**Decoding Cheap Talk: How communication influences effort coordination in output-sharing partnerships**

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November 8 2016

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**Acknowledgements:**

We thank Laura Cooper and Stephanie Thomas for valuable research assistance. This research was funded by the Social Science and Humanities Research Council of Canada (Grant # 410-2008-0563). The views expressed are those of the authors alone.

## Abstract

Organizing individual appropriators into output sharing groups has been found to effectively solve the tragedy of the commons problem (Schott (2001), Schott et al. (2007), Heintzelman et al (2009). We experimentally investigate the robustness of this solution by introducing different channels of communication that naturally arise from group competitions. Buckley et. al (2016) have shown that allowing local communication within output-sharing groups substantially decreases this efficiency enhancement because it reduces free riding and boosts between-group competition. The efficiency-reducing effect of local communication is mitigated when random partners instead of fixed partners are sharing output over time, and is nearly eliminated when random partners are formed with users who belong to different communication groups. This paper examines the type and frequency of different message categories and their impact on individual effort adjustments in different communication and output-sharing treatments. Overall volume of messages is positively related to increasing individual effort in the partnerships. The magnitude of the positive effect is reduced as the experiment progresses. The effect of different types of messages varies by treatment and by the period of the session studied. Fixed partnerships are able to sustain their effort levels by a less frequent communication about specific proposals and agreements about the proposals. Random linked groups are less successful in using communication in increasing effort levels and rely on group identity and strategy messages. Unlinked communication groups were not able to prevent free-riding in partnerships.



**Keywords:** Common pool resources, communication, coordination, cooperation, free-riding, behavior in teams, experiments

**JEL classification codes**: Q20, C92, C72

## 1. INTRODUCTION

The pioneering work by Elinor Ostrom and others convincingly demonstrated that the decentralized governance of CPRs and public goods is possible as long as agents are able to communicate with each other on a regular basis. In several experimental studies with unitary agents (not teams) is has been shown that communication in the form of non-binding cheap talk improves cooperation in common-pool resource and voluntary public good games and can overcome the "tragedy of the commons" or free-riding behavior in the provision of public goods [Chan et al. (1999), Hackett et al. (1994), Isaac and Walker (1988), Kinukawa et al. (2000) , Ledyard (1995), Ostrom et al. (1994). The laboratory studies that support non-binding cheap talk as a coordinating mechanism that can lead to the reduction of inefficient exploitation of a CPR are conducted with relatively small groups of appropriators, typically eight, that communicate directly with each other face-to-face. Ostrom's insights into solutions to cooperation that do not strictly depend on government regulation or state ownership have motivated others to look at alternative solutions to more cooperative governance without the change of property rights. Schott (2001) proposed that exploitation of a common pool resource (CPR) might be efficiently managed by creating output-sharing partnerships. Members of each partnership pool their harvest and share it equally. This introduces an incentive for agents to free ride on their partners by reducing their own work effort. This shirking reduces overall effort and offsets the over-harvesting incentive inherent to the social dilemma framework of the CPR. Heintzelman et al. (2009) study formally the endogenous formation and stability of output-sharing groups and determine the conditions under which output sharing in optimal partnerships becomes a subgame perfect Nash equilibrium in a two-stage game.

Schott et al. (2007) examined the exploitation of CPRs with output-sharing partnerships in a laboratory setting. Partnership sizes are varied among single resource users (no output sharing), a socially optimal partnership size and a larger than optimal partnership size. They find that sharing output in partnerships significantly reduces resource-extraction effort thus facilitating a solution to the social dilemma. They also find that when the theoretically optimal group size is established, the groups in fact allocate the optimal amount of effort to appropriation. A complication may arise however if members of the teams can coordinate their actions. For example, coordination amongst team members could mitigate the shirking incentive while leaving the original over-harvesting incentive unabated.

Communication among members of a group is likely an important factor influencing coordination. Buckley et al. (2016) report the results of introducing non-binding cheap talk into a 12-person CPR environment and find that although effort is significantly reduced, appropriation remains far from the efficient level. If it generally becomes more difficult for large groups of individuals to coordinate through non-binding cheap talk, perhaps output-sharing partnerships will lead to more effective management of the CPR than communication. However, while communication has been shown to be a positive influence in small group social dilemma settings, coordination induced by communication within output-sharing partnerships is a potential threat to the viability of output sharing as a management strategy for CPRs such as fisheries. In a classic fishery dominated by many small fishermen from geographically dispersed villages it would seem natural to form output-sharing teams within each community. Under such circumstances communication within local teams would seem normal but such

communication might reduce the shirking characteristic of groups in the absence of communication and result in the over-harvesting that output sharing was intended to cure. For this reason the impact of communication on effort and output when communication is confined to subgroups of players needs to be examined in more detail.

One important aspect of intra-group communication when competition exists among teams is the composition and longevity of communication and output-sharing groups. These do not need to be identical. For example, communication in a fishery might take place within local communities while output sharing might be implemented anonymously over a greater territory, so that output-sharing group members might be from different communities and might not know each other. A further complication arises if teams are remixed regularly so as to prevent tacit agreements and understandings from building up over time. Sufficient anonymity and remixing might eliminate the coordination-enhancing effects of communication in a repeated setting.

A second intriguing aspect is the mechanism of communication itself. Exactly how does communication within groups lead to coordination? Investigating such questions requires a protocol for recording and coding messages. One method is to restrict communication to computer-mediated chat rooms and to apply the methodology of content analysis to the transcript in the manner of Zhang (2009) We adopt this method for the present study.

The purpose of this paper is to summarize the effect of communication on effort supply in the different output-sharing partnership environments presented in Buckley et

al. (2016)[1] and then to investigate the relationships between the provision of effort and the type and volume of messages arising through communication within output-sharing groups. We analyze the frequency and content of messages in the different communication treatments and offer insight into how message content and frequency are related to differences in behavior, and how they can lead to behavior which supports the efficient allocation of effort to extraction from a CPR.

## 2. EXPERIMENTAL DESIGN

This section briefly presents the experimental design used by the treatments presented here and used by Buckley et al. (2016) to study both within-group and between-group communication in a CPR environment. Each session involves 12 participants divided into three output-sharing groups of four participants each. Each decision period every participant is required to allocate a fixed endowment of effort, 'e', between a private activity which provides a known return of 'r' per unit of effort and a resource extraction activity which provides a varying return that depends upon the aggregate effort devoted to resource extraction of all 12 participants.

The total output and return (price is normalized to one) from the common-pool resource is given by

$$Y = 32.5X - 0.09375X^2 \qquad (1)$$

[1] The focus of this paper is on investigating experimental environments in which private communication occurs within sub-groups of appropriators from a common social dilemma setting, a CPR. The treatments analyzed here are also presented in Buckley et al. (2016), however Buckley et al. (2016) also presents comparisons to environments involving full public communication, with and without private sub-group communication.

where $Y$ is total output appropriated from the CPR and $X$ is the sum of the resource-extraction effort of all participants.[2] Output is distributed to output-sharing groups in proportion to their group effort, $X_g$, and this output is distributed equally to all group members. Thus the individual profit function under output sharing is

$$\pi_i = \mathrm{r}(\mathrm{e} - x_i) + \frac{1}{4}\frac{X_g}{X}Y \quad . \qquad (2)$$

Five of the treatments addressed in Buckely et al. (2016) are considered here. In two of them, treatments R and F, no communication among participants is permitted. In treatment R output-sharing groups are randomized each period. In treatment F output-sharing groups remain fixed. These two treatments are the no-communication "partners" and "strangers" treatments in Schott et al. (2007). The remaining treatments permit communication among members of each output-sharing group at the beginning of each decision period. In all communication treatments participants are assigned to one of three communication groups of four persons each. The communication group may or may not be the same as the output-sharing group. These are "linked" and "not linked" treatments respectively. The output-sharing group may be fixed across periods or randomized at the beginning of each period. There are three communication treatments: a fixed-fixed-linked (FF) specification in which output-sharing groups and communication groups are both fixed across periods and linked, a random-random-linked specification (RR) in which output-sharing groups and communication groups are randomized each period but linked, and a random -not-linked (RF) specification in which output-sharing groups are

[2] The experiment is conducted with neutral framing. Effort is referred to as "Investment" and the two activities are termed Market One and Market Two.

scrambled every period but communication groups are fixed and therefore at not linked to the output-sharing group. Table 1 summarizes the five treatments.

-insert table 1-

Communication is introduced by way of a chat window that appears on the computer screens of the participants.[3] Prior to the first decision round, individuals are given four minutes to send messages to other members in their communication group. No private messages are allowed. After the four-minute communication period, individuals make private and anonymous decisions about the number of units of effort they will allocate to appropriation from the common pool. The remaining units of effort are automatically allocated to the private activity. Subjects then share their output from the common pool amongst all output-sharing group members and are given a summary providing their earnings for the period, the average earnings of others in their group and the average earnings of others outside of their group. Prior to the second and third decision rounds, individuals are given three minutes to communicate. Prior to the fourth round this is set at two minutes and from the fifth through the fifteenth rounds, communication is limited to one minute. Communication is non-binding. Individuals are not required to adhere to any agreement they may have reached during the communication period by way of the chat window.[4]

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[3] Bochet et al. [3] compare different forms of communication in public goods laboratory experiments and find little difference between the effects of face-to-face communication and verbal communication through a chat room.

[4] Groups used up to 234 seconds, 178 seconds, 177 seconds and 118 seconds respectively in the first four periods and less than 60 seconds in the following periods. Thus there was no evidence that decisions were forced because of time pressure in our experiment.

## 3. Data Analysis

The data support the expectation that communication within output-sharing groups will increase system effort. This suggests that communication among group members is counteracting the free-riding incentives provided by output sharing. Moreover, the offset effect is much larger when appropriators are communicating and sharing output with the same group of participants each decision round (comparing FF with RR, Mann-Whitney U test, $p$-value = 0.0209, $n = m = 4$). Intuitively, it is more difficult for appropriators to enter into tacit or explicit agreement regarding appropriation when they are randomly assigned to groups in each decision round. Allowing non-binding communication increases effort when communication and output-sharing groups are linked and especially when the composition of the groups is fixed. We now investigate how communication is shaped by the rules for linking and remixing the output-sharing groups to discover the forms of communication that are most effective in coordinating behavior. To do this we conduct a detailed analysis of the content of the chat messages.

### 3.1. Coding the Messages

Following Zhang (2009) we organized the chat transcripts into coded-message units.[5] After examining a small sub-sample of messages we identified the 14 non-exclusive categories listed in Table 5. Two coders who were not otherwise involved in the analysis of the data from this experiment independently coded all messages according to the 14

[5] A coded-message unit consists of the information submitted by a participant to the other members of the participant's group during one communication sequence. A sequence starts when the participant begins typing a message and ends when the participant hits the "enter" button on the keyboard to submit the message to the group.

categories.[6] Each message can be coded under as many or few categories as the coders deem appropriate.

Table 3 summarizes the relative frequency across all 15 rounds of communication of coded-message units by category along with Cohen's Kappa statistic.[7] All of the measured Kappas are significantly greater than 0. Only three of the 42 Kappa estimates, for Categories 4, 9, and 10 in treatment RF, indicate less than moderate agreement. Messages in these categories occurred with very low frequencies (2.1%, 1.83%, and 0.94% of messages sent in treatment RF). We have no conjecture for why these categories exhibited such low agreement in this particular treatment (the mean Kappa exceeds 0.55 for these same three categories in both treatments RR and FF).

3.2. Volume of Messages by Treatment and Category and Decision Round

The volume of messages is clearly different across treatments. Subjects in treatment RR (linked groups with random reassignment) send the most messages (3218). Treatment FF has fewer messages than treatment RR (2752) and the unlinked treatment RF has the fewest messages (1808). These differences are highly significant ($\chi^2 = 398$, df = 2, $p < 0.001$) and are consistent with the nature of the communication regimes. In treatment RR agreements must be renegotiated with a new group each period. Fewer messages may be

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[6] A variable for each category records whether any specific message-unit has been classified to that category. A message is coded as 1 in any given category if it is deemed to fit into that category and 0 otherwise. If the two coders disagree on classification to a specific category, the corresponding variable is coded as one-half.

[7] The Kappa statistic measures the degree of agreement between two coders above that expected by chance. It has a maximum value of 1 when agreement is perfect, 0 when agreement is no better than by chance and it takes negative values when agreement is less than by chance. The general conventions regarding the interpretation of other values are as follows: $0 < K \leqslant 0.20$ is poor agreement, $0.20 < K \leqslant 0.40$ is fair agreement, $0.40 < K \leqslant 0.60$ is moderate agreement, $0.60 < K \leqslant 0.80$ is good agreement and $K > 0.80$ is very good agreement (Neuendorf (2005)).

required in treatment FF because agreements can be carried over relatively easily from period to period. Treatment RF prevents subjects from communicating with their specific output-sharing group. Consequently communication may have been viewed as futile. The pattern of messages over the course of a session is similar across treatments. Figure 3 presents these time series. Note the consistent decline in messages from the first to fifth period of approximately fifty percent in all treatments and the relatively stable time paths for the remaining ten periods. Except for period six, the messages in RR exceed the messages in both FF and RF. The messages in FF always exceed the messages in RF. The relative relationship between treatments and total messages sent are consistent over time.

There are interesting variations by treatment in the distribution of messages across categories. Table 3 reports and Figure 4 illustrates these distributions. Categories 3, 5 and 7 are the top three categories to which messages are coded for each of the three treatments and the only categories which were coded more than 10% of the time for all three treatments. Category 3 "Propose an amount to invest in market 2" is the modal category for treatments FF (29%) and RR (32%) and second most frequently coded category for RF (21%). Category 7 "Talk about the investment decisions or payoffs made in the previous rounds" is the modal category for treatment RF (27%). This is the third most frequently coded category for treatments FF (16%) and RR (11%). Category 5 "Agreement" is the second most coded category for treatments FF (23%) and RR (21%) and the third most coded category for treatment RF (21%). These three message categories account for more than fifty percent of all of the coded messages in treatments RF (57%), RR (50%) and FF (55%).

Discussion frequently focuses on proposals to coordinate effort to appropriation when communication groups and output-sharing groups are linked (message categories C3 and C5). When these groups are not linked, these messages occur less often, although they still account to a substantial proportion of messages. When groups are not linked, messages about experiences from previous rounds occur most frequently (message category C7). This is likely because their messages cannot be directed to output sharing group members (who are unknown) and so their comments focus more on general obeservations as the sessions progress, and not so much on what should happen next within their group. Ultimately, the significance of the relationship between the message and appropriation effort may not depend upon the frequency that the message is repeated in a round, but rather whether it is or is not sent. We now turn to the relationship between messages and effort.

### 3.3. Aggregate Volume of Messages and Effort

We now investigate whether there is any systematic relationship between the aggregate number of messages exchanged by group members in a period and the amount of individual effort expended on appropriating the common pool resource in that period. We investigate both simple correlations between chat messages and effort and regression models which control for changes in message activity within treatment and over time.

The relationship between the chat variables and individual effort within the group is probably bi-directional. That is, the number and content of chat messages may influence the level of group effort and also the level of group effort may influence the number and content of messages in later periods. This is most likely to be true when the composition of communication groups is fixed across periods. To avoid this issue of causality we first

examine the simple correlations between individual effort per period and the total number of messages. We adopt the Kendall Tau Rank Correlation coefficient, which is a non-parametric measure of association between observations on two variables. This coefficient is computed by classifying every possible pair of observations as concordant (ranked the same on both variables) or discordant (ranked differently on the two different variables) and expressing the difference as a fraction of the total number of pairs. A value of 1 implies that every pair of observations is concordant, -1 implies that every pair is discordant, and 0 implies that half the observations are discordant and half concordant.[8] The Kendall Tau correlation coefficients and associated p-values are presented in the first row of Table 4.

Table 4 shows immediately that the total number of messages seen by an individual is not significantly correlated with effort in any treatment. This is not the entire story, however, because both the overall volume of messages and their relation to effort may be changing over the course of the session. To address this we estimate the linear regression model reported in Table 5. This model interacts a trend variable (inverse period) with aggregate message volume generated by a group of appropriators. Overall there is a highly significant positive relationship between the volume of messages generated by the group and the level of individual effort, suggesting that coordination on increasing effort is indeed promoted by communication.

There is a negative interaction between volume and inverse period, especially for the fixed communication group treatments FF and RF. This negative interaction outweighs the positive main effect of volume in the first period, so that the estimated relationship

[8] The quantity (1 + tau)/(1 – tau) is the odds ratio (probability of concordance)/(probability of discordance).

between individual effort and message volume is negative in Period 1 for both treatments FF and RF. By Period 2, however, the estimated relationship is clearly positive for both treatments. For treatment RR, the marginal effect on effort of increasing group message volume is always positive.

The marginal effect of time on effort depends upon the group's volume of messages. Over the last ten periods of the sessions, the average number of messages in a group is approximately 15, 18 and 10 for treatments FF, RR and RF respectively. These result in marginal effects of time over the last ten periods that are roughly positive for FF, negative for RR and negative for RF. Over time, individual effort in FF is rising, however in RR and RF it is falling.

**Result 1.** *After the first period, there is a strong positive relationship between the total volume of messages and the level of appropriation effort*

3.4. Specific Message Categories, Volume of Messages and Effort

Table 4 also reports on the relationship between effort and messages in specific categories. The Kendall tau coefficients for treatment FF show that individual effort is significantly and negatively correlated with the volume of messages in Categories 1, 2, 7, 10, 11 and 12 (messages focusing on initiating discussion, clarification of proposals, effort and payoffs in previous rounds and negative talk about the group). Effort is significantly and positively correlated with Categories 9 and 14 (messages focusing on positive talk about the group and noting the last round). There are no other significant correlations. While correlations with most of these categories may be subject to reverse causation in fixed groups (i.e. previous effort affecting messages), it is likely that

messages asking group members to clarify their proposals (Category 2) are associated with poor group coordination and likely the cause of significantly reduced effort levels.

Simple correlations in treatment RR are less likely to be the result of reverse causation than those in Treatments FF because the groups are remixed each period. Consequently the actions in previous periods have no direct relevance to the groups in the current period. There are only three significant simple correlations. Individual effort is positively correlated with talk about previous rounds and positive talk about the group (Categories 7 and 9) but is negatively correlated with talk of luck or random play (Category 12). In treatment RF only message Category 13 (other miscellaneous messages) is significantly correlated with individual effort.

As with total volume, the effects of individual categories of messages may be masked by within-session trends in the volume of messages. We have attempted to accommodate different intertemporal effects by separating the data into observations over the first four decisions rounds and the last eleven decision rounds. We do this with reference to the time series of total messages displayed in Figure 3 which show a distinct common pattern of total messages across the three communication treatments. To investigate the affect of the volume of messages of a specific category generated by a group on individual effort we estimated coefficients for a random effects panel model regressing individual effort levels on communication message categories in each of the first four periods and in the each of the last eleven periods for each of the three communication treatments. The estimation assumes random effects at the session level to account for correlation among effort decisions made by each subject and uses robust standard errors to correct for possible heteroskedasticity across subjects. The assumption

of random-effects at the individual level fits the experimental context well, for any subject-specific effects (individual heterogeneity) are independent of changes in the experimental treatments (exogenous regressors).

In addition to the separate treatment regressions, we have also reported regressions that pool the data across treatments in an attempt to identify significant variation that may exist across treatments but not within treatments. This may occur because of the absence of variability of effort within a treatment but substantial variability across treatments.

Table 6 presents the results of the eight regressions described above. Several results are particularly important. First, the amount of variation in individual effort that is accounted for by the fourteen message categories is not large. Second, the null hypothesis that the constant in the regression model for the unlinked treatment with randomly reassigned output-sharing groups is the best predictor of effort for this treatment over the first 4 decision rounds cannot be rejected ($p = 0.203$). For the final eleven decision rounds, this null hypothesis can be rejected ($p = 0.054$) at the 10 percent level.

3.4.1. Results from Regressions for Each Treatment

Table 7 presents only the statistically significant regression coefficients for the eight regression equations.[9] The constant is included to provide a basis for comparing the other coefficients. The time series of mean group messages for each of the categories included

[9] Message categories C14 (noting it is, or is about to be, the last round) and C12 (talk about luck or play random) are excluded from this table because we have no meaningful conjectures about how these messages may be related to the effort level that an individual may select.

in Table 7 that are not included in Figures 5 and 6 ( C4, C6, C9 and C10) are presented in the four panels of Figure 7.

The effect of different types of messages varies by treatment and by the period of the session studied. During the first four decision rounds increases in messages in category C2 (ask for/inquire/clarify proposals of other group members) is significantly related to reductions in effort for both treatments FF and RR. These are not important during the final eleven periods. This suggests that after several rounds of trial and error, proposals became clearer to all group members. Learning occurred that made it easier for group members to communicate with one another. Also during the first four rounds increases in messages in category C4 (disagreement or doubts) were important for treatment FF and RR. Their effects, however, were different. For fixed, linked groups, disagreement or doubt led to reductions in effort. For randomly reassigned linked groups disagreement or doubt led to increased effort. During the last eleven decisions rounds, this type of message was no longer important for the fixed, linked groups, but it remained important for the randomly reassigned linked groups but increasing messages of this type now led to reductions in effort rather than increases. Without reference to specific messages, it is difficult to explain why these changes occurred.

Increased messages of agreement (C5) led to increases in effort for treatment RR during the first four decision rounds, but had no significant effect after that. The reverse was the case for the fixed output-sharing groups. Agreement was not important early in the session, but after the fourth round a greater number of agreement messages led to more effort. Message types C6 (talk about the investment decision and payment relationship) and C8 (talk about the conflict/competition/coordination issues) had

significant positive effects on effort for treatment RR during the final eleven rounds but none of the other treatments displayed any effect from these messages. Increasing positive comments about the group (message C9) resulted in increasing effort for treatment RR and RF during the first four rounds and for treatment FF during the last eleven rounds. Negative comments about the group had a significant effect only in treatment FF and during the last eleven periods. The effect of increased numbers of these comments was to reduce individual effort. Based on the regression equation, negative and positive comments effectively offset one another.

Discussion about the rules of the game (message type C11) has a significant effect on reducing effort during the first four rounds in FF, but increasing effort during the final eleven rounds. This may be related to how the participants learned about the game. Ultimately they discover that they must coordinate to "beat" the other groups and so discussion of the rules of the game help them focus on coordination and increasing effort.

**Result 2** The effect of specific messages on coordination of individual effort varies across treatments. In Treatment FF messages related to negotiation of proposals are most effective. In Treatment RR messages related to strategy and group identity are most effective in raising effort. In Treatment RF no messages are effective in raising effort.

### 3.4.3. Summary

Our content analysis shows that the rules regarding communication protocol have a powerful effect on the nature of the communication and its effectiveness in coordinating group behavior. Treatment FF allowed the most successful coordination. Because groups were fixed the results of negotiation could be carried across periods, so fewer messages were needed than in the second most coordinated treatment, RR. Because group identity was known and formed, messages in Treatment FF could focus on specific proposals for

effort and signaling agreement with these proposals. In this treatment there is a clear positive association between specific proposals and greater coordination (signaled in this experiment by higher individual effort levels).

Treatment RR allowed the second most coordination. Because groups were remixed every period, group agreements had to be renegotiated every period. This led to a high total volume of messages. Discussion of specific proposals dominated the communication in this treatment, to an even greater extent than in Treatment FF. It is fascinating to note, however, that under these conditions a high frequency of proposals and agreement was not sufficient to guarantee higher coordination. Instead, messages related to game rules, strategy and group identity were most clearly associated with increased effort. Although their relative frequency was no greater than in Treatment FF, these messages appear to have played a major role in creating a sense of group identity in Treatment RR.

Treatment RF exhibited the lowest efforts, least coordination, and least communication. Discussion in this treatment shifted away from specific proposals, which were irrelevant when the communication group was not linked to the output-sharing group, and focused more on what had happened in previous rounds. Such discussion was not effective in promoting coordination in the output-sharing groups.

## 6. DISCUSSION AND CONCLUSIONS

We have investigated the effect of alternative structures for communication on the performance of output-sharing partnerships exploiting a common pool resource. Our group size was chosen so that within-group shirking incentives would precisely offset between-group over-harvesting incentives and the Nash equilibrium would be socially optimal. In our baseline, no-communication treatments, aggregate effort was not

significantly different from this efficient Nash equilibrium. In our other treatments we found that non-binding within-group communication was sufficient to reduce the within-group shirking incentive and to lead to significantly more effort provision provided communication groups were linked to output-sharing group. The effect was greatest when group communication remained constant over the experiment. Total effort was, however, ebevn in the fixed groups significantly lower than at the nocooperative Nash equilibrium without output-sharing. When communication and output-sharing groups were not linked there was no significant effect of communication, and total effort was not significantly idfferent from the socially efficient effrt level.

The volume and content of messages are affected by the communication structure. Messages are most frequent when teams are linked but remixed every period. This can be explained by their desire to coordinate effort provision within the group but specific proposalas and agreement about provision proposals could not be followed through in random partnerships. In fixed partnerships discussion about startegices and agreements about chosen paths explained the effectiveness of communication for overall effort provision by the group. Random groups instead had to rely on trying to create strong group identity for one round, and discuss overall game rules and strategies. Nonlinked communication groups did not have a real incentive to discuss groups specific proposals and identitiy, and therefore, did not counteract free-riding in groups.

Our results indicate that communication within output-sharing groups can take on different forms and has different impacts depending on the communication treatement, its link to output-sharing partnerships and the types of messaging individual members engage in. Paying more attention to the content and frequency of messages at different

stages of a game illuminates the elusive effects of nonbinding communication. We increasingly enagge in digital messaging of all types in everyday group dcision-making. A better understanding is crucial to either discourage shirking in team production or to encourage free-riding in output-sharing from a common pool resource. Possible reactions could be to choose different optimal team sizes to either increase or decrease free-riding or to unlink communication and output-sharing groups.

A further extension of this work could examine the role of communication and output-sharing in an environment with endogenous group formation or in an environment with communication in which the appropriators are able to design and implement the control mechanism. Resource users could, for example, either vote on the optimal size of output-sharing groups or an outside mediator could simply suggest the optimal group size (as suggested by Heintzelman et al.(2009)). Pre-play communication furthermore has been shown to induce subjects to pursue the payoff-dominant strategy (see for example Cooper et al.(1992)). Will output sharing prevail as a management mechanism in such a setting? Can the appropriators from a CPR reach an efficient allocation through communication and effort constraints approved by all appropriators? Will groups evolve with the correct group size for the effects different communication environments create and will there be a role for randomly assigned output-sharing groups in this environment? These research questions are relevant not only in the area of the provision of public goods and harvesting resources from a common pool, but also for competition in oligopolistic markets and the efficient supply of effort by teams in large corporations.

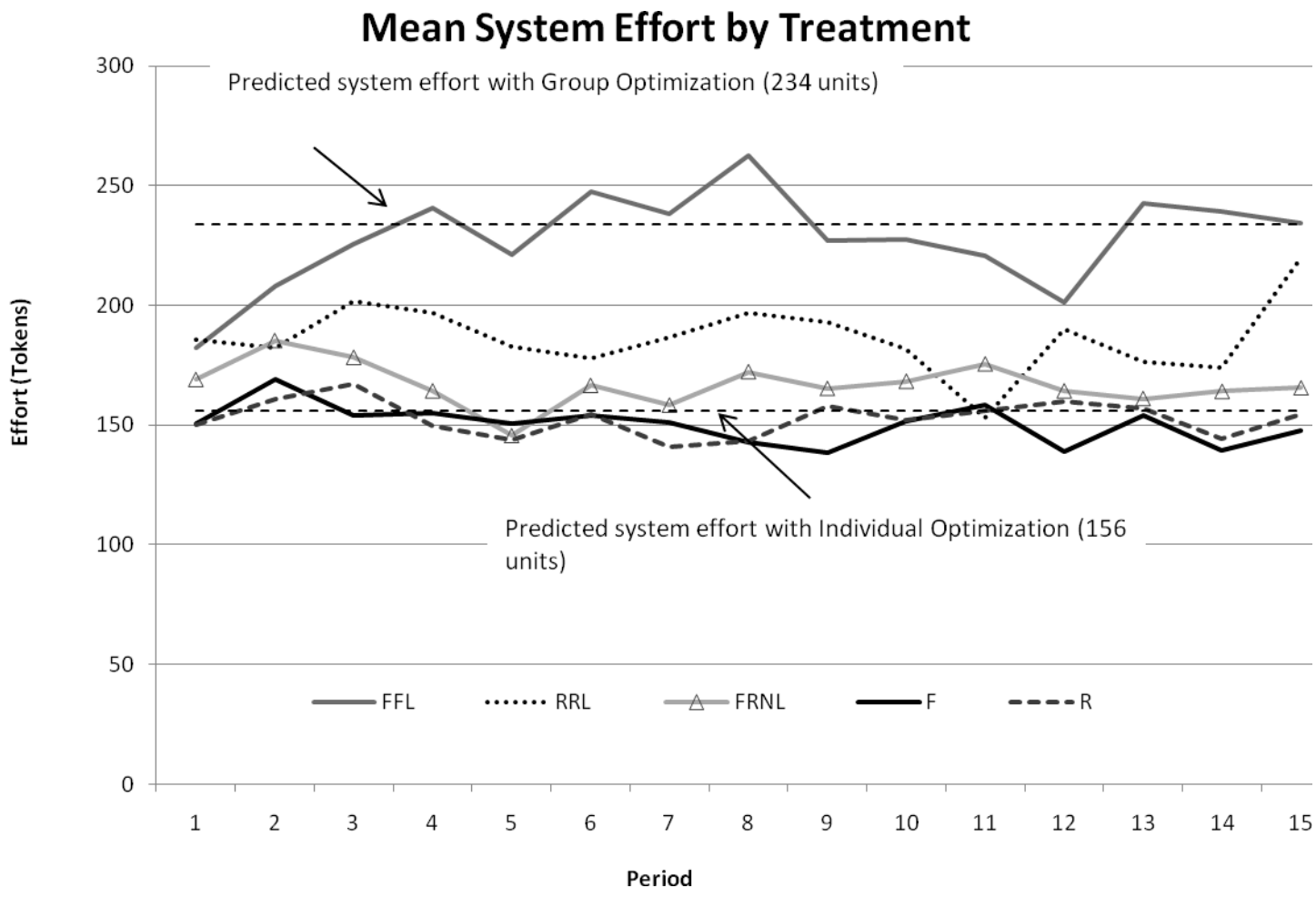


Figure 1. Mean system effort allocated to appropriation from the common pool

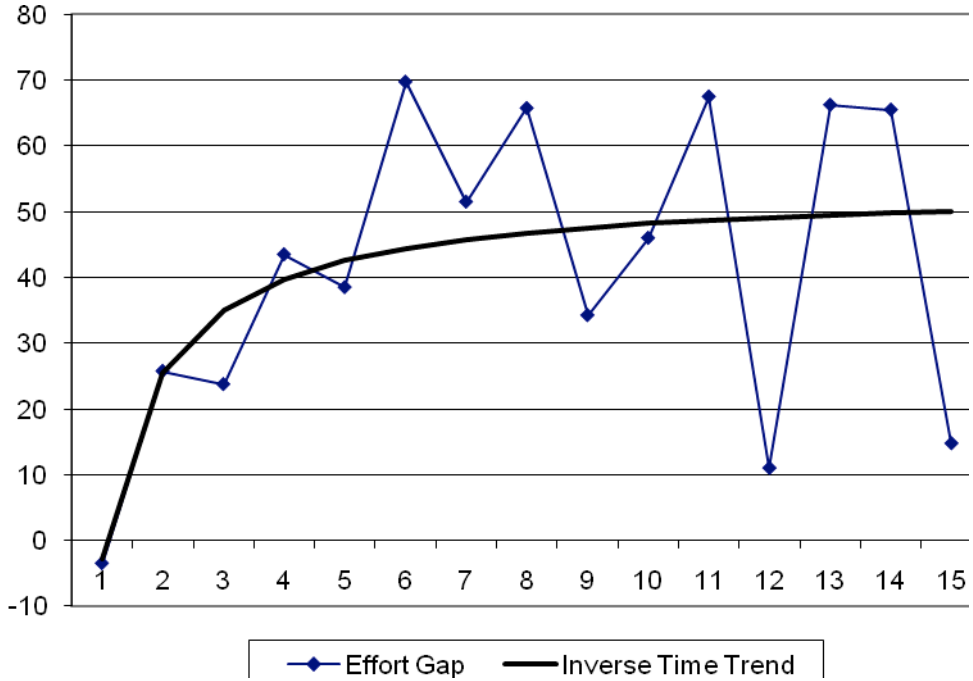


Figure 2. Mean FF Effort less Mean RR Effort by Period and Inverse Time Trend Line

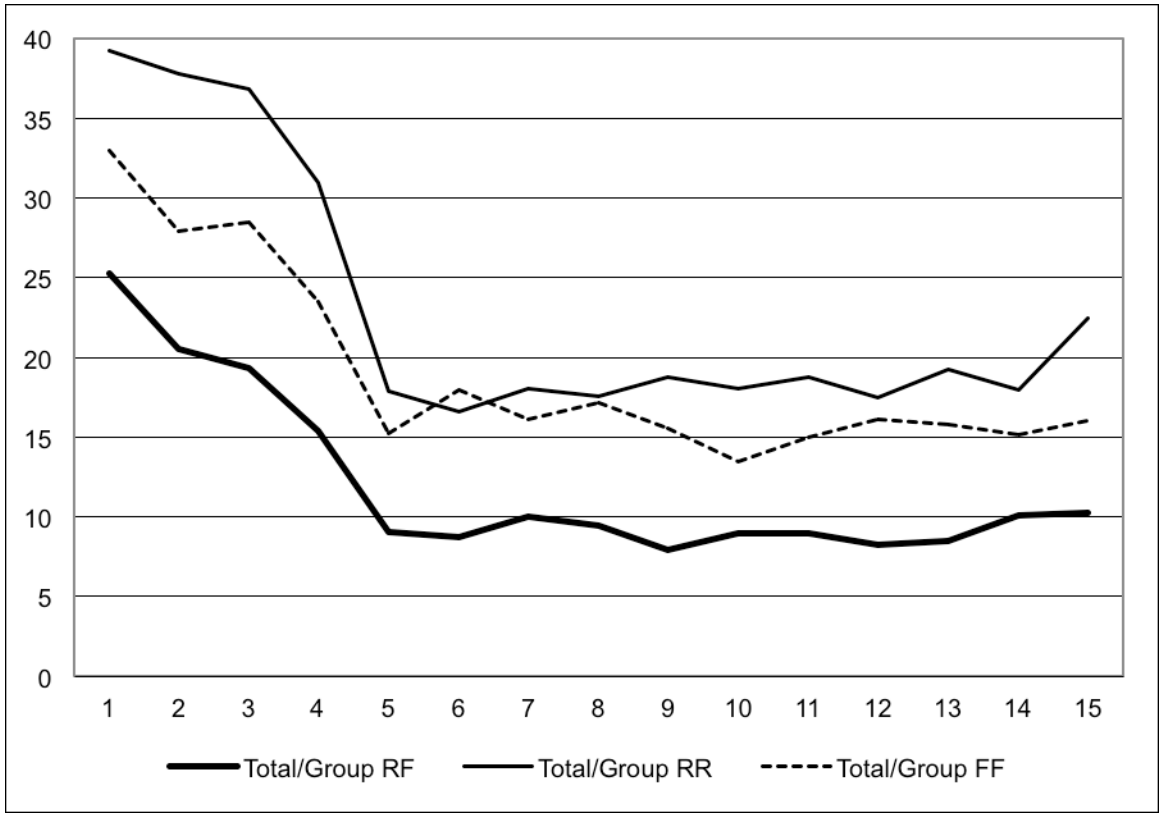


Figure 3. Mean Total Messages per Group by Treatment and Session Period

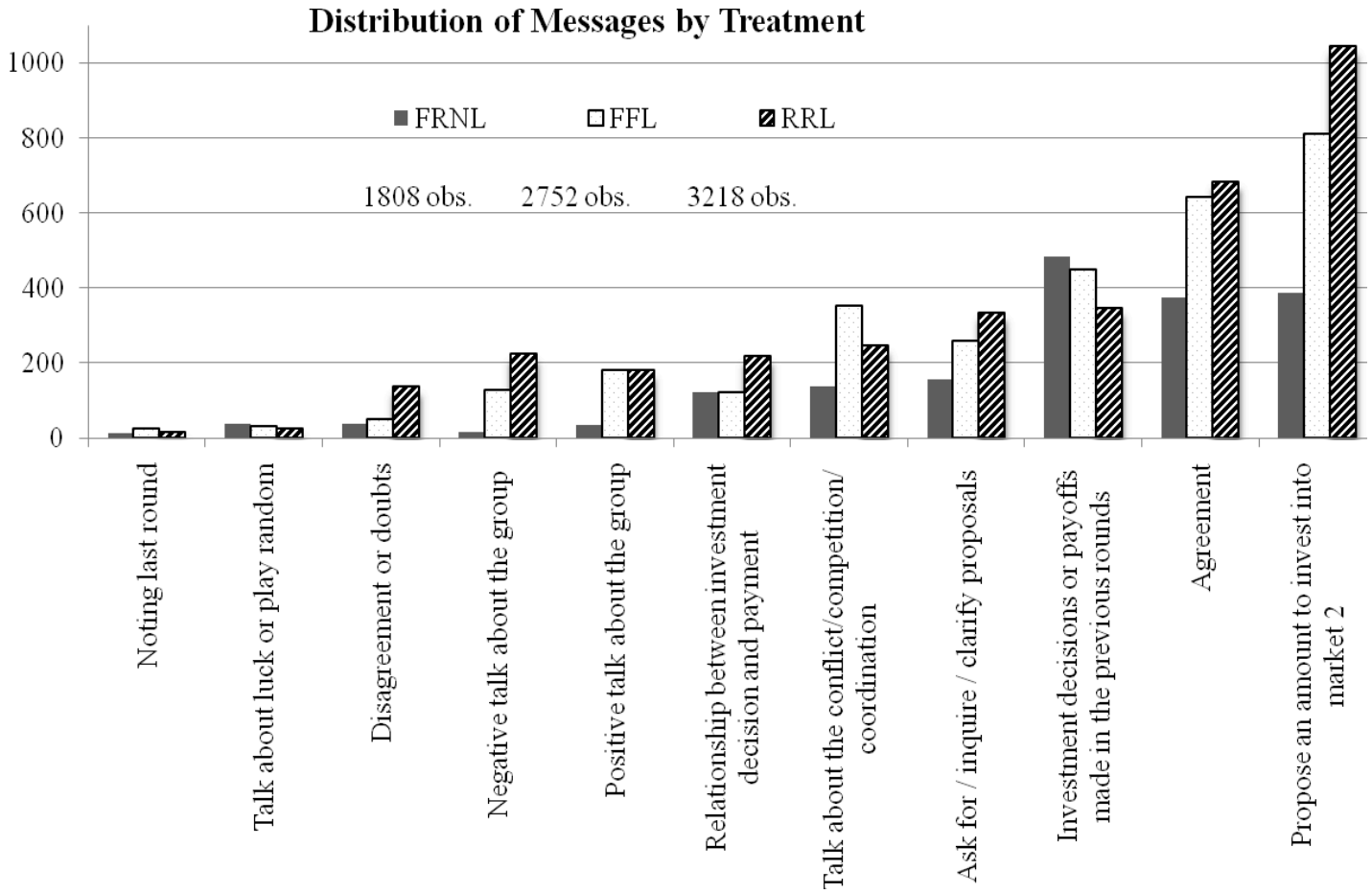


Figure 4. Distribution of communication messages by treatment

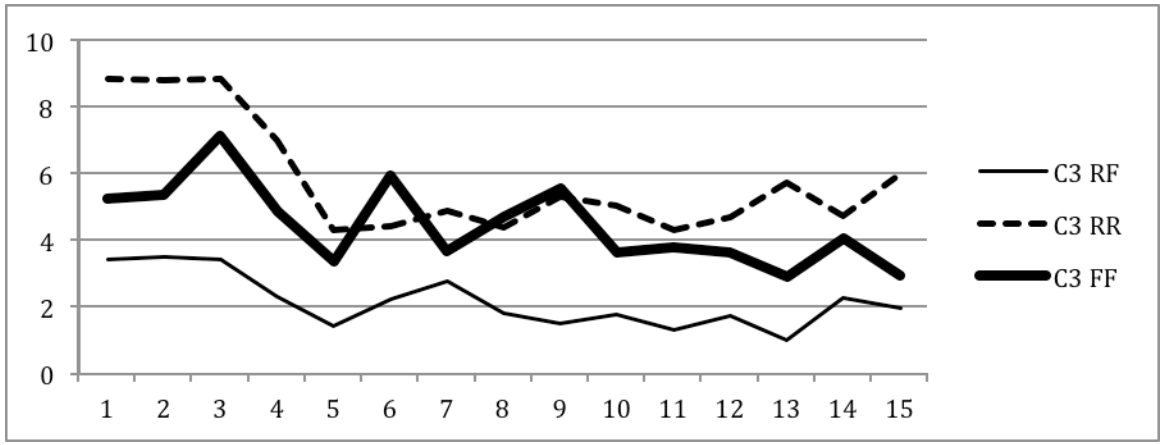


Figure 5a. Mean messages per group per period for category C3 (Propose an amount to invest into market 2)

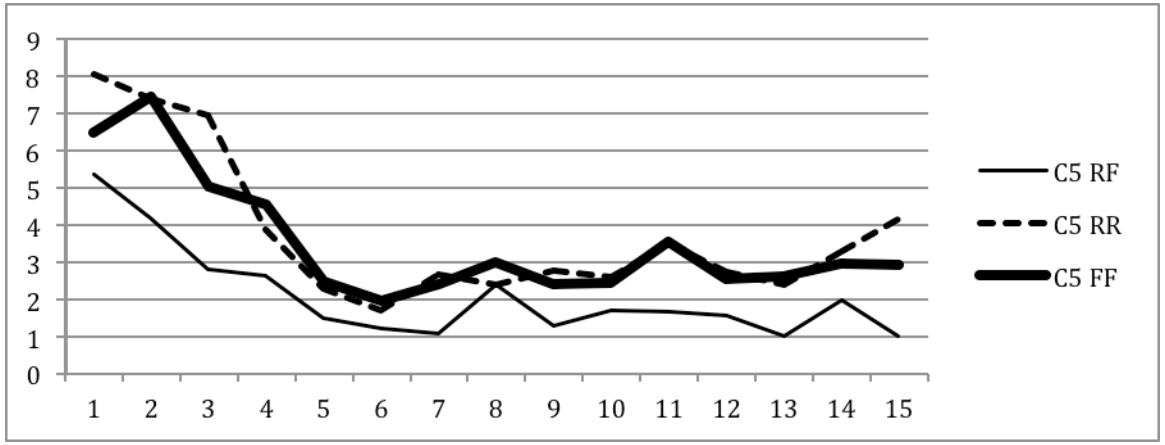


Figure 5b. Mean messages per group per period for category C5 (Agreement)

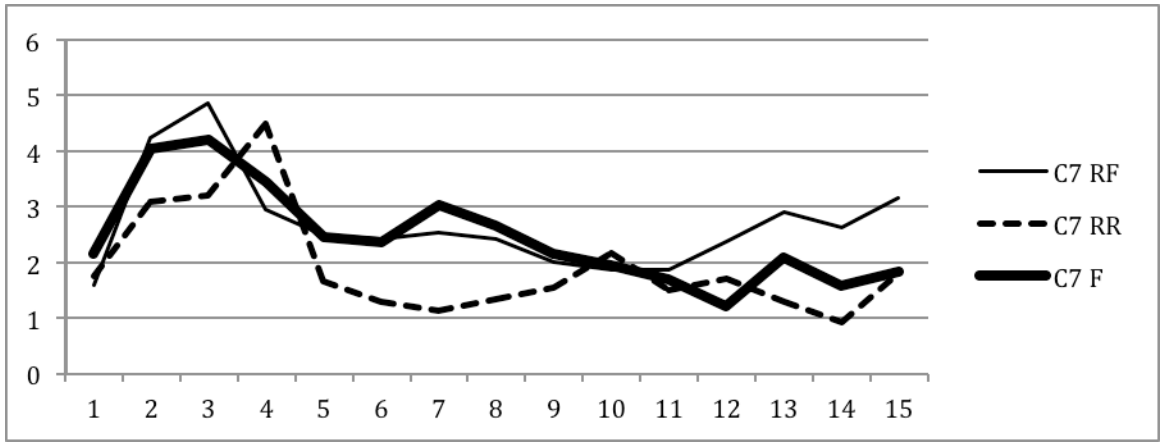


Figure 5c. Mean messages per group per period for category C7 (Talk about the investment decision or payoffs made in the previous rounds)

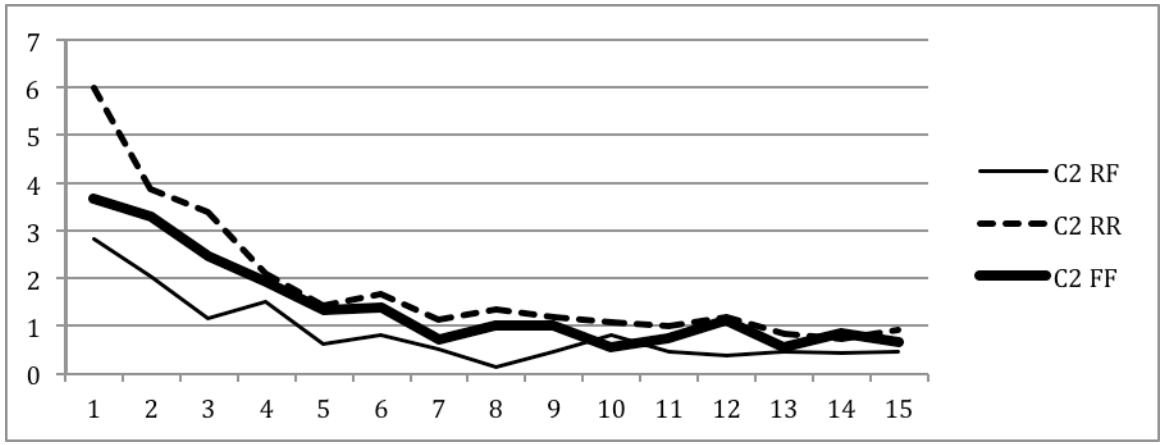


Figure 6a. Mean messages per group per period for category C2 (Ask for/inquire/clarify proposals of other group members)

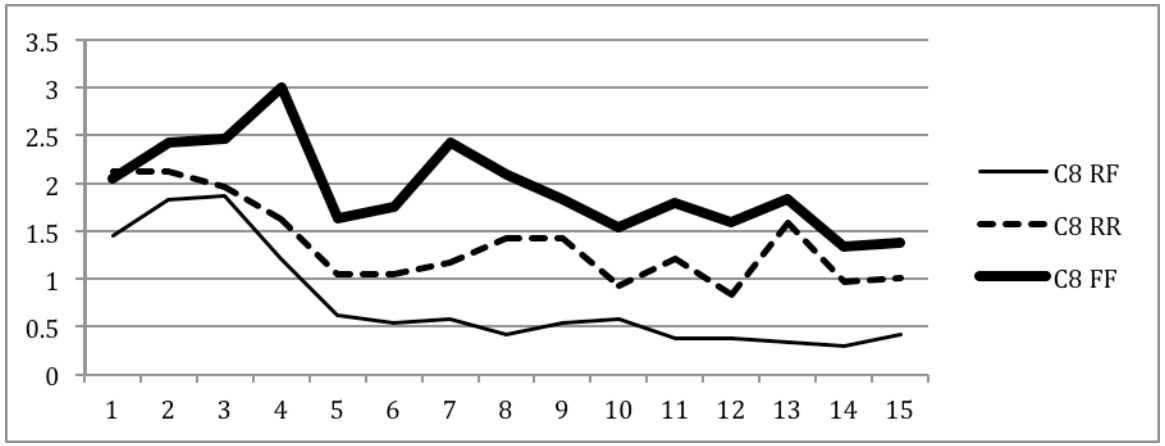


Figure 6b. Mean messages per group per period for category C8 (Talk about the conflict/competition/coordination)

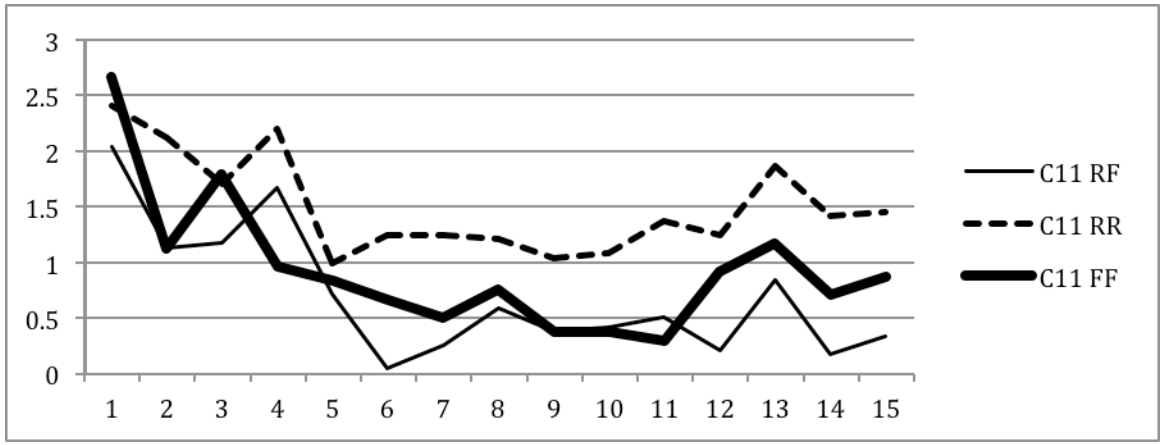


Figure 6c. Mean messages per group per period for category C11 (Talk about the game rules)

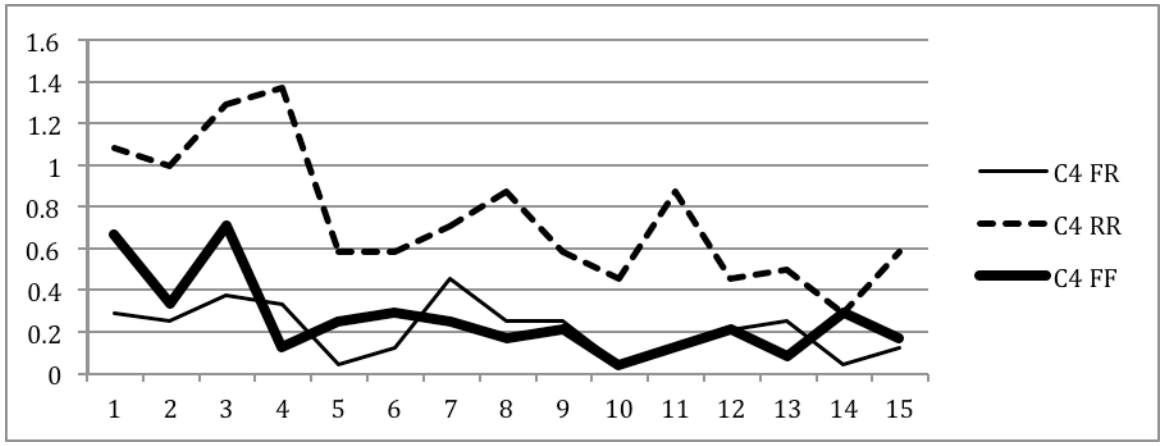

Figure 7a. Mean messages per group per period for category C4 (Disagreement or doubts)

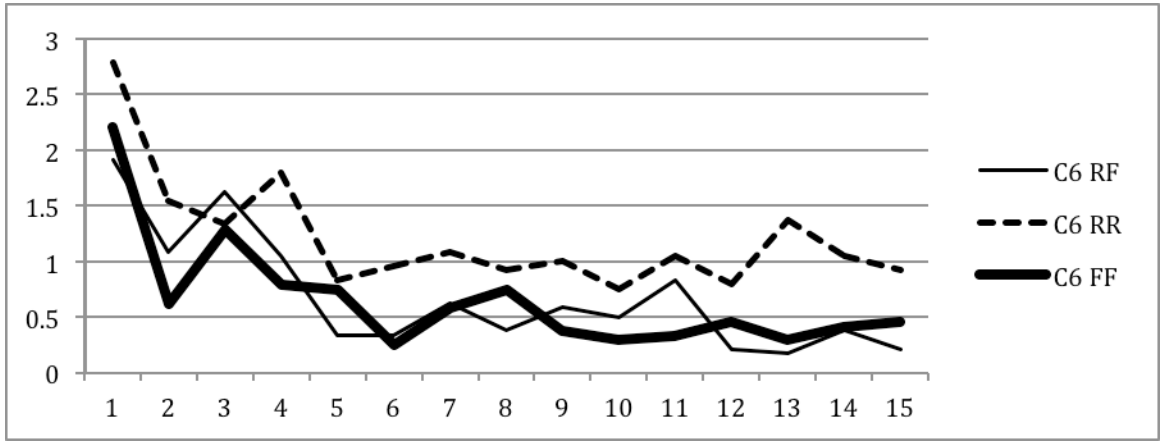


Figure 7b. Mean messages per group per period for category C6 (Talk about the investment decision and payment relationship)

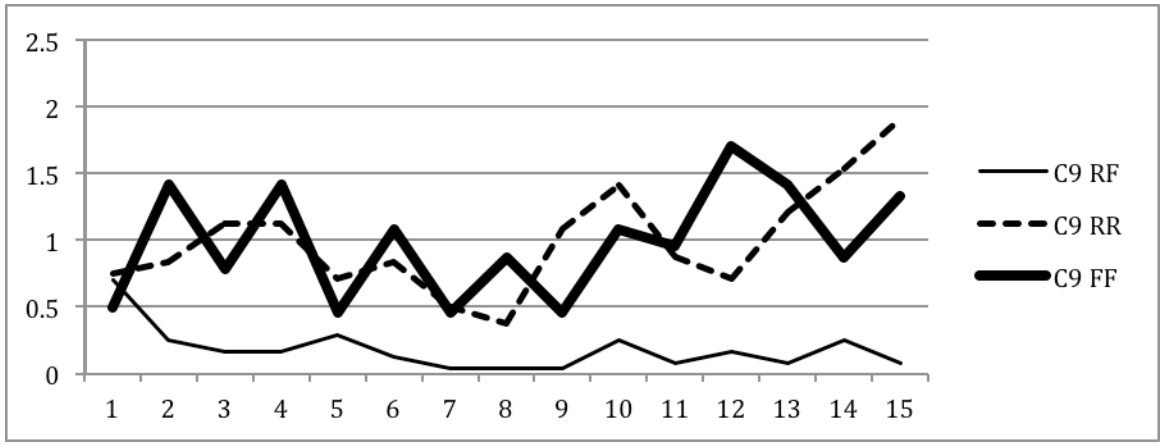


Figure 7c. Mean messages per group per period for category C9 (Positive talk about the group)

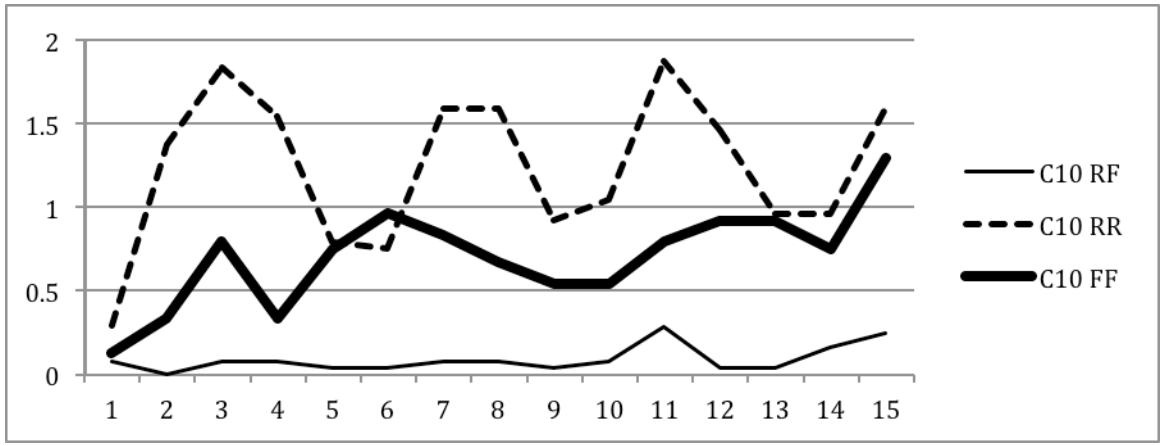


Figure 7d. Mean messages per group per period for category 10 (Negative talk about the group)

Table 1. Experimental Design

| Treatment | # of Sessions | Communication | Group Assignment |
|---|---|---|---|
| R | 4 | No | Random |
| F | 4 | No | Fixed |
| RR | 4 | Yes, linked to output-sharing group | Random Communication Group Linked to Random Output Sharing Group |
| FF | 4 | Yes, linked to output-sharing group | Fixed Communication Group Linked to Fixed Output Sharing Group |
| RF | 4 | Yes, not linked to output-sharing group | Fixed Communication Group not Linked to Random Output Sharing Group |

Table 2. Mean system effort per session by treatment

| Treatment | F | R | RF | RR | FF |
|---|---|---|---|---|---|
| Predicted system effort | 156 | 156 | 156 | 156-234 | 234 |
| Mean system effort | 150.40 (7.38) | 152.77 (20.27) | 166.87 (17.21) | 186.57 (10.90) | 227.92 (6.97) |

Notes: Standard deviations of the session means are in parentheses. The means and standard deviations are based upon four observations for each treatment.

Table 3. Reliability indexes and frequency of message coding by treatments

| Code | Category Description | RF (1808 units) | | RR (3218 units) | | FF (2752 units) | |
|---|---|---|---|---|---|---|---|
| | | Kappa | Relative frequency | Kappa | Relative frequency | Kappa | Relative frequency |
| C1 | Initiating discussion | 0.97 | 6.14 | 0.93 | 6.67 | 0.81 | 1.05 |
| C2 | Ask for / inquire / clarify proposals of other group members | 0.57 | 8.63 | 0.62 | 10.35 | 0.56 | 9.34 |
| C3 | Propose an amount to invest into market 2 | 0.79 | 21.40 | 0.72 | 32.40 | 0.76 | 29.41 |
| C4 | Disagreement or doubts | 0.33 | 2.10 | 0.55 | 4.20 | 0.48 | 1.72 |
| C5 | Agreement | 0.84 | 20.77 | 0.77 | 21.24 | 0.79 | 23.28 |
| C6 | Talk about the relationship between investment decision and payment | 0.46 | 6.78 | 0.58 | 6.76 | 0.52 | 4.35 |
| C7 | Talk about the investment decisions or payoffs made in the previous rounds | 0.80 | 26.80 | 0.63 | 10.77 | 0.62 | 16.28 |
| C8 | Talk about the conflict/competition/ coordination | 0.51 | 7.61 | 0.52 | 7.61 | 0.60 | 12.81 |
| C9 | Positive talk about the group (e.g., team work and group spirit, loyalty, honesty, equity) | 0.26 | 1.83 | 0.52 | 5.59 | 0.62 | 6.53 |
| C10 | Negative talk about the group (e.g., distrust, dishonesty, defection) | 0.11 | 0.94 | 0.63 | 6.91 | 0.56 | 4.64 |
| C11 | Talk about the game rules (e.g., conversion rate, grouping; what can be revealed in the chat) | 0.63 | 6.91 | 0.45 | 8.45 | 0.44 | 6.17 |
| C12 | Talk about luck or play random | 0.75 | 2.05 | 0.57 | 0.70 | 0.87 | 1.14 |
| C13 | Others (e.g., humor, time, comments) | 0.47 | 7.44 | 0.61 | 7.27 | 0.57 | 8.77 |
| C14 | Noting last round | 0.59 | 0.75 | 0.83 | 0.45 | 0.55 | 0.86 |

Notes: Relative frequency is the number of messages coded in a category divided by the total number of messages recorded in a treatment times 100. The sum of the relative frequency can be greater than 100 because some messages are assigned to several categories. Messages coded as Category 2 do not specifically refer to a contribution level. For each category, the p-value is less than 0.005 for the relevant Kappa. These p-values are the probabilities of incorrectly rejecting the null hypothesis that coder agreement is no better than chance.

Table 4. Kendall Tau Correlation Coefficients: Individual Effort versus Number of Messages (probability of making an error by rejecting null that coefficient is equal to zero)

| | | Treatment | | |
|---|---|---|---|---|
| Code | Message Type | FF | RR | RF |
| | Total Messages | -0.035 | 0.002 | 0.041 |
| | | (0.207) | (0.935) | (0.172) |
| C1 | Initiating discussion | -0.071 * | 0.042 | 0.005 |
| | | (0.023) | (0.168) | (0.868) |
| C2 | Ask for / inquire / clarify proposals of other group members | -0.136 * | -0.055 | 0.023 |
| | | (0.000) | (0.058) | (0.452) |
| C3 | Propose an amount to invest into market 2 | 0.020 | 0.011 | 0.055 |
| | | (0.484) | (0.678) | (0.061) |
| C4 | Disagreement or doubts | -0.057 | -0.014 | 0.000 |
| | | (0.065) | (0.644) | (0.988) |
| C5 | Agreement | 0.049 | 0.008 | 0.012 |
| | | (0.081) | (0.775) | (0.694) |
| C6 | Talk about the investment decision and payment relationship | -0.028 | 0.027 | 0.050 |
| | | (0.350) | (0.369) | (0.102) |
| C7 | Talk about the investments or payoffs made previously | -0.094 * | 0.060 * | -0.003 |
| | | (0.001) | (0.040) | (0.913) |
| C8 | Talk about the conflict/competition/ coordination | 0.052 | 0.014 | -0.016 |
| | | (0.075) | (0.642) | (0.597) |
| C9 | Positive talk about the group | 0.133 * | 0.103 * | 0.031 |
| | | (0.000) | (0.001) | (0.318) |
| C10 | Negative talk about the group | -0.122 * | 0.033 | 0.033 |
| | | (0.000) | (0.273) | (0.297) |
| C11 | Talk about the game rules | -0.073 * | 0.010 | 0.029 |
| | | (0.016) | (0.736) | (0.345) |
| C12 | Talk about luck or play random | -0.120 * | -0.080 * | 0.052 |
| | | (0.000) | (0.010) | (0.096) |
| C13 | Others | -0.032 | -0.017 | 0.062 * |
| | | (0.287) | (0.567) | (0.043) |
| C14 | Noting last round | 0.087 * | 0.041 | 0.036 |
| | | (0.005) | (0.188) | (0.255) |

Notes: Kendall Tau statistics that are significantly different from zero at the 5% level are marked with an asterisk.

Table 5. Effects of volume of messages per period on individual effort

| Dependent Variable: individual effort | | | |
|---|---|---|---|
| Independent Variables | FFL | RRL | FRNL |
| Inverse period | 0.35 | -0.73 | 3.87** |
| | (2.64) | (2.39) | (1.95) |
| Volume of messages | 0.15*** | 0.14*** | 0.16*** |
| | (0.05) | (0.05) | (0.05) |
| Volume*inverse period | -0.27*** | -0.08 | -0.25** |
| | (0.10) | (0.08) | (0.10) |
| Constant | 17.86*** | 13.54*** | 12.28*** |
| | (1.01) | (1.08) | (0.63) |
| Observations | 720 | 720 | 720 |
| Number of individuals | 48 | 48 | 48 |

Notes: Robust standard errors in parentheses. *** significant at 1%, ** significant at 5%, * significant at 10%. All models include a random effects error structure, with the individual subject effects. The volume of the message is the total messages that an individual sent and received from his own group in a given period.

Table 6. Effects of messages on individual effort (robust standard errors in parentheses)

| | Treatment (Messages Pooled over Periods 1 to 4) | | | | Treatment (Messages Pooled over Periods 5 to 15) | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Message Type | FF | RR | RF | Pooled | FF | RR | RF | Pooled |
| C1 | 0.04 | 0.73 | -0.71 | -0.38 | 1.81 | 0.30 | 0.15 | -0.66 |
| | (0.140) | (0.658) | (0.664) | (0.245) | (1.141) | (0.476) | (0.451) | (0.414) |
| C2 | -0.44* | -0.52* | -0.13 | -0.22 | -0.79 | 0.51 | -0.27 | -0.04 |
| | (0.170) | (0.217) | (0.456) | (0.163) | (0.505) | (0.396) | (0.178) | (0.293) |
| C3 | 0.15 | -0.14 | 0.28 | -0.04 | 0.24* | -0.07 | 0.24 | 0.25* |
| | (0.160) | (0.099) | (0.203) | (0.130) | (0.077) | (0.232) | (0.247) | (0.140) |
| C4 | -1.04* | 1.09* | 1.43 | 0.93*** | 0.76 | -1.23* | -0.68 | -1.13** |
| | (0.405) | (0.436) | (1.233) | (0.280) | (1.584) | (0.469) | (0.313) | (0.452) |
| C5 | 0.10 | 0.33* | 0.11 | 0.18 | 0.48* | 0.11 | 0.16 | 0.38* |
| | (0.212) | (0.126) | (0.125) | (0.112) | (0.182) | (0.253) | (0.091) | (0.196) |
| C6 | 0.04 | 0.58 | 0.39 | 0.12 | 0.37 | 0.34* | 0.34 | -0.18 |
| | (0.368) | (1.045) | (0.232) | (0.252) | (0.573) | (0.124) | (0.333) | (0.174) |
| C7 | -0.15 | -0.03 | -0.25 | -0.08 | 0.25 | 0.60 | -0.05 | 0.08 |
| | (0.266) | (0.335) | (0.333) | (0.146) | (0.176) | (0.562) | (0.164) | (0.216) |
| C8 | 0.30 | -0.10 | 0.23 | 0.41** | 0.01 | 0.43* | -0.37 | 0.95*** |
| | (0.257) | (0.442) | (0.585) | (0.182) | (0.275) | (0.160) | (0.223) | (0.236) |
| C9 | 0.74 | 2.03** | 1.09** | 1.35*** | 1.18* | 1.13 | -0.99 | 1.04*** |
| | (0.573) | (0.370) | (0.325) | (0.402) | (0.407) | (0.608) | (0.768) | (0.315) |
| C10 | 0.59 | 0.10 | 1.69 | -0.01 | -1.09** | 0.62 | 1.55 | -0.34 |
| | (0.750) | (0.111) | (1.828) | (0.129) | (0.274) | (0.388) | (1.524) | (0.260) |
| C11 | -0.55** | -0.72 | -0.18 | -0.41** | 0.93* | -0.95** | 0.42** | -0.02 |
| | (0.164) | (0.384) | (0.188) | (0.152) | (0.341) | (0.266) | (0.122) | (0.330) |
| C12 | -1.98** | 1.57 | -0.32 | -0.34 | -1.03* | -1.08 | 1.33* | -0.27 |
| | (0.476) | (1.581) | (0.618) | (0.976) | (0.370) | (1.164) | (0.534) | (0.467) |
| C13 | -0.16 | -0.62 | -0.17 | -0.20 | -0.24 | -0.17 | 0.04 | 0.02 |
| | (0.162) | (0.273) | (0.083) | (0.139) | (0.543) | (0.487) | (0.112) | (0.370) |
| C14 | | | | | -0.60 | 0.96 | 0.77* | 0.47 |
| | | | | | (0.694) | (0.817) | (0.315) | (0.488) |
| Constant | 18.54*** | 13.66** | 14.04*** | 15.39*** | 16.59*** | 13.03*** | 12.86*** | 13.42*** |
| | (0.666) | (4.081) | (2.242) | (1.107) | (1.715) | (1.324) | (1.112) | (1.146) |
| Observations | 192 | 192 | 192 | 576 | 528 | 528 | 528 | 1584 |
| R-squared | 0.27 | 0.19 | 0.09 | 0.15 | 0.18 | 0.07 | 0.04 | 0.11 |
| p-value for Model's F-test | 0.000 | 0.000 | 0.203 | 0.000 | 0.000 | 0.000 | 0.054 | 0.000 |

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
Message types are C1: Initiating discussion, C2: Ask for/inquire/clarify proposals of other group members, C3: Propose an amount to invest in Market 2, C4: Disagreement or doubts, C5: Agreement, C6: Talk about the investment decision and payment relationship, C7: Talk about the investments or payoffs made previously, C8: Talk about the conflict/competition/coordination, C9: Positive talk about the group, C10: Negative talk about the group, C11: Talk about the game rules, C12: Talk about luck or play random, C13: Other comments, C14: Noting it is (or about to be) the last round.

Table 7. Regression coefficients for significant messages with respect to individual effort (robust standard errors are in parentheses)

| | Treatment (Messages Pooled over Periods 1 to 4) | | | | Treatment (Messages Pooled over Periods 5 to 15) | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Message Type | FF | RR | RF | Pooled | FF | RR | RF | Pooled |
| C2 | **-0.44*** | **-0.52*** | | | | | | |
| | (0.170) | (0.217) | | | | | | |
| C3 | | | | | **0.24*** | | | **0.25*** |
| | | | | | (0.077) | | | (0.140) |
| C4 | **-1.04*** | **1.09*** | | **0.93***** | | **-1.23*** | | **-1.13**** |
| | (0.405) | (0.436) | | (0.280) | | (0.469) | | (0.452) |
| C5 | | **0.33*** | | | **0.48*** | | | **0.38*** |
| | | (0.126) | | | (0.182) | | | (0.196) |
| C6 | | | | | | **0.34*** | | |
| | | | | | | (0.124) | | |
| C8 | | | | **0.41**** | | **0.43*** | | **0.95***** |
| | | | | (0.182) | | (0.160) | | (0.236) |
| C9 | | **2.03**** | **1.09**** | **1.35***** | **1.18*** | | | **1.04***** |
| | | (0.370) | (0.325) | (0.402) | (0.407) | | | (0.315) |
| C10 | | | | | **-1.09**** | | | |
| | | | | | (0.274) | | | |
| C11 | **-0.55**** | | | **-0.41**** | **0.93*** | **-0.95**** | **0.42**** | |
| | (0.164) | | | (0.152) | (0.341) | (0.266) | (0.122) | |
| Constant | **18.54***** | **13.66**** | **14.04***** | **15.39***** | **16.59***** | **13.03***** | **12.86***** | **13.42***** |
| | (0.666) | (4.081) | (2.242) | (1.107) | (1.715) | (1.324) | (1.112) | (1.146) |

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ (these are for two-sided tests)
Message types are C2: Ask for/inquire/clarify proposals of other group members, C3: Propose an amount to invest in Market 2, C4: Disagreement or doubts, C5: Agreement, C6: Talk about the investment decision and payment relationship, C8: Talk about the conflict/competition/coordination, C9: Positive talk about the group, C10: Negative talk about the group, C11: Talk about the game rules.

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## APPENDIX I

### 1. Equilibrium for CPR Environment when Individuals in Groups Attempt to Maximize Individual Profits when Output Sharing is Used as a Management Instrument

Total output as a function of "effort" of all individuals using the CPR ( $X$ ) is

$$Y = 32.5X - 0.09375X^2.$$

Individual Profit as a function of individual effort ( $x$ ), the effort by members of the individual's group ( $X_g$ ) and the effort by all individuals using the CPR ( $X$ ) is

$$\pi = 3.25(28 - x) + \frac{1}{n}\frac{X_g}{X}Y,$$

where $n$ is the number of people in the individual's group. If $n = 1$ then $X_g = x$.

Differentiating π with respect to $x$ and setting this equal to zero yields

$$-3.25 + 3.25\frac{1}{n} - 0.09375\frac{1}{n}(X + X_g) = 0.$$

This reduces to

$$X + X_g = (32.5 - 3.25n)\frac{1}{0.09375}.$$

There is an equation like this one for each member of each group. When the groups have more than one member, the equations for all of the members in any particular group are identical. This results in three unique equations of the form

$$X + {}^mX_g = \frac{(32.5 - 3.25n)}{0.09375},$$

where $m$ is the group identifier.

In the case of three four-person groups, there would be three equations with three unknowns, ${}^1X_g$, ${}^2X_g$, and ${}^3X_g$. The solution will be

$${}^mX_g = \frac{32.5 - 13}{0.09375} \times \frac{1}{4} = 52.$$

The important result is that there is not a unique equilibrium quantity for the individual. The equilibrium condition requires that the sum of the contributions of the individuals in a group equals a unique value. There is a unique group Nash equilibrium allocation of effort to appropriation from the

common pool. In this case, the unique group Nash equilibrium amount of effort is 52. The system effort is 156.

**2. Equilibrium for CPR Environment when Individuals in Groups Attempt to Maximize Group Profits when Output Sharing is Used as a Management Instrument**

Individual Profit as a function of individual effort ( $x$ ), the effort by members of the individual's group ( $X_g$ ) and the effort by all individuals using the CPR ( $X$ ) is

$$\pi = 3.25(28 - x) + \frac{1}{n}\frac{X_g}{X}Y.$$

Profit for the group is

$$\pi_g = 3.25 \times 28n - 3.25X_g + 32.5X_g - 0.09375XX_g.$$

Differentiating $\pi_g$ with respect to $X_g$ and setting this equal to zero yields

$$X + X_g = \frac{29.25}{0.09375}.$$

When there are twelve appropriators from the common pool and $n = 4$, there are three output-sharing groups and $x = 3X_g$, therefore

$$X_g = 78.$$

The Nash equilibria in the situations described above result in the following values. The important result is that there is not a unique equilibrium quantity for the individual. The equilibrium condition requires that the sum of the contributions of the individuals in a group equals a unique value. There is a unique group Nash equilibrium allocation of effort to appropriation from the common pool. In this case the unique group Nash equilibrium amount of effort is 78. The system effort is 234.

## APPENDIX II

## INSTRUCTIONS (Treatment RF)

### Introduction

You are about to participate in a project about economic decision-making. You will be asked to make decisions about the investment of resources between two activities, which will be referred to as Markets 1 and 2. The amount of money you will earn in today's session will depend on your investment in Market 1 and the sum of your and others' investments in Market 2. Your earnings will be paid to you privately, in cash, at the end of the session. The money for this project is provided by several funding agencies.

### The Environment

During this session you and 11 other people will have to make decisions to invest resources in two markets. You will participate in 18 decision rounds, called *periods*. The first 3 periods will be for practice. The last 15 periods will determine your earnings at the end of the session.

At the start of the first round the 12 participants in the session will be divided into 3 groups of 4 people. The distribution of people to groups is random and none of the participants will know who is in his or her group. *After each of the 18 periods is over, we will scramble the membership of all the groups, so that everyone is playing in a new group every period. Your* earnings will depend upon the investment decisions that you make, the investment decisions that the members of your group make, and the investment decisions that the members of the other groups make. Your earnings in each round will be reported to you in Laboratory Dollars (L$). These will be converted to Canadian Dollars (C$) at the end of the session using the relationship 0.0045×L$ = C$.

### The Markets

At the beginning of each period you and each of the other participants will be given 28 tokens to invest. These tokens may be distributed in any way you wish between the two markets. Each period you will decide how many tokens to invest in Market 2. Whatever you do not invest in Market 2 will be automatically invested in Market 1.

Each token you invest in Market 1 yields a fixed return of L$3.25. This return per token is independent of the amount you invest or others invest in Market 1. Your return from Market 2 depends on the total investment in this market by all participants in the session.

Although you keep all of your return from Market 1, you and the rest of your group will pool your returns from Market 2 and share them equally. Thus your *payoff* from Market 1 equals your return from Market 1 and your *payoff* from Market 2 equals your share of your groups' returns from Market 2. Your total payoff for the period is the sum of your payoffs in the two markets.

### Numerical Example

In today's session there will be 3 groups of 4 participants. Each participant will have an endowment of 28 tokens to distribute between investments in Market 1 and Market 2.

Suppose you invest 11 tokens in Market 2. Assume that each of the other members of your group invests 19 tokens. Assume that each of the other participants (not in your group) invests 17 tokens in Market 2. Here is how your payoffs in Market 1 and Market 2 are calculated:

You invest 11 tokens in Market 2, leaving 17 tokens to be invested in Market 1.

The total investment in Market 2 by the other members of your group is 3×19 = 57 tokens.

The total investment in Market 2 by the participants not in your group is 8×17 = 136 tokens.

The total investment in Market 2 by all participants is 11 + 57 + 136 = 204 tokens.

The Market 2 Total Return Table shows the total and average return per token for a number of values of total investment in Market 2. If 204 tokens are invested in Market 2 the total return will be L$2728.50. The average return per token is L$13.375.

**Market 2 Total Return Table**

| Tokens | Total Return | Average Return per Token |
|---|---|---|
| 0 | 0.00 | 0.000 |
| 25 | 753.91 | 30.156 |
| 50 | 1390.63 | 27.813 |
| 75 | 1910.16 | 25.469 |
| 100 | 2312.50 | 23.125 |
| 125 | 2597.66 | 20.781 |
| 150 | 2765.63 | 18.438 |
| 175 | 2816.41 | 16.094 |
| 200 | 2750.00 | 13.750 |
| 204 | 2728.50 | 13.375 |
| 225 | 2566.41 | 11.406 |
| 250 | 2265.63 | 9.063 |
| 275 | 1847.66 | 6.719 |
| 300 | 1312.50 | 4.375 |
| 325 | 660.16 | 2.031 |
| 336 | 336.00 | 1.000 |

Your return from the 11 tokens you invested in Market 2 is L$13.375 ×11 = L$147.125. The total return from the 19 tokens invested by each of the other members of your group is L$13.375 ×19 = L$254.125. Therefore the total return to your group is L$909.50. Since you share this return equally, your total *payoff* from Market 2 is L$909.50/4 = L$227.375.

The constant return in Market 1 is L$3.25 per token. Therefore the return from the 17 tokens you invested in Market 1 is 3.25×17 = L$55.25.

Your total *payoff* from both markets combined is L$55.25 + L$227.38 = L$282.63.

Each of your group partners total payoff, on the other hand, is L$227.38 + 9×L$3.25 = L$256.63.

To simplify these calculations, the computer will show you an abbreviated Payoff Table for Market 2 and a Payoff Wizard which will calculate the exact payoff for any combination of your investment, the average investment by others that are in your group, and the average investment by others that are not in your group. The abbreviated Payoff Table will be similar to the Payoff Table for Market 2 shown below.

| Payoff Table for Market 2: Your Payoff Only When There are 3 Groups with 4 Members in Each Group | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Average Investment of Tokens in Market 2 by Members of Your Group** | | **0** | **6** | **11** | **17** | **22** | **28** |
| **Average Investment of Tokens in Market 2 by All Participants Other Than Those in Your Group** | **0** | 0 | 181.50 | 312.13 | 444.13 | 533.50 | 616.00 |
| | **6** | 0 | 154.50 | 262.63 | 367.63 | 434.50 | 490.00 |
| | **11** | 0 | 132.00 | 221.38 | 303.88 | 352.00 | 385.00 |
| | **17** | 0 | 105.00 | 171.88 | **227.38** | 253.00 | 259.00 |
| | **22** | 0 | 82.50 | 130.63 | 163.63 | 170.50 | 154.00 |
| | **28** | 0 | 55.50 | 81.13 | 87.13 | 71.50 | 28.00 |

The payoff based upon the numbers given in the previous section can be easily calculated from this Payoff Table. Since your group invested 11 + 57 = 68 tokens, the average investment by people in your group is 68/4 = 17 tokens. Locate the column headed "17". Since the other participants not in your group each invested 17 on average, locate the row labeled "17". The number at the intersection of these rows and columns (227.38) is your share of your group's return from Market 2. Adding L$55.25 (your payoff from Market 1) to this gives your total payoff of L$282.63.

**Practice Periods**

To let you learn more about the environment we are going to run **3 practice periods.** The results from these periods will **not** contribute to your final earnings. If you have any questions during these 3 periods, please raise your hand and we will answer them.

After the 3 periods are over, we will scramble members of the groups and begin the 15 periods which contribute to your earnings.

(Monitor starts the session)

Please examine your computer screens. In the upper right hand frame you will find a Payoff Table like the one in your instructions. Locate the cell showing your Market 2 payoff if you invest 11 tokens, the others in your group invest 19 tokens and the people not in your group invest 17 tokens each. To find the cell you must calculate the average investment made by all of the members of your group (11 by you and 19 by each of the other 3 is 68 tokens; divided by 4 equals 17 tokens). Under these hypothetical conditions, your payoff from Market 2 would be L$227.38.

Please click on this cell. Now look at the Wizard at the upper left hand side of the screen. Note that the numbers from the Payoff Table have been entered into the Wizard. Your investment is identified as 17 tokens, the average investment of the others in your group is identified as 17 tokens, and the average investment of others not in your group is identified as 17 tokens. Note the displayed payoff from Market 2 is L$ 227.38 and your displayed Total Payoff is L$263.13.

Now use the spin-edit box to change your investment to 11 tokens and the average investment by others in your group to 19 tokens. Note that your payoff from Market 2 has not changed, but your Total Payoff has increased to L$282.63. This total payoff is identical to the payoff you calculated in the previous example, in which your group average investment was 17, but you invested 11 tokens, while each of the others in your group invested 19 tokens.

You can calculate the payoff for any other combinations of investments by altering the numbers in the spin edit box.

You make your decision by filling in the form at the lower left of your screen. Notice that the spin-edit box on this form shows the last value you entered into the Wizard. You can accept this value or change it any way you please. After you have entered your desired investment decision, push the **Press Here When Done** button.

We are now ready to start the practice sessions. Please make your decisions and submit them.

(after results are shown)

The computer screens are now showing the results of the period. When you are finished examining them, please press **Done**

(after screens change)

You are now ready to start the second practice period. Notice the results from last period are shown on the history page on the right hand side of your screen. Remember that the groups have all been scrambled and you will be in a new group every period. Please make your decisions and submit them as before.

(after results are shown)

The results of the second practice period are now being shown. Please examine them and then proceed to the third practice period.

(after third period begins)

This is the third and final practice period. Please make your decisions and submit them as before. When the results of the third session appear, do not press the **Done** until you have read the remaining instructions.

(after the results appear)

**Communication**

Prior to the first paid period, you will be able to send messages to other members in your group. Everyone in your group will see the messages you send. To see how, please click now on the messenger tab in the lower portion of your screen. The messenger window will open. Then click on the lower (white) part of the box and type "hello". Please everyone type "hello" now. Then click the 'Send' button, so that others in your group can read your message. If you look at the messenger window you will see how many seconds remain for exchanging messages. The messenger window will be active for four minutes before the first paid period.

After the exchange of messages you will make investment decisions. *Although you will make investment decision in a new group each period, the composition of your communication group is the same across all periods.*[10] More specifically, before making decisions, you will always be able to send messages to the same group as you communicate with in the first paid period.

Prior to the second and third decision periods, this is set at three minutes. Prior to the fourth round this is set at two minutes and from the fifth through the fifteenth rounds, communication is limited to one minute. Now please switch to the main window by clicking on the background.

Although we will record the messages your group sends to each other, only the people in your group will see them. In sending messages, you should follow two basic rules: (1) Be civil to one another and do not use profanities, and (2) Do not identify yourself in any manner. The communication channel is intended to discuss your choices and should be used that way.
Please **do not close any window at any time** because that will cause delays and problems with the software.

**Paid Periods**

We are now about to begin the paid portion of the session. **We will scramble the membership of all the groups so that your group will consist of a completely new set of 4 people in each of the next 15 periods.**

If you have any questions, please ask them now.
Please examine the results of the third practice period and press **Done.** When everyone has done this, the first paid period will begin automatically. Please continue to follow the computer prompts until the end of the session.

[10] In Treatments RR and FF, the sentence in italic is removed.

# APPENDIX III

SCREEN SHOTS

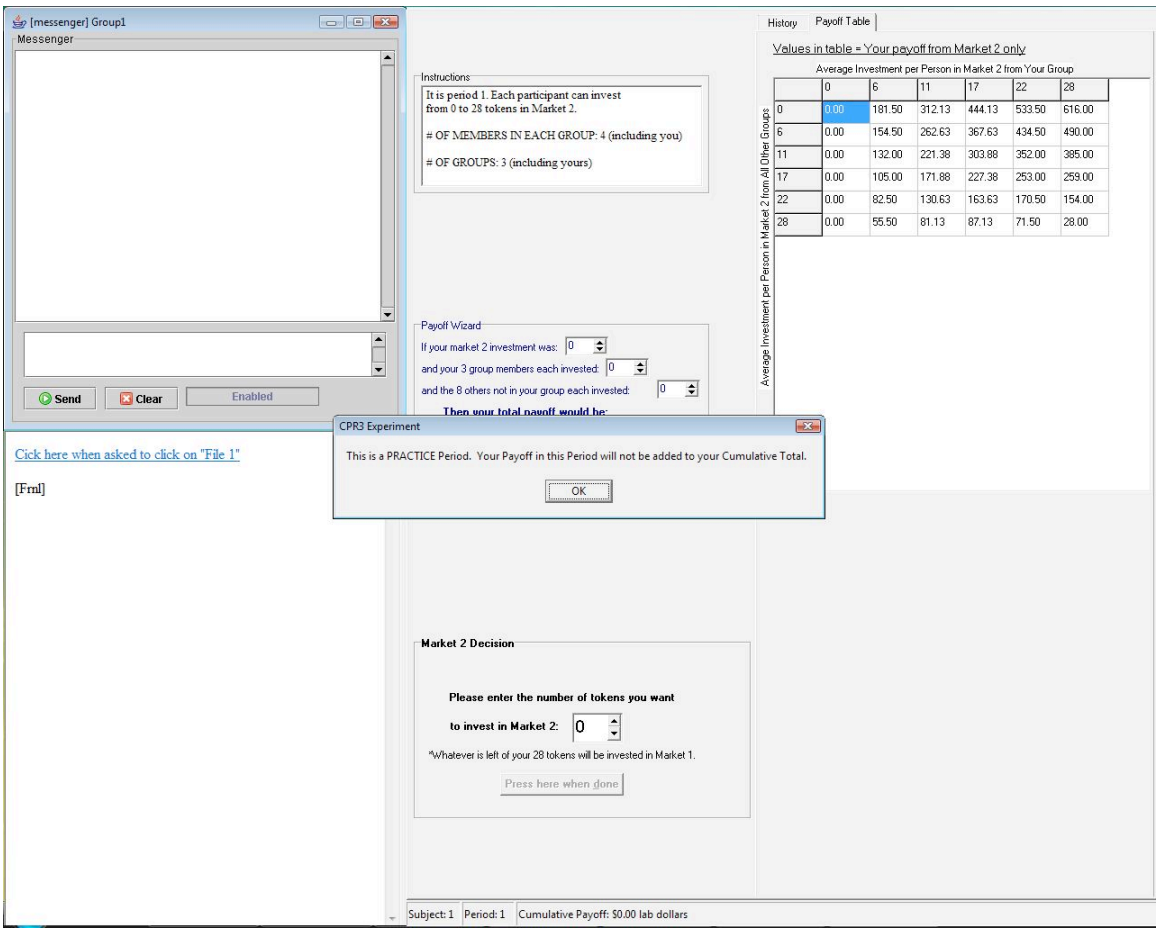


**Figure III.1 Decision Screen**

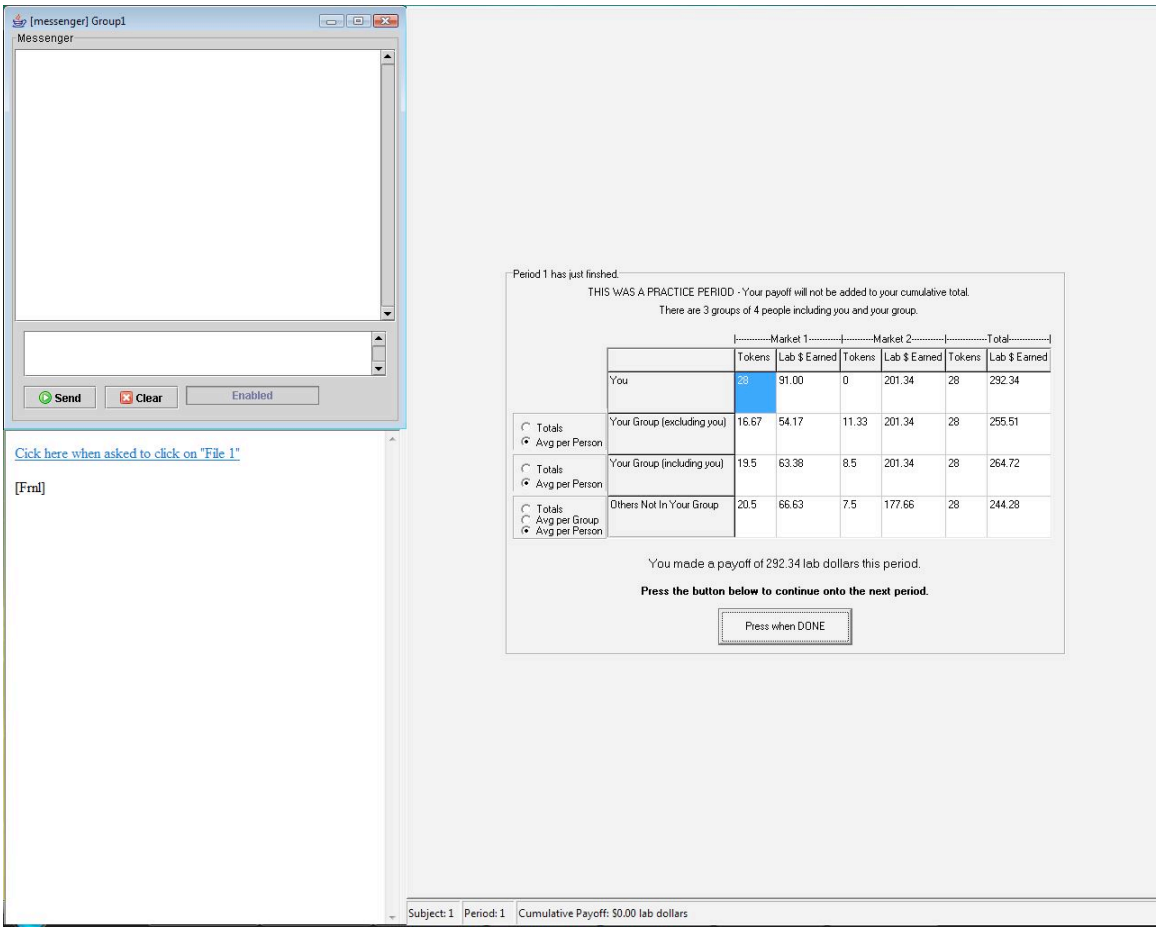


**Figure III.2 Outcome Screen**