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ABSTRACT

Cheap Talk with Multiple Audiences: an Experimental Analysis*

We examine strategic information transmission in a controlled laboratory experiment of a cheap talk game with one sender and multiple receivers. We study the change in equilibrium behavior from the addition of another audience as well as from varying the degree of conflict between the sender's and receivers' preferences. We find that, as in cheap talk games with just one receiver, information transmission is higher in games with a separating equilibrium, than in games with only a babbling equilibrium. More interestingly, we find clear evidence that the addition of another audience alters the communication between the sender and the receiver in a way consistent with the theoretical predictions. Deviations from the theoretical predictions that we observe tend to disappear with experience, and learning is faster precisely in the games where deviations are more pronounced.

JEL Classification: C92, D82 and D83
Keywords: cheap talk, communication and experiment

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1 Introduction

In many economic environments with communication of private information, the message sent by an informed sender may simultaneously influence the actions of many uninformed receivers with potentially conflicting interests. The financial statements of a firm, for example, are read by investors, unions, and other stakeholders; a politician's speech may be heard by constituencies with different agendas. In these cases, it is important whether the message is public (and so heard by all agents), or private (and so heard only by selected agents). As first shown by Farrell and Gibbons (1989) in a cheap talk game with one informed sender and two uninformed receivers, public communication may discipline the informed agent by inducing information transmission even when no information is sent in private; or it may make information revelation impossible even when information transmission to one of the receivers is possible in private.

Although there is a significant amount of literature that tests predictions of strategic models of communication with one sender and one receiver, there is no empirical study of communication between one sender and multiple receivers. In this paper we provide a first empirical investigation of this question by testing the predictions of Farrell and Gibbons (1989) in a controlled laboratory experiment. Following Farrell and Gibbons (1989), we start by studying communication in a simple cheap talk game: two states of the world; one informed sender who can send one of the two messages; and a receiver who can take one of the two actions. We then move to a similar setting with two receivers. Even when the payoffs of the receivers are independent from each other's actions (as in Farrell and Gibbons (1989)), the addition of a second receiver interferes with information transmission to the first receiver because it affects the sender's strategy. Will the sender choose a different strategy when addressing two receivers at once? Will the receivers recognize the change in the environment and update the way they interpret the sender's message? These questions cannot be answered without data on the sender's private signal, his or her message to the receivers, and the receivers' actions, and therefore are hard to address with field data. The laboratory setting helps to overcome these difficulties by allowing direct control of all the key strategic variables.

In the case of a 2-person (one-sender/one-receiver) cheap talk game, the results of our experiment are mostly in line with the previous literature. As in previous laboratory studies, we detect a tendency for the senders to reveal too much information, and for the receivers to trust the senders too much when compared to the theoretical predictions. However, the qualitative predictions of the theory are supported by the experiment: information transmission is much higher when the conflict of interest between the sender and the receiver is small. In addition, an analysis of individual behavior confirms that the individual players' strategies are in line with theoretical predictions: most of the senders tend to use uninformative strategies in games where there exists conflict of interest between them and their opponent, and truthfully reveal strategies otherwise; most of the receivers tend to ignore senders in games with conflict and believe their messages otherwise.

In the case of the 3-person (one sender/ two receivers), the design of the experiment is such that each game can be seen as the sum of two standard one-receiver component games that have the same sender and in which the sender's message is public. This design allows us to directly compare two-receivers games with their one-receiver components, and study the *marginal effect* of adding a second receiver. There are five possible cases, first described by Farrell and Gibbons (1989). In *one-sided discipline*, we have truthful revelation in public despite the fact that information transmission is possible with only one (but not the other) receiver in private. In *mutual discipline*, we have truthful revelation in public despite the fact that information transmission is not possible with any of the two receivers in private: in this case the conflicts of the sender with two receivers offset each other. In *subversion*, the addition of a second receiver in conflict with the sender induces no information transmission in public, despite the fact that truthful revelation is possible with the first receiver in private. In *full communication* and *no communication*, the behavior in the one receiver game is the same as in the two receivers case: in the first case, we have truthful communication both in private and in public; in the second case, no communication both in private and in public.

As in one-sender/one-receiver games, we find that information transmission is higher in one-sender/two-receivers games with a separating equilibrium than in games with only a babbling equilibrium. More interestingly, we find clear evidence that the addition of another audience alters the communication between the sender and the receiver in a way consistent with the theoretical predictions. We consider ten different scenarios: in each of the five cases mentioned above we compare the outcome of the two-receivers game with the outcome in each of the one-receiver components. In all ten scenarios, the sender changes behavior exactly according to the theory - by increasing truthful revelation in one-sided discipline and in mutual discipline cases; by reducing communication in the subversion case; and by not changing behavior in full communication and no communication cases. Similarly, in all except two of the ten comparisons, receivers modified their trust in the sender's message according to the theory.[1] All these effect are statistically significant.

We find, however, systematic evidence that the more complex strategic interaction of a three players' game has an effect on subjects' behavior and therefore on the quality of the theoretical predictions. The sender does not seem to be affected by the higher complexity of the interaction. The amount of truthful revelation of the state is statistically higher in all games in which truthful revelation is predicted by the model, and his/her behavior does not seem to be significantly affected by the component games. The behavior of the receivers, on the contrary, seems to be affected by the component games. It appears that receivers pay more attention to their "direct relationship" with the sender, and partially ignore the other receiver.

A study of learning in the game confirms that the deviations in behavior that we observe for the receivers are associated with the complexity of the game, and shows that they tend to disappear over time. We observe no statistically significant learning in the one-sender/one-receiver game. However, in the two-receivers game, there is statistically significant learning over time. Moreover, learning is more evident for the receivers than for the sender. Perhaps more importantly, learning is faster precisely in the games where deviations are more pronounced.

The remainder of the paper is organized as follows. In the following subsection we discuss the related literature. Section 2 describes the theoretical background. Section 3 describes the experimental design and the procedures. In Section 4 we discuss the results for the 2-person games, and in Section 5 the results for the 3-person games. In Section 6 we discuss learning effects. Section 7 concludes.

1.1 Related Literature

The experimental literature on cheap talk can be classified in two groups[2]. In the first group there are works that explore how cheap talk can be used to communicate intentions of play in environments with complete information[3]. In the second group the focus is on information trans-

[1] Of these two, in one case the sign of the effect is correct, but not statistically significant.

[2] A survey of the experimental literature on cheap talk can be found in Crawford (1998).

[3] See, for example, Cooper et al. (1992), Forsythe et al. (1991), Guarnaschelli et al. (2000), Valley et al. (2002), Roth (1985), Palfrey and Rosenthal (1991).

mission[4], and our paper belongs to this literature. Information transmission in classic cheap talk environments a' la Crawford and Sobel (1982) has been studied in Dickhaut et al. (1995), Blume et al. (1998), and Cai and Wang (2006). As in Crawford and Sobel (1982), these papers study situations in which there is one informed sender and one uninformed receiver, and there is no role for communication of intentions: the sender does not choose any action that affects the receiver's utility directly. Dickhaut et al. (1995) show that the key qualitative predictions of Crawford and Sobel (1982) are supported in the laboratory: notably, information transmission is higher when the degree of conflict is smaller. In a model with repeated anonymous interactions, Blume et al. (1998) show that informative communication emerges endogenously even when there is no common language (i.e. only symbols without an intrinsic meaning can be used by the sender). Cai and Wang (2006) also confirm Crawford and Sobel's main qualitative results, but they highlight a systematic tendency for senders to reveal more information than predicted in equilibrium.

Our paper departs from this literature by comparing the baseline case with one receiver to the case with multiple receivers. To our knowledge it is the first (and so far the only) paper to study the effect of public communication with multiple receivers in a laboratory experiment. The literature on multiple audiences has been exclusively theoretical. Farrell and Gibbons (1989) in their seminal paper consider the same environment that we study in our experiment. In a recent theoretical contribution, Goltsman and Pavlov (2010) have generalized the key insights of Farrell and Gibbons (1989) in an environment with a continuum of states and actions.

Palfrey and Rosenthal (1991) and Guarnaschelli et al. (2000) also study preplay communication in games with asymmetric information and more than two agents. In these works, therefore, each player is a sender and each message is heard by more than one receiver (the other players). This literature, however, is substantially different from our work for two reasons. First, these papers do not study the differences between private and public communication. Second, and most importantly, in this work the receiver's payoff is directly affected by the sender's actions: so communication of intentions of play and of information are not separated.

Table 1: 2-person matrix game payoff

Sender's payoff

	Heads	Tails
Action A	v_1	0
Action B	0	v_2

Receiver's payoff

	Heads	Tails
Action A	x_1	0
Action B	0	x_2

2 Theoretical Background

We adopt the same model of cheap talk used in Farrell and Gibbons (1989). In this model, there are two states of the world H, T. Nature chooses state H with the probability π and only one agent, the sender, is informed of the choice. After having observed the state, the sender selects a message (Heads or Tails) to send to the other players, the receivers, via a costless and a non-verifiable claim, i.e. cheap talk. Each receiver then takes an action (Action A or Action B) and the payoffs are realized. The payoff of each receiver depends only on the state and the action that he or she has chosen. The payoff of the sender depends on the state and the actions of all receivers.

We consider two basic treatments. In the 2-person game, there is only one receiver. The payoffs in this case can be described as in Table 1. For example, if the state is Heads and the receiver chooses action A, then the sender receives v_1 and the receiver receives x_1; if the sender chooses B, then both players receive 0. In all treatments we assume $x_1 > 0, x_2 > 0$. When both v_1 and v_2 are positive, then the players have the same ordinal preference over the actions in both states; in all the other cases there is a state in which the the sender and the receiver would choose different actions.

In the 3-person game there are two receivers. The payoff of the sender in this case is the sum of two components: the first depends only on the state and the action of receiver 1; the second component depends only on the state and the action of receiver 2. Table 2 represents the payoffs

[4]Guarnaschelli et al. (2000), Valley et al. (2002), Palfrey and Rosenthal (1991) study preplay communication in games with asymmetric information, so these papers belong to both groups.

Table 2: 3-person matrix game payoff

Sender's payoff

	Heads	Tails
Action A1	v_1	0
Action B1	0	v_2

Sender's payoff

	Heads	Tails
Action A2	w_1	0
Action B2	0	w_2

Receiver 1's payoff

	Heads	Tails
Action A1	x_1	0
Action B1	0	x_2

Receiver 2's payoff

	Heads	Tails
Action A2	y_1	0
Action B2	0	y_2

in this case. For example, if the state is Tails and receiver 1 chooses A1 and receiver 2 chooses A2, then receiver 1 obtains x_1, receiver 2 obtains y_1 and the sender obtains $v_1 + w_1$. In all treatments, we will assume $x_1 > 0, x_2 > 0$ and $y_1 > 0, y_2 > 0$. When both $v_1 + w_1$ and $v_2 + w_2$ are non negative, then the players have the same ordinal preference over the actions in both states; in all the other cases there is a state in which the the senders and at least one receiver would choose different actions.

In these games we can have two types of pure strategy equilibria. In the first type, the sender's message is uninformative and therefore is ignored by the receivers in equilibrium. Each receiver in such equilibrium chooses the action based on the prior only: $a_{pool} = A$ if $\pi x_1 \geq (1-\pi)x_2$, and $a_{pool} = B$ otherwise. This equilibrium always exists for any choice of parameters. We will refer to it as a *pooling equilibrium*. In the second type, the sender's message fully reveals the state. If we denote $m(s)$ the message sent in state s, and $\mu(s; m(s))$ the posterior probability of receiver i on state s in state s, we have $\mu(s; m(s)) = 1$. We will refer to this type of equilibrium as a *separating equilibrium*. It is easy to see that a separating equilibrium does not always exist. In a 2-person game a fully revealing equilibrium exists if and only if $v_1 > 0$ and $v_2 > 0$. In a 3-person game, a fully revealing equilibrium exists if and only if $v_1 + w_1 \geq 0$ and $v_2 + w_2 \geq 0$.

Comparing Table 1 and Table 2 it can be verified that a 3-person game can be seen as the sum of two 2-player games (one with receiver 1 and one with receiver 2) with the same Sender and in which the Sender is forced to make a public message heard by both. This design allows us to directly compare two-receivers games with their one-receiver components, and study the *marginal* *effect* of adding a second receiver. In the following we will call the "component games" of a 3-player game the two games that are defined by the 3-player game when one of the two receivers is eliminated.

From the conditions discussed above, it follows that if a separating equilibrium exists with both receivers in the component games, then it must exist in public setting as well. The converse does not hold. The five cases that may arise have been described in the introduction and are summarized here in Table 3.[5] Specific numerical examples will be presented in Section 3 where we discuss the treatments of the experiment.

Table 3: Types of private vs. public communication

	Separating Equilibrium in **private**	Separating Equilibrium in **public**
No Communication	No	No
Full Communication	Yes, with both receivers	Yes
One-Sided Discipline	With one receiver, but not with the other	Yes
Mutual Discipline	No	Yes
Subversion	With one receiver, but not with the other	No

On the basis of this discussion, we can organize the theoretical predictions of the model in two groups. First we have the predictions concerning how behavior depends on the degree of conflict in the game. The games, both 2-person and 3-person, can be classified in *conflict games*, where the unique equilibrium is pooling, and *no conflict games*, where there is a separating equilibrium. We have:

Hypothesis 1. *Both in 2-person and in 3-person games, the sender's strategy is less informative in games of conflict than in games of no conflict. Similarly, the receivers' actions are more correlated to the sender's message in games of no conflict than in games of conflict.*

Hypothesis 1 is a natural extension of the hypotheses tested in previous laboratory experiments of cheap talk games described in Section 1.1. With respect to this literature, here we extend the analysis by considering the case in which there may be more than one receiver. In the presence of multiple receivers the conflict depends on the 3 ways strategic interaction of the players.

Second, we can test how behavior changes as we move from a private setting with one receiver

[5] See Farrell and Gibbons (1989) for a formal derivation.

to a public setting with two receivers. We say that adding a second receiver has a *positive effect* if the sender increases the informativeness of his strategy, and receiver 1 increases the correlation of his action with the message. The effect is *negative* if the sender reduces the informativeness of his strategy and receiver 1 reduces the correlation of his action with the message; and it is *neutral* if the sender's and the receivers' strategies remain unchanged. The setup presented above leads us to the following Hypothesis:

Hypothesis 2. *Adding a second receiver to a 2-person game has a positive effect in games of One-Sided Discipline and Mutual Discipline, a negative effect in a game of Subversion, and a neutral effect in games of No Communication and Full Communication.*

Hypothesis 2 constitutes a direct test of the ability of the model to predict the marginal effect on information transmission of a second receiver. Note that in the statement of Hypothesis 2 (and in Table 3) we keep receiver 1 as our reference point and consider receiver 2 as the additional player. A statement similar (and equivalent) to Hypothesis 2 can be made taking receiver 2 the reference.

3 Experimental Design and Procedures

The experiment was conducted in the Princeton Laboratory for Experimental Social Science (PLESS) and programmed using z-Tree software (Fischbacher (2007)). We ran 4 sessions with a total of 48 subjects. All participants were registered students at Princeton University and had been recruited by e-mail. No subject participated in more than one session, and each session contained exactly 12 subjects. The typical experimental session lasted about 1.5 hours. During the experiment, participants accumulated "points," which were exchanged for dollars at a pre-specified rate[6]. Including the $10 show-up fee, the total earnings for the experiment ranged from $24.80 – $33.20.

Each session consisted of two parts. In the first part, participants were divided into pairs and played the game with one sender and one receiver for 18 periods. Table 4 presents 6 games, each of which was repeated 3 times in a random sequence of 18 games.[7] Each period subjects were randomly assigned to a group and given a role of a sender or of a receiver, so that the composition of groups and the roles changed every period. At the start of each period participants were informed

[6]In all of the sessions 25 points were equal to $1.00

[7]Note that the payoffs of Table 4 are an affine transformation of the payoffs described in Table 1. We chose this (equivalent) way of represent the game in the experiment to avoid negative payoffs.

of their role and the game that was to be played with their opponent. In addition, senders observed the state of the world and were asked to send a message (Heads or Tails) to their partner. Then receivers saw the message and chose their actions. At the end of each round, all participants viewed a summary screen that contained the state, the message, the action and their individual payoff for the round. The main purpose of Part I of the experiment was to familiarize the participants with the cheap talk game and get the baseline of the communication strategies in private setting.

Part II of each session was a test of cheap talk game with two receivers. Subjects were divided into groups of three, and each of the 4 groups had one sender and two receivers. Just like in Part I, the participants were re-matched and assigned roles at random each period. The 5 different games that were played in this round correspond to the five types of public communication described above and are presented in Table 5. [8] Each of these games was repeated 4 times for a total of 20 periods in Part II. Note that each of the 5 games is constructed by combining two games from Part I to allow for a direct comparison of private and public settings. Rounds in Part II were similar to rounds in Part I, i.e. only senders had information about the state of the world, which they had an opportunity to share with the receivers via a cheap talk message. The message had to be the same and was sent simultaneously to both receivers. Finally, each receiver took an action and the summary for the round was reported to all subjects. The total earning of the participants for Part I and Part II were a sum of the show-up fee and their earnings in each of the periods.

[8] Similarly as for the 2-person games, the payoffs of Table 4 are an affine transformation of the corresponding payoffs described in Table 2 to avoid negative payoffs.

Table 4: 2-person games

Game 1:

Sender's payoff

	Heads	Tails
Action A	10	0
Action B	0	10

Receiver's payoff

	Heads	Tails
Action A	10	0
Action B	0	10

Game 2:

Sender's payoff

	Heads	Tails
Action A	25	0
Action B	0	25

Receiver's payoff

	Heads	Tails
Action A	10	0
Action B	0	10

Game 3:

Sender's payoff

	Heads	Tails
Action A	15	0
Action B	0	15

Receiver's payoff

	Heads	Tails
Action A	0	15
Action B	15	0

Game 4:

Sender's payoff

	Heads	Tails
Action A	20	0
Action B	0	20

Receiver's payoff

	Heads	Tails
Action A	0	20
Action B	20	0

Game 5:

Sender's payoff

	Heads	Tails
Action A	0	10
Action B	10	30

Receiver's payoff

	Heads	Tails
Action A	10	0
Action B	0	10

Game 6:

Sender's payoff

	Heads	Tails
Action A	30	10
Action B	10	0

Receiver's payoff

	Heads	Tails
Action A	10	0
Action B	0	10

Table 5: 3-person games

Game 12 - Full Communication

Sender's payoff

	Heads	Tails
Action A1	10	0
Action B1	0	10

Sender's payoff

	Heads	Tails
Action A2	25	0
Action B2	0	25

Receiver 1's payoff

	Heads	Tails
Action A1	10	0
Action B1	0	10

Receiver 2's payoff

	Heads	Tails
Action A2	10	0
Action B2	0	10

Game 13 - Subversion

Sender's payoff

	Heads	Tails
Action A1	10	0
Action B1	0	10

Sender's payoff

	Heads	Tails
Action A2	15	0
Action B2	0	15

Receiver 1's payoff

	Heads	Tails
Action A1	10	0
Action B1	0	10

Receiver 2's payoff

	Heads	Tails
Action A2	0	15
Action B2	15	0

Game 23 - One-Sided Discipline

Sender's payoff

	Heads	Tails
Action A1	25	0
Action B1	0	25

Sender's payoff

	Heads	Tails
Action A2	15	0
Action B2	0	15

Receiver 1's payoff

	Heads	Tails
Action A1	10	0
Action B1	0	10

Receiver 2's payoff

	Heads	Tails
Action A2	0	15
Action B2	15	0

Continued on next page

Game 56 - Mutual Discipline

Sender's payoff

	Heads	Tails
Action A1	0	10
Action B1	10	30

Sender's payoff

	Heads	Tails
Action A2	30	10
Action B2	10	0

Receiver 1's payoff

	Heads	Tails
Action A1	10	0
Action B1	0	10

Receiver 2's payoff

	Heads	Tails
Action A2	10	0
Action B2	0	10

Game 34 - No Communication

Sender's payoff

	Heads	Tails
Action A1	15	0
Action B1	0	15

Sender's payoff

	Heads	Tails
Action A2	20	0
Action B2	0	20

Receiver 1's payoff

	Heads	Tails
Action A1	0	15
Action B1	15	0

Receiver 2's payoff

	Heads	Tails
Action A2	0	20
Action B2	20	0

4 Two person games

We analyze the experimental results in three subsections. In this section, we analyze the decisions in the 2-person games. We then analyze the decisions in 3-person games in Section 5. Finally, in Section 6 we discuss in detail the deviations from the theoretical equilibrium and the learning effects.

In order to describe senders' and receivers' strategies in the experiment, we construct two variables. The variable for the sender is called *telling_truth* and it is equal to 1 for a particular sender if the sender's message coincides with the state, and it is equal to 0 otherwise. The variable for the receiver is called *believing_sender* and is equal to 1 if the receiver's action is equal to the action that would be optimal if senders' message was in fact the true state, and 0 otherwise.

Telling_truth is designed to capture the informativeness of the sender's message strategy: if the sender is using a truthful strategy, the variable should be one; if the sender is uninformative it should be equal to 1/2.[9] Similarly, *believing_sender* is designed to describe the receiver's posterior beliefs: in fully revealing equilibria, we should expect it to be equal to one; in an uninformative equilibrium, it should be 1/2.[10]

In Table 6 we aggregate data for games of no conflict (games 1 and 2) and for games of conflict (games 3, 4, 5, and 6) and report the mean and the standard deviation for *telling_truth* and *believing_sender*. Theoretical values are presented in parentheses. Using the unpaired t-test we conclude that both senders' and receivers' strategies differ in games of no conflict and in games of conflict at 1% significance level (p-values = 0.000). In particular, senders pass more information to the receivers when their incentives are aligned, and receiver trust senders more in games of no conflict. Table 7 lets us take a closer look at strategies in different games of no conflict and in games of conflict. Senders' behavior is clearly in line with the theoretical prediction in games 1,2, and 5. Some aversion to lying, however is present in games 3, 4, and 6: H_0 : *telling_truth* = .5 is rejected with p-value 0.0001 for game 3 and with p-value 0.0329 for games 4 and 6. This phenomenon is in line with the findings of the previous literature on simple one-sender / one-receiver cheap talk reviewed in Section 1.1. Receivers do not appear to trust senders more (or less) than they should in games 1,2,3, and 4. This is evident in games 1 and 2. In games 3 and 4: H_0 : *believing_sender* = .5 is not rejected with p-value 0.3494 for game 3 and with p-value 0.2412 for game 4. There is however evidence for credulity in games 5 and 6: in both cases, we reject H_0 : *believing_sender* = .5 with p-value 0.000. The credulity bias we observe in the receivers' strategies is also consistent the findings in the literature of simple one sender-one receiver games, though less apparent than reported in this literature.[11]

The simple design of our experiment allows us to have a look at how individual strategies conform to the theoretical predictions. For each participant we gather information about their

[9] There may be a separating equilibrium in which the sender systematically reports the opposite of the true state. We will ignore this case, and there is no evidence in the experiment of these strategies.

[10] Here too we can have separating equilibria in which the receiver systematically chooses the opposite of the strategy recommended by the sender. We will ignore this case, and there is no evidence in the experiment of these strategies.

[11] A bias for credulity is observed in Cai and Wang (2006). The difference with their findings is probably due to the fact that our setting is simpler than the their setting, where a finite number of states (larger than two) is assumed.

Table 6: Two person games - summaries of the means

	telling_truth		**believing_sender**	
	mean	sd	mean	sd
No conflict	0.965 (1.0)	0.184	0.972 (1.0)	0.165
Conflict	0.601 (0.5)	0.491	0.694 (0.5)	0.461

Table 7: Two person games - means by game

	telling_truth		**believing_sender**	
Game	mean	sd	mean	sd
1	0.972 (1.0)	0.165	0.972 (1.0)	0.165
2	0.958 (1.0)	0.201	0.972 (1.0)	0.165
3	0.722 (0.5)	0.451	0.556 (0.5)	0.500
4	0.625 (0.5)	0.488	0.569 (0.5)	0.499
5	0.431 (0.5)	0.499	0.806 (0.5)	0.399
6	0.625 (0.5)	0.488	0.847 (0.5)	0.362

Table 8: Two person games - comparisons by game

telling_truth

	1	2	3	4	5	6
1		0.6517	0	0	0	0
2			0.0001	0	0	0
3				0.2162	0.0003	0.2162
4					0.0193	1
5						0.0193
6						

believing_sender

	1	2	3	4	5	6
1		1	0	0	0.0013	0.0086
2			0	0	0.0013	0.0086
3				0.8677	0.0012	0.0001
4					0.0021	0.0002
5						0.5126
6						

Table 9: Two person games - individual strategy profiles (out of the total of 48 subjects)

telling_truth

No Conflict	Truth			Mix			Lie		
Conflict	Truth	Mix	Lie	Truth	Mix	Lie	Truth	Mix	Lie
	10.4%	**75%**	4.2%	2.1%	8.3%	0	0	0	0

believing_sender

No Conflict	Trust			Mix			Deny		
Conflict	Trust	Mix	Deny	Trust	Mix	Deny	Trust	Mix	Deny
	20.8%	**68.8%**	2.1%	6.3%	2.1%	0	0	0	0

strategies in all rounds, then in Table 9 classify their strategies as a sender as"Truth," "Mix," or "Lie," depending on how often they tell the truth in games of conflict and of no conflict.[12] Similarly, we classify their strategies as a receiver as "Trust," "Mix," or "Deny" [13] in games of no conflict and in games of conflict. For example, an agent counted in the third sub-column ("Lie") of the first column ("Truth") is telling the truth with more than 80% probability in no conflict games, and with less than 20% probability in conflict games. According to the theory, in games of no conflict we should see that everybody is telling the truth and believing their partner, and in games of conflict everybody should mix. Thus, we expect all participants to be classified in the cell highlighted in bold. The evidence is obviously not as clear cut as the theoretical prediction, but we still find that most subjects choose strategies correctly according to this guideline: 75% of the senders, and 67% of the receivers. Because the majority of the deviations are in the "Truth-Truth" columns, Table 9 also provides another illustration of the fact that senders have a tendency to reveal the truth too frequently and the receivers tend to trust senders too much.

Despite theoretical predictions that all games of conflict have a unique pooling equilibrium, experimentally we find that not all games of conflict are the same. Table 8 presents p-values from the unpaired t-tests of equilibrium strategy comparisons for each pair of games and demonstrates that receivers choose different strategies in games 3&4 and games 5&6. For example, the fact that the cell in column 2, row 1 is large (.6517) implies that the null hypotheses that in games 1 and 2

[12]A sender is classified as a "Truth," "Mix," or "Lie" type if *telling_truth* is equal to 1 for, respectively, 80% or more, 20% to 80%, or 20% or less of the time.

[13]We use the same probability ranges as for the senders' strategies.

telling_truth is the same cannot be rejected with high confidence. On the other hand, the fact that the cell of column 4, row 2 is small (zero) signifies that the null hypothesis that *telling_truth* is the same in games 4 and 2 is rejected with high confidence. The difference between games 3&4 and 5&6 could possibly be attributed to the fact that the conflict is not as apparent in games 5&6 as it is in games 3&4. In games 5&6 receivers see that the conflict is only in one of the states, thus they may tend to believe the senders a lot more than in games 3 and 4. Moreover, from Table 8 we see that senders choose different strategies in games 3&4&6 and in game 5. While there is slight aversion to lying in game 6 (and in games 3&4), there is none in game 5. The difference between game 5 and game 6 could potentially be explained by subjects' lack of strategic sophistication. If subjects are pressed for time, or just inattentive, and only check whether or not there is conflict in the first state of the world (Heads), game 5 will look to them as a game of conflict while game 6 will look like a game of no conflict. Overall, we conclude that games 5 and 6 are cognitively more complicated compared to games 3 and 4, since in them it is not enough to just look at one of the states to determine whether or not this is a game of conflict. We will develop this issue further in Section 5 after discussing the results for 3-person games, where the lack of strategic sophistication is perhaps more evident.

5 Three person games

For the cheap talk games with two receivers we define the *telling_truth* variable for the sender as in the previous section. Receivers' actions are now described by two separate variables - *believing_sender1* and *believing_sender2* for receiver 1 and receiver 2 respectively. The conflict in the overall game is defined as before, i.e. whether or not there is a separating equilibrium for the sender: games 13 and 34 are games of conflict in which there is no informative equilibrium; while games 12, 23, and 56 are games of no conflict where there is an equilibrium where the sender fully reveals the state. Note that it is important to distinguish the roles of receiver 1 and receiver 2 because the games are not symmetric with respect to them. For example, according to the theory, in game 23 the sender is supposed to be truthful, and the receivers are supposed to believe him/her. For receiver 1 believing is optimal in game 2 (in which he is the only receiver), so believing is optimal even if receiver 2 is ignored. On the other hand, for receiver 2, believing is not an equilibrium in

Table 10: Three person games - summaries of the means

	telling_truth		**receiver 1 - believing**		**receiver 2 - believing**	
	mean	sd	mean	sd	mean	sd
No conflict	0.953 (1.0)	0.212	0.969 (1.0)	0.174	0.688 (1.0)	0.465
Conflict	0.680 (0.5)	0.468	0.383 (0.5)	0.488	0.695 (0.5)	0.462

Table 11: Three person games - means by game

	telling_truth		**receiver 1 - believing**		**receiver 2 - believing**	
Game	mean	sd	mean	sd	mean	sd
12	1.000 (1.0)	0.000	0.984 (1.0)	0.125	0.969 (1.0)	0.175
13	0.797 (0.5)	0.406	0.219 (0.5)	0.417	0.688 (0.5)	0.467
23	0.922 (1.0)	0.270	0.969 (1.0)	0.175	0.172 (1.0)	0.380
34	0.563 (0.5)	0.500	0.547 (0.5)	0.502	0.703 (0.5)	0.460
56	0.938 (1.0)	0.244	0.953 (1.0)	0.213	0.922 (1.0)	0.270

game 3 (where receiver 1 is not playing).

In the next two subsections we first present how equilibrium behavior in the 3 players' game changes when a separating equilibrium exists and when it does not; then we study the marginal effect of having a second receiver using the 2 players game as a benchmark.

5.1 Conflict and information revelation

The first column of Table 10 provides information on how the sender reacts to conflict in the 2-player games by aggregating the data in games with no conflict in which the theory predicts *telling_truth* $= 1$ and in games of conflict, in which the theory predicts *telling_truth* $= 1/2$. It is clear that the amount of truth telling is higher in the first class of games than in the second.[14] As an example, consider the mutual discipline game 56. In this case the sender is not supposed to report truthfully in private, that is in game 5 or in game 6. Indeed we find (Table 7), the expected value of *telling_truth* is 0.461 and 0.625 in games 5 and 6 respectively. When the message is public, and the sender is playing in the combined game 56 and truthful revelation is optimal: indeed *telling_truth* in game 56 is 0.938. Breakdown of the sender's mean strategies by game in Table 11 confirm this conclusion: senders reveal more information in the no conflict games, and

[14] Unpaired t-tests that compare the strategies in games of conflict vs. games of no conflict give p-values of 0.0000.

Table 12: Three person games - individual strategy profiles

telling_truth

No Conflict	Truth			Mix			Lie		
Conflict	Truth	Mix	Lie	Truth	Mix	Lie	Truth	Mix	Lie
	37.8%	**42.2 %**	8.9%	6.7%	0	4.4%	0	0	0

% out of the total of 45 subjects

believing_sender1

No Conflict	Trust			Mix			Deny		
Conflict	Trust	Mix	Deny	Trust	Mix	Deny	Trust	Mix	Deny
	14.6%	**56.3%**	20.8%	0	8.3%	0	0	0	0

% out of the total of 48 subjects

believing_sender2

No Conflict	Trust			Mix			Deny		
Conflict	Trust	Mix	Deny	Trust	Mix	Deny	Trust	Mix	Deny
	12.5%	**12.5%**	4.2%	31.3%	25%	10.4%	2.1%	2.1%	0

% out of the total of 48 subjects

the difference is statistically significant in all cases. Only in game 13 does the sender appear to report truthfully more than is predicted by the theory.

The analysis is less straightforward for the receivers. The second and third columns of Table 10 shows that while *believing_sender1* is significantly higher in no conflict games than in conflict games[15], *believing_sender2* is statistically the same.[16] Table 11 reveals that no difference in the second receiver's strategy is due to the fact that the second receiver does not trust in game 23 (which is a game of no conflict). On the other hand, receiver 1's behavior appears to be consistent with equilibrium predictions in all games. A possible explanation of this phenomenon, is that is in game 23 receiver 2 looks at the conflict between himself and the sender ignoring receiver 1. If receiver 2 ignores receiver 1, then he would play as in game 3, i.e. not trust the sender. We will explore this hypothesis in Section 6.

The results that emerge in the analysis of aggregate data are confirmed by the individual data.

[15]Unpaired t-tests that compare the strategies in games of conflict vs. games of no conflict give p-values of 0.0000.
[16]p-value of an unpaired t-test is 0.8827.

In Table 12 we classify each participant in terms of which strategies they use in each of the roles (sender, receiver 1, and receiver 2) and each type of the game (no conflict and conflict)[17]. The games with two receivers appear to be cognitively more complicated than the games with only one receiver: this can be seen by the fact that players are more uniformly dispersed across the possible strategy profiles, a sign of the fact that players are behaving less according to the theory. The equilibrium prediction is the mode of the distribution of players across strategy profiles for both the sender and receiver 1 (0.42% and 56% of the players respectively). Still, a large number of subjects fail to do so when they are in receiver 2's position (only 12.5% are in the equilibrium case). In summary, we find significant support in the data for Hypothesis 1 for both 2-person and 3-person games. On the other hand, the results for 3-person games are in contrast with the 2-player games, as we find much less evidence of excessive truthfulness in senders' strategies and credulity in receivers' strategies in the former class of games than we do in the latter.

5.2 The marginal effects of a second receiver

We now turn to the main question of the paper - what is the effect of a second receiver on a cheap talk communication? We can breakdown this question in two parts. First, does the sender's strategy change according to the theoretical prediction? Second, do receivers recognize that the sender's strategy has changed and change their behavior accordingly?

The first quadrant in Table 13 addresses the first question. The values in the table show the difference between the mean strategies in 3-person games and 2-person games. The rows in Table 13 correspond to the benchmark 2-person games and columns are the additional audience added to obtain a 3-person game. For example, the entry in the second row and third column is the difference between *telling_truth* in the 23 game and in the 2 game. The model predicts no difference in behavior, and indeed the difference reported is small and not statistically significant. On the contrary, the model predicts *telling_truth*$= 1$ in game 1 and *telling_truth*$= \frac{1}{2}$ in game 13. The extent to which this prediction is supported by the data can be verified by inspecting the entry in row 1 and column 3: as predicted, this entry is negative and statistically significant. Following a similar logic, we can interpret all the other ten values, that correspond to the ten possible marginal effects. When observed marginal effects are consistent with the theory, we write them in bold in Table 13.

[17] Again, we use 100-81%, 80-21% and 20-0% percentage intervals for classification

Table 13: Comparison between 2-person games and 3-person games

Telling_truth

	1	2	3	4	5	6
1	-	**0.0278**	$-$ **0.1753****	-	-	-
2	**0.0417**	-	$-$**0.0365**	-	-	-
3	**0.0747**	**0.1997****	-	$-$**0.1597**	-	-
4	-	-	$-$**0.0625**	-	-	-
5	-	-	-	-	-	**0.5069****
6	-	-	-	-	**0.3125****	-

Believing_sender

	1	2	3	4	5	6
1	-	**0.0122**	$-$**0.7535****	-	-	-
2	$-$**0.0035**	-	$-$**0.0035**	-	-	-
3	**0.1319**	-0.3837^{**}	-	$-$**0.0087**	-	-
4	-	-	**0.1337**	-	-	-
5	-	-	-	-	-	**0.1476****
6	-	-	-	-	0.0747	-

** p<0.01, * p<0.05

In all cases the results are consistent with the predictions. When behavior is different, the entries are different with the correct sign and statistically significant. When behavior is predicted to be the same, the differences in the entries are not statistically significant.

A similar analysis can be done for *believing_sender*. Of the ten possible cases, all but two are fully in line with the theoretical predictions. The theory predicts a statistically significant positive difference between *believing_sender2* in game 56 (*believing_sender2* $= 1$) and in game 6 (*believing_sender2* $= 1/2$). The difference in the entry of row 6 and column 5 has the correct positive sign, but this difference is not statistically significant at conventional levels[18]. A more interesting case is the comparison between game 23 and game 3. The theory predicts a statistically significant positive difference between *believing_sender2* in game 23 (*believing_sender2* $= 1$) and in game 3 (*believing_sender2* $= \frac{1}{2}$). The difference in the entry of row 3 and column 2, however, is negative and statistically significant. This suggests that receiver 2 is not believing the sender

[18]It is significant at 18% level.

more in 23 than in 3 (and in fact is believing less). As discussed in the previous section, an interpretation for this result is that receiver 2 looks at the conflict between himself and the sender ignoring receiver 1.

In summary, we find significant support in the data for Hypothesis 2. The evidence is in line with theoretical predictions in all of the ten cases for senders, and in eight over ten cases for receivers.

6 Deviations from equilibrium and learning

The discussion of the previous section shows that the marginal predictions of the model are supported by the data. Still, there are some obvious points of divergence in the data from the theory. When compared to Table 9, Table 12 makes it clear that subjects' behavior is more dispersed in the 3-person games, especially for receiver 2. This suggests that players find it harder to play it. This is not, perhaps, a surprising observation, since the 3-person games are considerably more sophisticated from a strategic point of view. The behavior of receiver 2 in game 23, in particular, diverges from the equilibrium: subjects in receiver 2's role behave as if they were in game 3 rather that in game 23. Although the evidence presented in Section 5.2 makes clear that players are strategic and internalize the presence of the second receiver, it is still possible to conjecture that they only partially internalize the strategic implications of the second receiver. Two sets of questions, therefore, seem relevant. First, to what extent players underestimate the impact of the second receiver, and focus too much on their "direct" relationship with the sender? Second, to the extent that players do underestimate this effect, to what extent does it persist over time?

6.1 Complexity of the game and strategic behavior

To address the first set of questions we study how the deviations from equilibrium behavior depend on the type of game that is played. The variables *mistake_of_receiver_i* and *mistake_of_sender* in game j measure the deviations from theoretical equilibrium: the first is the absolute value of the difference between the equilibrium probability of believing the sender and the empirical frequency of *believing_sender* in game j; the second is the absolute value of the difference between the equilibrium probability of revealing the true state, and the empirical frequency of *telling_truth* in game j.

Table 14 presents a regression where these measures of mistakes are regressed against a number of variables describing the characteristics of the game. Start by considering the last column ("all games"). The two regressions described in this column use data from both 2-person and 3-person games. *Conflict* is a dummy variable equal to one if it refers to a game of conflict; *3-person game* is a dummy equal to one if the game has 2 receivers; *period* is a control variable measuring the period. The clear finding is that players tend to make more mistakes in games of conflict than in games without conflict: for the sender and the receivers it is significantly positive at a 1% level. This suggests that games of conflict are more difficult to play than games without conflict. The second clear result is that receivers find 3-person games harder to play than 2-person games (the variable *3-person game* is positive and significant at a 1% level). Senders, on the contrary, do not seem to be affected by the numbers of receivers: for them the variable is not significant. The first and second columns of Table 14 focus on 2-person games and 3-person games and confirm the effect of the variable conflict described above.[19]

To further understand the relationship between mistakes and the complexity of the game, we introduce a variable that measures the complexity of game for two receivers, cog_i: it is 1 for receiver i if the conflict in the individual component game is different from the overall game. For example, game 13 is cognitively complicated for receiver 1, because he or she needs to consider *both* his own and receiver 2's component games: game 1 is a game of no conflict while the overall game 13 is a conflict game. In column (1) of Table 15 we report the result of a logit analysis where *mistake_of_receiver_i* is explained as a function of cog_i and other controls. Given the discussion of the previous section, it is not surprising that cog_i is always significant for receiver 2. This analysis also shows that after controlling for the period of the game, and the level of experience, the variable is significant for receiver 1 as well.[20] We can therefore conclude that there is evidence that players find the 2-receivers game more complicated to play, and that this complication is more pronounced in games that are in fact more complicated, i.e. with $cog_i = 1$. This suggests that receivers tend

[19]We will comment on the effect of the other control variables (*period*, *conflict experience*, and *experience as a sender*) in the next section, where we discuss learning effects.

[20]As it was mentioned before, the difference between receiver 1 and 2 is not due to the identity of the players (all agents are randomly and anonymously assigned to all the possible roles in the game), but due to the fact that the receivers' games are not symmetric.

Table 14: Learning regressions

	2-person games		3-person games		all games	
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	Mistake of Sender	Mistake of Receiver	Mistake of Sender	Mistake of Receiver	Mistake of Sender	Mistake of Receiver
Conflict	0.473**	0.466**	0.455**	0.333**	0.462**	0.377**
	(0.00963)	(0.00864)	(0.0108)	(0.0136)	(0.00688)	(0.00987)
Period	0.00420	-0.00719	-0.00269**	-0.00614**	-0.00176**	-0.00402**
	(0.00504)	(0.00452)	(0.000916)	(0.00115)	(0.000602)	(0.000854)
Conflict experience	-0.00803	0.0109				
	(0.00788)	(0.00707)				
Experience as a sender	0.000412	0.000412				
	(0.00215)	(0.00193)				
3-person game					0.00824	0.0651**
					(0.00683)	(0.0106)
Constant	0.0326**	0.0379**	0.0742**	0.234**	0.0534**	0.129**
	(0.0101)	(0.00910)	(0.0115)	(0.0145)	(0.00817)	(0.0129)
Observations	864	864	960	1,920	1,824	2,784
R-squared	0.812	0.847	0.651	0.243	0.730	0.347

Standard errors in parentheses
** p<0.01, * p<0.05

to underestimate the effect of the presence of a second receiver.

6.2 Learning

If it is true that subjects find that 3-person games are harder to play because of their complexity, then we should observe that learning is more pronounced in the 3-person games than in the 2-person games. Furthermore, we should expect to observe more learning for the receivers in games that are cognitively more complicated for them, that is in games with $cog_i = 1$ for receiver i. For the senders, we will control for both cog_1 and cog_2 to see if more learning occurs in cognitively complicated games.

In Table 14 we find that there are no significant learning effects in the 2-person games. In this table, *period* is a control for the period, the variable *conflict experience* is equal to the number of times that an agent has previously played a game of conflict, the variable *experience as a sender* measures the number of times an agent has played as a sender in previous periods. Not only the period variable, but also the other two measures of experience are insignificant. This is not surprising, since there are few mistakes in 2-person games, and subjects appear to play according to the equilibrium predictions.

Table 15: Learning regressions for 3-person games

	(1)			(2)			(3)			(4)		
Dependent Variable	Mistake of Sender	Mistake of Receiver 1	Mistake of Receiver 2	Mistake of Sender	Mistake of Receiver 1	Mistake of Receiver 2	Mistake of Sender	Mistake of Receiver 1	Mistake of Receiver 2	Mistake of Sender	Mistake of Receiver 1	Mistake of Receiver 2
Conflict	0.504***	0.467***	0.469***	0.499***	0.467***	0.467***	0.498***	0.469***	0.469***	0.504***	0.446***	0.496***
	(0.0155)	(0.00901)	(0.0287)	(0.0156)	(0.00899)	(0.0284)	(0.0157)	(0.00896)	(0.0281)	(0.0339)	(0.0191)	(0.0646)
Period				-0.00226**	-0.00185**	-0.00809***	-0.000337	0.000415	0.000816	0.0000	-0.000286	0.00241
				(0.000951)	(0.000774)	(0.00181)	(0.00141)	(0.00101)	(0.00247)	(0.00215)	(0.00113)	(0.00424)
Cog_1	-0.00781	0.0134		0.000396	0.0183**		-0.00961	0.0773***		-0.0108	0.0769***	
	(0.0117)	(0.00901)		(0.0122)	(0.00922)		(0.0241)	(0.0194)		(0.0249)	(0.0194)	
Cog_2	0.0742***		0.422***	0.0664***		0.409***	0.117***		0.604***	0.122***		0.622***
	(0.0155)		(0.0287)	(0.0158)		(0.0286)	(0.0247)		(0.0467)	(0.0328)		(0.0607)
Cog_1 x Period							0.00103	-0.00540***		0.00118	-0.00549***	
							(0.00199)	(0.00156)		(0.00212)	(0.00156)	
Cog_2 x Period							-0.00506***		-0.0188***	-0.00549*		-0.0204***
							(0.00190)		(0.00358)	(0.00284)		(0.00498)
Conflict x Period										-0.000592	0.00221	-0.00241
										(0.00285)	(0.00159)	(0.00521)
Constant	0.0000	0.0268***	0.0313	0.0255	0.0440***	0.122***	0.00379	0.0220*	0.0221	-0.0000	0.0296**	0.00415
	(0.0117)	(0.00637)	(0.0234)	(0.0158)	(0.00959)	(0.0309)	(0.0197)	(0.0115)	(0.0360)	(0.0269)	(0.0127)	(0.0529)
Observations	960	960	960	960	960	960	960	960	960	960	960	960
R-squared	0.656	0.744	0.234	0.659	0.746	0.250	0.661	0.749	0.271	0.661	0.750	0.271

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Therefore we can focus on learning in 3-person games. Let's first consider the behavior of receivers. In the second specification in Table 15, we control for the period, whether or not the current game is a game of conflict, and for cog_i. We find that the coefficients in front of the variable *period* are negative and significant, meaning that there are less mistakes over time, i.e. there is evidence of learning effects. Moreover, learning is more pronounced for receiver 2, which is not surprising give that subjects tend to make more mistakes in receiver 2's role compared to receiver 1's role. In the third specification in Table 15, we add an interaction effect $cog_i \times period$. This makes *period* not significant (essentially zero), while the coefficient in front of $cog_i \times period$ is negative and significant at the 1% level. This once again demonstrates that learning occurs in 3-person games that are most complicated.

Consider now learning of the sender in 3-person games. We simultaneously control for cog_1 and cog_2 and find (in the second specification in Table 15) that senders are more likely to make mistakes in games that are cognitively complicated for receiver 2 and that there is learning. The fact that senders tend to pay more attention to the game with the first receiver is interesting and can possibly contribute to higher number of mistakes by the second receiver. Since the coefficient in front of *period* is negative and significant, we observe learning. Adding interaction effects $cog_1 \times period$ and $cog_2 \times period$ demonstrates that learning for the sender occurs mostly in games with $cog_2 = 1$. Interestingly, in the fourth specification we find that after controlling for learning in cog_1 and cog_2 games, learning in just games of conflict disappears (the coefficient in front of $conflict \times period$ is not significant). This is because not all games of conflict are complicated. In fact only game 13 is cognitively complicated (and this effect is already accounted for in cog_2), and the other game of conflict - game 34 - is fairly straightforward with just a few mistakes in subjects' strategies. Thus, what matters for the amount of mistakes (and therefore for the high degree of learning) is the cognitive complexity of the game rather than the conflicting nature of a game.

The discussion in this section suggests that subjects' strategies in the 3-person game tend to become closer to the theoretical predictions over time. Learning is concentrated in the games that subjects find harder to play: that is the games with $cog_i = 1$ for receiver i and the games with $cog_2 = 1$ for the sender.

7 Conclusion

This article presents results from the first experimental study of cheap talk communication between one sender and multiple receivers. We find that despite the fact that subjects find games with multiple receivers cognitively more complicated than games with just one receiver, there is strong evidence that the effect of an additional audience on information transmission is in line with theoretical predictions. Furthermore, our analysis of learning suggests that mistakes in cognitively complicated games tend to disappear over time.

First, as a benchmark, we consider cheap talk communication between one sender and just one receiver. Our findings in this case are consistent to results reported in the previous literature.

In the second part of our experiment, we test the effect of adding another audience on information transmission. We find that in all cases the change in the sender's strategy is according to the theory, i.e. the senders reveal truth more frequently in case of one-sided discipline and mutual discipline, reveal truth less frequently in case of subversion, and do not statistically significantly change their strategy in case of full communication and no communication. Similarly, the marginal effects in the receivers' strategies are aligned with the theory in all but two cases.

Our analysis of mistakes in subjects' strategies and learning reveals that there are more mistakes and more learning in more complicated games. Thus, we find that since there are more mistakes in the 3-person games compared to 2-person games, there is more opportunity for subjects to learn in 3-person games. Indeed, receivers tend to learn more in games that are specifically complicated for them, i.e. in games with their own component game having a conflict when overall game does not (or vice versa). Similarly, the senders start by putting more weight on the game with the first receiver, but over time tend to learn to play according to the conflict in the overall game. Therefore, in cheap talk games with multiple audiences equilibrium strategies get closer to the theoretical predictions over time.

A Appendix

A.1 Instructions

Thank you for agreeing to participate in this research experiment on group decision making. During the experiment, we will require your complete and undivided attention, so please refrain from distractions such as outside books, homework, and internet. We also ask you to turn off your cell phones. It is important that you do not talk or otherwise communicate with any other participants. Raise you hand if you have any questions and one of us will come to you. Now please pull out the dividers to either side of your chair as far as they go to assure your privacy as well as the privacy of the other participants.

In this experiment you will be given an opportunity to earn money. How much you earn will depend on your decisions and the decisions of other participants. During the experiment you will be accumulating points, which will be exchanged for money at the following rate: 25 points = $ 1.00. All earnings will be paid in cash at the end of the session. You will be paid anonymously (no other participant will be informed of your earnings).

Part 1

This part of the experiment will consist of 18 decision rounds. Before each round the computer will randomly divide you into pairs. Hence, in each round your group consists of yourself and 1 other participant. In addition, for each group the computer will toss a fair coin such that there is an equal chance of getting Heads or Tails. Your and your partner's payoff for the round will depend on the outcome of the coin toss AND on the action. Here is a sample payoff structure:

[SHOW sample payoff tables here initial screen shot for each round]

Each of you will be assigned a role of an S-player or an R-player. In each group exactly one player will be assigned an S-role and one player will be assigned an R-role. If you are an S-player, you will observe the outcome of the coin toss and will have an opportunity to communicate it to the R-player. As an S-player, you will send a message whether the outcome of the coin toss is Heads or Tails, however, you are not required to provide truthful information to the R-player. The R-player will not observe the actual outcome of the coin toss, only the S-player's message about it. Finally, the R-player will choose action A or action B. Your final payoff for the round will be realized and reported to you.

In order to familiarize you with the experiment will go through two practice rounds together. Please do not click or input any information until you are instructed to do so. [To begin, please double-click on (z-leaf icon) on your desktop.] Remember that the first two rounds are the practice rounds, thus your payoff will not be counted towards the final earnings for the experiment. They will be followed by another 18 rounds with actual payoffs.

[Start practice rounds on server]

We are ready to begin. Each of you have been assigned a role [point out]. Here is the S-player's screen. Note that the outcome of the coin toss has been revealed to the S-player.

[slide]

And this is the R-player's screen. No information about the outcome of the coin toss is shown. If you are S-player, please select a message that is the same as your coin toss. If you are R-player, click OK.

[slide] [slide]

R-player now sees the message from S-player. If you are R-player, please select Action A. If you are S-player, click OK. Round summary and payoffs are then displayed to each player. [go through summary].

[slide]

Here are the round payoffs again for your reference. Please make sure you understand where your payoff is coming from. After you are done, please click OK to continue to the second practice round.

[Go through second practice round, now ask S-player to select opposite of his state and R-player select Action B]

Any questions?

Now we are going to complete a short quiz. Please answer all questions individually. If you have any questions, please raise your hand and one of us will come to assist you.

[start quiz]

We are now done with the quiz, and ready to begin Part 1 of the experiment.

[start part 2]

[DO PART 1 - 18 rounds]

Part 2

This part of the experiment will consist of 20 decision rounds. Now before each round the computer will randomly divide you into groups of three. Hence, in each round your group consists of yourself and 2 other participants. One participant in each group will be assigned an S-role and two participants will be assigned an R-role. Therefore, each of you will be randomly assigned a role of an S-player, R-player-1, or R-player-2. Just like before, for each group the computer will toss a fair coin such that there is an equal chance of getting Heads or Tails. If you are an R-player, your payoff will depend on the outcome of the coin toss AND your own action. If you are an S-player, your payoff will be determined as a sum of two numbers. The first number is calculated from the outcome of the coin toss AND action by R-player1. The second number is calculated from the outcome of the SAME coin toss AND action by R-player2. Here is a sample payoff structure:

[SHOW sample payoff tables here initial screen shot for each round]

If you are an S-player, you will observe the outcome of the coin toss and will have an opportunity to communicate it to the R-players. As an S-player, you will send the SAME message to both R-players whether the outcome of the coin toss is Heads or Tails. Again, S-player is not required to provide truthful information to the R-players. The R-players will not observe the actual outcome of the coin toss, only the S-players message about it. Finally, the R-player1 will choose action A1 or action B1, and the R-player2 will choose action A2 or action B2. Your payoff for the round will then be reported to you.

Any questions? Again, we start with two practice rounds, and they will be followed by 20 paying rounds. Please do not start until you are instructed to do so.

[start practice rounds]

[explain round 1: S-player selects the same message as the coin toss, R-player1 selects Action A1, R-player 2 selects Action A2]

[explain round 2: S-player selects opposite message. R-player1 selects Action A1, R-player 2 selects Action B2]

Any questions?

[Go through practice screen shorts, announce instructions to click to proceed]

We are now ready to proceed to PART 2 of the experiment. Any final questions?

Now we are going to complete a short quiz. Please answer all questions individually. If you have any questions, please raise your hand and one of us will come to assist you.

[start quiz]

We are now done with the quiz, and ready to begin Part 2 of the experiment.

[start Part 2]

[DO PART 2 - 20 rounds]

This is the end of the experiment. You should now see a screen, which displays your total earnings in the experiment. Please record this on the Earnings row of your payment receipt sheet. Also enter $10.00 on the show-up fee row. Add the two numbers and enter the sum as the total.

We will pay each of you in private in the next room in the order of your Subject ID numbers. Remember you are under no obligation to reveal your earnings to the other players.

Please put the mouse behind the computer screen and do not use either the mouse or the keyboard at all. Please be patient and remain seated until we call you to be paid. Do not converse with the other participants or use your cell phone. Thank you for your cooperation.

Could the person with subject ID number 0 please go to the next room to be paid. Please bring all your belongings with you, including your payment receipt sheet.

A.2 Sample Screenshots

Please see Figure 1 and Figure 2 for sample screen shots in 2-person and 3-person games.

Figure 1: Sample screenshot for a 2-person game

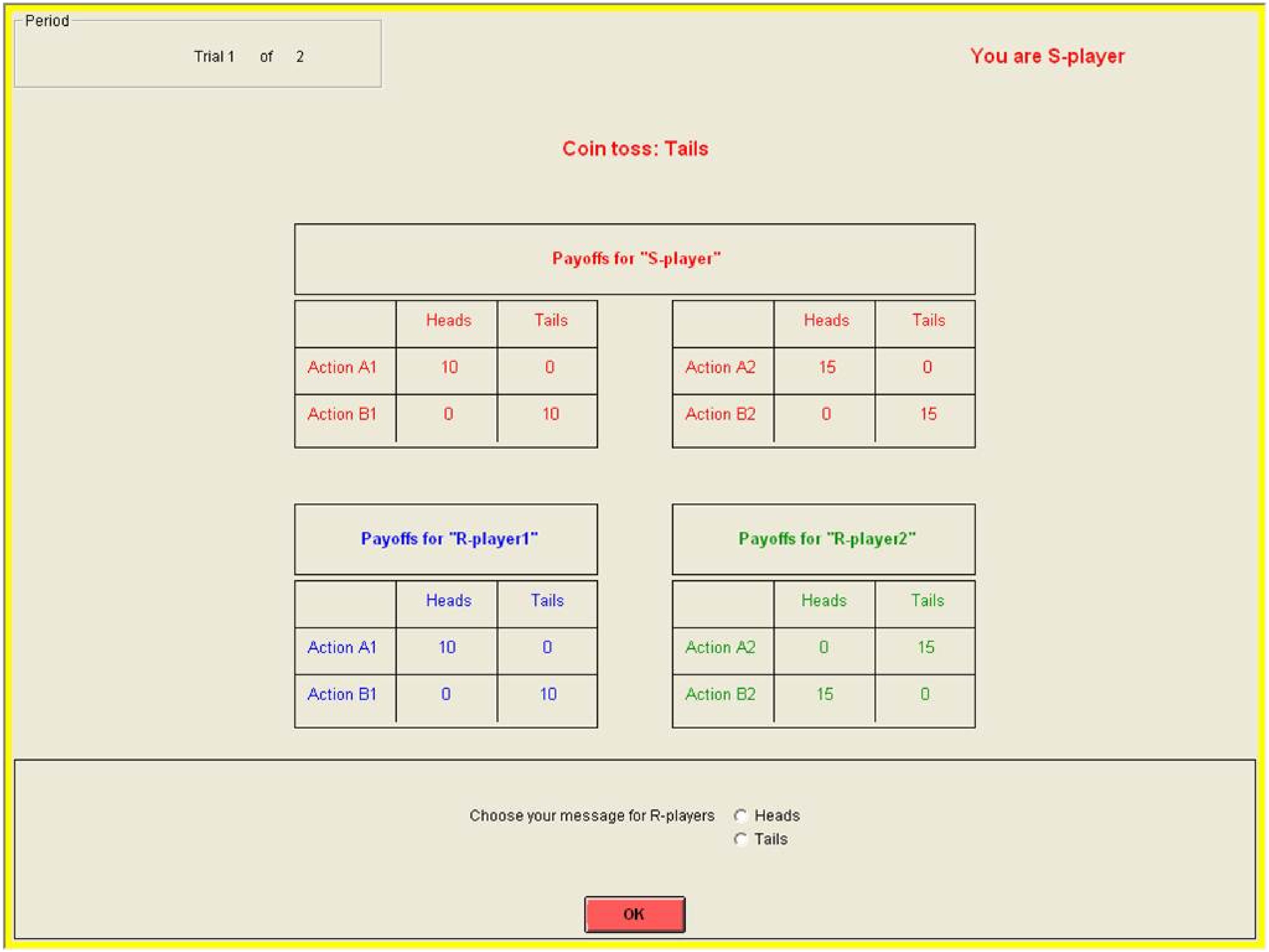

Figure 2: Sample screenshot for a 3-person game

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