Communication and Efficiency in Competitive Coordination Games

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Abstract

Costless pre-play communication has been found to effectively facilitate coordination and enhance efficiency in games with Pareto-ranked equilibria. We report an experiment in which two groups compete in a weakest-link contest by expending costly efforts. Allowing intra-group communication leads to more aggressive competition and greater coordination than control treatments without any communication. On the other hand, allowing inter-group communication leads to less destructive competition. As a result, intra-group communication decreases while inter-group communication increases payoffs. Our experiment thus provides evidence that communication can either reduce or increase efficiency in competitive coordination games depending on different communication boundaries. This contrasts sharply with experimental findings from public goods and other coordination games, where communication always enhances efficiency and often leads to socially optimal outcomes.

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1. Introduction

The early literature on coordination games with Pareto-ranked equilibria documents that coordination failure is common in the laboratory (Van Huyck et al., 1990, 1991; Cooper et al., 1990, 1992). This important finding has been interpreted as relevant for environments ranging from individual organizations to macroeconomies, and has led to an active research agenda to investigate possible mechanisms to resolve this coordination failure. Experiments have studied whether coordination improves through repetition and fixed-matching protocols (Clark and Sefton, 2001), full information feedback (Brandts and Cooper 2006), introduction of between group competition (Bornstein et al., 2002; Riechmann and Weimann, 2008), sequential play (Camerer et al., 2004), the use of entrance fees (Cachon and Camerer, 1996), and gradual increases in group size (Weber, 2006). One of the most effective solutions to the coordination failure problem is communication, even when it is merely nonbinding “cheap talk.”

Many experimental studies have shown that cheap talk can facilitate coordination on the efficient equilibrium in experimental games with Pareto-ranked equilibria (Cooper et al., 1992; Charness, 2000; Charness and Grosskopf, 2004; Duffy and Feltovich, 2002, 2006). For example, Van Huyck et al. (1993) demonstrate that pre-play communication is efficiency-enhancing in coordination games. Blume and Ortmann (2007) find that costless nonbinding messages, even when they have minimal information content, can facilitate quick convergence to the Pareto-dominant equilibrium. Communication also enhances efficiency in intergenerational coordination experiments (Chaudhuri et al., 2009). One reason that communication is so effective is that it apparently significantly reduces strategic uncertainty about other players’ behavior (Riechmann and Weimann, 2008). Since many economic interactions can be modeled
as coordination games, if this finding is general then it has a very important implication: improving communication in coordination games can increase efficiency and social welfare.

This paper departs from the conventional coordination game literature by embedding the coordination game in a competition between groups, and studying the impact of nonbinding and costless communication. In this experimental environment, two groups compete in a lottery contest by expending costly efforts in order to win a prize. The framework is based on the widely-studied and classical Tullock (1980) model of rent-seeking. One key characteristic of this type of group contest is that coordinating on higher efforts can increase the probability of winning the prize but does not necessarily increase the competitors’ payoffs. Excessive efforts can be socially wasteful in contexts ranging from R&D competitions and political or advertising campaigns to war battles. In the experimental literature on the Tullock lottery contest, wasteful efforts that even exceed the equilibrium level are common, as first observed in Millner and Pratt (1989). This previous literature, however, has almost exclusively considered individual contestants. We study contests between groups when efforts are aggregated within each group with a weakest-link production technology, so the effective group effort equals the lowest effort expended by an individual in the group. We investigate whether group competition in these conditions mitigates the excessive efforts often observed in previous studies.

The weakest-link feature of this contest competition resembles many real life competitions where the performance of the entire group depends on the worst performer in the group (Hirshleifer, 1983). For example, in many teamwork competitions each member of the team is responsible for a specific task. If any of the members performs his or her task poorly then the team loses the competition. Certain R&D competitions and teamwork projects have such characteristics, such as a software development project where one bad coding bug can make the
entire project fail. Also, in terrorist attacks and in some military battles, the attacker's objective is often to successfully attack one target, rather than a larger subset of targets, so success is determined by the defense level of the minimum target (Clark and Konrad, 2007).

The weakest-link contest combines features of a cooperative minimum effort game (Van Huyck et al., 1990) and a competitive contest (Tullock, 1980). Many experimental studies have shown that the introduction of competition between groups significantly increases individual efforts (Nalbantian and Schotter, 1997; Van Dijk et al., 2001; Sutter and Strassmair, 2009; Croson et al., 2009). Recent experiments have also documented that competition between groups can improve coordination within each group (Bornstein et al., 2002; Myung, 2008; Sheremeta, 2011).

Although it has strong coordination incentives, a key feature of this competitive coordination game is that efforts are socially wasteful so efficiency increases when players coordinate on lower effort levels. Without communication, we find that group members are able to achieve a modest level of coordination within each group. Allowing only intra-group communication before expending any efforts leads to significantly greater coordination and higher efforts, but it also results in more aggressive competition and substantially lower payoffs.\(^1\) Group efforts actually exceed the highest equilibrium level in this communication treatment. On the other hand, allowing inter-group communication leads to significantly lower efforts and higher payoffs. Since intra-group and inter-group communication have opposite effects, in another treatment with both types of communication permitted we find that the level of competition and payoffs are not significantly different from a no-communication baseline.

\(^1\) The fact that higher contributions lead to lower efficiency is the key feature of our experiment that differentiates our study from Nalbantian and Schotter (1997) and Sutter and Strassmair (2009). Although, Sutter and Strassmair (2009) also document that communication within groups increases individual contributions, such contributions lead to higher payoffs and higher efficiency. In contrast, in our experiment higher contributions lead to lower efficiency.
treatment. Our experiment thus provides evidence that communication improves coordination, but when the communication is restricted within certain boundaries such coordination reduces efficiency. This result contrasts with experimental findings from public goods and other coordination games, where communication always enhances efficiency and often leads to socially optimal outcomes.²

This suggests that enhanced communication opportunities afforded by new information technologies, such as “grassroots” internet-based political organizing that is increasingly being utilized by interest groups (Fisher, 1998; Sylvia, 2002), might reduce social efficiency even while it improves group cohesion and coordination.

2. The Model

Consider a contest between two groups A and B. Each group consists of N risk-neutral players. All players simultaneously and independently expend irreversible and costly individual efforts $x_{iA}$ and $x_{iB}$. Players within the winning group each receive the valuation of a prize $v$. Players within the losing group receive no prize. The total effective effort of each group depends on the lowest effort chosen by a member within the group – the so-called weakest-link. Group efforts determine winning probabilities using the widely-used Tullock (1980) lottery contest success function. Therefore, the probability of group A winning the prize is defined as:

$$p_A(x_{IA},x_{-IA}) = \frac{\min\{x_{1A},...,x_{NA}\}}{\min\{x_{1A},...,x_{NA}\} + \min\{x_{1B},...,x_{NB}\}}$$ (1)

² The finding that communication may reduce efficiency echoes the recent finding of Abbink et al. (2010), who show that by allowing intra-group punishment in inter-group contests leads to excessive and inefficient contest expenditures. In this study, we find that allowing intra-group communication in weakest-link contests leads to excessive effort expenditures. The crucial difference of this study is the finding that communication, commonly perceived to enhance efficiency, may cause inefficiency in a coordination game. Cooper et al. (1989) also find that more communication (two-way rather than one-way) in the battle-of-the-sexes game can reduce efficiency, since it increases miscoordination.
That is, each group’s probability of winning depends on the lowest effort within that group relative to the sum of the lowest efforts by both groups (groups win with equal probability if they both have a lowest effort equal to 0). The expected payoff for player \(i\) in group \(A\) can be written as:

\[
\pi_{iA}(x_{iA}, x_{-iA}) = p_A(x_{iA}, x_{-iA})v - x_{iA}.
\] (2)

Maximizing (2) with respect to \(x_{iA}\) and solving the (symmetric) best response functions simultaneously gives the theoretical predictions for this contest. Since this game is a coordination game, there exist multiple pure-strategy Nash equilibria in which the players within the same group match their efforts at the same level while best responding to the effort of the other group (Lee, 2008; Sheremeta, 2011). In particular, in any equilibrium, all players in each group best respond to the effort of the other group according to the following best-response functions:

\[
x_A \leq \sqrt{x_Bv - x_B} \quad \text{and} \quad x_B \leq \sqrt{x_Av - x_A}.
\]

Moreover, because of the weakest-link technology for aggregating individual efforts, in equilibrium all players in each group must match their effort levels, i.e. \(x_{iA} = x_A\) for all \(i\) and \(x_{jB} = x_B\) for all \(j\). The full set of pure strategy Nash equilibria is illustrated by the shaded area in Figure 1.

Two specific equilibria of interest are the group Pareto dominant equilibrium and the Pareto efficient equilibrium. The group Pareto dominant equilibrium may be focal because the players within a group have incentives to coordinate with each other to increase their effort levels at any other equilibrium within the shaded area. At the group Pareto dominant equilibrium all players expend efforts of \(v/4\) and no group has any incentive to deviate. On the other hand, the Pareto efficient equilibrium is when all players expend 0. In this equilibrium there is no dead weight loss from competition and each group is equally likely to win the contest. Note that any
symmetric or asymmetric equilibrium within the shaded area in Figure 1 is more efficient than the group Pareto dominant equilibrium and less efficient than the Pareto efficient equilibrium.

If communication within each group is possible (intra-group communication) then results in the existing literature suggest that all players within each group may act cooperatively as one player (Sutter and Strassmair, 2009; Zhang, 2009). In this case it is appropriate to model all players within a group as trying to maximize their joint payoff instead of their individual payoff (2), and so the objective function of player $i$ in group $A$ can be written as:

$$
\pi_{iA}(x_{iA}, x_{-iA}) = p_A(x_{iA}, x_{-iA})Nv - \sum_{i=1}^{N} x_{iA}
$$

Maximizing (3) with respect to $x_{iA}$ and solving the best response functions simultaneously gives us a unique Nash equilibrium where all players in each group match their efforts at the same level of $v/4$. Note that this is exactly the same as the group Pareto dominant equilibrium in the case with no communication, and is also the standard equilibrium in the two-player Tullock contest. The group Pareto dominant equilibrium is also a coalition-proof Nash equilibrium (Bernheim et al., 1987). Therefore, if communication indeed helps members within each group to improve coordination, they may select a more competitive (higher effort) equilibrium. Theory thus predicts that the introduction of intra-group communication may cause inefficiency.

Finally, if communication between both groups is possible (inter-group communication) then all players involved in a weakest-link contest may act cooperatively as one player and maximize their joint payoff by expending no effort. It is easy to verify that the joint payoff of all players is strictly decreasing in individual effort, i.e. $\sum_{i=1}^{N} \pi_{iA} + \sum_{i=1}^{N} \pi_{iB} = Nv - \sum_{i=1}^{N} x_{iA} - \sum_{i=1}^{N} x_{iB}$. Therefore, theory predicts that inter-group communication may help to reduce wasteful effort expenditures and achieve higher efficiency.
3. Experimental Design and Procedures

Our principal research question concerns the impact of communication in this competitive coordination game, so our experiment employs six treatments in a between-subjects design as shown in Table 1. In four group treatments (NOCOMM, INTRA, INTER, and INTRA+INTER), there are \( N = 3 \) players in each group and all players within the winning group receive the prize of \( v = 60 \) (equivalent to $2). The stage game was played for 30 periods. Subjects were placed into group \( A \) or \( B \) at the beginning of the first period, and they stayed in the same group for the duration of the experiment. They also competed against the same opposing group for all 30 periods. We chose this fixed matching protocol to allow subjects an opportunity to coordinate with each other on one of the many different equilibria. Therefore, the 48 subjects in each group treatment generate 8 statistically independent, 30-period, 6-player supergames.\(^3\) At the beginning of each period, each subject received 60 experimental francs as an endowment. Effort choices were framed in the instructions using the standard labels from public good provision experiments: subjects were informed that by allocating 1 franc to their individual account they would earn 1 franc, while by allocating 1 franc to their group account they could increase the chance of their group receiving the reward. Subjects could contribute any integer number of francs between 0 and 60.

The baseline treatment NOCOMM implements a group contest without communication. In treatments with communication, before subjects made their allocation decisions they had an opportunity to communicate with other participants via chat windows. In treatment INTRA, subjects in both groups could send messages to the two other members of the own group.

\(^3\) Subjects were informed that the session would last for exactly 30 periods, so the stage equilibrium prediction also holds for this finitely repeated game. As noted above, we conjectured that groups or individuals might coordinate on Pareto-improving outcomes in the repeated game, since this is frequently observed in the experimental literature even in finitely-repeated games with a unique equilibrium (e.g., Selten and Stoecker, 1986).
anonymously via a “3-person chat” window for 60 seconds each period. In treatment INTRA+INTER, besides the “3-person chat” window, messages could also be sent in a “6-person chat” window which would be viewed by all six subjects in the two groups. In treatment INTER, only the “6-person chat” window was available. Finally, in the two individual treatments (INDIVIDUAL-INTER and INDIVIDUAL-NOCOMM), two groups were replaced with two individual players who competed for a prize of $v=60$. In the INDIVIDUAL-INTER treatment the two players could communicate using a chat window for 60 seconds during each period, while no communication was allowed in the INDIVIDUAL-NOCOMM treatment. For all chat communications we asked subjects to follow two basic rules: (1) to be civil to one another and not to use profanity, and (2) not to identify themselves in any manner. Messages were recorded.

After the chat period, all subjects simultaneously made their effort (allocation) decisions, and then a random draw determined the winning group. A simple lottery was used to explain how the computer chose the winning group. At the end of each period subjects were informed of group $A$’s and $B$’s effective efforts (i.e., the minimum effort in each group); or in the case of the individual treatment, they learned both individuals’ effort choices. Subjects were paid for 5 randomly-drawn periods at the end of the experiment.

A total of 224 subjects participated in 18 sessions, generating 48 independent observations: eight groups of six in each of the treatments NOCOMM, INTRA, INTER, and INTRA+INTER and eight pairs of subjects each in treatments INDIVIDUAL-INTER and INDIVIDUAL-NOCOMM (Either 12 or 16 subjects participated in the lab for each data

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4 In these two treatments, the chat windows were active for 120 seconds at the beginning of the first 10 decision-making periods. From the 11th through 20th periods the chat time was set at 90 seconds, and for the final 10 periods the communication lasted for 60 seconds.

5 Probabilities were explained in the instructions as a number of tokens placed in a bingo cage based on effort choices, and then one randomly drawn token determined the winning individual or group.
collection period – 2 sessions of 6 subjects for the group treatments, or all 16 subjects in the individual treatments). Subjects were undergraduate students who participated in only one session of this study. Some students had participated in other economics experiments that were unrelated to this research.

The computerized experimental sessions were run using z-Tree (Fischbacher, 2007). At the beginning of each part subjects were given the written instructions, shown in Appendix A, and the experimenter also read the instructions aloud. Before the subjects played 30 periods of the stage game, we elicited subjects’ risk attitudes using multiple price list of 15 simple lotteries, similar to Holt and Laury (2002). At the end of the session, one of the 15 lottery decisions was randomly selected for payment.

Earnings were converted into US dollars at the rate of 30 francs to $1. Subjects earned about $21 on average and sessions lasted about 60 to 90 minutes.

4. Group Identity and Predictions

One important factor influencing group decision making is group identity. Inspired by Akerlof and Kranton’s (2000, 2005) pioneering work to incorporate social identity into the principal-agent model, experimenters have studied the effect of salient group identity on individual behavior in nonstrategic tasks with induced out-groups (Chen and Li, 2009), nonstrategic tasks without out-groups (Sutter, 2009) and in strategic tasks such as public goods games (Eckel and Grossman, 2005), bargaining games (McLeish and Oxoby, 2007), prisoner’s dilemma and battle of the sexes games (Charness, Rigotti and Rustichini, 2007).

6 Subjects were asked to state whether they preferred safe option A or risky option B. Option A yielded $1 payoff with certainty, while option B yielded a payoff of either $3 or $0. The probability of receiving $3 or $0 varied across all 15 lotteries. The first lottery offered a 0% chance of winning $3 and a 100% chance of winning $0, while the last lottery offered a 70% chance of winning $3 and a 30% chance of winning $0.
According to social identity theory (Tajfel and Turner, 1979), a salient group identity can cause a blurring of the boundaries between personal and group welfare and produce behavior that is contrary to personal self-interest and is instead in the interest of group benefit. In intergroup relations, individuals put themselves and others into different categories based on perceived similarities and differences (categorization), identify others as in-group or out-group members (identification), and compare their groups with other groups, discriminating in favor of the in-group and against the out-group (comparison). Individuals also tend to prefer their own identity to be both distinct and better than other groups (psychological distinctiveness).

Various methods have been used to induce saliency of group identity in economics experiments. Along with assigning a group task, associating individual decisions with payoff consequences for other group members, or revealing individual decisions to group members, exchanging nonbinding messages with other group members can effectively induce saliency (Sutter, 2009). The multiple group boundaries in our competitive coordination game allows us to manipulate communication channels to explore how individual and group behavior differs depending on the categorization and perception of individual, in-group and out-group membership.

Compared to the no communication treatment (NOCOMM), when intra-group communication is allowed in both groups (treatment INTRA), communication may shift individuals’ self-categorization from the individual to the 3-person group level. The inter-group

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7 Another set of economics experiments studies the effect of group identity, using primed group identity such as gender, ethnicity, native social groups, natural groups, and village communities. Chen and Li (2009) provide an excellent literature review on group identity.

8 Besides increasing group identity, communication also (1) provides information and facilitates understanding of the game; (2) promotes coordination of cooperative actions; (3) alters the expectations about other players’ behaviors; and (4) elicits social norms such as trust, commitment, promise-keeping (Bicchieri, 2002). The purpose of this study is not to identify which of these factors has the strongest explanatory power on the effect of communication, but to elaborate how individual and group behavior can differ depending on the availability of different communication channels.
competition can also lead them to identify the 3 people in the opponent group as out-group members, resulting in in-group favoritism that leads to greater coordination with in-group members and more intense competition with out-group members. Communication may even lead all individuals within the 3-person group to act as one player. In such a case, the stage game equilibrium prediction in treatment INTRA (and also in INDIVIDUAL-NOCOMM) is that all subjects should choose efforts equal to the group Pareto dominant equilibrium of 15. This prediction comes from a standard two-payer Tullock contest, based on the assumption that within groups in the INTRA treatment subjects coordinate their efforts to act as one player.

When messages are exchanged and viewed by all 6 individuals in the contest and no private messages can be exchanged between subsets of individuals (treatment INTER), according to social identity theory the 6-person collective boundary is more likely to be used as the basis for self categorization. This attenuates the competitiveness between the two 3-person groups, leading all 6 individuals to act as one player trying to achieve the highest efficient outcome. In treatments INTER and INDIVIDUAL-INTER, if subjects can coordinate on the most efficient equilibrium they should all choose efforts equal to the group Pareto dominant equilibrium of 0.

By contrast, when both public messages and private messages for each of the 3-person groups are allowed (treatment INTRA+INTER), group behavior may be more complex and depend on whether the communication strengthens the 3-person or 6-person group boundaries. The public messages could make the 6-person group membership more salient. Alternatively, if the 3-person group membership is more salient, individuals may strategically send misleading public messages to the opposing group and coordinate on higher effort levels in their private chat window. Therefore, social identity theory has ambiguous implications for the comparison between treatments INTRA+INTER and NOCOMM. In these treatments all subjects within each
group should coordinate on the same effort level, but this level can vary across groups and there is no strong reason to expect a particular equilibrium effort level between 0 and 15.

5. Experimental Results

5.1. Within-Group (INTRA) Communication

Figure 2 displays the time series of the average group effective (minimum) effort in the six treatments. In the NOCOMM treatment, average individual effort should be between 0 and 15. As shown in Table 2, the actual average effort is 11.18, indicating that subjects learn to coordinate their efforts at a substantial level. To measure the extent of coordination, we examine how much effort is wasted due to unequal effort choices within groups. We define mean wasted effort in a group by taking the average of the differences between individual effort and the group minimum effort within each group (Riechmann and Weimann, 2008). Complete coordination is reached when the group wasted effort equals zero. Figure 3a indicates that subjects in the NOCOMM treatment substantially reduced their miscoordination in the second half of the experiment relative to the first half (Wilcoxon signed-rank test, p-value < 0.05, n=8).9

The minimum effort does not decline to zero with repetition in this treatment without communication, and generally remains above 8 until the final period. This finding stands in sharp contrast to previous findings for the minimum effort coordination game (Blume and Ortmann, 2007; Deveetag and Ortmann, 2007), and could be due to our use of relatively small (three-person) groups or the competition between groups.10 To summarize:

**Result 1.** Even without communication, substantial but incomplete coordination exists

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9 All non-parametric tests employ only the independent observations of six subjects in group treatments and two subjects in individual treatments.

10 Camerer (2003, page 382-383) points out that smaller groups with fixed composition coordinate on more efficient outcomes over time in weakest link games.
within groups.

When intra-group communication is allowed, as in treatment INTRA, the overall average effort is 20.13. The average effective (minimum) effort within groups is higher than 15 in 28 out of 30 periods (Figure 2a), and the mean effective effort (18.86) is significantly greater than the highest equilibrium level of 15 (Wilcoxon signed-rank test, $p$-value < 0.05, $n=8$). Moreover, the average effective effort in the INTRA treatment is not significantly different from the INDIVIDUAL-NOCOMM treatment, suggesting that intra-group communication leads all subjects within the 3-person group to act as one player (Mann-Whitney test, $p$-value = 0.60, $n=m=8$).

Blume and Ortmann (2007) and Sutter and Strassmair (2009) document that intra-group communication leads to significantly higher coordination and efforts. Consistent with these previous studies, as well as predictions from social identity theory discussed above, the average and minimum efforts in the INTRA treatment are significantly higher than the average and minimum efforts in the NOCOMM treatment (Mann-Whitney test, $p$-value < 0.05, $n=m=8$).

Figure 4 displays individual or group average effective effort in the six treatments. Each bar in Figures 4a and 4b represents one independent observation, either a group of six interacting subjects in the NOCOMM, INTRA, INTER and INTRA+INTER treatments, or an interacting pair of subjects in the INDIVIDUAL-NOCOMM and INDIVIDUAL-INTER treatments. The efforts within each treatment are ranked from the lowest to the highest. Although considerable heterogeneity exists across groups, note that the distributions of average efforts in the INTRA and NOCOMM treatments only slightly overlap.

**Result 2.** Relative to no communication, intra-group communication increases average and minimum group efforts.
Although substantial coordination exists with and without intra-group communication, comparing the INTRA and NOCOMM treatments indicates that intra-group communication allows subjects coordinate better (Figure 3a). The degree of coordination is better in the INTRA treatment in almost all periods, and is significantly different from the NOCOMM treatment (Mann-Whitney test, $p$-value < 0.05; $n=m=8$).

**Result 3.** Intra-group communication improves coordination.

Recall that the Pareto efficient equilibrium occurs when all players expend 0 efforts. At this equilibrium there is no deadweight loss from competition, and each group is equally likely to win the prize of 60. Figure 5 displays average payoffs across all periods of the experiment. Because of the over-contribution of efforts in treatment INTRA the average payoff is substantially lower than the payoff in treatment NOCOMM in all 30 periods. As shown in Table 2, pooled across periods the average payoff in NOCOMM is about double that in INTRA. This treatment difference is statistically significant (Mann-Whitney test, $p$-value < 0.05, $n=m=8$).

**Result 4.** Intra-group communication decreases payoffs and efficiency.

This result contrasts with experimental findings from public goods, team production, and coordination experiments, where communication enhances efficiency and leads to socially optimal outcomes.\(^\text{11}\) To summarize, intra-group communication improves coordination and increases individual efforts. However, this increase in individual efforts reduces payoffs and is inefficient. Not only are efforts under communication higher than the efficient equilibrium effort of 0, but they also exceed the highest possible equilibrium effort of 15. Note that 15 is the

\(^{11}\) An exception is Buckley et al. (2009), who show that intra-group communication can be harmful in common pool resource games when individual appropriators share their output in groups of optimal size. Communication among sellers also causes inefficiency in oligopolistic competition if it leads to collusion (Friedman, 1967; Davis and Holt, 1998), but this inefficiency arises from reduced consumer surplus. Colluding sellers charge higher prices, increasing their own payoffs. In contrast, in our study symmetric intra-group communication reduces the payoffs of parties involved in the communication.
maximum rationalizable effort level for monetary payoff maximizers; i.e., given any effort level chosen by the opponents, 15 is the maximum effort that a rational player should expend (cf. Figure 1).\footnote{It is important to emphasize, however, that efforts above 15 may not necessarily be irrational. For example, if the event of winning carries some utility (i.e. Parco et al., 2005; Sheremeta, 2010) then 15 is no longer the appropriate maximum benchmark. In fact, analyzing the chat messages in the INTRA treatment, we find evidence that winning is an important element that enters subjects’ utilities. Every single mention of word “win” corresponds to a discussion about the effort level of at least 15, such as: “okay 30.. we will win” (period 18) or “this is bad.. it has to be 40.. or we won’t win..” (period 19). Some examples of chat room communications are shown in Appendix B.} As a result of this over-contribution of efforts, the average payoff in the NOCOMM treatment is twice as high as the average payoff in the INTRA treatment. These observed differences between the NOCOMM and INTRA treatments are consistent with implications of social identity theory outlined in the previous section. It appears that the INTRA communication promotes in-group favoritism and leads to greater coordination with in-group members and more intense competition with out-group members. Subjects choose significantly higher effort levels in the INTRA treatment, and these higher efforts generate a positive externality to in-group members and a negative externality towards out-group members.

5.2. Between-Group (INTER) Communication

In INDIVIDUAL-INTER and INTER treatments, the group Pareto dominant equilibrium is for all players to choose an effort of 0, although any effort level between 0 and 15, where all players within each group coordinate on the same effort level, is consistent with other equilibria. The actual average effort in treatment INDIVIDUAL-INTER is 5.33 and in treatment INTER is 5.81, and both of these are significantly lower than 15 (Wilcoxon signed-rank test, $p$-value <0.05, $n=8$ for both treatments). Efforts are not significantly different between these two treatments, neither are payoffs (Mann-Whitney test, $p$-value = 0.60 for effort and $p$-value = 1.00 for payoffs, $n=m=8$). The average and minimum effort in the INTER treatment is also
significantly lower than the average and minimum effort in the NOCOMM treatment (Mann-Whitney test, \( p\)-value = 0.06, \( n=m=8 \)).

**Result 5.** Relative to no communication, inter-group communication decreases average and minimum group efforts.

Although substantial intra-group coordination exists with and without inter-group communication, comparing INTER and NOCOMM treatments indicates that inter-group communication allows subjects to coordinate better. In particular, Figures 3a and 3b show that the mean wasted effort is lower with inter-group communication than without inter-group communication, and this difference becomes marginally significant in later periods (Mann-Whitney test, \( n=m=8 \); \( p\)-value = 0.14 pooled over all periods and \( p\)-value = 0.06 over last 10 periods).

Figure 6 illustrates between-group coordination using a histogram of the difference between the two groups’ effective efforts. The strong mode on 0 for the INTER treatments reflects the across-group coordination. When inter-group communication was allowed, groups spent a lot of time discussing the procedurally fair (but not allocatively fair) coin-flip determination of the winner. Subjects made statements such as, “lets all pick the same amount… that way its a 50-50 on who gets the bonus” or “if everyone is willing to collude and put 0 in the group account each time we're guaranteed at least 60 each time with a 50/50 shot of getting the other sixty”. As a result, everyone chose the same effort level 70% of the time in the INTER treatment, compared to only 28% of the groups who matched effective efforts in NOCOMM treatment. Among these tied contests in treatment INTER, groups matched efforts at 0 in 23% of the contests, and at 1 in 56% of the contests. The comparisons between treatments INDIVIDUAL-INTER and INDIVIDUAL-NOCOMM generate similar results. In the
INDIVIDUAL-INTER treatment, 60% of the contests had tied effort choices, and among these contests 20% were tied at effort of 0 and 53% were tied at effort of 1. Although positive efforts are inefficient, we conjecture that some groups struck agreements to match effort levels at 1 rather than 0 because such agreements are less susceptible to defection. Agreements at positive effort levels have a lower expected deviation payoff since higher effort choices are not sure to win.

Because of the lower efforts in the INTER treatment, subjects earn average payoffs that are significantly higher than the payoffs in the NOCOMM treatment (Mann-Whitney test, \( p \)-value = 0.06, \( n=m=8 \)). Similarly, efforts are lower (and payoffs higher) in the INDIVIDUAL-INTER than the INDIVIDUAL-NOCOMM treatment (Mann-Whitney test, \( p \)-values < 0.01, \( n=m=8 \)).

**Result 6.** Relative to no communication, inter-group communication improves both intra-group and inter-group coordination, and also increases payoffs and efficiency.

Compared to the INTRA treatment, with inter-group communication subjects not only achieved the same level of intra-group coordination (the mean wasted effort is 1.41 versus 1.27; Mann-Whitney test, \( p \)-value = 0.67, \( n=m=8 \)), but they also reduced effective efforts significantly via inter-group coordination (Mann-Whitney test, \( p \)-value < 0.01, \( n=m=8 \)). Subjects in the INTER treatment thus earned significantly more (Mann-Whitney test, \( p \)-value < 0.01, \( n=m=8 \)). To summarize, inter-group communication improves coordination and decreases individual efforts. This decrease in individual efforts increases payoffs. These treatment effects are consistent with social identity theory. The ability to communicate with the opponent group apparently leads subjects to identify with the 6-person group and lowers effort levels. To illustrate from the chats, subjects make statements such as “it's help 6 people instead of 3” and
“please be kind to the group”.

5.3. Within- and Between-Group (INTRA+INTER) Communication

When both intra- and inter-group communication were allowed, some groups tried to mislead the opponent group. For example, in their private (3-person) chat one group wrote, “why not we betray them. LOL”; “we could mess with them and go really high”; “are they telling us one thing and then doing another to get us”. But more often groups recognized the benefit of coordinating with the opponent group, as reflected in the following: “what if we try to strike a deal with the other group where you only allocate between 1 -10 that could maximize both our profits”; “its best for both teams in the long run”. Consequently, the differences in mean wasted effort, effective group effort and payoffs between INTRA+INTER and INTER are not statistically significant.

Differences in outcomes are statistically significant, however, between treatments INTRA+INTER and INTRA. Adding inter-group communication improves coordination (the mean wasted effort is 0.60 versus 1.26; Mann-Whitney test, p-value = 0.06, n=m=8), decreases group effort (9.69 versus 18.86; Mann-Whitney test, p-value = 0.01, n=m=8), and increases payoffs (19.70 versus 9.87; Mann-Whitney test, p-value = 0.01, n=m=8). These differences are consistent with the findings summarized in Results 5 and 6.

To summarize, we find that intra-group communication leads to greater coordination, more aggressive competition and lower payoffs when inter-group communication was not allowed. On the other hand, inter-group communication leads to greater coordination, but less competition and higher payoffs. Note that intra- and inter-group communications both enhance coordination. However, these types of communication have opposite impacts for competition and
payoffs in this competitive coordination game. Consequently, a comparison between treatments INTRA+INTER and NOCOMM reveals no significant differences in group effort or payoffs. The only significant difference is that coordination in INTRA+INTER treatment is significantly better than in NOCOMM treatment (the mean wasted effort is 0.60 versus 2.89; Mann-Whitney test, \( p \)-value < 0.01, \( n=m=8 \)).

### 5.4. Cournot Beliefs and Best Response Functions

As shown in Figure 1, for efforts less than \( v/4 \) (=15 in our experiment with \( v=60 \)) the best response functions are upward sloping, and for efforts above this threshold the best response functions are downward sloping. If subjects best respond to their beliefs about the other group’s effort, these slopes imply a positive (negative) relationship between their own effort and beliefs about the opponents’ effort when the opponent is expected to choose efforts less (greater) than 15.

While estimation of a structural belief-learning model is beyond the scope of this paper, consider the simple assumption that subjects form beliefs using Cournot expectations, which is a common approximation used in theoretical and empirical learning models (e.g., Ho, 2008). In other words, suppose subjects tend to believe that a higher effort by the opponent in the previous period is likely to be followed by a similar, high effort in the current period. Inspection of the recorded chat messages provides anecdotal evidence for such Cournot expectations.\(^{13}\) Table 3 reports results from a random effects model of individual effort choices that condition on previous period effective (minimum) effort chosen by the competing group. These models also

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\(^{13}\) For examples in the treatment INTRA: “I think we stick to 25, because they seem to stick to 21” (session 081110 group 2, period 7); “wow… they went for 30? let’s go for 31 then” (session 090311 group 4, period 3); “hmm…i guess they are just going 20…ya…how about we try 25?” (session 090303, group 4, period 11); “they are still at 30…suggestions? … 30…group consensus, yes?” (session 090331, group 1, period 11). The significant and positive group-effort\(_{-i,1}\) coefficients in Table 3 document significant persistence in efforts and provide a systematic empirical rationale for such a belief.
control for the risk attitudes inferred from the separate lottery choice task (risk; see footnote 6), whether that group won the prize in the previous period (\(\text{win}_{t-1}\)), the effective effort chosen by that group in the previous period and a nonlinear time trend \(1/\text{period}\). The models are estimated separately for observations in which the \(\text{othergroup-effort}_{t-1}\) is above (“High” column labels) or below (“Low” column labels) 15 because of the negatively- and positively-sloped reaction functions in these two cases.

The coefficient estimate on \(\text{othergroup-effort}_{t-1}\) shown in the top row is always positive and significant in the four columns labeled “Low,” consistent with the positively-sloped reaction function below 15. In the columns labeled “High,” for which \(\text{othergroup-effort}_{t-1}\) is greater than 15, a negative coefficient estimate on this variable is consistent with the downwardly-sloped reaction functions. The coefficient estimate, however, is significantly positive in model (4) for the INTRA treatments. Thus, in this range of above-equilibrium efforts, group competition with communication can lead to even greater effort choices.\(^{14}\)

In the INTRA treatment the \(\text{othergroup-effort}_{t-1}\) coefficient is always positive and significant (specifications 3 and 4) regardless of whether \(\text{othergroup-effort}_{t-1}\) is greater or less than 15. In other words, at least for this maintained assumption of Cournot belief updating, it appears that communicating groups either fail to recognize the incentive to reduce efforts in response to above-equilibrium efforts chosen by their competitors, or their communication creates strong in-group identity and favoritism that increases their utility of winning and thus leads to more intense competition. In our view the “group irrationality” explanation seems less likely given the rich and nearly free-form communication within groups permitted by the chat windows, as well as the previous literature that suggests groups often make more rational

\(^{14}\) The estimates in the INTER treatment exclude the first 6 periods of one session (out of the 8 total sessions in this treatment) because during that learning phase subjects chose some very high outlier effort choices. After period 6 their behavior in that session closely resembled the low, cooperative effort choices observed in the other 7 sessions.
decisions than individuals (Cooper and Kagel, 2005; Sutter, 2005). This explanation is also less likely because each member of the group has “veto” power to lower effective group effort in this minimum-effort game, and more rational individuals can employ this power when the group effort is unreasonably high. Individuals do not take advantage of the opportunity to unilaterally lower their group’s effective effort, however. On the other hand, the chat data suggest that subjects’ competitive tendencies are strengthened by their communications, consistent with a “group identity” explanation for the above-equilibrium efforts. Some examples are shown in Appendix B, which indicate subjects’ desire for their group to “win” the contest, even with effort levels greater than 15, such as: “okay 30.. we will win” (period 18) or “this is bad.. it has to be 40.. or we won’t win..” (period 19). This suggests that many groups focus on winning the contest as a group, even when their efforts already exceed the maximum equilibrium level.

6. Conclusion

Communication in coordination games has been shown to induce greater coordination, improve efficiency and increase individual payoffs. This study shows that both intra- and inter-group communication enhance coordination. However, these types of communication have opposite impacts for efficiency and payoffs in the competitive coordination game. Introducing intra-group communication leads to more aggressive competition and lower payoffs. On the other hand, inter-group communication leads to greater coordination across groups, less competition and higher payoffs.

Although our main finding is novel, it is not inconsistent with the broad literature discussed in the introduction highlighting the positive effects of communication in public goods and related games. We also find that both intra- and inter-group communication improves
coordination and reduces free-riding within groups. The key point that our experiment adds is that this improved coordination occurs even when it reduces, rather than enhances, efficiency (treatment INTRA). An interpretation based on social identity is that intra-group communication increases subjects’ identification with their group and shifts their self-categorization from the individual to the group level, leading them to compete more with the opponent group. Therefore, one way to enhance efficiency in such contexts is to restrict intra-group communication (treatment NOCOMM). When intra-group communication is unavoidable, one way to counterbalance the efficiency-reduction effect is to also allow communication across competing groups (treatment INTRA+INTER). The most effective way to improve efficiency in these environments is to allow inter-group communication (INTER). This appears to lead group members to shift their self-categorization from individual to the larger (6-person) group level and increase joint payoff.\(^\text{15}\)

The experimental environment implemented the classical Tullock model of rent-seeking, which has been widely used to model incentives for competing interest groups to influence public policy. While more confident conclusions await further research, we can note preliminary implications of our results for this setting. In particular, our findings indicate that intra-group communication results in greater wasteful rent-seeking. Drawing on results from Sutter and Strassmair (2009) and Sheremeta (2011), we conjecture that other mechanisms to aggregate individual efforts into group contests would also result in increased efforts when groups can

\(^{15}\) Similar effects of intra-group and/or inter-group communication were documented by Bornstein et al. (1989, 1992) in an intergroup step-level public goods game where the group with higher contributions wins a prize that is shared equally among all members in the winning group regardless of their individual contributions. This earlier research considers different games and also differs from ours in many dimensions, such as its focus on the one-shot game and by aggregating group contributions through the sum of individual contributions. Our experiment provides subjects a more favorable environment to reduce possible detrimental effect of communication: 1) subjects had opportunity to learn over time in a repeated game; 2) subjects could unilaterally lower the group effort by reducing their individual effort due to the weakest-link effort aggregation rule; and 3) communication was implemented via online chat instead of face to face communication, which preserves anonymity and excludes non-verbal stimuli so that the social cost of using this veto power is attenuated.
communicate. Our general conjecture is that in group rent-seeking contests, similar to the one studied in this paper, mechanisms such as communication that lead to better within-group coordination will reduce efficiency. Obviously, our results were obtained in the specific environment that was used in the experiment. Bornstein (1992) documents that intra-group competition (inter-group communication) is much more (less) effective in solving the within-group (between-group) conflict of the free-rider problem in the step-level public goods game than in a continuous public goods game. This is because the effectiveness of communication on solving within- or between-group conflicts largely depends on the extent that the collective interest and the individual selfishness coincide. Future research can investigate how robust our findings are when the best-shot or summation (perfect-substitutes) technology is used within groups instead of the weakest-link effort aggregation rule (Abbink et al., 2010; Sheremeta, 2011; Chowdhury et al., 2011). Two pilot sessions we have conducted suggest that the general conclusion of our experiment stands: intra-group communication also improves coordination but reduces efficiency in the best-shot and perfect-substitutes contests. We chose to focus on the weakest-link rule in the present study, since it affords subjects the ability to unilaterally reduce their group’s choice, increasing the chances that some group members would reduce the excessive effort expenditures and improve efficiency. Groups uniformly fail to take advantage of this opportunity, and so our experiment makes a clear point: communication is a good coordination-enhancing mechanism, but it should not be interpreted generally as an efficiency-enhancing mechanism.
References
Tables and Figures

Figure 1: The Pure-Strategy Nash Equilibria of the Game

[v/4, v/4] Pareto Efficient equilibrium

Group A best response function

Group B best response function

Group Pareto Dominant equilibrium

Pareto Efficient equilibrium
Figure 3a: Mean Wasted Effort

Figure 3b: Mean Wasted Effort
Figure 4a: Distribution of Minimum Efforts

Note: ID indexes the 8 independent session observations per treatment.

Figure 4b: Distribution of Minimum Efforts
Figure 6: Coordination Between Groups
Table 1: Experimental Design and Treatment Labels (224 Total Subjects)

<table>
<thead>
<tr>
<th>Communication Between Contestants</th>
<th>None</th>
<th>Both Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>NOCOMM (8 sessions, 48 subjects)</td>
<td>INTRA (8 sessions, 48 subjects)</td>
</tr>
<tr>
<td>Yes</td>
<td>INTER (8 sessions, 48 subjects)</td>
<td>INTRA+INTER (8 sessions, 48 subjects)</td>
</tr>
<tr>
<td>Individuals</td>
<td>INDIVIDUAL-NOCOMM (8 pairs, 16 subjects)</td>
<td>INDIVIDUAL-INTER (8 pairs, 16 subjects)</td>
</tr>
</tbody>
</table>

Table 2: Summary Statistics by Treatment (All Periods)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average Group Effective Effort</th>
<th>Average Individual Effort</th>
<th>Average Wasted Effort</th>
<th>Average Individual Payoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOCOMM</td>
<td>8.29 (0.12)</td>
<td>11.18 (0.20)</td>
<td>2.89 (0.16)</td>
<td>18.82 (0.81)</td>
</tr>
<tr>
<td>INTRA</td>
<td>18.86 (0.30)</td>
<td>20.13 (0.31)</td>
<td>1.27 (0.14)</td>
<td>9.87 (0.78)</td>
</tr>
<tr>
<td>INTER</td>
<td>4.40 (0.19)</td>
<td>5.81 (0.24)</td>
<td>1.41 (0.13)</td>
<td>24.19 (0.82)</td>
</tr>
<tr>
<td>INTRA+INTER</td>
<td>9.69 (0.27)</td>
<td>10.29 (0.28)</td>
<td>0.60 (0.08)</td>
<td>19.71 (0.81)</td>
</tr>
<tr>
<td>INDIVIDUAL-NOCOMM</td>
<td>18.96 (0.55)</td>
<td>11.04 (1.37)</td>
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<td></td>
</tr>
<tr>
<td>INDIVIDUAL-INTER</td>
<td>5.33 (0.47)</td>
<td>24.68 (1.41)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Standard errors shown in parentheses.
Table 3: Reactions to Previous Group Efforts Based on Individual Effort Choices

<table>
<thead>
<tr>
<th>Dependent variable, $effort_{t}$</th>
<th>Treatment and Data Subset</th>
<th>NOCOMM</th>
<th>Low</th>
<th>High</th>
<th>INTRA</th>
<th>Low</th>
<th>High</th>
<th>INTER</th>
<th>Low</th>
<th>High</th>
<th>INTRA+INTER</th>
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<tr>
<td>Model</td>
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<td>(6)</td>
<td>(7)</td>
<td>(8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$othergroup-effort_{t-1}$</td>
<td></td>
<td>0.35**</td>
<td>-0.01</td>
<td>0.16**</td>
<td>0.13*</td>
<td>0.48**</td>
<td>0.18</td>
<td>0.42**</td>
<td>-0.26*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[effective effort of other in $t-1$]</td>
<td>(0.08)</td>
<td>(0.32)</td>
<td>(0.06)</td>
<td>(0.06)</td>
<td>(0.07)</td>
<td>(0.24)</td>
<td>(0.06)</td>
<td>(0.11)</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$risk$</td>
<td></td>
<td>0.08</td>
<td>-0.02</td>
<td>0.06</td>
<td>0.19</td>
<td>0.14</td>
<td>-0.24</td>
<td>-0.02</td>
<td>0.52*</td>
<td></td>
<td></td>
<td></td>
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<td>[number of risky options B]</td>
<td>(0.33)</td>
<td>(0.64)</td>
<td>(0.16)</td>
<td>(0.20)</td>
<td>(0.08)</td>
<td>(0.75)</td>
<td>(0.07)</td>
<td>(0.23)</td>
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<td></td>
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<tr>
<td>$win_{t-1}$</td>
<td></td>
<td>-0.71*</td>
<td>0.15</td>
<td>-1.75*</td>
<td>0.52</td>
<td>-0.51</td>
<td>-4.12**</td>
<td>-0.89*</td>
<td>0.20</td>
<td></td>
<td></td>
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<tr>
<td>[1 if won in previous period]</td>
<td>(0.33)</td>
<td>(1.13)</td>
<td>(0.69)</td>
<td>(0.83)</td>
<td>(0.26)</td>
<td>(1.30)</td>
<td>(0.35)</td>
<td>(0.92)</td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>$group-effort_{t-1}$</td>
<td></td>
<td>0.32**</td>
<td>0.36</td>
<td>0.79**</td>
<td>0.53**</td>
<td>0.62**</td>
<td>0.01</td>
<td>0.68**</td>
<td>0.10</td>
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<tr>
<td>[effective group effort in $t-1$]</td>
<td>(0.07)</td>
<td>(0.32)</td>
<td>(0.03)</td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.13)</td>
<td>(0.06)</td>
<td>(0.07)</td>
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<tr>
<td>$1/period$</td>
<td></td>
<td>9.50**</td>
<td>4.86</td>
<td>3.57</td>
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<td>-3.41</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>[inverse of period number]</td>
<td>(3.09)</td>
<td>(10.74)</td>
<td>(2.36)</td>
<td>(3.27)</td>
<td>(1.97)</td>
<td>(8.21)</td>
<td>(1.55)</td>
<td>(5.46)</td>
<td></td>
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<td></td>
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<tr>
<td>Constant</td>
<td></td>
<td>4.29*</td>
<td>10.63</td>
<td>3.29**</td>
<td>6.56**</td>
<td>0.38</td>
<td>19.51**</td>
<td>1.18*</td>
<td>18.99**</td>
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<tr>
<td>(1.88)</td>
<td>(7.17)</td>
<td>(0.91)</td>
<td>(1.58)</td>
<td>(0.61)</td>
<td>(5.84)</td>
<td>(0.50)</td>
<td>(3.40)</td>
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<td>Number of Subjects</td>
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<td>12</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>12</td>
<td>48</td>
<td>39</td>
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</tr>
</tbody>
</table>

Standard errors robust to general heteroscedasticity are shown in parentheses. * significant at 5%, ** significant at 1%
INTER treatment estimates drop the first 6 periods of one session (out of 8 sessions total in this treatment) with outlier effort choices. All models include a random effects error structure, with individual subject effects. Columns labeled "High" ("Low") include only those observations in which $othergroup-effort_{t-1}$ is greater than (less than or equal to) 15.
GENERAL INSTRUCTIONS

This is an experiment in the economics of strategic decision making. Various research agencies have provided funds for this research. The instructions are simple. If you follow them closely and make appropriate decisions, you can earn an appreciable amount of money.

The experiment will proceed in two parts. Each part contains decision problems that require you to make a series of economic choices which determine your total earnings. The currency used in Part 1 of the experiment is U.S. Dollars. The currency used in Part 2 of the experiment is francs. Francs will be converted to U.S. Dollars at a rate of 30 francs to 1 dollar. At the end of today’s experiment, you will be paid in private and in cash. 12 participants are in today’s experiment.

It is very important that you remain silent and do not look at other people’s work. If you have any questions, or need assistance of any kind, please raise your hand and an experimenter will come to you. If you talk, laugh, exclaim out loud, etc., you will be asked to leave and you will not be paid. We expect and appreciate your cooperation.

INSTRUCTIONS FOR PART 1
YOUR DECISION

In this part of the experiment you will be asked to make a series of choices in decision problems. How much you receive will depend partly on chance and partly on the choices you make. The decision problems are not designed to test you. What we want to know is what choices you would make in them. The only right answer is what you really would choose.

For each line in the table in the next page, please state whether you prefer option A or option B. Notice that there are a total of 15 lines in the table but just one line will be randomly selected for payment. You ignore which line will be paid when you make your choices. Hence you should pay attention to the choice you make in every line. After you have completed all your choices a token will be randomly drawn out of a bingo cage containing tokens numbered from 1 to 15. The token number determines which line is going to be paid.

Your earnings for the selected line depend on which option you chose: If you chose option A in that line, you will receive $1. If you chose option B in that line, you will receive either $3 or $0. To determine your earnings in the case you chose option B there will be second random draw. A token will be randomly drawn out of the bingo cage now containing twenty tokens numbered from 1 to 20. The token number is then compared with the numbers in the line selected (see the table). If the token number shows up in the left column you earn $3. If the token number shows up in the right column you earn $0.

<table>
<thead>
<tr>
<th>Decision no.</th>
<th>Option A</th>
<th>Option B</th>
<th>Please choose A or B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$1</td>
<td>$3 never</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>$1</td>
<td>$3 if 1 comes out of the bingo cage</td>
<td>$0 if 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20</td>
</tr>
<tr>
<td>3</td>
<td>$1</td>
<td>$3 if 1 or 2</td>
<td>$0 if 3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20</td>
</tr>
<tr>
<td>4</td>
<td>$1</td>
<td>$3 if 1,2,3</td>
<td>$0 if 4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20</td>
</tr>
<tr>
<td>5</td>
<td>$1</td>
<td>$3 if 1,2,3,4</td>
<td>$0 if 5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20</td>
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<tr>
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<td>$1</td>
<td>$3 if 1,2,3,4,5</td>
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<tr>
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<td>$1</td>
<td>$3 if 1,2,3,4,5,6</td>
<td>$0 if 7,8,9,10,11,12,13,14,15,16,17,18,19,20</td>
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<tr>
<td>8</td>
<td>$1</td>
<td>$3 if 1,2,3,4,5,6,7</td>
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<td>$1</td>
<td>$3 if 1,2,3,4,5,6,7,8</td>
<td>$0 if 9,10,11,12,13,14,15,16,17,18,19,20</td>
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<td>$3 if 1,2,3,4,5,6,7,8,9</td>
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<td>$1</td>
<td>$3 if 1,2,3,4,5,6,7,8,9,10</td>
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<tr>
<td>13</td>
<td>$1</td>
<td>$3 if 1,2,3,4,5,6,7,8,9,10,11,12</td>
<td>$0 if 13,14,15,16,17,18,19,20</td>
</tr>
<tr>
<td>14</td>
<td>$1</td>
<td>$3 if 1,2,3,4,5,6,7,8,9,10,11,12,13</td>
<td>$0 if 14,15,16,17,18,19,20</td>
</tr>
<tr>
<td>15</td>
<td>$1</td>
<td>$3 if 1,2,3,4,5,6,7,8,9,10,11,12,13,14</td>
<td>$0 if 15,16,17,18,19,20</td>
</tr>
</tbody>
</table>
INSTRUCTIONS FOR PART 2
YOUR DECISION

The second part of the experiment consists of 30 decision-making periods. At the beginning of the first period, you will be randomly and anonymously placed into a group of 3 people: group A or group B. You will remain in the same group for all 30 periods of the experiment. At the beginning of the first period, your group will be paired with another group. This pairing remains the same for all 30 periods of the experiment. Either group A or group B will receive a reward. The reward is 60 francs to each group member.

Each period you will be given an endowment of 60 francs and asked to decide how much to allocate to the group account or the individual account. You may allocate any integer number of francs between 0 and 60. An example of your decision screen is shown below.

YOUR EARNINGS
After all participants have made their decisions, your earnings for the period are calculated. These earnings will be converted to cash and paid at the end of the experiment if the current period is one of the five periods that is randomly chosen for payment.

1) Your period earnings are the sum of the earnings from your individual account and the earnings from your group account.

2) For each franc in your individual account, you will earn 1 franc in return. So, if you keep all 60 francs that you are endowed with to your individual account you will earn 60 francs. But you can also earn some francs from your group account.

3) By contributing to the group account you may increase the chance of receiving the reward for your group. In determining which group receives the reward, the computer will consider only the lowest contribution in group A’s account and the lowest contribution in group B’s account. If the lowest contribution in group A’s account exceeds the lowest contribution in group B’s account, group A has higher chance of receiving the reward and vice versa. If your group receives the reward then in addition to the earnings from your individual account you receive the reward of 60 francs from your group account. A group can never guarantee itself the reward. However, by increasing your contribution, you can increase your group’s chance of receiving the reward.

4) The computer will assign the reward either to your group or to the other group, via a random draw. So, in each period, only one of the two groups can obtain the reward.
**Example 1. Random Draw and Earnings**

This is a hypothetical example used to illustrate how the computer is making a random draw. Let’s say the members of groups A and B allocate their francs in the following way.

<table>
<thead>
<tr>
<th>Group</th>
<th>If Group receives reward</th>
<th>Allocation to individual account</th>
<th>Allocation to group account</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member 1</td>
<td>60</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>Member 2</td>
<td>60</td>
<td>45</td>
<td>15</td>
</tr>
<tr>
<td>Member 3</td>
<td>60</td>
<td>50</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>If Group receives reward</th>
<th>Allocation to individual account</th>
<th>Allocation to group account</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member 1</td>
<td>60</td>
<td>59</td>
<td>1</td>
</tr>
<tr>
<td>Member 2</td>
<td>60</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>Member 3</td>
<td>60</td>
<td>55</td>
<td>5</td>
</tr>
</tbody>
</table>

In group A, member 1 contributes 20 francs, member 2 contributes 15 francs, and member 3 contributes 10 francs to group A’s account. In group B, member 1 contributes 1 franc, member 2 contributes 10 francs, and member 3 contributes 5 francs to group B’s account.

Then the computer chooses the **lowest contribution in group A’s account** and the **lowest contribution in group B’s account**. The two highest contributions in group A and the two highest contributions in group B will not be considered by the computer. In this example, member 3 has the lowest contribution of 10 francs in group A and member 1 has the lowest contribution of 1 franc in group B. For each franc of member 3 in group A the computer puts 1 red token into a bingo cage and for each franc of member 1 in group B the computer puts 1 blue token. Thus, the computer places **10 red tokens** and **1 blue token** into the bingo cage (**11 tokens total**). Then the computer randomly draws one token out of the bingo cage. If the drawn token is red group A receives the reward, if the token is blue group B receives the reward. You can see that since group A has more tokens it has a higher chance of receiving the reward (**10 out of 11 times** group A will receive the reward). Group B has a lower chance of receiving the reward (**1 out of 11 times** group B will receive the reward).

Let’s say the computer made a random draw and **group A receives the reward**. Thus, all the members of group A receive the reward of 60 francs from the **group account** plus they also receive earnings from the **individual account**. All members of group B receive earnings only from the **individual account**, since group B does not receive the reward. The calculation of the total earnings is shown in Table 2 below.

<table>
<thead>
<tr>
<th>Group</th>
<th>Earnings from group account</th>
<th>Earnings from individual account</th>
<th>Total earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member 1</td>
<td>60</td>
<td>40</td>
<td>60+40 = 100</td>
</tr>
<tr>
<td>Member 2</td>
<td>60</td>
<td>45</td>
<td>60+45 = 105</td>
</tr>
<tr>
<td>Member 3</td>
<td>60</td>
<td>50</td>
<td>60+50 = 110</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Earnings from group account</th>
<th>Earnings from individual account</th>
<th>Total earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member 1</td>
<td>0</td>
<td>59</td>
<td>59</td>
</tr>
<tr>
<td>Member 2</td>
<td>0</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Member 3</td>
<td>0</td>
<td>55</td>
<td>55</td>
</tr>
</tbody>
</table>

At the end of each period, the total number of francs in the two groups’ accounts, group which receives the reward, earnings from individual and group accounts, and total earnings for the period are reported on the outcome screen as shown below. Please record your results for the period on your **record sheet** under the appropriate heading.
Outcome Screen

IMPORTANT NOTES
You will not be told which of the participants in this room are assigned to which group. At the beginning of the first period, you will be randomly and anonymously placed into a group of 3 people: group A or group B. You will remain in the same group for all 30 periods of the experiment. At the beginning of the first period, your group will be paired with another group. This pairing remains the same for all 30 periods of the experiment. Either group A or group B will receive a reward. The reward is 60 francs to each group member. A group can never guarantee itself the reward. However, by increasing your contribution, you can increase your group’s chance of receiving the reward.

At the end of the experiment we will randomly choose 5 of the 30 periods for actual payment in Part 2 using a bingo cage. You will sum the total earnings for these 5 periods and convert them to a U.S. dollar payment.

Are there any questions?
Appendix B – Example Chats for Group 1 in Selected Periods of Session 081110

PERIOD 1
hey guys
yo
whats the lowest ur gna put?
I think we should bet real low on the first time like 10 francs
10
the other group will probably bet high and will lose money
so 10 good?
lets go for 15
i was thinking more like 5 cos we just get a dollar more per period if we win
okay 14

PERIOD 2
that sucked
how about 20 this time and yes it did suck
i still think we should bet low 20?
yes no?
we still win more per individual cos the guy who bet 20 would just earn 80
agreed?
and we earn 60 thats just 20/30 = 30 cents more

PERIOD 5
ok who put 0?
not me i put 10
u just lost me 20 francs
we should put 15 at least now
i didnt!
i know ... someone is putting 0
okay 15
yes? everyone agree
ok evry1 put 21 then.. thats 1 more than theirs and a sure victory
yeah

PERIOD 6
theres no use ... someone keeps putting 0
someone in here is bidding lower than their saying and is dumb...
ok whoever put 15.. u won 45.. had u put 21 u would have won 39 + 60= 99..
i'm putting 0 for the rest of them now, because of the idiot in our group
evryq put 21 please
once more then i'm done
21 ... everyone!
theyre winning at 20 each time its jst 1 franc more

PERIOD 7
that was good
keep putting 21 dont worry
just bad drawing
keep putting 21
okay fine 21 all the time?
yeah
its random clock generation the next is ours
21 again
this is stupid if we dont get drawn
one last time
we will ... its luck of the draw

PERIOD 8
there u go
finally my goodness!
okay 21 every time
21 is our lucky number ... keep goin' with it ...
ok its human psych.. they wil put 22 now../ evry1 put 25
or 21 if u wna try one more time.. ur call
evry1s bets quick
im staying with 21... if it gets too high it's not worth it
i think 21 is good
ok

PERIOD 9
i wont say i told u so
who did that
WHO'S PUTTING 0!!!!!!!!!!!!!!
i KNOW!!!!!!!
member 3 did you put 0????
no i stuck with 21.. but i told u theyd go higher
so lets just put 27 now
21

PERIOD 10
group b is going to be rich this is dumb
just keep putting 21 ... we have about half the bingo balls ... its a 50 % chance
IF WE ALWAYS PUT IN 21 !!!!
extactly
i am!
and someone dosent keep putting in 0
what the heck
21 gain
21 for the rest of the game
ok
fine
PERIOD 12
i'm pissed
they're on to 21... thts y we had 25 we need a diff number; go with 27
or 0 ur call
27 one time
ok
k?
yeah
cool

PERIOD 15
how bout 0 for one more and then we go in at 30...
agree?
keep going for 0.. they're just earning a dollar more per perid.. wait for them to go low
yeah cool
sounds good
gr8
60 francs is a dollar so if we bid 0 were garenteed that price... not bad

PERIOD 16
one more time ... then hit them with 30
30 now? or 0 for one more??
okay thier at 20 so lets go for 30!
elegant!!!
quik. i need ur bids
30 now or the next one?
next
they might even put in 15
I think NOW
so 0 for this one?
i bid 30
yes?
ok 30
ok
mem2 - 30?
30 yes

PERIOD 17
wonderful!
what do u want to hit them with this time?
lets keep on doin' 30
i think back to 0 it'll throw them off
go for 40 now.. we'll still earn 80
they're going to up their bid!
i think 30 will do it
exactly
no it has to be more
30!
35 final
35 fine
ok
cool
im hungry

PERIOD 18
stick to 30
we should have code names
i'll be sputnik
30's fine
ive noticed that we only win when they have more than 5 francs difference..
so 30 or 0?
what do you want to do
30!
0?
okay 30
we will win
ok 30 one more time
maybe
30
lol

PERIOD 19
they are also putting in 30
hwo the heck is the other group so lucky!
this is bad.. it has to be 40.. or we wont win..
this program is favoring
yes
how bout 40
we stil win 80
40?
sounds good
cool
40!
agreed?
yeah

PERIOD 20
lets keep it at 40
40 again?
they're not gonna go much higher than that
this is dumb though... if we lose we only get 20 francs
45 now.. we win 5 francs less.. but 15 more than 60
okay 45
45.. one time...
might as well take a risk ... we have no money anyway
true
ths the spirit...!
45
go for it
45

PERIOD 21
you have to be kidding me!
they are just gonna match whatever we put ur telling me..
lets just stay at 40
this program is favoring... we were higher again
no.. its no use.. lets go 0
agreed
0
let them come down.. then hit them like before
0?
yes

PERIOD 22
0 again?
we should go 0 one more time
gr8.. they just won 15 more.. 0 again
or 40? they'll know what were doing
okay 0
0 and then next time we do it .. we'll only do one 0
they're lucky not smart haha.. we're smarter
we should meet after to see who each other are
doesn't show

PERIOD 23
35?>
gr8.. now go 45
what if both groups put 0?
no
lets go 40 .... in between
they know.. we'll go high now
then either of us would just get the money
yeah.. 40
final
40 agreed
40 ... yeah