Dong, Lu; Montero, Maria; Possajennikov, Alex

Working Paper

Communication, leadership and coordination failure

CeDEx Discussion Paper Series, No. 2015-17

CENTRE FOR DECISION RESEARCH & EXPERIMENTAL ECONOMICS

The University of Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

Discussion Paper No. 2015-17

Lu Dong, Maria Montero and Alex Possajennikov

September 2015

Communication, Leadership and Coordination Failure

CeDEx Discussion Paper Series
ISSN 1749 - 3293

Suzanne Robey
Centre for Decision Research and Experimental Economics
School of Economics
University of Nottingham
University Park
Nottingham
NG7 2RD
Tel: +44 (0)115 95 14763
Fax: +44 (0) 115 95 14159
suzanne.robey@nottingham.ac.uk

Communication, Leadership and Coordination Failure*

Lu Dong[†]
University of Nottingham

Maria Montero[‡]
University of Nottingham

Alex Possajennikov[§]
University of Nottingham

September 3, 2015

Abstract

Using experimental methods, this paper investigates the limits of communication and leadership in aiding group coordination in a minimum effort game. Choosing the highest effort is the payoff dominant Nash equilibrium in this game, and communication and leadership are expected to help in coordinating on such an equilibrium. We consider an environment in which the benefits of coordination are low compared to the cost of mis-coordination. In this environment, players converge to the most inefficient equilibrium in the absence of a leader. We look at two types of leaders: a cheap-talk leader-communicator who suggests an effort level but is free to choose a different level from the one suggested, and a first-mover leader whose choice of effort is observed by the rest of the group. We study whether leadership can prevent coordination failure and whether leadership allows coordination on a higher effort after a history of coordination failure. We find that in this tough environment both types of leadership are insufficient to escape from the low-effort equilibrium but leadership has some (limited) ability to prevent coordination failure. With the help of the strategy method for the followers' responses we find that the main reason for the persistence of coordination failure in this environment is the presence of followers who do not follow (or would not have followed) the leader.

Keywords: minimum effort game, coordination failure, communication, leadership

JEL Codes: C72, C92, D23

*The authors would like to thank the Centre for Decision Research and Experimental Economics (CeDEx) at the University of Nottingham for financial support.

[†]Corresponding author. Centre for Decision Research and Experimental Economics (CeDEx), School of Economics, University of Nottingham, University Park, Nottingham NG7 2RD, United Kingdom. Email: lu.dong@nottingham.ac.uk

[‡]Email: maria.montero@nottingham.ac.uk

[§]Email: alex.possajennikov@nottingham.ac.uk

1 Introduction

Coordination problems arise in many organizations, and their resolution may determine the success or failure of the entire organization. Organizations may be successful in coordinating on a good outcome, or they may become trapped in an inefficient situation even though better outcomes are also potentially stable.

Few coordination problems are as stark as those arising in the *minimum effort* game (also called *weakest-link* game). In this game, all players simultaneously make a choice; each player's choice can be interpreted as effort and a player's payoff depends on his or her own choice as well as on the minimum choice in the group.[1] This game is a coordination game with multiple Pareto-ranked equilibria: any situation where all players make the same effort is a Nash equilibrium, but equilibria with a higher effort level have greater payoffs for all players.

Pareto dominance (Harsanyi and Selten, 1988) has been proposed as the primary equilibrium selection criterion in coordination games. However, this criterion turned out to have limited predictive power in the minimum effort game. Van Huyck et al. (1990) were the first to study this game experimentally and show that failure to coordinate on the efficient outcome is common in the laboratory. They pointed out that this coordination failure[2] is due to the severe effects of strategic uncertainty in this game: if there is a chance that *any* of the other players may choose a lower effort level, choosing a high effort may no longer be a best response. These experimental findings have been confirmed by later studies (see Camerer, 2003, Ch. 7, and Devetag and Ortmann, 2007, for an overview) and have led to an active research agenda to find a way to raise efficiency through changing certain features of the game.

The prevalence of coordination failure is higher if the benefits from coordinating on a higher effort are low relative to the cost of effort; coordination failure is also more likely with more players (Devetag and Ortmann, 2007). A typical pattern of behavior found in minimum effort game experiments is that initially many subjects choose relatively high levels of effort, but after several rounds the majority choose a low effort. Coordination failure could be *prevented* if the game is modified from the beginning in order to avoid subjects sliding to a low effort level. However, it is also worth asking whether and how a group can *restore* coordination on a higher effort level, thus overcoming coordination failure after a history of being trapped in an inefficient equilibrium. Most organizations have existed for a period of time and a mechanism that works with zero-experience groups might not work with groups that already have a history; for example, a device that is successful in a new company might not work in restructuring an old one.

[1]Examples of such situations include the classical stag-hunt game (Rousseau, 1755), and, more modernly, writing joint reports with several sections where completion of the report requires all sections to be completed (Weber et al., 2001) and airline departures, where for a plane to be able to depart several separate tasks must be completed (Knez and Simester, 2001).

[2]Van Huyck et al. (1990) distinguish two possibilities for players failing to coordinate on the efficient equilibrium: playing a Pareto-dominated equilibrium instead or not choosing the same effort level at all. We will use the term *coordination failure* to refer to the first situation, where subjects typically coordinate on the least efficient equilibrium. The second situation will be referred to as *mis-coordination*.

In this paper we investigate equilibrium selection in a minimum effort game with a low benefit-to-cost ratio and focus on two leadership mechanisms to improve coordination. One mechanism involves *cheap-talk* (CT) one-way pre-play communication, where one of the group members acts as a leader by suggesting an effort level; after observing the suggestion, all players choose an effort level simultaneously. The second mechanism entails a *first-mover* (FM) leader that leads by example. One player chooses an effort level prior to his followers, who observe this choice and then choose their own effort simultaneously. Both mechanisms are expected to help players to coordinate on a more efficient equilibrium since in both cases the leader's suggestion or choice may act as a focal point. In addition to the focal point effect, in the leading-by-example case, having the leader commit to an effort reduces the strategic uncertainty faced by the followers. On the other hand, the leader's commitment choice is more risky than a non-binding suggestion. Which mechanism is more successful overall is not clear a priori. A novel aspect of our experiment is to elicit responses of followers to all possible suggestions or choices by the leader using the strategy method. This allows us to analyze followers' behavior more systematically, and to conduct a counterfactual analysis of the effectiveness of the mechanisms.

Mechanisms similar to the ones we use have been applied previously to prevent coordination failure. For a stag-hunt two-player game, Cooper et al. (1992) find that one-way pre-play communication of a non-binding intention to play improves coordination on the efficient equilibrium; two-way communication does even better. In a minimum effort game with more players, Blume and Ortmann (2007) find that multilateral communication (all players sending a message of intention simultaneously) significantly increases overall efficiency relative to the baseline treatment without cheap talk.[3] For the leading-by-example mechanism, Cartwright et al. (2013) observe that it increases effort in a significant number of groups, although not many groups reached the maximum possible effort.[4] Sahin et al. (2015) compare both mechanisms (one-way communication and leading-by-example) and find that both lead to an increased group effort compared with the baseline treatment, and the magnitude of the increase is similar for both mechanisms.

The studies above show that both mechanisms are at least partially effective in preventing coordination failure in some parametrizations of the minimum effort game.[5] We study these mechanisms in a tougher environment in the sense of lower benefits of coordination relative to the cost of effort, and we also study whether the mechanisms can overcome coordination failure[6] (without changing other aspects of the game)[7]. For this purpose we use the parametrization of the minimum effort

[3]The result is sensitive to the cost and clarity of messages, as Manzini et al. (2009) and Kriss et al. (2012) find.

[4]Weber et al. (2004) consider a situation in which all subjects move sequentially, and find that subjects are more likely to coordinate on a high-effort equilibrium.

[5]Other mechanisms that have been shown to be able to prevent coordination failure in minimum effort games to some extent include advice from previous cohorts of players (Chaudhuri et al., 2009), post-play disapproval messages (Dugar, 2010), and inducing social identity (Chen and Chen, 2011).

[6]Weber et al. (2001) introduce a one-off cheap-talk leader intervention after two rounds of play, hence their experiment does not exactly fit with either preventing or overcoming coordination failure. This intervention was not successful in leading to a high effort in large groups. Cartwright et al. (2013) have sessions where leadership by example is introduced after subjects have played the simultaneous game; however, the groups are re-shuffled, hence subjects in the group do not have a common history of coordination failure.

[7]There are several studies on the effect of introducing financial incentives to overcome coordination failure, possibly

game introduced by Brandts and Cooper (2006) to induce coordination failure in the absence of any mechanism. In our experiment leaders are chosen randomly[8] and the leader-communicator in our cheap-talk mechanism can only suggest an effort level rather than send a more complicated message.[9] Our implementations of the leadership mechanisms are thus minimal as they do not require extended messages or (potentially costly) tests to determine who is going to be the leader. By using a challenging environment (especially after a history of coordination failure) and minimal implementations of the mechanisms, we explore the limits of what these mechanisms can achieve.

After having confirmed that coordination failure happens in our tough environment without a mechanism present, we find that this history of coordination failure is a powerful attractor, and the leadership mechanisms fail to provide a means to overcome it in the long run. Nevertheless, shortly after the introduction of the mechanisms, average effort is higher as some subjects do attempt to make use of the mechanisms. Even without a history of coordination failure, both types of leadership have only a limited ability to prevent it in this environment, with about 30-40% of the groups avoiding their minimum effort sliding to the lowest level.

Given the relatively poor performance of the mechanisms in terms of escaping from and even preventing coordination failure, what are the reasons for this? Is it due to an ineffective leadership or to the reluctance of other players to follow? We find that followers do follow the leader's suggestion or choice to some extent (more in the first-mover than in the cheap-talk mechanisms, and more without a history of coordination failure) but there is a sizable minority that always chooses the lowest possible effort. We also find that not all leaders dare to choose a high effort (even after they have suggested it); hence, both leaders and followers can be blamed for the poor performance to some degree. Using the data from the strategy method, even if leaders had chosen a higher effort, they would not have increased their payoff. The presence in a group of just one player who is not responsive to the leader's suggestion or choice makes it impossible to avoid coordination failure, as it is then individually rational for a leader and for any of the followers to choose the lowest possible effort.

The remainder of the paper is organized as follows. Section 2 provides a general background on the minimum effort game and a discussion of possible effects of the leadership mechanisms. Section 3 describes the experimental design and hypotheses. The results of the experiment are discussed in section 4 and section 5 concludes.

together with communication (Brandts and Cooper, 2006, 2007; Hamman et al., 2007; Brandts et al., 2007, 2014). The increase in the benefits of coordination is found to improve efficiency, although to a lesser degree than communication. Efficiency is also found to increase once post-play monetary punishment is introduced (Le Lec et al., 2014).

[8]Alternative ways of choosing a leader can involve letting players volunteer to be the leader (Cartwright et al., 2013), elections (Brandts et al., 2014) or administering a test (Sahin et al., 2015).

[9]Free-form communication by a leader is found to shift group effort to a more efficient level in Brandts et al. (2014).

2 Effects of leadership in the minimum effort game

2.1 The minimum effort game

In the minimum effort game there are n players. Player i's strategy is denoted by $x_i \in X_i \subseteq \mathbf{R}_+$, where X_i is a finite set. Players' strategies can be interpreted as effort levels. The payoff function of player i is:

$$u_i(x_1, x_2, ..., x_n) = a + b \cdot \min\{x_1, ..., x_n\} - c \cdot x_i,$$

where a, b, c are exogenous constants with $b > c > 0$.

Any strategy profile in which all players in the group choose the same effort is a Nash equilibrium. A unilateral increase in x_i incurs a cost without changing the minimum. A unilateral decrease in x_i reduces the minimum; the effect of this reduction outweighs the saving on cost since $b > c$. The multiple Nash equilibria in the game can be Pareto-ranked according to the players' choice: any equilibrium with a higher choice Pareto-dominates any equilibrium with a lower choice.

Every player choosing the highest possible effort is the payoff-dominant equilibrium and thus it would be selected by Harsanyi and Selten's (1988) primary selection criterion. However, choosing a high effort is risky because a player may incur a large cost if the group's minimum effort happens to be low. There is a conflict between the appealing Pareto-efficiency property of everybody choosing the highest possible effort and the insurance value for an individual player of choosing the lowest effort. The lower uncertainty associated with the choice of a lower effort is related to Harsanyi and Selten's (1988) secondary risk-dominance selection criterion. One generalization of this criterion to n-player potential games (of which the minimum effort game is an example) is maximization of the potential function (Monderer and Shapley, 1996; Goeree and Holt, 2005). In the minimum effort game, maximization of the potential selects coordination on the highest effort level if $n < b/c$ and on the lowest effort level if $n > b/c$.[10]

2.2 Effects of leadership

In a game with multiple equilibria, players' beliefs about the strategies of the other players play an important role in equilibrium selection. We will discuss how our two leadership mechanisms, while not altering the payoff function of the game, can affect players' beliefs and therefore possibly change their behavior allowing coordination on a different equilibrium. In our experiment we have three types of games based on the payoff function above but differing in the dynamic structure. The baseline game is the *simultaneous* game, where all players make their choices at the same time. The other two games correspond to our mechanisms. Recall that in the *cheap-talk* (CT) mechanism, an exogenously chosen player (the leader-communicator) first sends a message from the set X_i of possible effort levels. This message is interpreted as a suggestion to the players. The message is seen by all players; then all players (the leader and the $n-1$ followers) choose an effort level simultaneously.

[10]Evidence from experimental studies tends to support this prediction (Goeree and Holt, 2005; Chen and Chen, 2011).

In the *first-mover* (FM) mechanism an exogenously chosen leader makes the choice first. The other $n-1$ players (followers) observe this choice and then make their choices simultaneously.

Cartwright et al. (2013), who discuss only the game corresponding to our FM game, offer two reasons why leadership may increase the minimum effort in the group. First, the leader's choice may act as a focal point that facilitates coordination. Second, the leader's choice reduces the strategic uncertainty faced by the followers, who are now effectively playing a coordination game with $n-1$ players. Both effects are present in our FM game but only the focal point effect is present in our CT game; our analysis makes clear the differences between the two games.

Let $F_i(k)$ denote player i's beliefs about the probability that another player will choose an effort level of at least k in the simultaneous game. Then i's beliefs about the probability that the minimum effort of the $n-1$ other players is at least k is given by $M_i(k) = [F_i(k)]^{n-1}$.

Suppose that in our CT game the players observe a suggested effort L. Denote by $F_i^{CT}(k|L)$ player i's beliefs about the probability that a follower's effort in the CT game is at least k conditional on suggestion L. We represent the *focality* effect by assuming $F_i^{CT}(k|L) \geq F_i(k)$ for all $k \leq L$ and for all L. This means that, for effort levels smaller than L, i believes that the distribution shifts towards higher levels.[11] Because the leader still needs to choose an effort level, we assume that other players' beliefs treat the leader as one more follower. In our FM game, where L is the leader's effort choice, the above focality effect is also present. Arguably, the effect is no weaker in FM, where the leader is committed to L, than in CT, where the leader still can make a different choice. Hence we assume $F_i^{FM}(k|L) \geq F_i^{CT}(k|L)$ for all $k \leq L$ and for all L, that is, after having observed an effort choice of L by the leader in FM, i's beliefs about other players are at least as optimistic as if i had observed a suggestion of L in CT. We summarize our assumptions as

Assumption 1 *The beliefs of the players satisfy* $F_i^{FM}(k|L) \geq F_i^{CT}(k|L) \geq F_i(k)$ *for all* $k \leq L$ *and for all* L.

Analogously to $M_i(k)$ for the simultaneous game, denote by $M_i^{CT}(k|L)$ and $M_i^{FM}(k|L)$ the beliefs of player i about the probability that the minimum effort of the other players is at least k, conditional on the suggestion (in CT) or the choice (in FM) of the leader being L. Then the beliefs about the minimum effort of the other players satisfy $M_i^{CT}(k|L) = \left[F_i^{CT}(k|L)\right]^{n-1}$ and $M_i^{FM}(k|L) = \left[F_i^{FM}(k|L)\right]^{n-2}$ for all $k \leq L$ and for all L.[12] If all players' beliefs satisfy Assumption 1, then $M_i^{CT}(k|L) \leq M_i^{FM}(k|L)$ for all $k \leq L$ and for all L. Hence, for a fixed L, the optimal effort level in FM for follower i will be at least as high as the optimal effort level in CT. Therefore, one can expect that the distribution of followers' choices in FM is at least as high as in CT.[13]

Turning to the comparison with the choices in the simultaneous game, $M_i(k) = [F_i(k)]^{n-1} \leq \left[F_i^{CT}(k|L)\right]^{n-1} = M_i^{CT}(k|L)$ for all $k \leq L$ and for all L. Denote the optimal choice in the simultaneous game, given the beliefs $M_i(k)$, by $\hat{k}_i$, the optimal follower's choice in CT given L as $\hat{k}_i^{CT}(L)$,

[11] It seems natural to also assume that for effort levels strictly above L the distribution shifts towards L; however, we do not need this assumption in what follows.

[12] Notice that the lower exponent $n-2$ in FM represents the reduction in strategic uncertainty compared with CT.

[13] This further justifies the assumption $F_i^{FM}(k|L) \geq F_i^{CT}(k|L)$.

and the optimal follower's choice in FM as $\hat{k}_i^{FM}(L)$. Then $M_i(k) \le M_i^{CT}(k|L) \le M_i^{FM}(k|L)$ implies $\hat{k}_i \le \hat{k}_i^{CT}(L) \le \hat{k}_i^{FM}(L)$ if $\hat{k}_i \le L$.[14] We can expect the distribution of effort for the followers to go up, compared with the simultaneous game, in CT (and even more in FM) for those efforts that are not higher than the leader's suggestion/choice L. If $\hat{k}_i > L$, then, since $M_i(k) \le M_i^{CT}(k|L) \le M_i^{FM}(k|L)$ for $k \le L$, the optimal choices of a follower satisfy $\hat{k}_i^{CT}(L) \ge L$ and $\hat{k}_i^{FM}(L) \ge L$. If a player would find it optimal to choose $\hat{k}_i > L$ in the simultaneous game, the player would not find it optimal to choose an effort below L as a follower in CT or FM because the focality assumption means that the minimum effort of the other players is less likely to be strictly below L. We summarize the above reasoning as

Lemma 1 *Suppose all players' beliefs satisfy assumption 1 and let L be the leader's suggestion/choice. Then* $\hat{k}_i^{FM}(L) \ge \hat{k}_i^{CT}(L) \ge \min\{L, \hat{k}_i\}$.

Let us now turn to the leader's choice. Suppose the leader's beliefs satisfy assumption 1. In addition, we assume that the leader believes that higher efforts are more likely after a higher suggestion/choice. Formally, for both leadership games

Assumption 2 *For all* L' *and* L'' *such that* $L' \le L''$ *it holds that* $F_i^{CT}(k|L') \le F_i^{CT}(k|L'')$ *and* $F_i^{FM}(k|L') \le F_i^{FM}(k|L'')$ *for all k.*

Could the leader's optimal choice be lower than the choice in the simultaneous game? Consider again player i with beliefs $M_i(k)$ in the simultaneous game, whose optimal choice is denoted by $\hat{k}_i$, thus the expected payoff $Eu_i(\hat{k}_i|M_i(k)) \ge Eu_i(k_i'|M_i(k))$ for all $k_i' \in X_i$. This, in turn, implies $bM_i(\hat{k}_i) - c \ge 0$.[15] Assumption 1, for the FM game, implies $M_i(\hat{k}_i) \le M_i^{FM}(\hat{k}_i|L = \hat{k}_i)$ and therefore $bM_i^{FM}(\hat{k}_i|L = \hat{k}_i) - c \ge 0$. Assumption 2 implies that $M_i^{FM}(k|L') \le M_i^{FM}(k|L'')$ for all k if $L' \le L''$. Take $L'' = \hat{k}_i$ and $L' < \hat{k}_i$. Using assumption 2, the difference in expected payoffs for the leader between these choices is $Eu_i(\hat{k}_i|M_i^{FM}(k|L = \hat{k}_i)) - Eu_i(L'|M_i^{FM}(k|L = L')) \ge (bM_i^{FM}(\hat{k}_i|L = \hat{k}_i) - c)(\hat{k}_i - L') \ge 0$. Therefore no $L < \hat{k}_i$ can be optimal in FM for player i as the leader. For CT, the same reasoning shows that if the leader is restricted to choose effort equal to suggestion, then the optimal choice (and therefore suggestion) is at least $\hat{k}_i$.[16]

In CT, the leader is not restricted to choose an effort equal to his/her own suggestion L. Recall that assumption 2 means that the distribution of efforts is expected to be higher after a higher L. The assumption implies that the leader would find it optimal to suggest the highest L possible but not necessarily follow it.[17] The leader's actual effort would not be below $\hat{k}_i$ because the focality effect

[14] This goes some way in justifying the assumption $F_i^{CT}(k|L) \ge F_i(k)$ for all $k \le L$ we made previously.

[15] This is because $Eu_i(\hat{k}_i|M_i(k)) - Eu_i(k_i'|M_i(k)) \ge (bM_i(\hat{k}_i) - c)(\hat{k}_i - k_i')$ if $\hat{k}_i > k_i'$.

[16] Without assumption 2 it need not be the case than the optimal leader's choice $L \ge \hat{k}_i$. Consider the parametrization of the minimum effort game in section 3 that we use in the experiment. Let beliefs be $M_i(40) = M_i(30) = 0$, $M_i(20) = M_i(10) = 0.85$, $M_i(0) = 1$. With these beliefs, effort 20 is optimal in the simultaneous game. Consider now $L = 20$ and assume that beliefs become $M_i^{FM}(40|L = 20) = M_i^{FM}(30|L = 20) = 0$, $M_i^{FM}(20|L = 20) = M_i^{FM}(10|L = 20) = 0.9$, $M_i^{FM}(0|L = 20) = 1$. The expected payoff of the leader from $L = 20$ is then 208. Assume that for $L = 10$ the beliefs become $M_i^{FM}(40|L = 10) = M_i^{FM}(30|L = 10) = M_i^{FM}(20|L = 10) = 0$, $M_i^{FM}(10|L = 10) = 0.99$, $M_i^{FM}(0|L = 10) = 1$. The expected payoff from $L = 10$ is then 209.4. Therefore the leader would choose $L = 10$ in FM. These beliefs satisfy assumption 1 but violate assumption 2 because $M_i(10|L = 10) = 0.99 > M_i(10|L = 20) = 0.9$.

[17] If we interpret the suggestion as a statement of the leader's intention to play, suggesting the highest possible L is not *self-signaling*, since the leader has an incentive to shift the followers' beliefs upwards for other intended effort

of the highest possible L cannot lead to an effort lower than $\hat{k}_i$ being optimal. Thus, one can expect that the suggestion L in CT is higher than the effort choice L of leaders in FM, and the actual choice of leaders is not lower in FM and CT than in the simultaneous game. Thus,

Lemma 2 *Suppose all players' beliefs satisfy assumptions 1 and 2 and let* $\hat{k}_l^{CT}, \hat{k}_l^{FM}$ *denote the optimal choices of the leader in the corresponding games. Then* $\hat{k}_l^{CT} \geq \hat{k}_i$ *and* $\hat{k}_l^{FM} \geq \hat{k}_i$.

Lemmas 1 and 2 together imply

Proposition 1 *Suppose all players' beliefs satisfy assumptions 1 and 2. Then the minimum group effort with a leader cannot be lower than the minimum group effort in the simultaneous game.*

Given our assumptions, if a player whose $\hat{k}_i$ would have determined the minimum effort in the simultaneous game is acting as a leader, we have shown that this player's effort would not be lower than $\hat{k}_i$ (lemma 2). Other players may lower their effort but not below $\hat{k}_i$ (lemma 1). If a player whose $\hat{k}_i$ was strictly above the minimum effort in the simultaneous game acts as a leader, the players whose effort was above $\hat{k}_i$ (if any) again cannot have effort lower than $\hat{k}_i$ as followers; the players whose effort was below $\hat{k}_i$ will not decrease their effort (lemma 1).

In our experiment we will test whether leadership, either in CT form or in FM form, increases effort. Comparing CT and FM games, if leaders were restricted to follow their own suggestion in CT, due to the reduction in strategic uncertainty and a greater focality in FM, one would expect that a higher effort in FM would shift beliefs more and therefore is more likely to be optimal and be chosen. Despite this intuition, it may be optimal for a leader to choose a higher effort in CT than in FM. Suppose that a high L shifts beliefs towards a medium level of effort by followers, whereas a medium L keeps beliefs low. Then the leader in FM would find it optimal to choose a low level of effort. The leader in CT may find it optimal to send a high L and then choose a medium effort level. Our assumptions do not exclude this possibility and therefore they do not have unambiguous implications for the comparison between minimum group efforts in CT and FM.

In the next section we describe our experimental design in more detail and formulate hypotheses based on the theoretical analysis of leadership mechanisms above.

3 Experimental procedures and hypotheses

3.1 Experimental design

The baseline game that we investigate is the minimum effort game introduced in Brandts and Cooper (2006). There are four players and five effort levels, $x_i \in \{0, 10, 20, 30, 40\}$. Player i 's payoff is given by

$$u_i = 200 + 6 \cdot \min\{x_1, x_2, x_3, x_4\} - 5 \cdot x_i.$$

Table 1 shows the corresponding payoff matrix. This payoff matrix with five Pareto-ranked equilibria along the main diagonal was used by Brandts and Cooper (2006, 2007), Hamman et al. (2007) and

choices as well (a message is called self-signaling if the sender wants to send it *if and only if* it is true, see Farrell and Rabin, 1996).

Brandts et al. (2014). It is an economical way of "inducing" coordination failure by making $n \gg b/c$ with a relatively small number of players, $n = 4$.[18]

Table 1: Minimum Effort Game with $a = 200$, $b = 6$, $c = 5$

		Minimum Effort in the Group				
		0	10	20	30	40
Effort of Player i	0	200	-	-	-	-
	10	150	210	-	-	-
	20	100	160	220	-	-
	30	50	110	170	230	-
	40	0	60	120	180	240

The main part of the experiment consists of two blocks of ten rounds (see table 2). In each round, a group of participants play either the baseline game or one of the mechanisms, according to table 2. The group composition remains fixed for the entire experiment. We divide experimental sessions according to the type of leadership mechanism and according to the timing of the introduction of the mechanism. Both mechanisms involve a randomly selected player (a leader) acting before others at the beginning of each round. The role of the leader is fixed during the entire block. In our CT treatments, the leader suggests a number; after seeing this number all players (including the leader) simultaneously choose their effort level.[19] In the FM treatments, the leader makes an effort choice before the rest of the group. Having observed the leader's choice, the other players (the followers) make their effort choice simultaneously.

Table 2: Experimental Design

Timing	**Mechanism**	**Block 1 (Rounds 1-10)**	**Block 2 (Rounds 11-20)**
Restore	CT (15 groups)	Baseline	Cheap Talk Leader
	FM (15 groups)	Baseline	First Mover Leader
Prevent	CT (14 groups)	Cheap Talk Leader	Baseline
	FM (14 groups)	First Mover Leader	Baseline
Control (5 groups)		Baseline	Baseline

We consider two scenarios for the timing of the introduction of the mechanisms. In Restore sessions, the mechanism is introduced in the second block, after the group has played the baseline minimum effort game for ten rounds. This simulates an attempt to turn around an existing organization that has (likely) experienced coordination failure (the "turnaround game" of Brandts and Cooper, 2006). In Prevent sessions, the order of the blocks is reversed: a group starts with a randomly assigned

[18]Note that the game has a particularly low ratio of benefits b from coordinating on a higher effort to cost c of effort, $b/c = 1.2$.

[19]In the instructions, we specified that for the leader "the choice ... is the one used to calculate the points, and it could be different from the suggested number".

leader for ten rounds and then plays another block of ten rounds without a leader. We also run a control treatment in which no mechanism is used and the baseline game is played in all rounds.

At the end of each round, subjects are shown the group minimum effort from the current round and the effort levels selected by all subjects. These efforts are sorted from highest to lowest, so they cannot be traced to individual group members. The feedback format is similar to the one used by Brandts and Cooper (2006). Note that all blocks have in common the number of rounds, the group size and the feedback after each round.[20]

In the mechanisms, we use the strategy method to elicit followers' decisions. Specifically, we ask followers to enter an effort choice for each possible suggestion (in CT) or effort choice (in FM) of the leader. In this way we are able to collect data on followers' complete strategies rather than only on the choices in response to one actual suggestion/choice of the leader. With these strategies, we are able to test the theory about the followers' responses to different suggestions/choices of the leader and conduct a counterfactual analysis of group effort for different leader's choices.[21] For leaders, we elicited their (point) beliefs about the minimum effort of the followers in response to their actual suggestion or choice; leaders got 20 points if their prediction was correct.

The experimental sessions were conducted in the CeDEx laboratory at the University of Nottingham, United Kingdom. The experiment was computerized using z-tree (Fischbacher, 2007) and subjects were recruited with ORSEE (Greiner, 2004). Our sample consisted of 252 participants from various fields of study in 13 sessions with 16-20 participants per session. We ensured the recruited subjects had not participated in a similar experiment (i.e., in a minimum effort game or a public goods game) before. At the beginning of a session, subjects were seated at a computer terminal in a cubicle. An experimenter read the instructions aloud in front of all the participants. Subjects received the relevant instructions at the beginning of each block, hence they were not aware of the second part of the session when they were in the first block. As in Brandts and Cooper (2006) and subsequent papers on the turnaround game, the instructions were framed in a corporate context where the four players in the group are referred to as "employees" and are told that they are working for a "firm". We used "employee X" and "employee Y" to represent the leader and the follower roles, where applicable. Before the beginning of a block, subjects were required to answer several quiz questions regarding the payoff function and procedure details. At the end of a session, subjects were paid in private the amount they earned. The conversion rate was 400 points = 1 British pound. The quiz, 20 rounds of decision-making, and the questionnaire lasted approximately one hour and subjects earned on average £9.63.

[20]In Restore sessions, there was a third block consisting of ten more rounds of the baseline setup. Since the participants were not informed about how many blocks there would be in the experiment and the instructions for the next block were given only at the beginning of each block, there should be no effect on the first two blocks in the sessions.

[21]Experimental results with the strategy method usually do not differ much from results with the direct response method (see Brandts and Charness, 2011, and Fischbacher et al., 2012). We ran two sessions (CT-Restore and FM-Prevent) using the direct response method and confirmed that results are not significantly different.

3.2 Hypotheses

Based on our analysis of possible leadership effects in section 2, we formulate the following hypotheses.[22] According to proposition 1, leadership cannot lead to the minimum effort in a group with a leader being lower than if the players were choosing simultaneously. Therefore,

Hypothesis 1 *The minimum group effort is higher in CT and FM than in Baseline.*

The history of the group is likely to affect players' beliefs $F_i(k)$. If beliefs are higher, then the chosen effort is also likely to be higher. Our Restore sessions are designed to induce coordination failure thus it can be expected that the beliefs are lower in Restore than in Prevent. The actual efforts are then also likely to be lower in Restore than in Prevent.

Hypothesis 2 *The minimum group effort is lower in Restore than in Prevent, holding the treatment (CT or FM) constant.*

The previous hypotheses, although formulated on the aggregate level of the group, are based on assumptions on individual behavior discussed in section 2. Our strategy method design is well suited to test whether the contingent strategies of the followers are consistent with the properties of individual behavior used in that discussion. Those properties were based on players' beliefs; it is natural to expect beliefs to be more optimistic in Prevent than after coordination failure in Restore, and we argued that beliefs are likely to be more optimistic in FM than in CT.

Hypothesis 3 *For a given suggestion/choice of the leader, the effort choices of the followers are higher in FM than in CT, and they are higher in Prevent than in Restore.*

We also argued in section 2 that a leader's suggestion is expected to be higher in CT than a leader's choice in FM. Some leaders may realize that, with repeated interactions, not following their own suggestion would reduce the focality effect of it, thus they may decide to suggest the effort they are actually going to choose. In this case, it cannot be optimal to suggest (and therefore do) less than what a player would have chosen in the simultaneous game. The actual choice of the leader in both treatments should be above the corresponding choice in Baseline.

Hypothesis 4 *The suggestion of leaders in CT is higher than the choice of leaders in FM. The effort choice of leaders in CT and FM is higher than in Baseline.*

In the next section we look at the data from the experiment and test these hypotheses.

4 Results

We first present an overview of group outcomes over time in our treatments. We then look at the individual behavior of the subjects and try to determine what role is played by leaders and followers during the coordination process.

[22] In the experiment, we have repeated interaction rather than a one-shot game. There is no obvious reason why assumptions 1 and 2 would not hold with repeated interactions. Subjects may have preferences different from the risk-neutral own-payoff-oriented preferences used in the analysis. However, risk aversion is expected to preserve the assumption $F_i^{FM}(k|L) \geq F_i^{CT}(k|L)$ due to the reduced strategic uncertainty in FM. Reciprocity motives would also tend to preserve assumption 1.

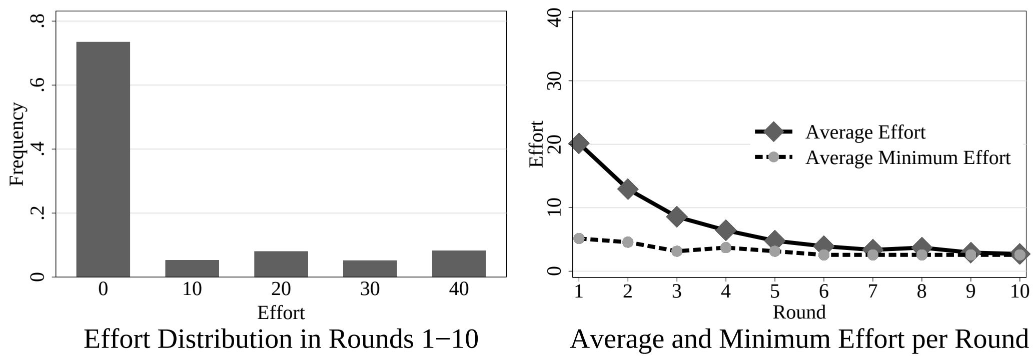


Figure 1: Efforts in rounds 1-10 in Restore and Control

4.1 Group effort and coordination with and without leadership

In the analysis below, first we look whether the mechanisms were successful in the toughest environment, after a history of coordination failure in Restore sessions. Then we look at their performance in preventing coordination failure (Prevent sessions). Finally, we discuss how the timing of the introduction of the mechanisms affected their performance and influenced overall payoffs.

4.1.1 Trying to overcome coordination failure

For the Restore sessions, a low effort level serves as a necessary condition to analyze the effectiveness of leadership in overcoming coordination failure. We consider as a coordination failure the situation in which the minimum effort in a group is zero in round 10. Indeed, during the first ten rounds in Control and Restore sessions, there is a clear trend towards lower effort levels, as seen in figure 1, and the minimum effort is zero in 32 out of 35 groups in round ten.[23] There is no significant difference between CT, FM and Control treatments in the first ten rounds, reflecting the identical design setup across those treatments (the smallest p-value of the two-sided Wilcoxon-Mann-Whitney rank-sum tests is 0.111 in round-by-round comparisons of group average or group minimum efforts across pairs of treatments).

The results from the first block in Restore and Control sessions confirm the findings in the previous literature (Brandts and Cooper, 2006, 2007, Hamman et al., 2007, Brandts et al., 2014). Coordination failure after ten rounds is not surprising if one realizes how tough the environment is. The cost of not being the minimum-effort player is high in this environment, compared with the benefits of coordination on the most efficient equilibrium. A player who chooses effort 40 instead of 0 may gain 40 if all other players choose 40 as well, but may lose 200 if any of the other players chooses 0.

In the analysis below we focus on the 32 groups in which coordination failure occurred. Starting from round 11, groups in Restore sessions face a mechanism (either CT or FM). One can expect that players would increase their effort in round 11 compared with the effort they chose in round

[23] 14 out of 15 groups in CT, 13 out of 15 in FM, and all 5 groups in Control.

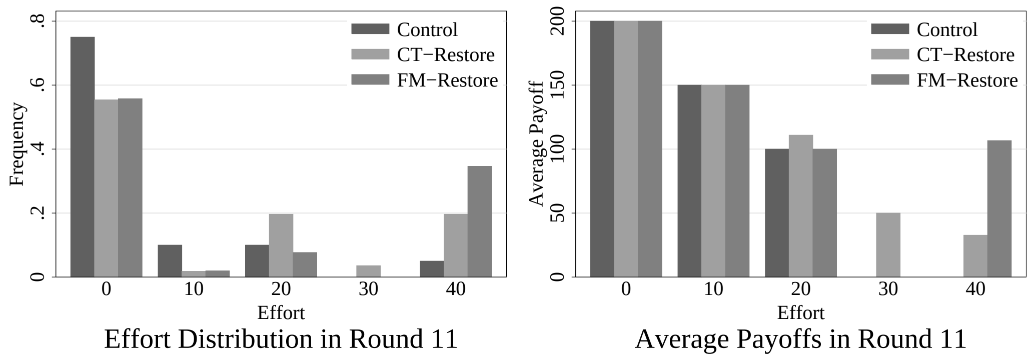


Figure 2: Effort and payoffs in round 11 for coordination failure groups in Control and Restore

10. Indeed, 48 out of 108 subjects increase their effort in round 11. The average effort level in round 11 is 14.26 in Restore sessions with a history of coordination failure (13.04 in CT and 15.58 in FM). Figure 2 shows the distribution of choices in round 11 and the average payoff obtained for each choice in these groups.

With a leadership mechanism, group average efforts are significantly higher in round 11 than in round 10 (p-value of the two-sided Wilcoxon matched-pairs sign-rank test < 0.001). Group minimum efforts are only marginally significantly different though between rounds 10 and 11 (two-sided p-value 0.083), and the right panel in figure 2 shows that players choosing lower efforts still had higher payoffs. Thus it is not surprising that this increase in average effort is short-lived as figure 3 shows: we observe an irreversible decrease in effort level during the second block. All groups that were trapped in coordination failure in round 10 also experience it in round 20.[24] As can be seen from the figure, there are no clear differences between CT and FM treatments and statistical tests confirm this (minimum p-value for the two-sided rank-sum tests on average group efforts is > 0.1 for all rounds except round 15 where $p = 0.028$; for tests on minimum group effort in rounds 11-20 the minimum p-value is 0.299).

The increase in effort in round 11 may come partly from a restart effect, as often happens in similar experiments (Brandts and Cooper, 2006, Hamman et al., 2007, Brandts et al., 2014, Le Lec et al., 2014). There is a visible restart effect in Control treatment in figure 3 but it is much smaller than in CT and FM treatments, thus the increase in effort after the mechanism is introduced is only partly explained by the restart effect. Although average group effort in (pooled) CT and FM treatments is not significantly higher than in Control in round 11 (p-value of the one-sided rank-sum test is 0.106) and only marginally significantly higher in round 12 (p-value of the one-sided rank-sum test is 0.064), the difference is perceptible in the figure in rounds 11 and 12.

Following Brandts and Cooper (2006, 2007), we use regression analysis to tease out possible treatment effects. For the minimum group effort it is clear from figure 3 that there are no treatment differences; indeed there is too little variability in the data for a meaningful regression analysis.

[24]There are three groups who coordinated on a non-zero effort level in the first ten rounds, and they continued to coordinate on that level for the rest of the experiment.

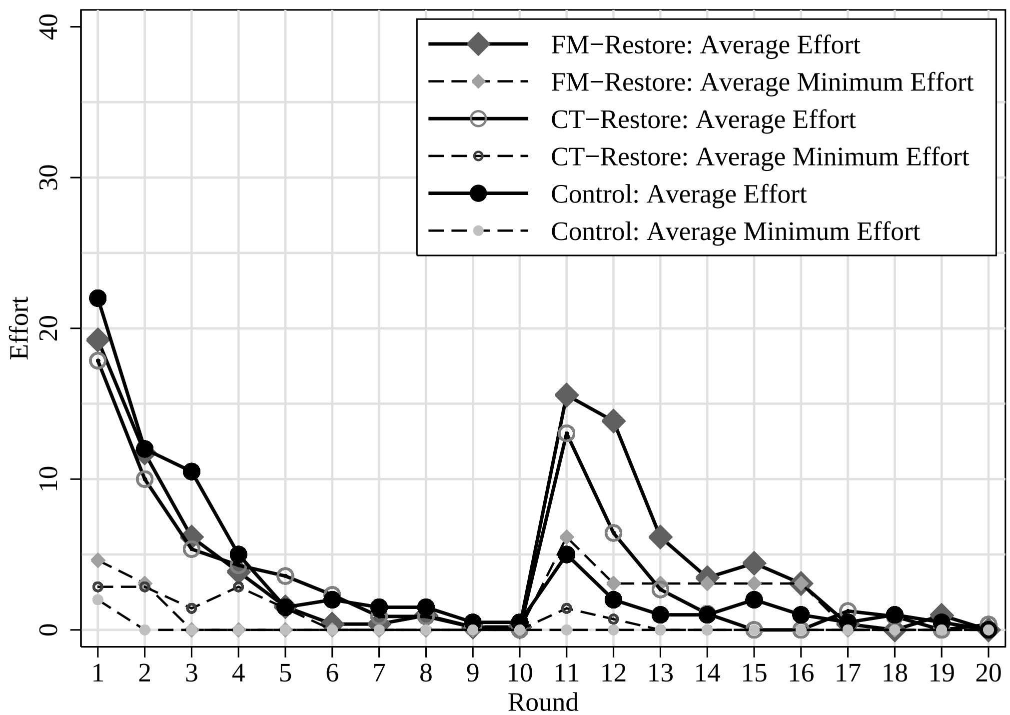


Figure 3: Evolution of average and minimum group effort in Restore and Control sessions

Instead, we run random-effects linear regressions for average group effort and ordered probit regressions for individual effort, with standard errors clustered by group.[25] The regressions are run for data from rounds 6-20. In order to distinguish between earlier and later rounds of the second part of the experiment, we use a dummy variable for rounds 11-12 and another one for rounds 13-20. To control for group or individual history, we include the group average effort or the individual effort in round 1. Table 3 shows the results of the regressions.

The first two columns compare how effort changes with respect to rounds 6-10. The regressions confirm that there was an increase in effort in the short run (rounds 11-12) but not in the long run (rounds 13-20). The magnitude of the increase in rounds 11-12 is higher in FM than in CT, which in turn is higher than the restart effect in Control. The last two columns confirm that the effect of the introduction of the mechanisms goes beyond the simple restart effect. Compared with rounds 11-12 in Control, the mechanisms, especially FM, increased effort more. The value of the group average effort in round 1 did not significantly affect the group average effort in rounds 6-20; however, for individuals their behavior in round 1 appears to have a positive effect for their effort in subsequent rounds.

Result 1 *After a history of coordination failure, the mechanisms (especially FM) increase average*

[25] We also tried a tobit and an ordered probit specification for regressions with group average effort as dependent variable and a random-effects regression for individual effort. The significance of the coefficients stays broadly the same.

Table 3: Regressions for group and individual effort in Restore

Dependent variable:	Average group effort (Random effects)	Individual effort (Ordered probit)	Average group effort (Random effects)	Individual effort (Ordered probit)
Rds 6-10	(Base)	(Base)	-2.360* (1.388)	-0.720** (0.293)
(Rds 11-12)×Control	2.360* (1.388)	0.720** (0.293)	(Base)	(Base)
(Rds 11-12)×CT	8.974*** (2.555)	1.343*** (0.213)	6.614** (2.969)	0.622 (0.419)
(Rds 11-12)×FM	14.158*** (3.822)	1.639*** (0.275)	11.798*** (4.091)	0.919** (0.434)
(Rds 13-20)×Control	-0.265 (0.203)	0.188 (0.312)	-2.625* (1.344)	-0.532*** (0.096)
(Rds 13-20)×CT	0.023 (0.169)	-0.123 (0.191)	-2.337 (1.438)	-0.844* (0.433)
(Rds 13-20)×FM	1.755 (1.471)	0.291 (0.313)	-0.606 (2.060)	-0.430 (0.481)
Average group effort in Round 1	0.106 (0.065)		0.106 (0.065)	
Individual effort in Round 1		0.010** (0.004)		0.010** (0.004)
Constant	-1.294 (1.127)		1.066 (1.978)	
N	480	1920	480	1920

standard errors clustered by 32 groups in parentheses; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

effort in the short run but not in the long run. They do not have a significant effect on group minimum effort.

We therefore conclude that the strong form of hypothesis 1 (that mechanisms strictly increase effort) is not confirmed after a history of coordination failure. Could our mechanisms have prevented coordination failure if they were available from the beginning? The next subsection looks at this question.

4.1.2 Preventing coordination failure

We saw in the previous subsection that neither of the leadership mechanisms was successful in overcoming coordination failure in groups that experienced it. In our Prevent sessions, one of the mechanisms is present from round 1, thus the first block in those sessions allows the analysis of the effectiveness of communication and leading-by-example in avoiding coordination failure.

The left panel of figure 4 displays the distribution of choices in the first round of the simultaneous game (our Control and Restore sessions). Similarly, the left panels of figure 5 do the same separately for CT and FM mechanisms in our Prevent sessions and for leaders and followers. As can be seen

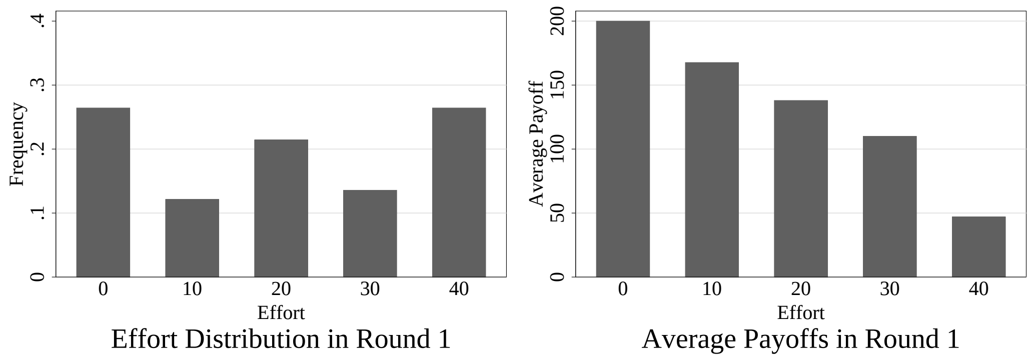


Figure 4: Effort distribution and average payoff in round 1 of Control and Restore sessions

in the figures, choices in round 1 are quite variable. The average effort in the first round in Control and Restore sessions is 20.14. The average effort of the leaders in round 1 is 21.43 in both CT and FM Prevent treatments; the average effort of the followers is 25.24 in the CT treatment and 19.76 in the FM treatment. The distribution of leaders' choices (which are independent while the followers' choices depend on the choices of the leader in their group), pooled over CT and FM treatments, does not differ significantly from the distribution of first-round choices in Control and Restore treatments (p-value of the one-sided rank-sum test is 0.363). Thus the mechanisms do not per se lead to choices of higher efforts in round 1. Since followers' efforts are correlated with their group leader's effort (correlation coefficient 0.424 for round 1 with CT and FM pooled), the average minimum effort across groups is higher in Prevent sessions than in Control and Restore sessions (10.71 in Prevent vs 5.14 in Control and Restore). As we see below, this has a significant effect for the evolution of play in subsequent rounds.

The right panel of figure 4 shows that in round 1 of Control and Restore sessions players who chose lower efforts got on average a higher payoff. We have seen in the previous subsection that in these treatments almost all groups converged to the lowest-effort equilibrium. From the right panels of figure 5, in round 1 of Prevent sessions average payoffs still tend to decline with effort but sometimes a higher effort leads to a higher payoff. The possibility of getting a higher payoff by choosing a higher effort arises because of the correlation of the choices of the followers.

Note that the average effort of the followers in round 1 is higher in CT than in FM, while the average effort of the leaders is the same in both treatments. Recall that in CT treatments leaders could choose an effort different from the number they suggested; in fact, 6 out of 14 leaders did so in round 1, thus the average suggestion in CT (which is 30.00) is higher than the average effort by the leaders in either CT or FM (21.43). Since followers mostly matched the suggestion (29 out of 42 followers chose effort equal to the suggested number), this resulted in a higher average effort by followers in CT than in FM. The "deceptive" behavior of leaders is, of course, likely to lead to a decrease of effort in the future in their group.

The evolution of average and minimum group efforts over the first 10 rounds in Prevent sessions, separately for CT and FM treatments, can be seen in figure 6. There appears to be no significant

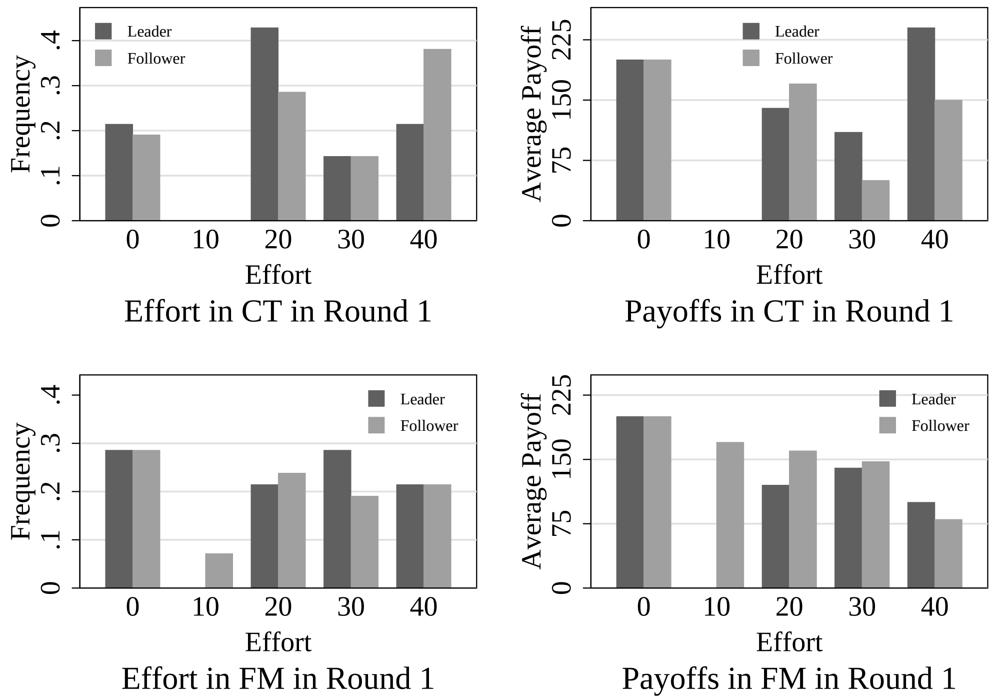


Figure 5: Effort distributions and average payoffs in round 1 in Prevent sessions

difference between the mechanisms, which is confirmed by statistical tests (minimum p-value of the two-sided rank-sum tests on average and minimum group effort is 0.180 in round-by-round comparison). As in Restore sessions, average effort declines over time, although average minimum effort increases in some rounds. By round 10, there are 9 out of 28 groups that have a minimum group effort above zero in our Prevent sessions (4 out of 14 groups in CT and 5 out of 14 in FM). Although this proportion of groups with non-zero effort is not very high, recall that only 3 out of 35 groups in Control and Restore sessions had a positive minimum effort in round 10.

Taking rounds 1 to 10, pooling CT and FM in Prevent sessions and comparing with Control and Restore sessions (i.e. with the simultaneous game without mechanisms), there is a significant difference in average group effort in each round after round 4 (all p-values < 0.05 for the one-sided rank-sum tests for rounds 4-10). The average minimum effort in Prevent sessions is stable around 10 and is significantly higher than in Control and Restore sessions for each round after round 2, according to the one-sided rank-sum tests (for all these rounds $p < 0.05$). As Cartwright et al. (2013) and Sahin et al. (2015) found in different parametrizations of the minimum effort game, we also observe that both CT and FM mechanisms have some ability to raise average and minimum effort.

Do the effects of the mechanisms persist after the mechanism is removed? One can expect that because of a lock-in in an equilibrium, most subjects would continue to choose the same effort in round 11 as in round 10. Nevertheless, some subjects may increase their effort due to the restart effect discussed earlier; other subjects may reduce their effort due to beliefs being affected by the

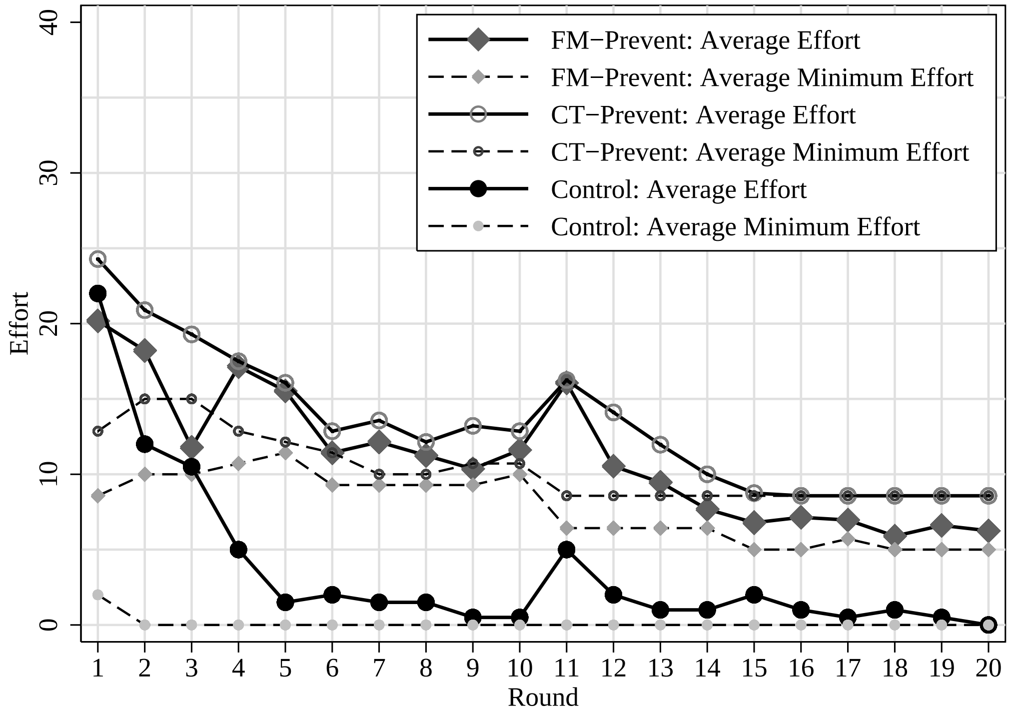


Figure 6: Evolution of average and minimum group effort in Prevent and Control sessions

removal of the mechanism. In our experiment, 20% (11 out of 56) of the subjects in CT treatment and 32% (18 out of 56) in FM treatment increased their effort in round 11 compared with round 10. On the other hand, 9% (5 out of 56) of subjects reduced their effort in CT and 7% (4 out of 56) in FM. Overall, for FM treatment, the average effort level in round 11 is significantly higher than in round 10 (p-value of the two-sided sign-rank test 0.047); for CT treatment this difference is not significant. However, the average minimum effort goes down between rounds 11 and 10 (see figure 6), and this difference is marginally significant in FM treatment (p-value of the two-sided sign-rank test is 0.084); for CT treatment the difference is also negative but not significant. Of the 9 groups that achieved a non-zero minimum effort in round 10, only 6 groups still have a positive minimum effort in round 11. Thus the removal of the correlation device (the suggestion or the choice by the leader) has an immediate effect on the ability to avoid zero minimum effort in some groups. By the end of the experiment (round 20), only 5 groups still maintain a minimum effort higher than zero. Comparing the group average and minimum effort in the first block of Control and Restore sessions (including all 35 groups in those sessions) with the second block of Prevent sessions (i.e. comparing round 12 in Prevent with round 2 in Control and Restore etc.), there is no significant difference for each round comparison from round 12 in Prevent onwards (minimum p-value of the two-sided rank-sum tests is 0.136).

Similarly to the previous subsection, we use regression analysis to check the medium- and long-term effects of the mechanisms. Table 4 reports the regressions of group minimum and average effort,

Table 4: Regressions for group and individual effort in Prevent and Restore

Dependent variable:	Minimum group effort (Ordered probit)	Average group effort (Random-effects)	Individual effort (Ordered probit)
(Rds 6-10)×(Control&Restore)	(Base)	(Base)	(Base)
(Rds 6-10)×CT-Prevent	0.401	6.807*	0.855**
	(0.567)	(3.944)	(0.367)
(Rds 6-10)×FM-Prevent	0.809**	8.004**	0.877**
	(0.410)	(3.367)	(0.350)
(Rds 11-12)×Control		2.127*	0.137
		(1.164)	(0.401)
(Rds 11-12)×Restore	0.641**	10.596***	1.147***
	(0.303)	(2.131)	(0.206)
(Rds 11-12)×CT-Prevent	0.113	9.057**	1.082***
	(0.661)	(3.663)	(0.316)
(Rds 11-12)×FM-Prevent	0.360	9.951***	1.061***
	(0.488)	(2.943)	(0.295)
(Rds 13-20)×Control		-0.498**	-0.415
		(0.253)	(0.453)
(Rds 13-20)×Restore	0.248	0.731	0.127
	(0.192)	(0.666)	(0.103)
(Rds 13-20)×CT-Prevent	0.113	3.075	0.537
	(0.661)	(4.168)	(0.434)
(Rds 13-20)×FM-Prevent	0.255	3.746	0.472
	(0.543)	(3.129)	(0.372)
Minimum/average group effort/ individual effort in Round 1	0.079***	0.674***	0.031***
	(0.016)	(0.065)	(0.007)
Constant		-10.249***	
		(2.894)	
N	895	945	3780

standard errors clustered by 63 groups in parentheses; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

and of individual effort, on dummy variables representing various time periods and the presence or absence of the mechanisms. We use ordered probit for group minimum effort and for individual effort, and random-effects linear regression for group average effort.[26] We include data from rounds 6-20 from all treatments and we take rounds 6-10 in Control and Restore sessions as the baseline (including groups that did not suffer coordination failure).[27] Since the mechanisms performed more or less equally in Restore sessions, we use one dummy variable (Restore) for the presence of the mechanisms there, while Control indicates their absence. As before, effort in round 1 is included as a control for the group or individual history and standard errors are clustered on the group level.

[26]Tobit and ordered probit specifications for group average effort or a linear specification for individual effort produce similar significance results.

[27]For the minimum group effort regression, in rounds 11-20 in the Control session the minimum was always zero, implying perfect predictability; these data are excluded from the regression.

We find that the mechanisms have some effect in rounds 6-10, especially FM that has higher coefficients and is more consistently significant. This confirms the previous finding that the mechanisms increased effort in the medium run. The regressions also confirm the short-term effect of introducing mechanisms in Restore sessions (rounds 11-12) found in the previous subsection. The regressions further corroborate the observation that the effect of the mechanisms in Prevent sessions persists only for a short time after the mechanism is removed and only for average effort rather than for minimum effort. In the long term there are no significant effects of the mechanisms, either in Prevent or in Restore sessions. In Prevent sessions, after the removal of the mechanisms, efforts are not significantly different from those of rounds 6-10 in Control and Restore. In Restore sessions, as was observed before and the regressions here confirm, efforts in rounds 13-20 are also not significantly different from the baseline, even though the mechanisms are present in those periods.

Result 2 *The leadership mechanisms have some ability to prevent coordination failure but there is no lasting effect after the mechanisms are removed.*

4.1.3 Timing of the mechanisms and welfare

The rules of the second block of the Restore sessions are the same as those of the first block of the Prevent sessions. The only difference between these two blocks is the history of coordination failure in Restore sessions (although not all groups experienced it). Pooling the two mechanisms (CT and FM) together, the average effort level is noticeably higher in the first block of Prevent sessions compared with the second block of Restore sessions, as figure 7 shows. Comparing the first block of Prevent sessions with the second block of Restore sessions (i.e. comparing round 1 in Prevent with round 11 in Restore etc.), the difference is significant in each round (p-values of the one-sided rank-sum round-by-round tests are < 0.05). There is also a noticeable difference in minimum group efforts in the figure; the p-values of the one-sided rank-sum tests of group minimum efforts are below 0.05 for all rounds after round 2. Thus there is some evidence that groups achieved a significantly higher average and minimum effort in Prevent sessions than in comparable rounds of Restore sessions.

The regressions in the previous subsection also provide (indirect) evidence of the importance of the timing of the mechanisms. Efforts are significantly higher in Prevent sessions in rounds 6-10 than in the control group represented by the base dummy. For Restore sessions, efforts in rounds 13-20 are not significantly different from efforts in the control group. This confirms our hypothesis 2 that an early introduction of the mechanisms (in Prevent sessions) leads to a higher effort, compared with the late introduction in Restore sessions.

Result 3 *The effectiveness of the leadership mechanisms is higher if these mechanisms are introduced early.*

As we have seen in the previous subsections, the mechanisms have a positive effect on average effort. Choosing a higher effort might induce a group to coordinate on a more efficient equilibrium. However, since the average minimum effort remains relatively flat in each treatment, within a treatment a

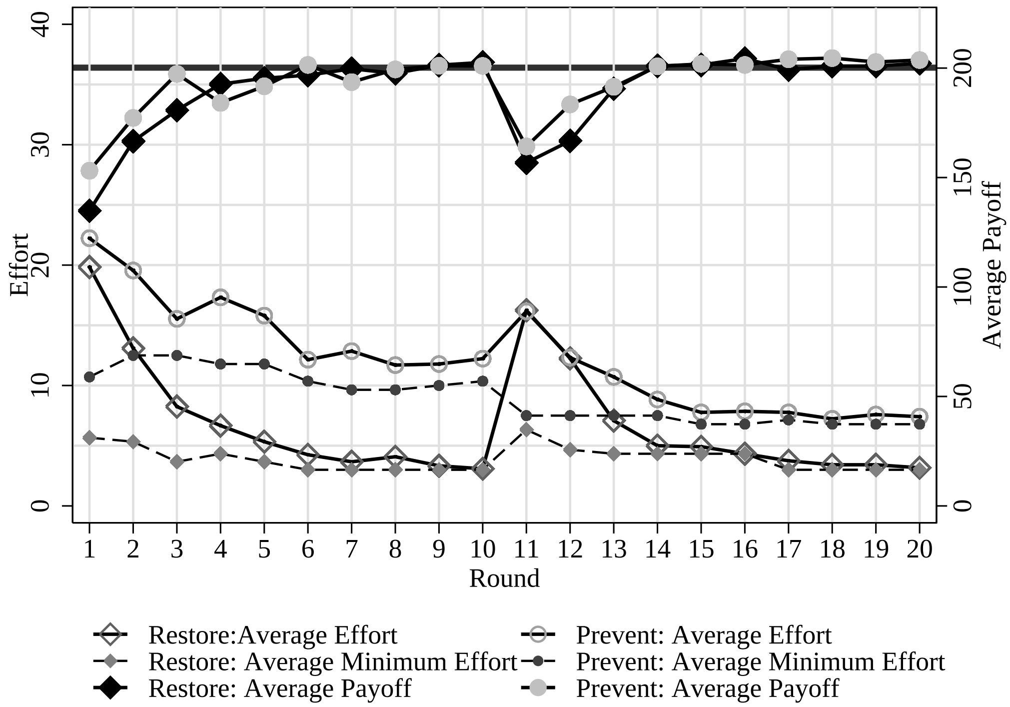


Figure 7: Average efforts and payoffs for Restore and Prevent sessions

higher average effort means that there is more mis-coordination. Because of the high cost of mis-coordination in our environment, a higher average effort resulted in a lower average payoff. This can be seen on figure 7, which, along with the average and minimum effort levels, shows the average payoff (on a different scale) in each treatment over time.

Across treatments, the group payoffs, averaged over all twenty rounds, are not significantly different between Prevent and Restore sessions (p-value of the two-sided rank-sum test is 0.797). These payoffs, pooled over Prevent and Restore sessions, also do not differ significantly from those of groups in the Control session (in Control, groups had an average payoff 182.9 across all rounds; in the other groups the average payoff was 191.2). Thus the mechanisms have no significant effect on group average payoffs. Note also that the average payoffs are below 200, the profit that any player could guarantee by choosing effort 0; in fact, the difference of average profits from 200 is significant (p-value of the two-sided sign-rank test based on all 63 groups is < 0.001).

4.2 Individual behavior

Recall that in our analysis of possible leadership effects we talked about followers' reactions to leader's suggestion or choice. One innovative aspect of our design is the use of the strategy method to elicit followers' contingent strategies. Followers were asked to state an effort level for each possible choice (suggestion in CT treatment and actual effort in FM treatment) of the leader. In this section we analyze the strategies of the followers, the choices of the leaders, and perform a counterfactual analysis to address the question of whether the responsibility for coordination failure lies with the leader or with the followers.

4.2.1 Followers' strategies

Figure 8 shows the followers' strategies in each of the mechanisms for each round of the leader-follower block (rounds 1-10 in Prevent and rounds 11-20 in Restore). Each bar represents the frequency of a certain choice by the followers in a certain round, given the leaders' suggestion or choice. For example, the leftmost bar in the bottom-left corner of panel (a) of the figure indicates that about 30% of the followers would choose 0 effort in round 11 (round 1 of the leader-follower setup in Restore) if the leader suggested 40; the rightmost bar in the same corner shows that about 75% of the followers would choose 0 effort in round 20 (round 10 of the leader-follower setup in Restore) if the leader suggested 40.

As can be seen in the figure, the most common strategies were either to match the leader's suggestion or choice (the bars on the diagonal of each panel) or to choose zero effort irrespective of the leader's suggestion or choice (the bars in the left column of each panel).[28] We define the *Match+* strategy as a strategy in which a follower chooses at least[29] L for all effort levels L that the leader might suggest or choose. *Always-zero (All0)* is a strategy where a follower chooses zero regardless of what the leader might suggest or choose.

Figure 9 condenses the information in figure 8 to show the evolution of the use of these two strategies. Initially, Match+ is more frequent than All0. However, in all treatments, the play of the All0 strategy increases over time. The play of the Match+ strategy generally decreases over time except in the FM-Prevent treatment where it stays roughly constant. The reason behind this change in the use of the All0 and Match+ strategies is that the Match+ strategy is effective only if all three followers adopt it, but is risky if there is at least one follower who chooses the All0 strategy (if the leader suggests or chooses a non-zero effort level, the Match+ strategy would hurt the follower who uses it).

From our discussion of leadership effects in section 2, followers are expected to be responsive to the leader's suggestion/choice compared with the choices players would make in the simultaneous game, and more so in FM than in CT (our assumption 1). For any given suggestion/choice of the leader, we find that the difference in followers' choices between CT and FM is not significant in round 1 of Prevent sessions, but the pooled distribution of follower's choices in CT and FM is significantly higher than the distribution of choices of players in the simultaneous game.[30] Similarly,

[28] Note that the strategies in the figure are consistent with our assumption 2 in section 2. Followers do not choose zero more often after a higher suggestion/choice of the leader and their non-zero choices match the leader's choice, thus their distribution of efforts shifts toward a higher effort.

[29] Choosing an effort above what the leader chooses or suggests might seem irrational but may be done either in expectation that the leader *will* actually choose a high rather than a low effort (thus what the follower chooses for a low effort of the leader is irrelevant), or in order to "teach" the leader the virtue of choosing a high effort. Therefore strategies that choose more than the leader are counted together with the matching strategy.

[30] If the leader suggestion/choice is 40, the distributions can be directly compared. For other suggestions/choices

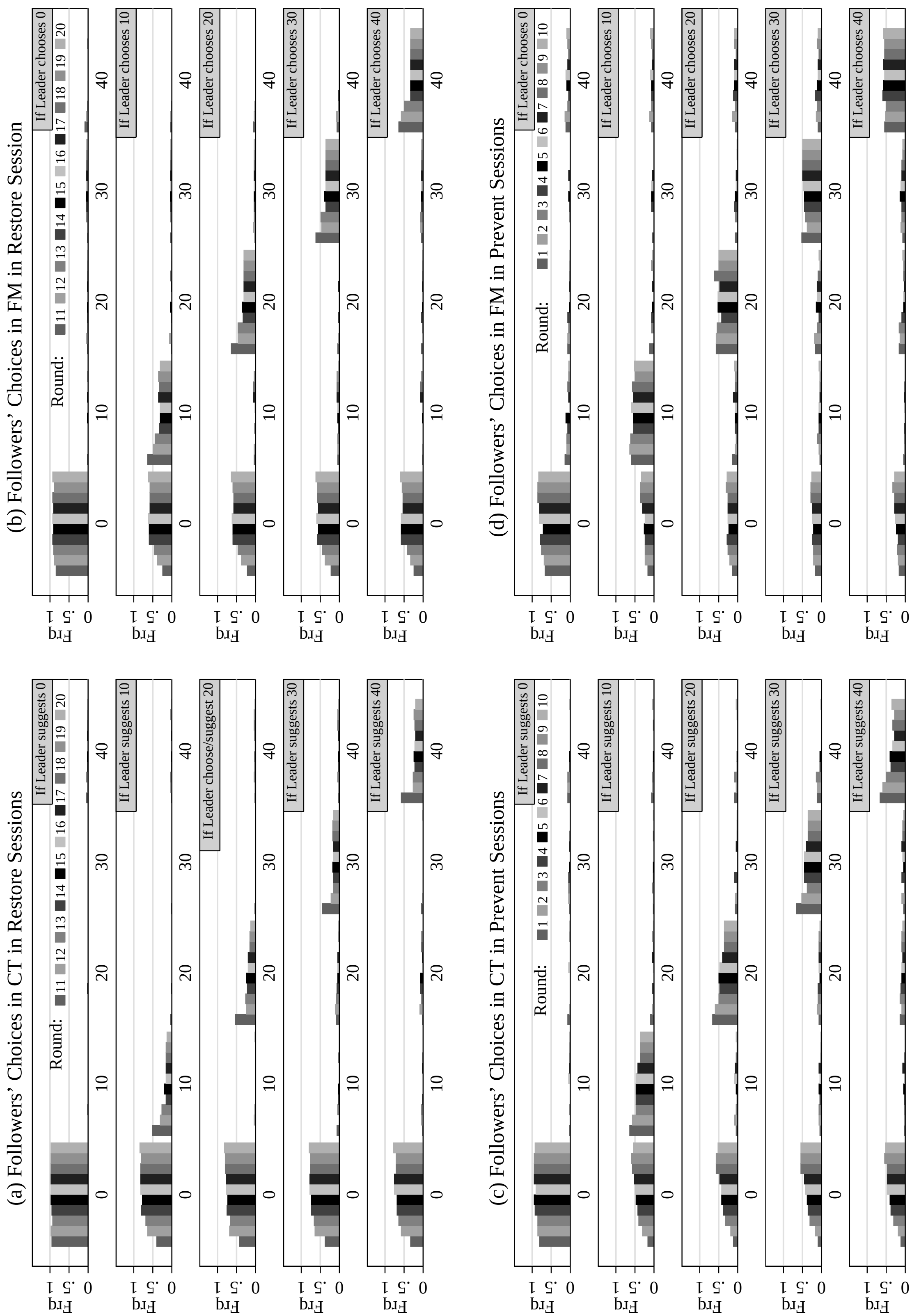


Figure 8: Followers' choice in response to leader's suggestion/choice

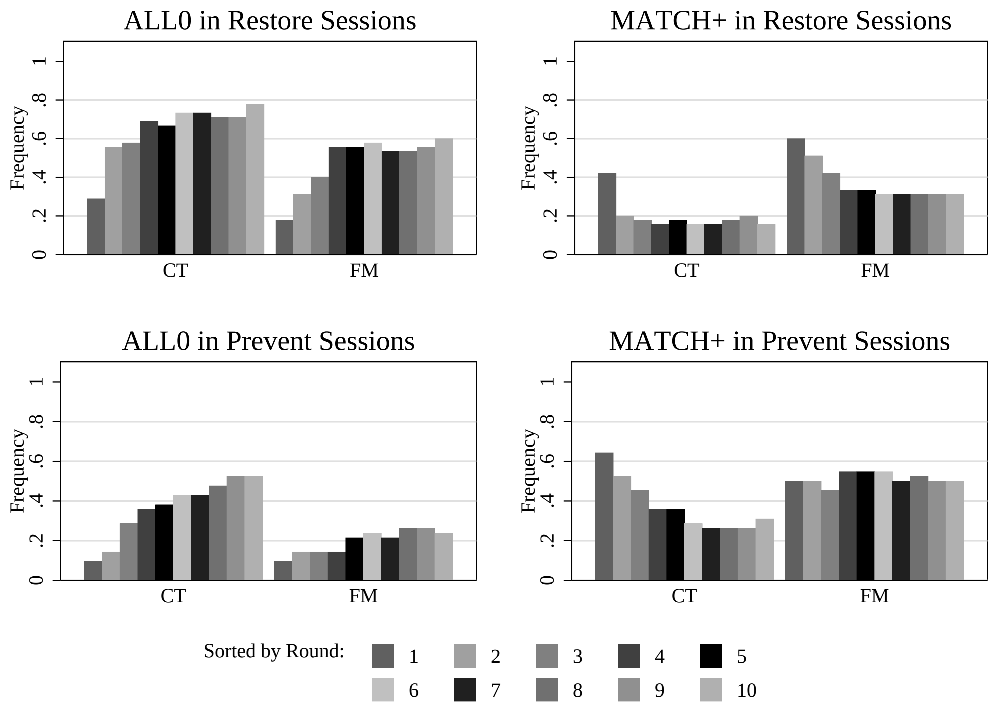


Figure 9: Evolution of All0 and Match+ strategies

for Restore sessions, in groups with coordination failure in round 10, the difference between CT and FM followers' choices in round 11 is also not significant for most suggestions/choices of the leader, but the pooled distribution of followers' choice in CT and FM is significantly higher than the choices of players in round 11 in the Control session. Thus the followers' actual strategies are consistent with assumption 1.

Followers are also expected to be more responsive to the leader's suggestion/choice in Prevent sessions compared with Restore sessions. In order to include this comparison, since the choices of the followers in a group are not independent after round 1, we take, for a given suggestion/choice of the leader, the average choice of the followers in the same group over all ten rounds as a measure of responsiveness of the followers in this group. This gives us, for each treatment (CT-Restore, CT-Prevent, FM-Restore, FM-Prevent), as many independent observations as there are groups in the treatment. With this measure, for each possible suggestion/choice of the leader, we are able to reject the hypothesis that there are no differences between the four treatments (maximum p-value of the Kruskal-Wallis tests is 0.022). In pairwise comparisons of the treatments, the most significant differences are found between CT-Restore and CT-Prevent, and FM-Restore and FM-Prevent. When we pool CT and FM treatments and compare Restore with Prevent sessions, we find a significantly higher responsiveness in Prevent sessions (the largest p-value of the one-sided tests is 0.006). When we pool Restore and

of the leader (for example, $L = 30$), we look only at the distribution of choices in the simultaneous game that do not exceed L.

Table 5: Regressions for followers' choices

Dependent variable:	Effort (Ordered probit)	Effort (Random-effects)	Effort (Ordered probit)	Effort (Random-effects)
	Rounds 1 and 11		Rounds 2-10 and 12-20	
CT-Restore	-0.557*** (0.191)	-6.286*** (2.046)	-0.341 (0.213)	-3.667** (1.621)
CT-Prevent	(Base)	(Base)	(Base)	(Base)
FM-Restore	-0.210 (0.175)	-2.463 (1.994)	0.088 (0.183)	-0.271 (1.686)
FM-Prevent	-0.077 (0.175)	-1.095 (2.047)	0.592*** (0.165)	5.355*** (1.653)
Leader's suggestion/choice	0.051*** (0.005)	0.582*** (0.037)	0.042*** (0.003)	0.394*** (0.031)
Group minimum effort in the previous round			0.037*** (0.004)	0.226*** (0.048)
Round			-0.045*** (0.010)	-0.426*** (0.083)
Constant		7.309*** (1.532)		3.161** (1.375)
N	870	870	7830	7830

standard errors clustered by 174 subjects in parentheses; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Prevent sessions and compare CT with FM, the responsiveness in FM is also significantly higher than in CT (the largest p-value of the one-sided tests is 0.038). Thus we find support for our hypothesis 3.

We also run regressions of followers' choices on leader's suggestion/choice, including treatment dummies, separately for period 1 in Prevent (and period 11 in Restore), and for all other periods where we also include the history of the group represented by the minimum effort in the previous round and a time trend. Table 5 reports the results of ordered probit and random-effects regressions.[31]

The leader's suggestion/choice variable is highly significant, as expected, and the coefficient in the random-effects linear regressions shows that, for a unit increase in leader's effort, followers increase their effort on average only by 0.58 in round 1 and by 0.39 in rounds 2-10, confirming that they do not match the leader's suggestion/choice perfectly. The regressions also confirm that there are significant differences between CT-Restore and CT-Prevent in round 1 (round 11 in Restore). In the other rounds there is a significant difference between CT-Restore and CT-Prevent, and CT-Prevent and FM-Prevent treatments, again confirming that in Restore sessions followers' choices are lower than in Prevent sessions, as well as that in CT treatment choices are lower than in FM treatment. In addition to the leader's suggestion/choice and treatment dummies, group history is important,

[31]We also ran regressions that included interaction terms of the variables with treatment dummies. Most of those interaction terms were insignificant and the coefficients reported in the table and their significance remained broadly unchanged.

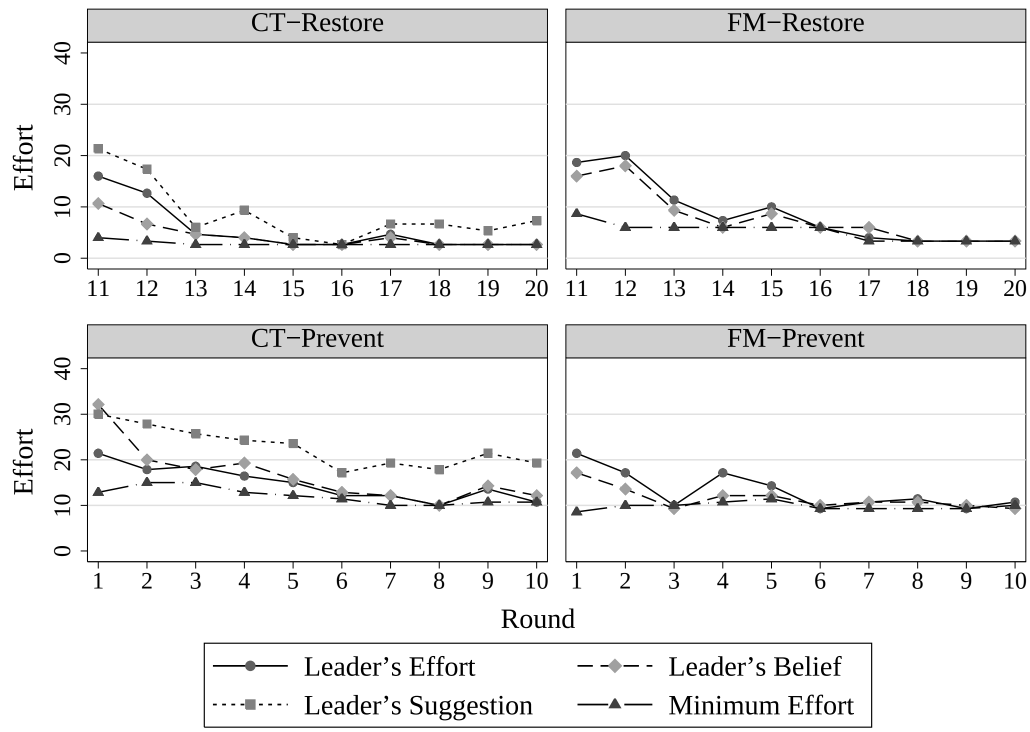


Figure 10: Leaders' average effort choices, suggestions and beliefs

and there is also a significant downward trend not explained by the other variables.

Result 4 *On average, followers match a leader's increase in effort only partially. For a given suggestion/choice of the leader, the effort choices of the followers are higher in FM than in CT, and they are higher in Prevent than in Restore.*

4.2.2 Leaders' choices

In the previous subsection we looked at the decisions of the followers. How did the leaders make their choices in our experiment? In our FM treatment leaders simply choose effort; in CT treatment leaders also suggest a number that is seen by their followers but they could choose an effort different from the suggested number. In all treatments, leaders also state their beliefs about what they expect the minimum effort of the followers to be. Figure 10 shows average leaders' effort choices, suggestions and beliefs in each round, together with the average group minimum effort in the round.

One can see from the figure that the average effort choices of the leaders do not differ much across treatments. Recall that from our theoretical discussion in section 2 we could not make an unambiguous prediction about in which of the two mechanisms leaders would choose a higher effort. The two-sided rank-sum tests on leader's effort choices find no differences between CT and FM treatments, either in round 1 of Prevent, round 11 of Restore, or averaging each leader's choices over all ten rounds of a mechanism. Pooling CT and FM together and comparing the averages of leaders' effort choices in the ten rounds of Prevent and Restore sessions, we find that leaders in Prevent choose a significantly higher effort than in Restore (p-value of one-sided rank-sum test is 0.042).

According to hypothesis 4, we expect that the effort of leaders in the mechanisms would be no lower than the effort of players in the simultaneous game. Although in round 1 of Prevent sessions there is no significant difference of leader's efforts from those in round 1 of the simultaneous game (i.e. Restore and Control sessions), the one-sided rank-sum test on the average efforts over ten rounds (averaging all players in a group in the simultaneous game) finds that efforts by leaders are marginally significantly higher (p-value is 0.075). In Restore sessions, looking at the leaders with a history of coordination failure compared with the simultaneous game in the Control treatment we find that leaders' effort is significantly higher in round 11 (p-value of the one-sided rank-sum test is 0.014). This provides some evidence in support of the hypothesis.

Figure 10 also shows that, while beliefs, actions and minimum effort become very close in all treatments after a few rounds, average suggestions in CT treatments are higher than average actions for almost all rounds, especially in Prevent sessions. While a majority of leader-communicators' decisions coincide with the suggestion, a sizable minority of effort choices by a leader when the suggestion was not zero is below the suggested number (around 44% in both Restore and Prevent). In Prevent sessions, the suggestions of leaders in CT are significantly higher than the choices of leaders in FM according to the one-sided rank-sum tests (p-values 0.066 for round 1 and 0.022 for averages over rounds 1-10). In Restore sessions, we do not find a significant difference between suggestions in CT and efforts in FM by the leaders. One may expect that the leader would be more responsive to his/her own message than the followers; this is not always the case in the data. The average actual effort of leaders in CT-Prevent is lower than that of the followers (14.79 vs 16.76), implying that the leaders followed their own suggestion (on average 22.64) even less than their followers did. This difference is not significant though, according to the sign-rank test on efforts of leaders and followers averaged over ten rounds.

To get more insight into leaders' decisions, we use regression analysis. Unlike followers, leaders did not have a suggestion or choice of another player to base their decisions on; the amount of information they have available is similar to that of players in the simultaneous game. We therefore combine leaders' effort choices with those of players that did not experience a leadership mechanism (rounds 1-10 in Restore and Control sessions and rounds 11-20 in Control session in our experiment). In the first two columns of table 6 we report the results of random-effects regressions of effort choices on treatment dummies, group history and a time trend.[32] The regressions are done separately for rounds 1 and 11 (first rounds in a block), and for the other rounds.

The regressions confirm that there is little difference in leaders' efforts across treatments; they also do not find a significant difference in efforts between the first ten rounds of the simultaneous game and the leaders' efforts in Prevent. The signs of the coefficients show that leaders' efforts were not below the choices in the simultaneous games, not contradicting hypothesis 4. The only significant

[32] An ordered probit specification produces similar significance results. We also tried including interaction terms and lagged effort in the regression; the results stay broadly similar.

Table 6: Regressions for leader's efforts and suggestions

Dependent variable:	Effort Rounds 1 and 11	Effort Rounds 2-10 and 12-20	Suggestion/choice Rounds 1 and 11	Suggestion/choice Rounds 2-10 and 12-20
Simultaneous Part 1	-1.186 (4.290)	-0.641 (0.746)		
FM-Prevent	(Base)	(Base)	(Base)	(Base)
CT-Prevent	$<$0.001 (5.493)	-0.508 (1.040)	8.571 (6.240)	7.869*** (2.500)
Simultaneous Part 2 (Control session)	-16.963*** (4.698)	-2.443*** (0.864)		
FM-Restore	-3.680 (6.209)	-0.213 (1.185)	-2.762 (6.135)	-1.524 (1.655)
CT-Restore	-4.429 (5.450)	-0.997 (0.887)	-0.095 (6.135)	-0.119 (2.151)
Group minimum effort in the previous round		0.948*** (0.020)		0.705*** (0.072)
Round		-0.720*** (0.073)		-0.842*** (0.209)
Constant	21.429*** (4.082)	7.281*** (0.911)	21.429*** (4.412)	10.393*** (1.884)
N	218	1962	58	522
Clusters (by subject)	168	168	58	58

standard errors adjusted for clusters in parentheses; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

difference is that the efforts in the second ten rounds of the simultaneous game are lower than the efforts of the leaders. Analogously to the followers' regressions, the history of the group, summarized by the minimum effort in the previous round, plays a large role in the effort choice of the leader, and there is a downward time trend.

The last two columns in table 6 regress leaders' suggestions (in CT) and choices (in FM) on treatment dummies and the other variables. Although in rounds 1 and 11 we are not able to detect significant differences between suggestions and efforts, over all ten rounds of the mechanisms the suggestions of the leaders in CT-Prevent are found to be significantly higher than the leaders' efforts in FM-Prevent, while there is little difference for the other treatments. Since the efforts of the leaders are not significantly different across treatments, this confirms the previous evidence that in CT leaders often put a higher suggestion than the effort they choose.

Result 5 *Efforts of the leaders are similar in the two leadership mechanisms, and only marginally higher than the efforts of players in the simultaneous game. In CT-Prevent treatment, leaders, similarly to their followers, do not follow their own suggestion to the full extent.*

4.2.3 Coordination failure: leader's or followers' responsibility?

Knowing followers' strategies, we can see if it would have been possible for leaders (or for individual followers) to achieve a higher group effort by unilaterally changing their choice (and possibly the suggestion in CT). We find that if the leader had chosen a different effort level (and corresponding suggestion in CT), the minimum effort in 22 out of 58 groups would have increased in the first round for which the leader-follower setup is implemented (i.e. round 11 in Restore sessions and round 1 in Prevent sessions). Despite the fact that many groups' effort level could be increased if the leader had chosen differently, there are also many cases where leaders end up with an effort higher than the minimum effort of their followers (29 out of 58 groups).[33] Therefore, if the followers would choose differently, those 29 groups could have a higher minimum effort level.

Given the distribution of the followers' choices, we ask what the expected payoff for leaders would be from choosing various effort levels (in FM) or suggesting various numbers and following them (in CT). The leader's expected payoff is calculated as follows: using followers' choices collected by the strategy method, we calculate the distribution of the minimum effort of three randomly selected followers for each possible choice of the leader, and use this distribution to find the leader's expected payoff for each choice. We also do this for the followers, calculating expected payoffs a follower would get from following various possible choices or suggestions of the leader. For this, we take into account the probability distribution for the choices of the other two followers in the group, randomly chosen from the observed population of followers. Figure 11 shows the leader's and a follower's expected payoff calculated in this way.

In all panels of the figure, the highest payoff corresponds to effort 0. The two left panels are for leaders. Expected payoffs are higher in Prevent sessions than in Restore sessions for each effort level, reflecting the fact that followers more often chose to match the leader's suggestion or choice in Prevent. In Restore, the leader's payoff would have been higher in FM than in CT for each corresponding effort choice; leaders in Prevent would have expected a higher payoff in CT than in FM for each corresponding effort choice. Zero effort is, nevertheless, still the optimal choice for the leaders in all treatments. The two right panels are for the follower's expected payoff. Again, for all effort levels strictly higher than 0, the expected payoffs are lower than the payoff 200 that a player could guarantee by always choosing 0. Note here that the payoffs of followers are calculated for cases in which the leader would choose (in FM) or suggest and choose (in CT) the given effort level and the follower would follow that leader's choice. What the figure thus shows is that fully following the leader's suggestion/choice is not optimal even for a risk-neutral follower (and even if CT leaders always followed their own suggestion). The uncertainty arising from the decisions of only two (rather than three as for the leader) other followers in a group is still sufficiently high, so that the expected payoff of a follower is lower than 200 (the highest expected payoff from a non-zero

[33]Note that a low minimum group effort could be both leader's and followers' fault. For example, suppose that the minimum of the followers' effort is zero except in the case in which the leader chooses 40. If the leader chooses 20, the group minimum is zero while at the same time the leader could have chosen 40 and the whole group would coordinate on the efficient effort of 40.

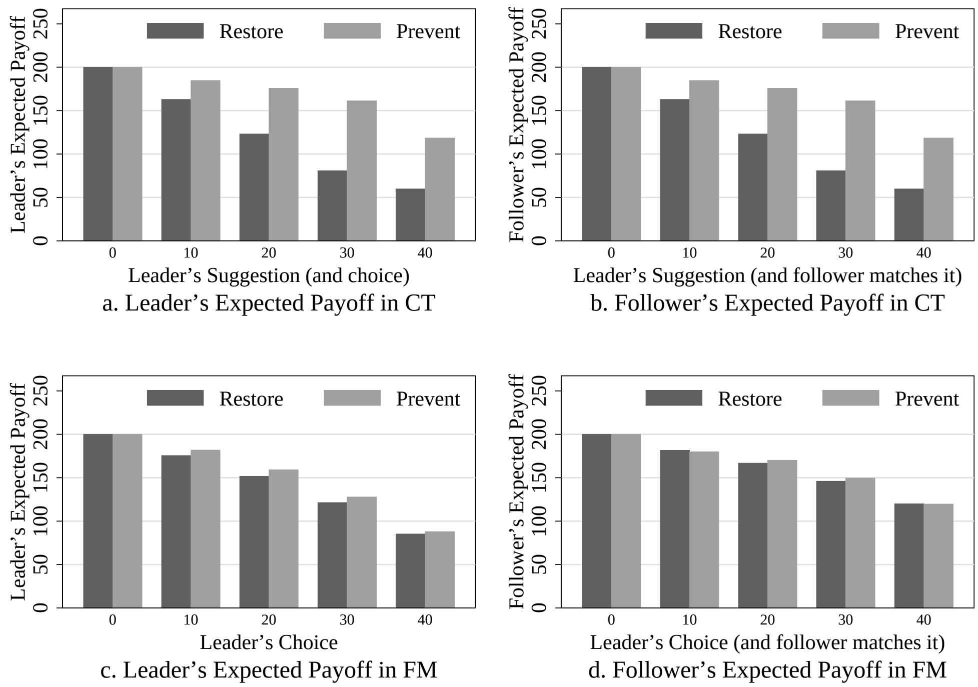


Figure 11: Leader's and follower's expected payoffs given followers' choices in strategy method

effort is 191.67, for effort 10 in Prevent sessions). The payoffs in figure 11 are based on the first round of the leader-follower setup. Given that the strategies of the followers become less responsive over time, in subsequent rounds effort 0 remains the optimal choice.

Result 6 *Given the population distribution of followers' choices, neither the leader nor a follower would individually be better off in expected terms in the first round of the mechanisms by choosing an effort other than 0.*

The main blame for this observation lies with followers: the proportion of them playing the All0 strategy is too high for any positive effort to be profitable. Leaders are also partially to blame though: their persistent failure to follow their own suggestion in CT may be a reason why not all followers follow the leader's suggestion, and in many groups a different leader's choice could have increased the minimum effort. Overall, it is a collective failure: players could not unilaterally have increased their expected payoff by choosing a higher effort, thus it was individually rational to choose the safe option of zero effort.

5 Conclusion

We analyzed the effects of two leadership mechanisms (pre-play communication and leading-by-example) in a tough parametrization of the minimum effort game. In this challenging environment, the mechanisms failed to overcome coordination failure and had only limited effectiveness in preventing it. The mechanisms did have some effect in the short-run as some players attempted to choose a higher effort but in the long-run most players fell back to the lowest possible effort.

In both leadership mechanisms a substantial proportion of followers chose the effort level corresponding to the leader's suggestion or choice. Followers appeared to follow the leader more in the first-mover mechanism than in the cheap-talk mechanism. They also followed the leader more without a history of coordination failure. However, in each treatment, there was also a considerable number of followers who, instead of following the leader, always chose zero effort, irrespective of the suggestion or choice of the leader. Since the group outcome depends on the minimum effort in the group, the presence of just one such player often led in the long run to the group falling back to the lowest effort. Given the non-negligible proportion of such players in our data, we found that the expected payoff of both leaders and followers would be maximized by choosing zero effort.

Our results delineate the limits of the leadership mechanisms for preventing and overcoming coordination failure. Despite the game possessing a payoff-dominant Nash equilibrium, in our tough environment the mechanisms were not sufficient to overcome coordination failure and their effectiveness in preventing it was rather limited. Our mechanisms involved a quite minimal implementation: our leaders were randomly chosen and communication consisted of a single number (interpreted as a suggestion of effort); more complicated mechanisms are needed to enable players to avoid coordination failure in this game.

References

Blume, A. and Ortmann, A. (2007). The effects of costless pre-play communication: Experimental evidence from games with Pareto-ranked equilibria. *Journal of Economic Theory*, 132: 274–290.

Brandts, J. and Charness, G. (2011). The strategy versus the direct-response method: A first survey of experimental comparisons. *Experimental Economics*, 14: 375–398.

Brandts, J. and Cooper, D. J. (2006). A change would do you good .... An experimental study on how to overcome coordination failure in organizations. *American Economic Review*, 96: 669–693.

Brandts, J. and Cooper, D. J. (2007). It's what you say, not what you pay: An experimental study of manager-employee relationships in overcoming coordination failure. *Journal of the European Economic Association*, 5: 1223–1268.

Brandts, J., Cooper, D. J., and Fatas, E. (2007). Leadership and overcoming coordination failure with asymmetric costs. *Experimental Economics* 10: 269–284.

Brandts, J., Cooper, D. J., and Weber, R. A. (2014). Legitimacy, communication, and leadership in the turnaround game. *Management Science*, forthcoming. doi: 10.1287/mnsc.2014.2021.

Camerer, C. F. (2003). *Behavioral Game Theory: Experiments in Strategic Interaction.* Princeton University Press, Princeton NJ.

Cartwright, E., Gillet, J., and van Vugt, M. (2013). Leadership by example in the weak-link game. *Economic Inquiry*, 51: 2028–2043.

Chaudhuri, A., Schotter, A., and Sopher, B. (2009). Talking ourselves to efficiency: Coordination in inter-generational minimum effort games with private, almost common and common knowledge of advice. *Economic Journal*, 119: 91–122.

Chen, R. and Chen, Y. (2011). The potential of social identity for equilibrium selection. *American Economic Review*, 101: 2562–2589.

Cooper, R., DeJong, D. V., Forsythe, R., and Ross, T. W. (1992). Communication in coordination games. *Quarterly Journal of Economics*, 107: 739–771.

Devetag, G. and Ortmann, A. (2007). When and why? A critical survey on coordination failure in the laboratory. *Experimental Economics*, 10: 331–344.

Dugar, S. (2010). Nonmonetary sanctions and rewards in an experimental coordination game. *Journal of Economic Behavior and Organization*, 73: 377–386.

Farrell, J. and Rabin, M. (1996). Cheap talk. *Journal of Economic Perspectives*, 10: 103–118.

Fischbacher, U. (2007). z-Tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics* 10: 171–178.

Fischbacher, U., Gächter, S., and Quercia, S. (2012). The behavioral validity of the strategy method in public good experiments. *Journal of Economic Psychology*, 33: 897–913.

Goeree, J. K. and Holt, C. A. (2005). An experimental study of costly coordination. *Games and Economic Behavior*, 51: 349–364.

Greiner, B. (2004). An online recruitment system for economic experiments. In: Kremer, K. and Macho, V. (eds) *Forschung und wissenschaftliches Rechnen*. GWDG Berich 63, Ges. für Wiss. Datenverarbeitung, Göttingen, 79–93.

Hamman, J., Rick, S., and Weber, R. A. (2007). Solving coordination failure with "all-or-none" group-level incentives. *Experimental Economics* 10: 285–303.

Harsanyi, J. C. and Selten, R. (1988). *A General Theory of Equilibrium Selection in Games*. MIT Press, Cambridge MA.

Knez, M. and Simester, D. (2001). Firm-wide incentives and mutual monitoring at Continental Airlines. *Journal of Labor Economics*, 19: 743–772.

Kriss, P. H., Blume, A., and Weber, R. A. (2012). Organization coordination with decentralized costly communication. Working paper, Carnegie Mellon University.

Le Lec, F., Rydval, O., and Matthey, A. (2014). Efficiency and punishment in a coordination game: Voluntary sanctions in the minimum effort game. CERGE-EI working paper 526.

Manzini, P., Sadrieh, A., and Vriend, N. J. (2009). On smiles, winks and handshakes as coordination devices. *Economic Journal*, 119: 826–854.

Monderer, D. and Shapley, L. S. (1996). Potential games. *Games and Economic Behavior*, 14: 124–143.

Rousseau, J.-J. (1755). *Discours sur l'origine et les fondemens de l'inégalité parmi les hommes.* Marc-Michel Rey, Holland. English translation: *A Discourse upon the Origin and Foundation of the Inequality among Mankind*. Dodsley, London, 1761.

Sahin, S. G., Eckel, C., and Komai, M. (2015). An experimental study of leadership institutions in collective action games. *Journal of the Economic Science Association*, 1: 100–113.

Van Huyck, J. B., Battalio, R. C., and Beil, R. O. (1990). Tacit coordination games, strategic uncertainty, and coordination failure. *American Economic Review*, 80: 234–248.

Weber, R. A., Camerer, C. F., and Knez, M. (2004). Timing and virtual observability in ultimatum bargaining and "weak link" coordination games. *Experimental Economics*, 7: 25–48.

Weber, R., Camerer, C., Rottenstreich, Y., and Knez, M. (2001). The illusion of leadership: Misattribution of cause in coordination games. *Organization Science*, 12: 582–598.

Appendix: Experimental Instructions (for CT-Restore Sessions)

General Information and Payments:

The purpose of this experiment is to study how people make decisions in a particular situation. From now until the end of the experiment, any communication with other participants or use of mobile phones is not permitted. If you have a question, please raise your hand and one of us will come to your desk to answer it.

This experiment will have several *parts*. In each part there will be several *rounds*. You will earn some points each round during the experiment. Upon completion of the experiment the total amount of points will be converted into pounds, and will be paid to you in cash.

The conversion rate is 400 Points = 1 Pound.

Payments will be confidential, i.e., no other participant will be told the amount you make. To ensure your anonymity, your actions in this experiment are only linked to your participant ID number contained in the white envelope. Now, please enter your participant ID number on the screen.

Description of the Decision Task in a Round in Part I of the Experiment:

In Part I there will be ten *rounds*. After these ten rounds have finished, we will give you instructions for the next part of the experiment. In each round you will be in a *group* with three other participants. The participants you are grouped with will be the same in all rounds of Part 1.

You and the other members of your group are employees of a firm. You can think of a round of the experiment as being a workweek. In each week, each of the employees in the firm spends 40 hours at the firm. You have to choose how to allocate your time between two activities, Activity A and Activity B. Specifically, you will be asked to choose how much time to devote to Activity A. The available choices are 0 hours, 10 hours, 20 hours, 30 hours, and 40 hours. Your remaining hours will be put toward Activity B. For example, if you devote 30 hours to Activity A, this means that 10 hours will be put toward Activity B.

Payoffs:

The payoff that an employee receives in a round depends on the number of hours he/she chooses to spend on Activity A and the number of hours chosen by the others in his/her firm to spend on Activity A.

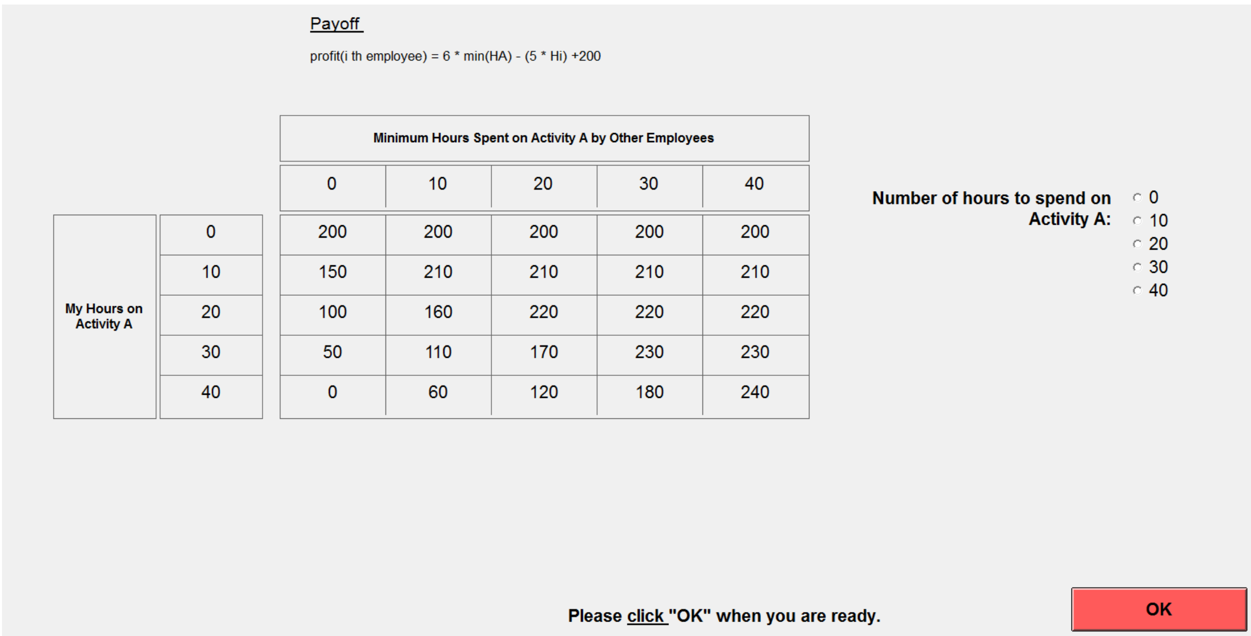
The payoff (in points) for the i^{th} employee of the firm, π_i, is given by the formula below where H_i is the number of hours spent by the i^{th} employee of the firm on Activity A, and $\min(H_A)$ is the smallest number of hours an employee of the firm spends on Activity A. You do not need to memorize this formula — the computer program will give you payoff tables at any point where you need to make a decision:

$$\pi_i = 6 \cdot \min(H_A) - 5 \cdot H_i + 200$$

Playing a round:

For each round of the experiment, the computer will display a screen like the one shown below (See Screenshot 1) representing your possible payoffs calculated from the formula above.

Screenshot 1.



Payoff

profit(i th employee) = 6 * min(HA) - (5 * Hi) +200

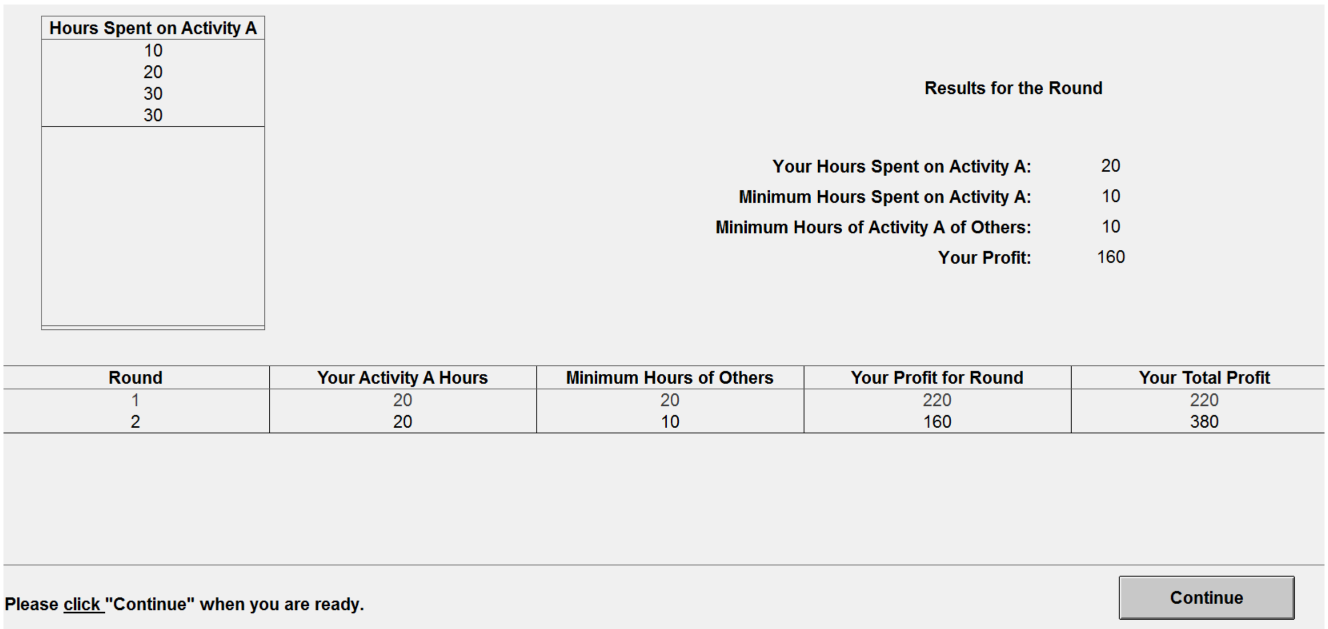
My Hours on Activity A	Minimum Hours Spent on Activity A by Other Employees: 0	10	20	30	40
0	200	200	200	200	200
10	150	210	210	210	210
20	100	160	220	220	220
30	50	110	170	230	230
40	0	60	120	180	240

Each employee will choose a number of hours to spend on Activity A using the buttons on the right-hand side of the screen. You will be given 1 minute for each round and you may change your choice as often as you like, but once you click "OK", the choice is final. Note that when you make your decision you will *not* know what the other employees in your firm are doing in the round. At no point in time will we identify the other employees in your firm. In other words, the actions you take in this experiment will remain confidential.

Information that you will receive:

After each round you will be informed about the number of hours you have spent on Activity A, the lowest number chosen by all of the employees in your firm, your payoff for the latest round, and your accumulated payoffs through the current round. ***You will also be shown your decisions and the decisions of all the other employees of your group for the current round.*** *These decisions will be sorted from lowest to highest, and will not include any identifying information about which employee was responsible for which choice* (see Screenshot 2).

Screenshot 2 (Numbers are provided for explanatory purposes only)



Payoff Quiz 1:

Before we begin the experiment, please answer the following questions. The payoff table is shown below. We will go through the answers to a sample problem before you do the rest of the quiz.

		Minimum Hours Spent on Activity A by Other Employees				
		0	10	20	30	40
My Hours on Activity A	0	200	200	200	200	200
	10	150	210	210	210	210
	20	100	160	220	220	220
	30	50	110	170	230	230
	40	0	60	120	180	240

Sample Question:

Suppose you choose to spend 10 hours on Activity A. The other employees choose to spend 30, 20, and 40 on Activity A. The minimum number of hours an employee of the firm spends on Activity A is **10** . Your payoff is **210** points.

Now, please do the following quiz. If you have trouble answering any of the questions or have finished the quiz, please raise your hand.

Quiz

1. Suppose you choose to spend 20 hours on Activity A. The other employees choose to spend 30, 0, and 10 hours on Activity A. The smallest number of hours an employee of the firm spends on A is ___. Your payoff is ___ points.

2. Suppose you choose to spend 30 hours on Activity A. The other employees choose to spend 20, 30, and 40 hours on Activity A. The smallest number of hours an employee of the firm spends on A is ___. Your payoff is ___ points.

3. At the end of each round, the decisions of each employee in my group will be displayed in the upper left corner of the information screen, without revealing the identity of each employee. (True/False)

4. I am grouped with the same three individuals for the entire Part 1 of the experiment. (True/False)

5. My actions and payoffs will be confidential. (True/False)

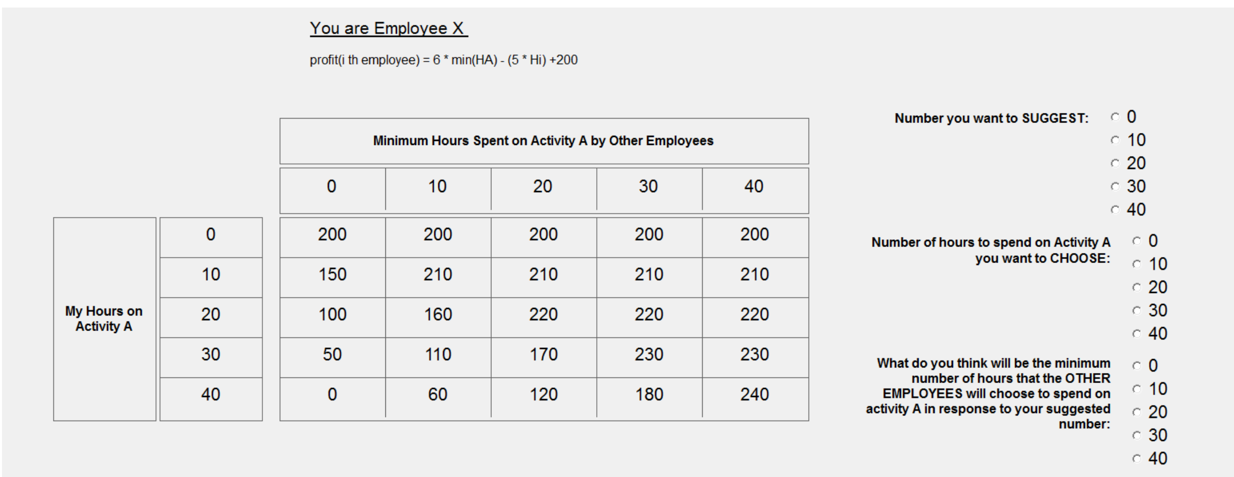
Instructions for Part 2:

In Part 2, there will be *ten* rounds. In all rounds, you will *still* be grouped with the same three individuals as in Part 1 of the experiment. However, ONE of you will be randomly chosen to play the role of Employee X and the other THREE group members will play the role of Employee Y. You will learn whether your role is Employee X or Employee Y at the start of Part 2. These roles will remain *fixed* during the entire Part 2. The profit table will be the same as in Part 1.

First, Employee X **suggests a *number*** for the group each round. He/she will also **make a *choice*** of how many hours to spend on activity A. Note, however, that the *choice* of how many hours to spend on activity A is the one used to calculate the points, and it could be different from the suggested *number*. This suggested number will be available to the other group members.

Employee X will also **make an *estimate*** about "the minimum number of hours that the other three employees will choose to spend on activity A in response to his/her suggested number" (see screenshot 3). There will be 20 extra points for each correct estimate. Those points will be added up at the final payment stage.

Screenshot 3.



You are Employee X

profit(i th employee) = 6 * min(HA) - (5 * Hi) +200

		Minimum Hours Spent on Activity A by Other Employees				
		0	10	20	30	40
My Hours on Activity A	0	200	200	200	200	200
	10	150	210	210	210	210
	20	100	160	220	220	220
	30	50	110	170	230	230
	40	0	60	120	180	240

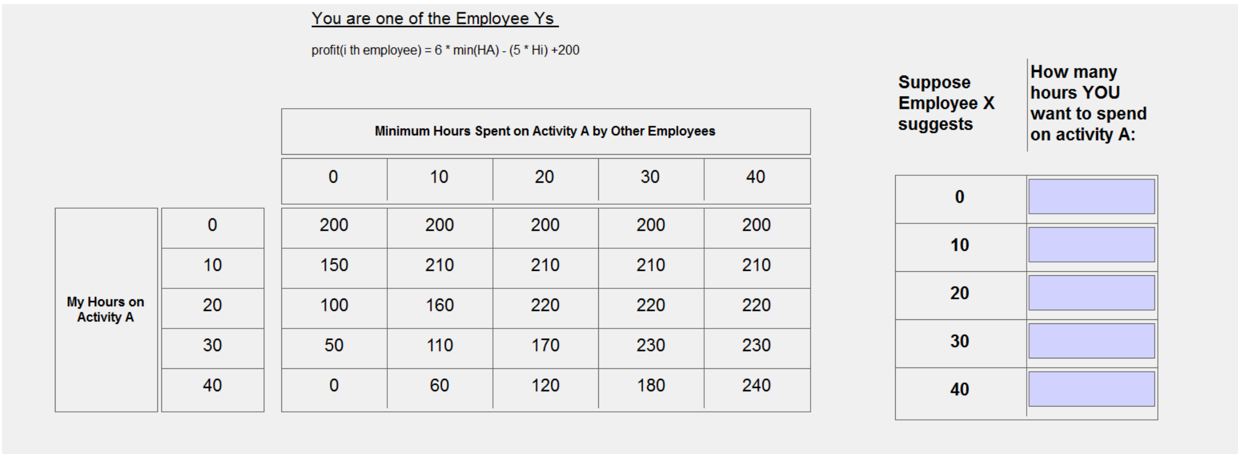
Number you want to SUGGEST: 0 / 10 / 20 / 30 / 40

Number of hours to spend on Activity A you want to CHOOSE: 0 / 10 / 20 / 30 / 40

What do you think will be the minimum number of hours that the OTHER EMPLOYEES will choose to spend on activity A in response to your suggested number: 0 / 10 / 20 / 30 / 40

After Employee X suggests the number, each Employee Y will choose how many hours to spend on activity A. While in principle each Employee Y decides after Employee X, Employee Y will be asked to decide before learning the actual suggested number of Employee X. Specifically, Employee Y will ***fill in a table*** where he/she can indicate how many hours he/she wants to spend on activity A for each possible number Employee X might suggest (see screenshot 4).

Screenshot 4.



My Hours on Activity A	0	10	20	30	40
0	200	200	200	200	200
10	150	210	210	210	210
20	100	160	220	220	220
30	50	110	170	230	230
40	0	60	120	180	240

- In the first box: how many hours you want to spend on activity A if Employee X suggests 0,
- In the second box: how many hours you want to spend on activity A if Employee X suggests 10,
- In the third box: how many hours you want to spend on activity A if Employee X suggests 20, etc.

After every employee in the group makes their decision, Employee X's suggested *number* will be revealed to all group members. ***The relevant decision of Employee Y will be determined by Employee X's actual suggested number.*** For example, if employee X suggested 10, the only relevant decision for Employee Y is the number entered in the second box.

At the end of each round, you will receive the same information as in Part 1. That is, you will be informed about the (relevant) number of hours you have spent on activity A, the lowest number chosen by all of the employees in your firm, your payoff for the latest round, and your accumulated payoffs through the current round. *You will also be shown all (relevant) decisions in your group sorted from lowest to highest.*

Quiz 2:

Before we begin Part 2 of the experiment, please answer the following questions. The payoff table is shown below. We will go through the answers to a sample problem before you do the rest of the quiz. Please raise your hand if you are having trouble answering any of the questions.

Sample Question: Suppose you are employee X, you suggest 10 and choose to spend 10 hours on Activity A. The three employee Y's choices are listed in Figure 1 (numbers are provided for explanatory purpose only). Thus, the relevant choices of the three employee Ys are **10**, **0**, and **40** on Activity A. The minimum number of hours an employee of the firm spends on Activity A is **0** . Your payoff is **150** points.

Figure I

Employee Y1's choice:		Employee Y2's choice:		Employee Y3's choice:	
Suppose Employee X suggests	**How many hours YOU want to spend on activity A:**	**Suppose Employee X suggests**	**How many hours YOU want to spend on activity A:**	**Suppose Employee X suggests**	**How many hours YOU want to spend on activity A:**
0	0	**0**	0	**0**	40
10	10	**10**	0	**10**	40
20	10	**20**	20	**20**	40
30	20	**30**	40	**30**	40
40	30	**40**	40	**40**	40

		Minimum Hours Spent on Activity A by Other Employees				
		0	10	20	30	40
My Hours on Activity A	0	200	200	200	200	200
	10	150	210	210	210	210
	20	100	160	220	220	220
	30	50	110	170	230	230
	40	0	60	120	180	240

Now, please do the following quiz. If you have trouble answering any of the questions or have finished the quiz, please raise your hand.

Quiz

1. Employee Y will learn Employee X's suggested number each round. (True/False)
2. Suppose you are employee X, and you suggest 30 and choose to spend 20 hours on Activity A. The three employee Y's decisions are listed in Figure 1. The three employee Ys' relevant choices are ___, ___, and ___ on Activity A. The minimum number of hours an employee of the firm spends on Activity A is ___. Your payoff is ___ points.
3. Suppose you are employee Y2, your payoff is ___ points in this scenario.
4. I am grouped with the same three individuals for Part 1 and 2 of the experiment. (True/False)