 3: 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 3 strengthens Hypothesis 1. In particular, for an *n* player game with leadership to really look like a standard *n – 1* player game *the leader must choose 7*. If the leader chooses anything less than 7 then there is no reason to expect choices to be as high in the game with leadership as the standard game. Clearly, therefore, we still need that (a), leaders choose high numbers, but have slightly raised the bar for how high a number they should choose. We have also raised the bar for our expectation of followers. Specifically, we now require that (b) a leader choosing a high number causes followers to choose a *higher* number than they would do in a standard weak link with as many players as there are followers. Only in this case can we really think of followers as having responded to the leader's example.

4.4. Method

To test our hypotheses we performed a laboratory experiment in which we compared four different versions of the weak link game, all sharing the payoff structure as given in table 4.1:

Simultaneous 3 player game (Sim3): There are 3 players in the game who all simultaneously chose a number without knowing what the other players have chosen.

Simultaneous 4 player game (Sim4): There are 4 players in the game who all simultaneously chose a number without knowing what the other players have chosen.

Exogenous leader (Exo): There are 4 players in the game. One player is randomly selected to choose before the other three. When this player has made their decision, this decision is made public to the other 3. These remaining 3 players then all simultaneously chose a number.

Endogenous leader (End): There are 4 players in the game. Any one of the 4 players can choose to go first by simply being the first to choose a number. Once one player has chosen, their choice is made public to the other 3. These remaining 3 players then all simultaneously chose a number. In the event that no one chooses to go first (we imposed a cut-off of 30 seconds) the game is changed to one where all four players have to choose simultaneously as in Sim4.[46]

Each experimental session consisted of 3 distinct parts. In each part participants were grouped into groups of 3 or 4, as appropriate, 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. Specifically, we ran seven sessions in all, each with four groups. In one session participants played Sim3 in all 3 parts of the experiment. 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 4.2.

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

Table 4.2: Summary of sessions.

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 example, session 4 participants were first given general instructions and then short specific instructions to Exo and played 10 rounds. They were then told the revised instructions for Sim4 and reminded that they would now be matched with new players before playing 10 rounds of Sim4. Finally, they were given the revised instructions for End and again reminded that they would

[46] In the end, this never happened. During the game there was always someone who wanted to choose first.

now be matched with new players before playing 10 rounds of End. The instructions are available in appendix 4A.

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’. Also, in each round once participants had made their decision the lowest - and only the lowest - number in the group, and the earnings were announced. Note that announcing the full distribution of choices, rather than just the minimum, has been shown to make it easier for subjects to coordinate, and so we provide a tougher test of leadership (Berninghaus and Ehrhart 2001 and Brandts and Cooper 2006a).[47]

The experiment was programmed and conducted with the software Z-tree (Fischbacher, 2007) and run at the University of Kent in March 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 minutes.

4.5 Results

To give a first snapshot of the overall results, table 4.3 summarizes the average choice, the average minimum choice and average total earnings per group over all 10 rounds for the four games. To put the average total earnings into context, if players coordinate on 7 in each round then average total earnings would be 13, and if they coordinate on 1 they would be 7. Note that we have pooled the results across the sessions thereby ignoring the order in which subjects play a particular game (this is justified in appendix 4B).

There is no statistically significant difference in average choice between the Exo and End leadership conditions (Mann-Whitney, $p = .571$). Pooling the averages from both leadership conditions over the 10 rounds the difference between the Sim4 condition and the combined leadership conditions is statistically significant for the average choice (M-W, $p = .024$) and for the average minimum choice (M-W, $p = .040$) and marginally so for the average earnings (M-W, $p = .082$). This suggests support for hypothesis 1 but not for hypotheses 2 and 3.

[47] 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.

	Average choice	Average choice (round 1)	Average choice (round 10)	Average minimum choice	Average earnings
Sim4	3.00 (1.33)	4.23 (1.05)	2.56 (1.46)	1.93 (1.14)	6.85 (1.31)
Exo	3.78 (1.48)	4.03 (1.73)	3.67 (2.36)	2.61 (1.63)	7.44 (1.97)
End	4.01 (1.71)	4.16 (1.78)	4.28 (2.34)	3.00 (1.78)	7.99 (2.09)
Exo + End	3.90 (1.59)	4.09 (1.74)	3.97 (2.34)	2.81 (1.70)	7.71 (2.04)
Sim3	4.23 (1.71)	4.33 (.98)	3.89 (2.16)	3.45 (1.99)	8.67 (2.35)

Table 4.3: Average choice (total, in round 1 and round 10), minimum choice and total earnings, standard errors in brackets.

To get a more dynamic picture of behavior, figures 4.1, 4.2 and 4.3 plot the development of, respectively, the average choice, minimum choice and average difference between choice and minimum over the course of the 10 rounds. Average choices decline significantly over time in Sim4 (with coefficient -.151 (.027), $p < .01$) and marginally so in Sim3 (-.051 (.014), $p = .06$) but remain relatively stable in the conditions with leadership (0.00 (.019), $p = .97$ for Exo and .003 (.022), $p = .88$ for End). Furthermore, the minimum choice in the two leadership conditions increases over time (.101 (.013), $p < .01$ for Exo and .085 (.027), $p = .014$ for End) and is constant in Sim3 (.034 (.026), $p=.224$) (and marginally significantly declining in Sim4 (-.023 (.012), $p = .084$). There is, therefore, some evidence of a dynamic benefit of leadership. The suggestion would still be, however, that efficiency is essentially catching up with that in Sim3. We see in figure 4.3 that in all four conditions there is a steady convergence of choices. Thus, players do learn to coordinate on a Nash equilibrium.

Another way of looking at the dynamic developments is by comparing the average choices made in the first and the last round (columns 2 and 3 in table 4.3). Differences in average choice between the four different treatments are not significant in round 1 (Kruskal-Wallis, $p = .982$) and marginally so in the 10^{th} round (K-W, $p = .059$). In the final round the average choice in the combined End-Exo treatments is significantly higher than that in Sim3 (M-W, $p = .015$) but not than that in Sim4.

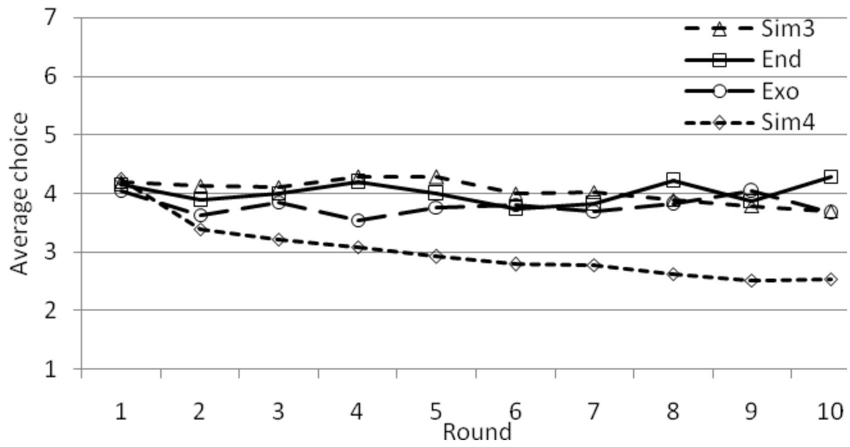

Figure 4.1: Average choice per round.

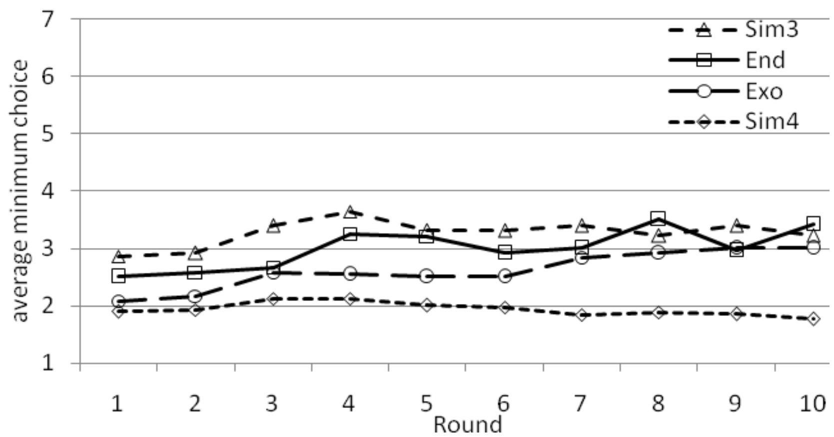

Figure 4.2: Average minimum choice per round.

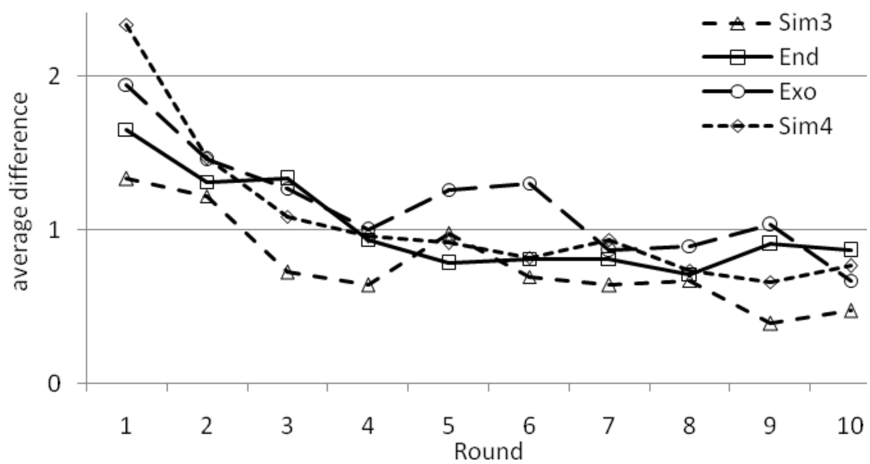

Figure 4.3: Average difference between choice and minimum choice per round.

At this point we can begin to summarize our findings.

Result 1: Overall, leadership does lead to increased efficiency. It does not have any apparent effect on initial choices but does lead to increased efficiency in some groups after repeated interaction.

Despite the positive effects of leadership it is clear that leadership has not completely removed inefficiency. We also see no evidence at this stage for hypotheses 2 or 3. We need to look in more detail at whether leaders chose high numbers and whether followers reacted to the leader's choice.

4.5.1 Follower Choice

Figures 4.4 and 4.5 plot the average and minimum choice of followers as a function of leader choice for all 10 rounds. Clearly, we do see evidence that follower choice is positively correlated to leader choice. The correlation between the number chosen by the leader and (the average) number chosen by followers is high. The Pearson correlation is .873 in the exogenous condition and .822 in the endogenous condition. Both correlations are significant ($p < .001$). While follower choice does correlate it is noticeable that followers pick a significantly lower number than the leader. The average difference between leader choice and (average) follower choice is .54 for exogenous leaders and .38 for endogenous leaders. Both differ significantly from zero ($p < .001$ and $p = .001$ respectively) but not from each other ($p = .149$).

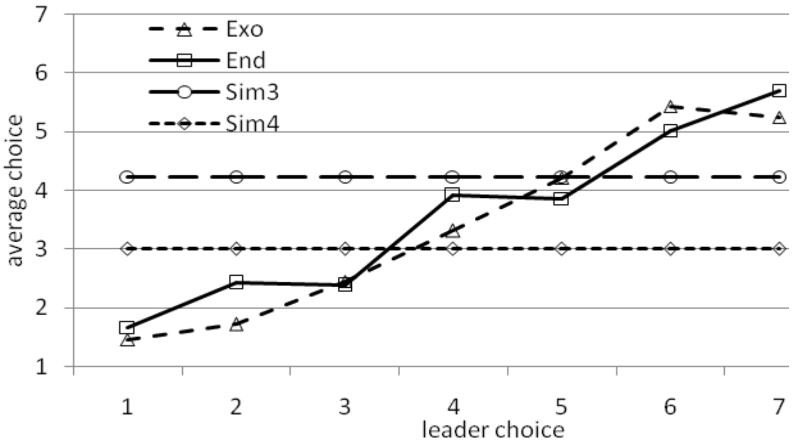

Figure 4.4: The average choice of followers per leader choice.

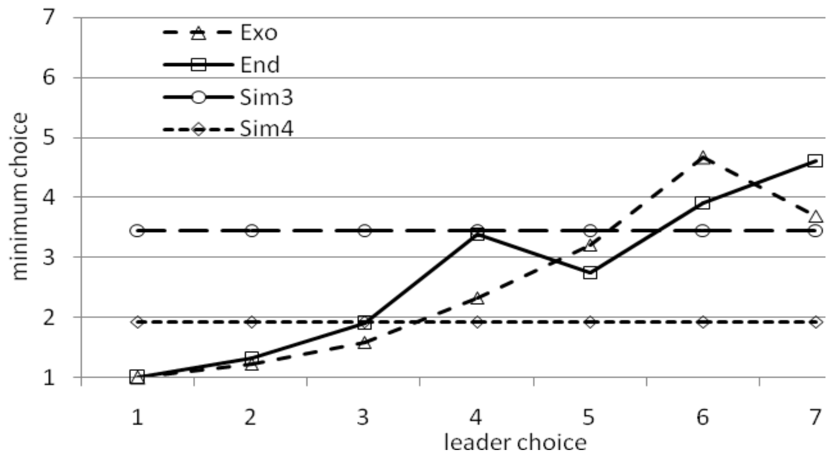

Figure 4.5: The minimum choice of followers per leader choice.

Of particular relevance to us is whether a *high* leader choice causes followers to choose high numbers, and higher than those chosen in Sim3. Figures 4.4 and 4.5 suggest that it does. The average choice made by followers given that the leader has chosen 7 is 5.25 (2.14) in the Exo condition and 5.70 (1.92) in End. This is significantly higher than the average choice in either Sim3 and Sim4 (M-W, $p < .001$ for the comparisons with Sim3 and $p = .004$ for the End-Sim3 and $p = .044$ for Exo-Sim3).

Figure 4.6 further supports this by detailing how the average and minimum choice of followers if the follower chooses (6 or) 7 develops over time. We see in figure 4.6 that the minimum choice of followers, conditional on a leader choosing a high number, is increasing over the 10 rounds (with coefficient (standard error) of 0.203 (0.036)).[48] It would seem that a leader's choice sets a good example for followers and this signal becomes stronger with repeated interaction.

[48] For clarity we have pooled the leadership data but the data for Exo and End follow a very similar pattern.

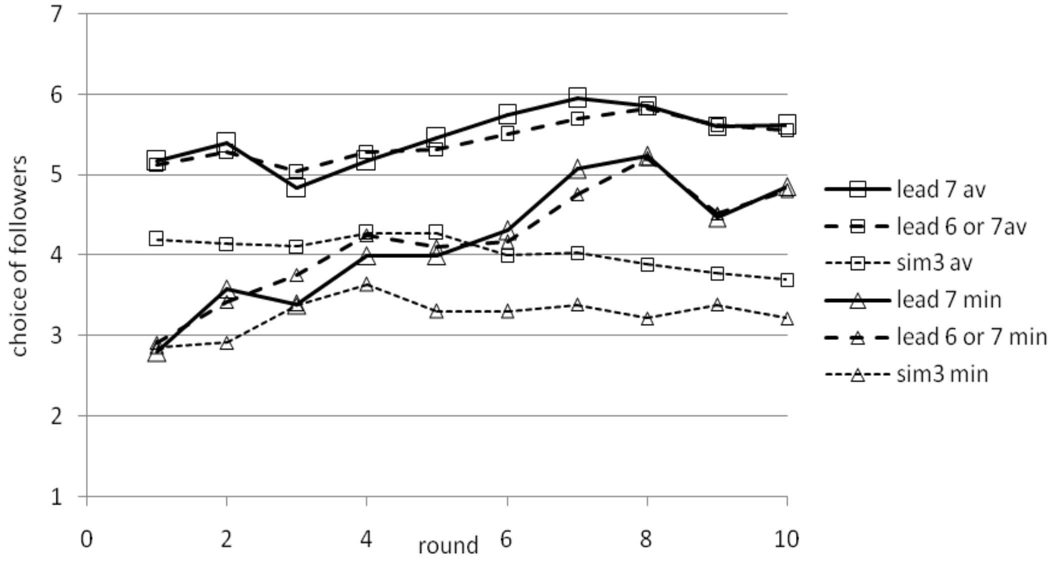

Figure 4.6: The average and minimum choice of followers if leaders choose 6 or 7.

The picture is now, hopefully, starting to become a little clearer. We summarize with our second result.

Result 2: If leaders choose a high number, then followers typically learn to respond to this, and there is higher efficiency than can be explained solely by the reduced strategic uncertainty. That is, they choose higher numbers than in the Sim3 treatment.

4.5.2 Overcoming Coordination Failure in the Group

The picture we are getting is that leadership works in some groups and not others. Furthermore, result 1 and 2 suggested that the effect of leadership emerges after repeated interaction. This leads to the interesting notion that leadership may help overcome coordination failure in the group. In a standard weak link game it typically proves impossible to escape from a low choice equilibrium (e.g. Weber *et al.* 2001, Brandts and Cooper 2006a, 2007 and Chaudhuri *et al*. 2009). Maybe leadership changes this. To explore these issues further we look individually at each of the 48 groups from the leadership conditions and characterize what happens in each group. Clearly any characterization is somewhat subjective and arbitrary, because all groups are different, but we think that there some consistent trends are observable (and our characterization can be easily checked using the information in appendix 4C). We distinguish groups according to the following categories:

Persistent coordination failure (CF): If there was a minimum of 1 in all 10 rounds then we say that there was persistent coordination failure. Table 4.4 shows an example.

Reversal of coordination failure to 4, 5, 6 or 7 (Rx): If there was a round with a minimum of 1 and then a *later* round with a minimum of *x = 4, 5, 6* or *7* then we say that there was a reversal of coordination failure to *x*. This category allows a fairly mixed selection of dynamics as illustrated by the two examples in Table 4.4.

Table 4.5 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 see evidence that groups could overcome coordination failure. For example, in none of the 23 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.[49]

Category	**Group**	**Round**									
		1	2	3	4	5	6	7	8	9	10
CF	11 Exo	7 1	1 1	4 1	1 1	7 1	7 1	4 1	5 1	5 1	2 1
R4	23 End	4 3	1 1	1 1	5 4	5 4	1 1	6 4	1 1	5 4	1 1
R7	2 End	2 1	1 1	6 5	7 6	7 7	7 7	7 7	7 7	7 1	7 2

Table 4.4: Examples of group dynamics, showing the leader and minimum choice by round for example groups.

	R7	**R6**	**R5**	**R4**	**CF**
Exogenous (n = 20)	1	3	9	10	6
Endogenous (n = 17)	2	2	3	7	4
Sim4 (n = 18)	0	0	0	1	10
Sim3 (n = 5)	0	0	0	2	0

Table 4.5: Characterizing group dynamics by leadership condition. The number of groups that fit into each category.

[49] There were 23 and 37 groups where the minimum choice was 1 at some point. In all other groups the minimum choice was always above 1 and so there is no opportunity to overcome coordination failure as we define it.

The data clearly suggest that that leadership did work in some groups to alleviate coordination failure. In all the 12 groups where the minimum did increase to 5 it did so because a leader chose 6 or 7.

Result 3: In the 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 did help overcome coordination failure.

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.

4.5.3 Leadership

Figure 4.7 plots the average choice of leaders in each round. Of interest to us is whether leaders choose higher numbers than in the simultaneous treatments. For comparison we, therefore, plot average choices in the simultaneous treatments as well. The clear suggestion in figure 4.7 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 (4.33 (2.4) vs. 4.39 (2.44), M-W, p = .963). There is also no evidence that leader choices in the combined leadership treatments differ from choices in the simultaneous treatments in round 1 (4.71 (2.40) vs 4.23 (1.05), M-W p = .138, for Sim4 and 4.33 (.98) M-W p = .354, for Sim 3). By round 10 there is evidence that leader choices differ from average choices in Sim4 (4.50 (2.69) vs. 2.56 (1.46), M-W p = .013) but not those in Sim3 (vs. 3.89 (2.16), M-W p = .513).

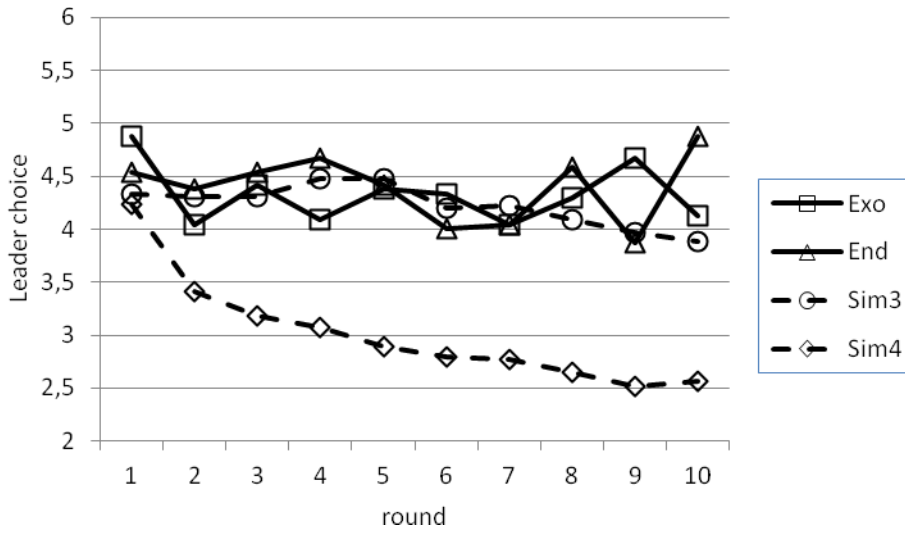

Figure 4.7: The average leader choice by treatment and round compared to average choice in the simultaneous treatments.

Recall that part (a) of hypothesis 1 said that leaders should choose higher numbers than they would have done in the simultaneous treatments.

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, does 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. 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.

4.5.3 Exogenous versus Endogenous Leadership

Finally, we compare endogenous versus exogenous leadership. The raw data is consistent with Hypothesis 2: The average number chosen by endogenous leaders is higher than by exogenous leaders (4.39 versus 4.33); the minimum choice of followers in the endogenous condition is closer to leader choice than in the exogenous condition (0.38 versus 0.54);

followers choose on average a higher number if an endogenous leader chooses 6 or 7 compared to an exogenous leader (5.55 versus 5.28); finally, as we saw in table 4.3, average and minimum choice, and payoffs, are higher in the endogenous compared to exogenous leadership condition.[50] None of these differences are, however, large or statistically significant. Whether this is because of lack of data or lack of an effect we cannot tell. This leads to our final result.

Result 5: We find no significant difference between games with an endogenous and exogenous leader.

To try and understand why we may observe this lack of difference, we first note that if results 2 and 3 suggest high leader choices can ultimately lead to improved group efficiency they leave open the question of whether choosing high numbers pay off for leaders. Recall from table 4.1 that a leader can guarantee a payoff of 0.7 by choosing 1. If he chooses 7 then he needs the minimum choice of followers to be at least 4 in order to get a payoff of 0.7 or above. It is clear from figure 4.6 that this may not be the case, particularly in the early rounds. In fact leaders do earn slightly less (but not significantly so) than followers in both conditions, as detailed in table 4.7, and the average payoff of leaders is increasing over rounds (with coefficient (standard error) 0.02 (0.003)). Leaders do not earn significantly more or less than players in the Sim4 condition. In fact only followers in the endogenous condition do significantly different than they would have done in the simultaneous condition ($p = .012$). For followers in the exogenous condition the difference is not significant ($p = .187$).

	Leader	**Followers**
Exogenous	0.69 (.21)	0.76 (.18)
Endogenous	0.76 (.22)	0.81 (.20)
Sim4	0.69 (0.11)	

Table 4.7: Average earnings per round for leaders and followers per leadership condition.

[50] All participants in sessions 1 to 6 played games End, Exo and Sim4. The group a participant was with would change for each game so a direct comparison will be distorted by group effects. It still seems an interesting comparison, however, to see how a particular participant did across the three games. Choices and payoffs were higher in End than Exo for a statistically insignificant majority (50 and 53 out of 96).

Now consider a player who believes that the high choice of a leader might increase efficiency over time. In the End condition this player has the opportunity to lead and choose a high number. Whether he does so will likely depend on whether he is willing to gamble on followers responding and whether he expects some other player to do it. If he does expect some other player to do it then it is best to be a follower with its higher expected payoff.[51] In the Exo condition this last possibility is removed as no other player could possibly lead. This creates two countervailing forces: (i) In the End condition one or two players who decide it is worthwhile to lead and choose high numbers can do so in every period, but in the Exo condition they are constrained to wait their turn. (ii) In the End condition players willing to gamble on followers responding may wait for someone else to do so, and nobody does, but in the Exo condition their turn comes along and they take the gamble. The overall effect is ambiguous because (i) suggests greater efficiency in the End condition and (ii) in the Exo condition. Some support for this is seen in figure 4.8 where see that there are more groups where leaders consistently choose high numbers or never choose higher numbers in the End than Exo condition.

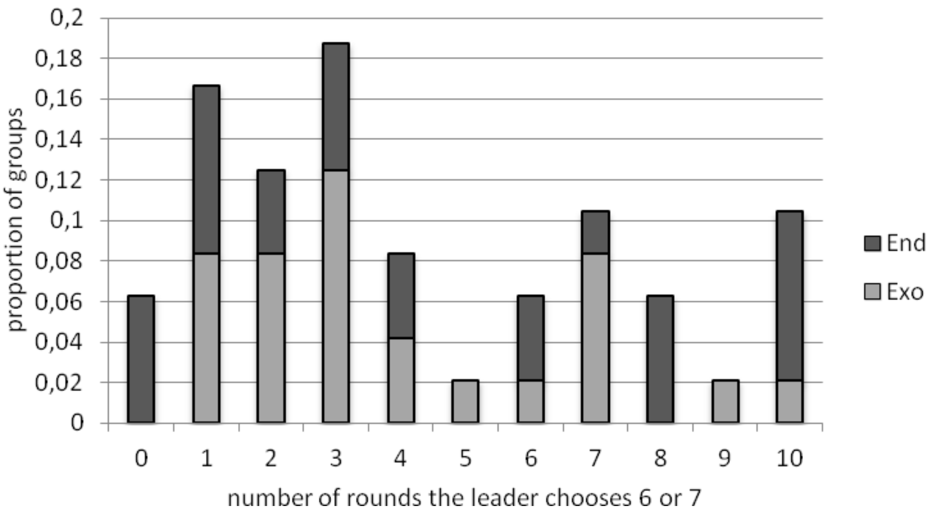

Figure 4.8: The number of rounds (out of 10) the leader chooses 6 or 7 per group.

[51] More formally, a leader who chooses 7 is gambling on the choices of 3 followers. A follower choosing 7 after a leader has chosen 7 is gambling on the choices of only 2 other followers.

4.6 Conclusions

The provision of many public and private goods hinges on the actions of the weakest link in the chain, that is the lowest contributor (Hirshleifer 1983 and Camerer 2003). The evidence suggests that in such cases the likely outcome is coordination failure. Various possible solutions have been considered in the literature and our objective in this chapter was to consider a novel solution, leadership. By leadership we mean that one person, the leader, announces their contribution first thereby setting an example for the rest of the group. Our main hypothesis was that by choosing a high number the leader could improve efficiency.

We find that leadership did increase efficiency in a significant proportion of groups. More surprising was that it did so with a delayed effect. Specifically, leadership generally failed to establish efficiency in the early rounds but there was a rise in efficiency over time in many groups. That leadership produced increased efficiency over time is because individuals took time to follow the example of leaders. Our main conclusion is therefore that leadership can work if individuals persistently set a good example and eventually pull up the efficiency of the group. We found no discernible difference between voluntary and imposed leaders.

We finish by relating our results to some related work. In concurrent and on-going work, Coelho *et al*. (2009), address a very similar question to that which motivated this chapter. They consider a 10 player weak link game in which a leader, the person in the group with the highest 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 by followers. These results seem quite different to ours and 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 (see also Gillet, Cartwright and Van Vugt 2011 and Appendix 4D).

Appendix 4A: Instructions

In this experiment you are going to play a number of, slightly similar, games.

You will play these games in groups of four. Each game lasts for ten rounds and during these ten rounds you will be playing with the same people. When we start a new game we also change the group you are playing with. All groups are formed randomly. You will **never** play a game with the same player twice.

In each round of this game you will have to pick a number. Your earnings depend on the number you pick and the numbers picked by the other players in your group.

You can pick any *whole* number between 1 and 7.

Your earnings are determined by your choice and the **lowest number** chosen by the players in your group. Mathematically your earnings (in pounds) are determined by the following formula:

$$0.60 + 0.10 \text{ x [minimum choice]} - 0.10 \text{ x [your choice} - \text{minimum choice]}$$

To keep it simple the table below describes your earnings for each combination of your choice (columns) and the minimum choice in your group (rows). This table will also be on your screen during the experiment.

Choice:	**1**	**2**	**3**	**4**	**5**	**6**	**7**
min = 1	0.7	0.6	0.5	0.4	0.3	0.2	0.1
min = 2		0.8	0.7	0.6	0.5	0.4	0.3
min = 3			0.9	0.8	0.7	0.6	0.5
min = 4				1	0.9	0.8	0.7
min = 5					1.1	1	0.9
min = 6						1.2	1.1
min = 7							1.3

An example (and the numbers used in this example are picked for clarification purposes only):

- You pick 5 and the other players in your group pick 7, 6 and 3. The minimum choice in your group is 3. Since you have picked 5 your earnings are 0.7 (and the player picking 7 earns 0.5, the player choosing 6 0.8 and the player choosing 3 0.9)

It doesn’t matter who picks the lowest number or how many players pick the lowest number. The earnings for **all players** are calculated as in the table.

In general, you won’t learn what player picked what number (nor will the other players know what number you have picked). In each round we will just tell you the **lowest number** and how much you have earned.

As said, you will play a number of different versions of this game; each time with different people. All your earnings of the ten rounds in a particular game will be summed together. Afterwards we will randomly select **one of the games** you have played and pay you your earnings of that game.

Before playing Sim4

In this version of the game everybody picks their numbers **simultaneously**.

In every round players choose their numbers without knowing the number the other three pick. When everybody has chosen their number (and clicked ‘ok’) the computer announces the lowest choice in the group and your earnings. We then proceed to the next round.

Before playing Exo

In this version of the game one player is selected to pick his/her number **before the rest**. Who goes first is determined randomly for each round.

After the first player has chosen his/her number, the other players learn what number was picked and then pick their own numbers **simultaneously**. The three remaining players pick their numbers without knowing what number the other two pick. When everybody has chosen their number (and clicked 'ok') the computer announces the lowest choice in the group and your earnings. We then proceed to the next round.

Being the first to pick a number does **not affect** your earnings in any way. The earnings for all players are calculated as in the table regardless of order.

Before playing End

In this version of the game one player can decide to pick his/her number **before the rest**.

A player can become the one to choose before the rest by being the first to pick a number (and to click 'ok').

After the first player has chosen his/her number, the other players learn what number was picked and then pick their own numbers **simultaneously**. The three remaining players pick their numbers without knowing what number the other two pick.

In each round there are 30 seconds for players to pick a number before the rest. If none of the players do so in this time the **whole group** will choose their number simultaneously. Then all four players pick their number without knowing what number the other three pick.

When everybody has chosen their number (and clicked 'ok') the computer announces the lowest choice in the group and your earnings. We then proceed to the next round.

Being the first to pick a number does not affect your earnings in any way. The earnings for all players are calculated as in the table regardless of order.

Additionally for each new game

Remember, by starting a new version of the game we also change the group of players you're playing with. Which player plays in which group is determined randomly. The only thing that is certain is that you will **never** play a game with the same participants twice.

Appendix 4B: Order Effects in the Weak-link Game

One issue that we need to address is whether there were any order effects in playing the game. Recall that all participants in the four player conditions played each of the different versions once, as detailed in table 4.2. The experiment was designed in a way so as to try and remove any order effects by, for example, completely changing groups for every game. Even in a perfect stranger set-up, however, we cannot simply rule out the possibility of the existence of some sort of learning effect caused by playing – a similar version of – the game three times in a row. In fact, we find no evidence of an order effect. For example, when we take the average choice over all three four-player conditions together participants chose in the first the game they played 3.44 (1.1), in the second game 3.68 (1.72) and in the third 3.68 (1.81). There is no significant difference (Kruskal-Wallis, $p = .989$) in the average choice between these games. Participants do not, on average, pick higher numbers as they play related games in a row. The one exception is Session 7 where subjects played Sim3 three times in a row and improved efficiency each time. We are not, however, too concerned about this exception because its only consequence will be that we *overestimate* how well players coordinate in Sim3.

Figure 4B.1 plots the average choice for each of the seven sessions and suggests that session effects outweighed any group effects. In Session 1, for example, choices are relatively high and in session 5 they are relatively low. We might conjecture that this is because in session 1 game Exo was played first and in session 7 Sim4 was played first. A look at session 3 (which started with game Sim4 but saw relatively high choices), and session 4 (which started with game Exo but saw relatively low choices) shows, however, that this conjecture does not get much support. It might be interesting to note that in all sessions bar one payoffs are higher in End than Exo than Sim4. In this remaining session they are higher in Exo than End than Sim4.

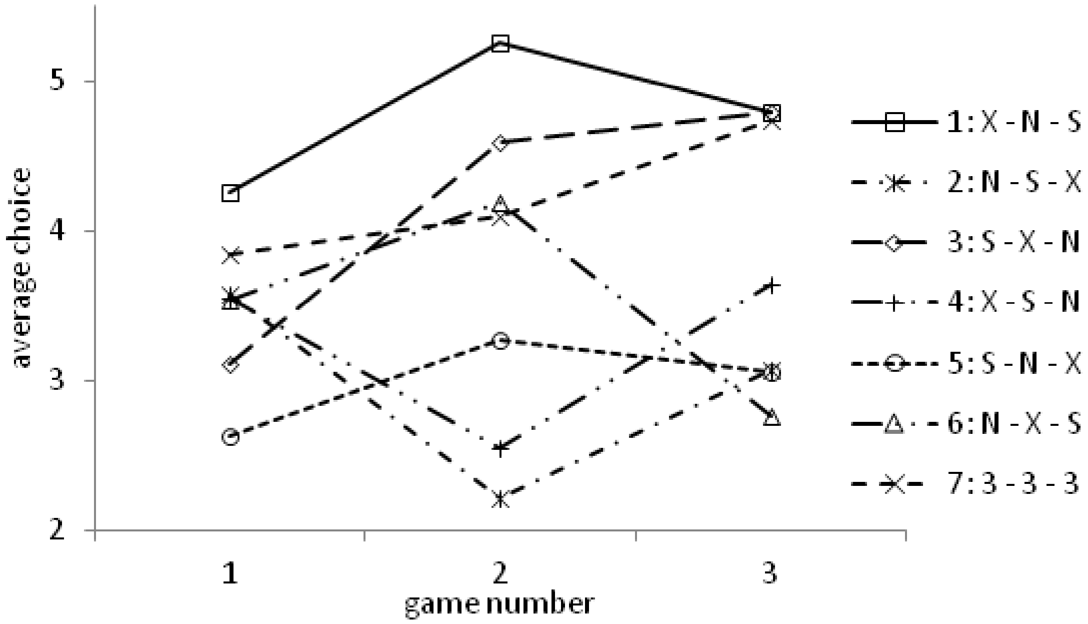

Figure 4B.1: The average choice by session and game number, X = Exo, N = End, S = Sim4 and 3 = Sim3.

Appendix 4C: Leader, Minimum and Overall Choice Frequencies

We provide some of the more detailed data from which the tables in the main text were derived. First we detail the minimum and overall choice frequencies over the 10 rounds. For example, in the Sim4 condition 12.50% of times the minimum choice in round 5 was 4.

Sim4 (n=24):

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	58.33	50.00	50.00	45.83	54.17	58.33	62.50	54.17	66.67	58.33
2	12.50	20.83	8.33	25.00	16.67	16.67	12.50	25.00	8.33	25.00
3	12.50	20.83	25.00	8.33	12.50	4.17	12.50	0.00	4.17	0.00
4	16.67	4.17	12.50	16.67	12.50	16.67	8.33	20.83	16.67	16.67
5	0.00	4.17	4.17	0.00	0.00	0.00	0.00	0.00	4.17	0.00
6	0.00	0.00	0.00	4.17	4.17	4.17	4.17	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Endogenous (n=24):

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	54.17	62.50	58.33	50.00	50.00	54.17	41.67	41.67	50.00	50.00
2	12.50	8.33	4.17	8.33	4.17	4.17	8.33	8.33	0.00	0.00
3	20.83	8.33	4.17	8.33	8.33	4.17	16.67	8.33	4.17	8.33
4	4.17	4.17	8.33	8.33	20.83	16.67	8.33	20.83	16.67	12.50
5	0.00	4.17	8.33	20.83	16.67	16.67	16.67	8.33	12.50	8.33
6	8.33	12.50	12.50	4.17	0.00	4.17	0.00	4.17	8.33	12.50
7	0.00	0.00	4.17	0.00	0.00	0.00	8.33	8.33	8.33	8.33

Exogenous (n=24):

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	41.67	37.50	41.67	29.17	33.33	37.50	50.00	37.50	50.00	41.67
2	16.67	20.83	0.00	8.33	16.67	20.83	8.33	8.33	8.33	4.17
3	12.50	12.50	25.00	16.67	4.17	4.17	4.17	4.17	0.00	12.50
4	16.67	8.33	20.83	20.83	16.67	16.67	4.17	12.50	16.67	8.33
5	4.17	16.67	8.33	4.17	8.33	0.00	8.33	8.33	4.17	4.17
6	8.33	4.17	4.17	20.83	12.50	12.50	12.50	12.50	4.17	4.17
7	0.00	0.00	0.00	0.00	8.33	8.33	12.50	16.67	16.67	25.00

Sim3 (n=12):

	1	2	3	4	5	6	7	8	9	10
1	8.33	25.00	8.33	16.67	16.67	16.67	16.67	25.00	16.67	25.00
2	33.33	25.00	33.33	8.33	25.00	25.00	16.67	16.67	16.67	16.67
3	25.00	16.67	16.67	25.00	25.00	25.00	33.33	25.00	33.33	25.00
4	16.67	0.00	8.33	16.67	0.00	0.00	0.00	0.00	0.00	0.00
5	16.67	16.67	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33
6	0.00	16.67	16.67	8.33	8.33	8.33	8.33	8.33	8.33	8.33
7	0.00	0.00	8.33	16.67	16.67	16.67	16.67	16.67	16.67	16.67

Table 4C.1: Minimum choice frequencies by condition and round, column = round, row = choice and cell = frequency.

Sim4 (n=96):

	1	2	3	4	5	6	7	8	9	10
1	16.67	22.92	31.25	32.29	38.54	41.67	40.63	41.67	46.88	45.83
2	7.29	15.63	10.42	13.54	13.54	12.50	13.54	11.46	15.63	16.67
3	13.54	14.58	19.79	12.50	10.42	10.42	12.50	13.54	7.29	6.25
4	15.63	19.79	10.42	18.75	14.58	13.54	14.58	14.58	13.54	14.58
5	15.63	8.33	12.50	8.33	9.38	10.42	6.25	13.54	8.33	5.21
6	8.33	9.38	6.25	8.33	7.29	5.21	5.21	3.13	3.13	6.25
7	22.92	9.38	9.38	6.25	6.25	6.25	7.29	2.08	5.21	5.21

Endogenous (n=96):

	1	2	3	4	5	6	7	8	9	10
1	26.04	29.17	23.96	31.25	29.17	29.17	28.13	23.96	33.33	35.42
2	4.17	13.54	13.54	9.38	7.29	7.29	9.38	9.38	3.13	9.38
3	15.63	11.46	6.25	12.50	7.29	9.38	11.46	10.42	4.17	6.25
4	12.50	10.42	16.67	9.38	16.67	8.33	11.46	15.63	7.29	7.29
5	7.29	6.25	7.29	14.58	12.50	16.67	14.58	17.71	14.58	8.33
6	5.21	5.21	13.54	4.17	8.33	12.50	5.21	4.17	13.54	10.42
7	29.17	23.96	18.75	18.75	18.75	16.67	19.79	18.75	23.96	22.92

Exogenous (n=96):

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	19.79	25.00	21.88	19.79	17.71	27.08	29.17	28.13	34.38	29.17
2	7.29	12.50	7.29	7.29	16.67	10.42	9.38	7.29	9.38	4.17
3	14.58	11.46	14.58	11.46	8.33	8.33	13.54	6.25	1.04	7.29
4	11.46	8.33	11.46	14.58	17.71	19.79	5.21	7.29	13.54	10.42
5	13.54	10.42	14.58	9.38	5.21	5.21	10.42	5.21	5.21	4.17
6	9.38	6.25	10.42	17.71	14.58	9.38	6.25	16.67	5.21	7.29
7	23.96	26.04	19.79	19.79	19.79	19.79	26.04	29.17	31.25	37.50

Sim3 (n=36):

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	2.78	8.33	5.56	5.56	8.33	13.89	13.89	13.89	13.89	16.67
2	11.11	11.11	16.67	11.11	11.11	8.33	11.11	13.89	16.67	13.89
3	25.00	19.44	16.67	19.44	22.22	27.78	25.00	16.67	25.00	25.00
4	19.44	11.11	19.44	16.67	8.33	5.56	5.56	11.11	5.56	5.56
5	13.89	19.44	8.33	13.89	8.33	8.33	5.56	16.67	5.56	5.56
6	8.33	13.89	11.11	8.33	16.67	11.11	11.11	5.56	8.33	13.89
7	19.44	16.67	22.22	25.00	25.00	25.00	27.78	22.22	25.00	19.44

Table 4C.2: Overall choice frequencies by condition and round, column = round, row = choice and cell = frequency.

Next we detail the minimum choice, in Sim4 and Sim3, and the leader choice and minimum choice, in Exo and End, by round for all groups. Recall that participants in groups are randomized after each game, so the participants in group 1 of the Sim4 condition will definitely not be the same as those in group 1 of the Exo condition etc. It may be worth noting, however, in looking through the data that each session had 4 groups and the groups are provided in order. This means that the participants in groups 1-4 of the Sim4 are the same as in groups 1-4 of the Exo and End conditions etc. There was only one session of the Sim3 condition.

Group	Round										Category
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1	4	3	4	2	3	4	4	4	4	2	-
2	3	4	5	6	6	6	6	4	5	4	-
3	3	5	2	4	4	4	3	4	4	4	-
4	4	1	3	3	2	3	3	2	2	2	-
5	1	1	1	1	1	1	1	1	1	1	CF
6	2	2	2	2	2	2	2	2	2	2	-
7	1	1	1	1	1	1	1	1	1	1	CF
8	1	1	1	1	1	1	1	1	1	1	CF
9	1	3	3	2	2	1	1	2	1	2	-
10	1	3	3	2	2	1	1	2	1	2	-
11	1	2	3	4	4	4	4	4	4	4	R4
12	1	1	1	1	1	1	1	1	1	1	CF
13	2	2	1	2	1	1	1	1	1	1	-
14	1	1	1	1	1	1	1	1	1	1	CF
15	1	1	1	1	1	1	1	1	1	1	CF
16	1	2	3	4	1	1	1	2	1	2	R4
17	2	1	1	1	1	1	1	1	1	1	-
18	1	1	1	1	1	1	1	1	1	1	CF
19	1	1	1	1	1	1	1	1	1	1	CF
20	4	3	4	2	3	4	2	2	3	2	-
21	1	1	1	1	1	1	1	1	1	1	CF
22	1	1	1	1	1	1	1	1	1	1	CF
23	1	1	1	1	1	1	1	1	1	1	-
24	1	2	3	3	3	2	2	2	1	1	-

Table 4C.3: The minimum choice by round and group in the Sim4 condition.

	Round										**Category**
Group	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1	5 3	7 1	4 1	3 1	7 4	1 1	2 2	5 4	6 6	6 6	R6
2	3 2	3 2	2 1	2 1	2 1	6 4	3 3	4 3	6 4	7 5	R5
3	7 4	4 2	7 6	7 5	7 4	7 4	4 3	7 5	6 5	5 4	-
4	4 3	5 5	4 4	5 2	4 3	7 1	1 1	4 3	3 3	5 3	-
5	1 1	7 3	5 3	7 5	3 1	7 5	7 5	7 4	6 4	7 3	R5
6	7 1	1 1	7 1	1 1	1 1	1 1	5 1	1 1	1 1	1 1	CF
7	4 2	3 2	2 1	1 1	5 1	1 1	6 1	1 1	1 1	1 1	-
8	1 1	7 3	4 1	7 3	6 3	3 1	1 1	3 1	1 1	1 1	-
9	7 1	7 6	7 7	5 5	5 5	5 5	7 7	7 7	7 7	7 7	R7
10	7 6	7 6	6 6	7 5	7 5	7 6	7 7	7 7	7 7	7 7	-
11	7 1	1 1	4 1	1 1	7 1	7 1	4 1	5 1	5 1	2 1	CF
12	7 1	4 1	3 1	7 1	1 1	5 1	3 1	1 1	1 1	1 1	CF
13	7 1	2 1	6 5	1 1	4 1	5 1	7 1	4 1	7 1	1 1	R5
14	7 1	7 1	4 4	7 4	7 4	5 5	5 5	7 6	5 5	6 6	R6
15	7 3	4 1	2 1	1 1	7 1	1 1	2 2	2 2	7 1	2 1	-
16	3 2	3 1	6 1	7 2	1 1	3 2	4 3	4 2	3 1	5 1	-
17	1 1	7 1	4 1	1 1	1 1	1 1	1 1	3 1	1 1	1 1	CF
18	1 1	1 1	1 1	1 1	7 1	7 1	1 1	5 1	7 1	1 1	CF
19	7 6	7 6	6 6	7 6	6 5	6 5	6 5	5 4	7 6	7 6	-
20	7 1	3 1	1 1	4 1	1 1	1 1	1 1	1 1	1 1	1 1	CF
21	4 2	2 1	7 2	2 1	4 2	7 4	7 4	5 4	7 4	7 5	R5
22	1 1	4 4	7 5	6 5	7 5	4 3	7 5	7 4	7 1	7 4	R5
23	4 3	1 1	1 1	5 4	5 4	1 1	6 4	1 1	5 4	1 1	R4
24	7 2	1 1	1 1	3 3	4 4	6 4	5 3	7 5	5 5	4 4	R5

Table 4C.4: The leader choice and minimum choice by round and group in the Exo condition

Group	Round										Category
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1	3 2	4 3	2 1	3 1	4 3	4 2	3 2	7 5	7 5	7 5	R5
2	2 1	1 1	6 5	7 6	7 7	7 7	7 7	7 7	7 1	7 2	R7
3	7 5	5 5	4 4	6 6	7 5	7 6	7 6	7 6	7 7	7 7	-
4	6 6	7 4	7 3	5 5	6 6	4 4	5 5	7 7	4 4	7 7	-
5	7 6	7 6	6 4	6 4	6 4	4 1	7 2	7 4	5 2	7 3	R4
6	7 1	6 1	7 1	7 1	1 1	1 1	7 1	7 1	1 1	7 1	CF
7	4 3	3 2	2 1	1 1	5 1	1 1	6 1	1 1	1 1	1 1	-
8	3 2	1 1	7 1	7 3	6 2	6 2	1 1	7 1	2 1	6 3	-
9	7 1	1 1	3 3	3 3	4 4	4 4	5 5	6 6	7 7	7 7	R7
10	7 3	7 2	7 4	7 6	7 6	7 6	7 6	7 6	7 6	7 7	-
11	1 1	7 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	7 1	CF
12	7 4	7 5	6 5	6 6	6 6	7 6	7 7	7 7	7 7	7 7	-
13	6 1	3 3	5 3	7 4	2 2	5 2	3 1	1 1	1 1	1 1	R4
14	7 4	7 5	7 6	7 6	7 7	7 7	7 7	7 7	7 7	7 7	-
15	2 1	7 2	2 1	1 1	3 1	1 1	1 1	1 1	1 1	1 1	-
16	5 3	5 2	6 3	3 2	2 1	1 1	1 1	3 2	2 1	3 1	-
17	7 4	7 5	7 4	7 3	7 5	7 2	7 6	6 4	7 4	7 4	-
18	1 1	1 1	1 1	1 1	4 1	2 1	1 1	1 1	1 1	1 1	CF
19	1 1	1 1	1 1	4 4	4 4	4 4	4 4	4 4	7 4	4 4	R4
20	5 1	1 1	1 1	5 1	1 1	1 1	1 1	1 1	1 1	1 1	CF
21	5 3	3 2	5 3	7 4	2 2	6 4	3 3	6 5	4 4	7 6	-
22	1 1	7 4	7 3	4 3	7 1	3 1	1 1	1 1	1 1	1 1	R4
23	2 2	1 1	5 1	3 2	3 2	2 2	2 1	5 2	3 1	1 1	-
24	6 4	6 3	4 4	4 4	4 4	4 3	3 1	3 3	2 2	6 3	-

Table 4C.5: The leader choice and minimum choice by round and group in the End condition

Group	Round										Comments
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1	3	1	2	4	3	3	3	3	3	3	R4
2	1	2	3	4	3	3	3	3	3	3	R4
3	2	3	4	3	2	3	3	3	3	3	-
4	2	1	2	3	1	2	2	1	2	1	-
5	4	5	5	5	5	5	5	5	5	5	-
6	2	1	1	1	1	1	1	1	1	1	-
7	4	5	6	7	7	7	7	7	7	7	-
8	2	2	2	2	2	2	2	2	2	2	-
9	3	3	2	3	3	2	3	2	3	2	-
10	5	6	7	7	7	7	7	7	7	7	-
11	5	6	6	6	6	6	6	6	6	6	-
12	3	2	3	1	2	1	1	1	1	1	-

Table 4C.6: The minimum choice by round and group in the Sim3 condition.

Appendix 4D: Selfish or Servant Leadership? Leadership Personalities in a Weak-Link Game

In this appendix we report the results of a personality questionnaire that was part of the weak-link experiment described in this chapter. Our aim was to shine light on the question what kind of person chooses to lead.[52]

The collapse of the banks, the invasion in Iraq and the election of Barack Obama, the first Black president in US-history, all invariably point to the importance of leadership. Leadership is arguably one of the main themes in current social affairs and is one of the most widely studied subjects in the social sciences. Yet the question “Who leads” has not been fully addressed. For instance, it remains to be seen whether leaders are primarily concerned with serving their own selfish interests or the interest of their followers. Personality research on leadership has found a stable set of traits cross-culturally associated with good leadership such as intelligence, generosity, vision and competence (Den Hartog *et al.* 1999). Yet, it is also clear that there are many dominant, authoritarian, and despotic leaders out there who try to exploit group resources to benefit themselves and their close allies.

An evolutionary approach suggests that there are two contrasting theoretical positions on the origins of leadership in humans with implications for the types of personalities that are attracted to leadership positions (Van Vugt 2006; Van Vugt *et al.* 2008b). The first is a by-product theory which views leadership as the outcome of dominance battles between (mostly male) group members. The argument is that evolution has equipped individuals with the psychological tendencies to compete over status and dominance because someone’s position in the hierarchy of the group determines their access to reproductively relevant resources. Leadership is thus the product of status competitions whereby leaders occupy the top positions in the hierarchy and by virtue of their position can exercise power over lower-ranked individuals. This is how most evolutionary biologists and psychologists write about leadership (Wilson 1975).

The alternative perspective is that leadership is a group-level adaptation that enables individuals to function better in groups (Wilson *et al.* 2008). Leadership is a coordination device that helps groups solve problems with regard to the planning and execution of group tasks such as collective movement, resource sharing and group decision-making. Having

[52] This appendix is based on Gillet, Cartwright and van Vugt (2011)

someone as leader serves the interests of followers because they can reap the benefits of being in a highly coordinated and cohesive group. This is essentially the concept of servant leadership as coined by Robert Greenleaf (2002) to depict a style of leadership in which the primary service is to the followers (Liden *et al.* 2008).

The dominance versus coordination perspectives thus make different predictions about the personalities of individuals emerging as leaders in formerly leaderless groups. According to the leadership-as-dominance view leadership emergence is expected to correlate with essentially selfish and egotistic traits whereas the leadership-as-coordination perspective hypothesizes an association between leadership and prosocial personality traits -- we can refer to these in terms of the selfish leadership versus servant leadership hypothesis.

We define leadership behaviorally in terms of the individual who coordinates group activities by making the first move in a coordination game (of course first movers only emerge as leaders if their moves are being followed by the rest). This is essentially leadership-by-example -- one individual acting publicly before the rest and thereby influencing others into taking a particular course of action (Yukl 1989). Leading by example is a prominent form of leadership among both humans and nonhumans (for a recent review see King *et al.* 2009) but it has not yet been sufficiently studied in humans. Examining this kind of leadership in an economic game enables us to investigate if there are stable personality differences in the propensity to take the lead in situations in which the (monetary) pay-offs for leadership varies (Cartwright, Gillet & Van Vugt, 2009, Cartwright, Gillet & Van Vugt, 2011). So, the core question in this game is who leads and how do they fare compared to followers in terms of their earnings in the game?

This core leadership question has not been addressed in the economic and psychological literatures although there is an increasing interest in studying leadership in coordination games and social dilemmas (Brandts & Cooper 2006b; Coats *et al.* 2009; Coats & Neilson 2005; Cooper 2006; Gächter *et al.* 2009; Güth, *et al.* 2007; Weber *et al.* 2004). So far the economic literature has primarily focused on the benefits of leadership in terms of helping players coordinate while neglecting questions about the potential costs for the individuals moving first. O'Gorman *et al.* (2009) found some evidence for altruistic or "servant" leadership in a public good game where leaders were given the opportunity to punish freeriders. Servant leadership increased cooperation within the group but at a significant cost to the leaders. In addition, the literature has been relatively ignorant about the personalities of individuals who take on leadership roles in these games (these roles are usually determined by the experimenter; O'Gorman *et al*. 2008).

What we typically observe, however, in these games is that leaders receive lower payoffs than followers. Two distinct reasons for this are noted. First, leaders may try to signal something to followers but followers miss the meaning of or ignore the signal. Second, followers can punish a leader who appears to exploit any strategic advantage from leadership. All of this supports the social coordination or servant leadership hypothesis that pro-social people are more likely to want to lead (and are more likely to be successful leaders).

At the same time there is also some evidence for the dominance or selfish leadership hypothesis. This comes mainly from historical records of leadership such as the writings on kings, emperors, and tyrants who often use their leadership positions to enrich themselves and their relatives (Betzig 1993) and from experimental social psychological research on social dilemmas. For instance, when people are assigned to leadership positions – even if they are randomly allocated – they tend to harvest more points from a common resource pool than ordinary group members. The amount they took was also predicted by their personality: Individuals with prosocial personalities took less than individuals with proself personalities (De Cremer & Van Dijk 2005). In addition, leadership emergence in unstructured laboratory groups is associated with personality traits such as Machiavellianism and Narcism (that together with Psychopathy form the so-called Dark Triad) which produce manipulative and self-centered leaders (Van Vugt 2006). Thus, these findings support the idea that selfish people are more likely to want to lead.

To test the selfish versus servant leadership hypothesis we examined decision-making in a standard weak-link game (Van Huyck *et al.* 1990). The selfish hypothesis predicts that leaders do better (earn more) than followers in the game and that they score highly on personality traits associated with dominance and selfishness. The alternative servant leadership hypothesis predicts that overall leaders do worse (earn less) in the game than followers, and that they score low on dominance and selfishness traits. In order to measure personality we asked participants to complete the dominance scale (Heckert *et al.* 1999), the social value orientation measure (Kuhlman & Marshello 1975; Van Lange & Kuhlman 1994), and for exploratory purposes the NEO-FFI (aka the Big Five) scale (Costa & McCrae 1992).

Method

The participants, design and procedure of the Weak Link experiment are covered in chapter 4. We measure leadership by counting how many times a particular player chooses first in the END treatment. We measure leadership *quality* by measuring how high the numbers chosen as a leader were and the costs/benefits of leadership by points earned.

Personality measures. After the game (but before being told how much they had earned) participants filled out a number of psychological questionnaires:

First, we administered the standard NEO-FFI (Big5) personality questionnaire measuring extraversion, agreeableness, conscientiousness, neuroticism and openness via 44 items on five-point Likert scales (1=completely agree to 5 = completely disagree).

Social Value Orientation was measured with 9 items where the participants were asked to divide a (hypothetical) amount of money between themselves and a non-identified other. Each item had 3 options which can be classified as the prosocial, equally sharing option (eg. 480 for me, 480 for the other), the competitive, difference maximizing option (480 for me, 80 for the other) and the individualistic, individually maximizing option (540 for me, 280 for the other). We scored participants who chose the pro-social distribution $\geq$ 6 times as 'social' and those choosing the individualistic distribution $\geq$ 6 time or the competitive distribution $\geq$ 6 times as 'selfish'

Dominance was measured with a 5-item questionnaire consisting of 5-option (1= completely agree to 5 = completely disagree) Likert-scale questions such as 'I would enjoy being in charge of a project' and 'I strive to be 'in command' when I am working in a group'.

Results and Summary

First, we find that per round Leaders earn significantly fewer points than Followers (M_{leader} = 0.72, SD = 0.29 vs. $M_{follower}$ = 0.78, SD = 0,26; t(798) = 2.334; p = .02; Mann-Whitney's U = 53779.5, p = .024). We see therefore that leading in a weak link game came at a cost to the individual at the benefit of the group as predicted by the servant leadership hypothesis.

Consistent with the servant leadership hypothesis we also find that participants who were classified as 'pro-social' chose to lead more often than participants classified as 'pro-self' ($M_{prosocial}$ = 2.94, SD = 2.97 vs. $M_{proself}$ = 1.00, SD = 1.35; t(62) = 2.1936; p < .05; Mann-Whitney's U = 182.5, p = .023). We find no significant correlation between how many times a participant acted as leader and their score on the dominance-scale (r = .213, p = .112).

With respect to the NEO-FFI questionnaire we only find a (marginally) significant negative correlation between 'times going first' and openness to experience ($r = -.248$, $p = .063$). Thus, people who are more open to new experiences chose to lead less often, suggesting that leadership is more about prosociality than risktaking.

Finally, looking at the numbers they pick, men as leaders pick a significantly higher number than women leaders and are thus more effective ($M_{male} = 5.18$, SD= 2.158 vs $M_{female} = 3.73$., SD=2.090; $t(57) = 2.5451$; $p < .05$; Mann-Whitney's U = 256.5, $p = .017$). There were no personality traits associated with effective leadership in this game. See table 4D.1 for an overview of the correlations between the various measures in the experiment.

	Choiclead	**Extrav**	**Agree**	**Consc**	**Neuro**	**Open**	**Domin**	**Alpha**
Timeslead	-.073	.019	-.030	-.055	-.114	-.248+	.213	na
Choicelead	1	-.034	-.182	-.146	-.080	.190	.195	na
Extrav		1	.331**	.163	-.273**	.255*	.418**	.877
Agree			1	.381**	-.336**	.250*	-.015	.899
Consc				1	-.231*	.147	.316**	.852
Neuro					1	-.241	-.128	.834
Open						1	-.013	.807
Dominance							1	.839

Notes: Timeslead = how many times a participant acted as a leader, Choicelead = average choice made as a leader, Extrav = NEO-FFI, Extraversion, Agree = NEO-FFI, Agreeableness, Consc= NEO-FFI, Conscientiousness, Neuro = NEO-FFI, Neuroticism, Open = NEO-FFI, Openness to new experience, Alpha = Cronbach's alpha. N = 80.

+ p < .10

* p < .05

** p < .01

Table 4D.1: Pearson correlations between measures in the Weak-link game

Discussion

Our results are consistent with the evolutionary hypothesis that leadership can be a social good for the group by being associated with self-sacrificial behavior; behavior that is good for the group but comes at a cost to the leader. This is to our knowledge the first experimental evidence for servant leadership. We find various traces of evidence for servant leadership. Leaders, on average, earned less money than followers and dispositionally social participants (on the basis of their social value orientation) chose to lead more often than selfish participants. Additionally there is no relationship between leadership and the kind of personality traits that are usual1y associated with selfish leadership, most notably personal dominance.

In the game leadership improves the group outcome - setting a good example can help coordinate on the group on a better, more profitable outcome (as shown in chapter 4) - but acting as a leader involves potential costs (risk of not being followed). That leaders earns less than followers - but that, at the same time, followers do better than they would have done in a situation without leadership - supports the idea of the servant nature of leadership (Wilson et al., 2008). The finding that leaders are more likely to have a prosocial personality corroborates this explanation.

Our research paradigm may seem to favour the servant leadership hypothesis. The weak-link game we used is a coordination game and invites leadership strategies that help the group by making coordination easier. Also, the fact that the experiments were run in a totally anonymous setting did not enable group members to form status and dominance hierarchies as you see in the real world. We are not claiming that leadership-as-dominance does not exist but that there are specific situations in which alternative, more social leaders emerge. Further research will have to be conducted to examine the determinants of servant leadership further and when it turns into selfish leadership.