Cheap Talk with Two Audiences: An Experiment*

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Abstract

In this paper we experimentally test strategic information transmission between one informed and two uninformed agents in a cheap talk game. We find evidence of the disciplining effect of public communication as compared to private; however, it is much weaker than predicted by the theory. Adding a second receiver naturally increases the complexity of strategic thinking when communication is public. Using the level-k model, we exploit the within subject design to show that receivers decrease their level-k in public communication. Surprisingly, we find that they become more sophisticated when they communicate privately with two receivers rather than one.

Keywords: Cheap Talk, Communication, Experiment, Level-k, Cognitive ability, Cognitive Reflection Test.

JEL Classification: C72; C92; D83.

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1 Introduction

Examples of strategic information transmission ("cheap talk") from an informed agent to an uninformed one abound and have been studied extensively since the seminal paper by Crawford and Sobel (1982). In a cheap talk model, one party, called "sender", has private information about the state of the world. He communicates this information to another party, called "receiver", by sending a costless, non-binding and non-verifiable message. The receiver then takes an action. The payoffs of both the sender and the receiver depend on the state and the taken action but not on the message sent.

In many instances, however, there is more than one receiver listening to the "talk". For example, a CEO talks to firm's investors and workers; a politician's speech is heard by voters and by leaders in other countries, a senior bureaucrat talks to politicians with different policy preferences. There are two key features present in all these cases. First, the sender might want to say different things to different receivers. A CEO may want to convince investors that the company is doing well, while he might wish to convey just the opposite to the workers to reduce the wage bill. Voters like populist and nationalistic gestures, while other countries' leaders prefer to deal with a reasonable and cooperative politician. Second, the sender can send messages publicly and/or privately. Public messages are heard by everybody, say, through press releases and public speeches while private messages are destined for a particular receiver only. For example, politicians may say something more belligerent to the public while they may defend a more moderate stance in private.[1]

In this paper, we conduct an experiment on a cheap talk model where the sender faces two receivers with preferences that are sometimes different from his own and from each other. We identify how communication with one receiver is affected by the presence of the other one when it is public. We find that subjects behave in a way which is broadly consistent with the theoretical predictions. In particular, talking to two receivers with opposing preferences improves communication due to the so-called "mutual discipline" effect. We also use the level-k model of non-equilibrium strategic thinking to explain individual behavior. Public communication is more complex than the private one. Exploiting the within subject design, we show that receivers decrease their level-k when communicating publicly.

Before presenting our experimental design, let us briefly comment on the related the-

[1]During the 2016 US elections Hillary Clinton's private speeches to bankers were leaked and showed a more moderate image than what she used in her campaign (The New York Times, 2016).

oretical literature. In a seminal paper Crawford and Sobel (1982) showed that despite messages being cheap talk, some information transmission is nevertheless possible provided that the sender and the receiver's preferences are not too apart. As the preferences of the sender and the receiver become closer, more information can be transmitted. Two papers studied cheap talk with two receivers. Farrell and Gibbons (1989) consider two states of the world and two possible messages. The sender either reveals the true state or lies. Depending on the parameters, there are three possible cases where public and private communication differ. First, one-sided discipline arises when the sender reveals the truth to only one receiver in private and reveals the truth in public. On the contrary, subversion arises when the sender does not reveal the truth in the public mode. Finally, under mutual discipline, the sender reveals the truth in the public mode but lies to either receiver in the private mode. Goltsman and Pavlov (2011) generalize this analysis to the continuous-state setup of Crawford and Sobel (1982). They show that, if the two receivers are equally important, the sender behaves as if there were a single receiver with a bias equal to the average bias of the two receivers.

Our experimental approach to study the effect of multiple audiences builds on the experiments on the standard (one sender - one receiver) cheap talk model of Cai and Wang (2006) and Wang, Spezio and Camerer (2010) which broadly confirm Crawford and Sobel (1982) main predictions. Our experimental design adds a second receiver to their design and considers the possibility of private and public communication with the receivers. In the private communication mode the sender sends a (private) message to each receiver, while in the public mode the sender sends a single (public) message to both receivers. For comparability with the previous experimental work, we use the same parameter values as in Wang, Spezio and Camerer (2010) and subjects first play a standard one-receiver cheap talk game.

In our experiment, we vary the sender bias(es) in a way to have a fully informative, a partially informative and a fully uninformative ("babbling") equilibrium in each of the three communication modes. In the one-receiver mode, our results are in line with the previous literature. In particular, as compared to the theoretical most informative equilibrium, there is less information transmitted when the preferences diverge significantly and there is more information transmitted when they are close. We then compare the private and public modes and find evidence of both mutual discipline and one-sided discipline/subversion.[2]

[2]In richer settings—such as the one we consider—than the two-state setting of Farrell and Gibbons (1989), the sharp distinction between one-sided discipline and subversion is lost and the two effectively

The experimental evidence on cheap talk (Dickhaut, McCabe and Mukherji (1995), Cai and Wang (2006), Kawagoe and Takizawa (2009) and Wang, Spezio and Camerer (2010) among others), confirm the main insight of Crawford and Sobel (1982), that is, the amount of information communicated decreases as the preferences of the sender and the receiver diverge. However, it has also documented over-communication, i.e., senders reveal more information and receivers trust senders more than predicted by the theory. These systematic deviations of the subjects' behavior from the theoretical predictions have been rationalized using the level-k model of non-equilibrium strategic thinking (Stahl and Wilson, 1994, 1995; Nagel, 1995).[3] The distribution of levels-k that we find in the one-receiver mode is similar to the ones found in Cai and Wang (2006) and Wang, Spezio and Camerer (2010).

Our within-subject design further allows us to explore the evolution of strategic thinking as we change the complexity of the game. Adding a second receiver and letting the sender communicate privately does not make the game more complex and we expect the distribution of levels to stay unchanged. Surprisingly, we find that receivers increase their level-k on average in the private mode. Our explanation is that in the private mode, where each player looks at the payoff tables of the two other players, it becomes even more salient to guess what other players would do and, therefore, to think strategically—but only for receivers who had been trying to decipher senders' messages while for senders the game has been entirely in their head.[4] Another potential explanation is that receivers learn even though no feedback is given since they observe the sequence of past messages; however, we do not find any evidence of learning within the modes.

become one case. If the sender has a small or zero bias with one receiver and a large one with the second, the communication in the public mode is somewhat in between the individual communications. There is less information transmitted than the sender transmits privately to the first receiver but more than he transmits privately to the second one.

[3]This non-equilibrium model of strategic thinking assumes that the population is partitioned into types that differ in their depth of reasoning. *L0* type is non-strategic which, in cheap talk games, means a truth-telling sender and a completely trusting receiver (Crawford, 2003). A higher *Lk* sender best responds to the belief that the receiver is *Lk-1*, while a *Lk* receiver best responds to the belief that the sender is of the same level.

[4]Costa-Gomes, Crawford and Broseta (2001) study subject initial responses to normal-form games and find a decline in equilibrium compliance in more complex games. This finding is also somewhat in line with recent experimental evidence that players change their strategic behavior depending on the characteristics of other players. The best known example is, arguably, Palacios-Huerta and Volij (2009) who find that the behavior of chess grandmasters in a standard centipede game is dramatically different depending on whether they face another chess grandmaster or a student. Closer to this paper, subjects are found to decrease their level-k in a beauty contest experiment when playing against a computer (Coricelli and Nagel, 2009 and Agranov et al. 2012) and against subjects with lower ability (Gill and Prowse, 2016 and Agranov et al. 2012). We are not aware of any evidence for cheap talk games.

In the public mode the game does become significantly more complex, as players now need to take into account the biases of both receivers when sending or interpreting the message. We expect subjects to decrease their level-k on average and that is exactly what receivers do despite the fact that the public mode is played last, i.e., the subjects have been longer in the game and might have learned more. While this finding is intuitive, ours is the first experiment where distributions of levels-k from two similar—and unambiguously ranked in terms of the complexity—games are compared.

Related literature There is by now a developed literature testing various models of strategic information transmission. First papers (Dickhaut, McCabe and Mukherji, 1995; Forsythe, Lundholm and Rietz, 1999) tested the key predictions of the original model of Crawford and Sobel (1982). The literature then looked at non-equilibrium behavior (Cai and Wang, 2006; Kawagoe and Takizawa, 2009; Wang, Spezio and Camerer, 2010), equilibrium selection and refinement (Kawagoe and Takizawa, 2009; de Groot Ruiz, Offerman and Onderstal, 2014; Lai and Lim, 2018), cheap talk with multiple senders (Lai, Lim and Wang, 2015; Minozzi and Woon, 2016; Vespa and Wilson, 2016), repeated cheap talk (Wilson and Vespa, 2020; Ettinger and Jehiel, 2021) and other extensions; see also Blume, Lai and Lim (2020) for a recent survey.

Battaglini and Makarov (2014) (BM14) is the closest paper to ours—the only one with an experiment on cheap talk with one sender and two receivers. They run an experiment very close to the model of Farrell and Gibbons (1989), that is, with two states/messages/actions. As in our experiment, their results are broadly consistent with theoretical predictions. Yet, there are multiple differences between their design and ours that make the two papers complementary.[5] Because of their two-state structure, there is no bias in the standard sense of Crawford and Sobel (1982) and hence, BM14 cannot test the prediction of Goltsman and Pavlov (2011)—that talking to two receivers is as if talking to one receiver with the average bias. Also, in BM14 in most "games"—configurations of payoffs—*L0* and *L2* behave in the same way. Hence, they do not present a distribution of levels-k but rather a distribution of behavior which takes just three forms, truth, mix and lie (see Tables 16-18 in BM14). Our five-state design allows to identify level-k of each subject and to compare their distributions between the modes.[6] Another important difference is that BM14 compare the one-receiver and public modes. Instead, we also run

[5] As BM14 say on p. 164 "An experimental test of a game with a richer state and strategy spaces would be an interesting direction for further research".

[6] BM14 use the "counting" way to identify levels while we employ the spike-logit analysis introduced by Costa-Gomes and Crawford (2006).

the private mode and show that, although theoretically it is identical to the one-receiver mode, in practice the players' behavior is quite different.

Finally, the literature studying the effect of cognitive abilities on strategic play (e.g., Brañas-Garza, García-Muñoz and Hernán González, 2012; Carpenter, Graham and Wolf, 2013; Gill and Prowse, 2016)—though not in cheap talk experiments—is also related. The subjects did the Cognitive Reflection Test (Frederick, 2005) at the end of the experiment. We find some inconclusive evidence that a higher performance on this test is associated with a higher level-k.

The rest of the paper is organized as follows. Section 2 describes the three communication modes, theoretical framework and our hypotheses. Section 3 presents the experimental design. The results are contained in Section 4: Section 4.1 describes the information transmission and Section 4.2 reports the analysis of the level-k model. Section 5 concludes. Appendix A contains additional tables. Appendix B contains experimental instructions, the understanding tests and screenshots.

2 Theoretical framework and hypotheses

Our experimental design is based on the standard cheap talk design (with one receiver) of Wang, Spezio and Camerer (2010). In order to compare our results with the previous literature, we first run their design with one receiver only (one-receiver mode). Then, with the same parameter specification, we add a second receiver. We let the sender communicate first privately with each receiver (private mode), and then publicly with both receivers at the same time (public mode). At the beginning of each round, the sender is informed about the true state of the world, s, which is uniformly distributed on $\{1, 2, 3, 4, 5\}$, and about bias(es), that is, the differences in preferences that he has with the receiver(s). The receiver(s) know the biases but do not know the realization of the state.

The sender sends a private message $m \in \{1, 2, 3, 4, 5\}$ to each receiver in the one-receiver and private modes. In the public mode, the sender sends a unique message m that is received by both receivers at the same time.[7] After observing the message m, (each) receiver takes an action $a \in \{1, 2, 3, 4, 5\}$. The utility of the receiver is $u_R(s, a) =$

[7]Following previous experiments on cheap talk, we assume that subjects use messages in their natural language meaning. This is based on two reasons: First, Blume et al. (2001) find that equilibrium messages tend to be consistent with their natural language meanings, and second, the communication protocol is highly structured.

$110 - 20|s-a|^{1.4}$. The receiver's ideal action is to match the state. The utility of the sender depends on the particular communication mode.

2.1 Benchmark: One-receiver mode

In this mode, the utility of the sender is $u_S(s,a) = 110 - 20|s-a+b|^{1.4}$ where b is the sender's bias. The sender prefers the receiver to take an action equal to the state plus the bias. As in Wang, Spezio and Camerer (2010), we use the following bias configuration: 0 (20% of rounds), 1 (40% of rounds) and 2 (40% of rounds).

Proposition 1 *Depending on the magnitude of bias b, the most informative equilibrium*[8] *of the one-receiver game is the following:*

- *If $b = 0$, a separating equilibrium: The sender truthfully reveals the state of the world s and the receiver follows the message by choosing an action equal to it.*
- *If $b = 1$, a partially pooling equilibrium: The sender sends a message equal to 1 when the state is 1. When the state is above 1, the sender sends messages from $\{2,3,4,5\}$ in a way such that any message is equally likely for each state. The receiver follows the message $m = 1$ by taking an action equal to 1 and takes action 3 or 4 otherwise.*
- *If $b = 2$, a babbling equilibrium: The sender sends messages from $\{1,2,3,4,5\}$ in a way such that any message is equally likely for each state; the receiver chooses 3 regardless of the message.*

When the bias is 0, the sender perfectly reveals the state and, consequently, the receiver believes him and takes the action that matches the message. When the bias is 2, the opposite happens: The sender's message is uninformative about the state and the receiver disregards it choosing $a = 3$ based on his prior beliefs. There are many different equilibrium messages that lead to this partition. For instance, the sender can send the same message (e.g., $m = 4$) in all the states or he can randomize over some messages, but in the same way for all the states. Finally, when the bias is 1 there is some but not perfect information transmission. The sender chooses action 1 when seeing message 1, and is indifferent between actions 3 or 4 otherwise.[9]

[8] As is standard in cheap talk models, there is always a babbling equilibrium whereby the sender sends an uninformative message which the receiver disregards. Following the literature, we focus on the most informative equilibrium.

[9] There also "non-robust" equilibria with partitions $[1,2],[3,4,5]$ and $[1],[2,3],[4,5]$ (the sender is indifferent in "border" states). Wang, Spezio and Camerer (2010) do not mention them.

2.2 Multiple audiences: Private and public modes

With two receivers, the utility of the sender becomes the average of the utilities from each receiver

$$u_S(s, a_1, a_2) = \frac{1}{2}\left(110 - 20|s - a_1 - b_1|^{1.4} + 110 - 20|s - a_2 - b_2|^{1.4}\right),$$

where a_i and b_i are the receiver i's action and the sender's bias with respect to receiver $i = 1, 2$. We use the following bias configurations for both modes: $(2, 2)$, $(0, 2)$, $(2, 0)$, $(-2, 2)$ and $(2, -2)$ for 20% of rounds each. The reasons behind this choice of biases are discussed at the end of this section.

In the private mode, the sender sends a private message to each receiver. In doing so, the sender takes into account only his bias with that particular receiver, and each receiver pays attention only to the sender's bias with respect to him and his message. Consequently, this game is equivalent to the standard one-receiver game and hence, Proposition 1 applies.[10]

In the public mode, the sender sends a single message that is observed by both receivers. This is the setting studied by Goltsman and Pavlov (2011). They show that the sender behaves as if there were a "representative" receiver with the bias equal to the average of the two biases. Thus, when biases are $(0, 2)$, the average bias is 1, when the biases are $(-2, 2)$, the average bias is 0 and when the bias combination is $(2, 2)$, the average bias is 2. The next proposition follows.

Proposition 2 *Depending on the magnitude of biases b_i and b_j, the most informative equilibrium of the public communication game is:*

- *If $(b_i, b_j) = (-2, 2)$, a separating equilibrium equivalent to the one in Proposition 1 for $b = 0$.*
- *If $(b_i, b_j) = (0, 2)$, a partially pooling equilibrium equivalent to the one in Proposition 1 for $b = 1$.*
- *If $(b_i, b_j) = (2, 2)$, a babbling equilibrium equivalent to the one in Proposition 1 for $b = 2$.*

In the language of Farrell and Gibbons (1989), the bias combination $(-2, 2)$ corresponds to the case of "mutual discipline". Indeed, with private communication the sender

[10] The case of a negative bias is symmetric to the one of a positive bias with the same absolute value. Thus, when the bias is -2 there is only babbling equilibrium as in the case of bias equal to 2.

would send the same message to each receiver regardless of the state; while communicating publicly makes the sender tell the truth. With the bias combination $(2, 2)$ there is "no communication" in neither the private nor the public modes. Their case of "one-sided discipline" or "subversion" corresponds to the bias combination of $(0, 2)$. Under public communication, the amount of information transmitted should be larger than when the sender is privately communicating with the receiver of bias 2, but smaller than with the one of bias 0. If the amount of information is large enough we will have one-sided discipline, otherwise we will have subversion.

Finally, we chose these bias combinations so that the average bias is 0, 1 or 2 and hence we are able to compare the public mode to the one-receiver mode and private modes testing the predictions of Goltsman and Pavlov (2011). The two other options, $(0, 0)$ and $(1, 1)$, were deemed not to be interesting enough given the length of the experiment.

2.3 Hypotheses based on equilibrium behavior

We are now ready to summarize our first hypothesis implied by the theory above.

Hypothesis 1 *Equilibrium behavior.*

(i) *No communication.* When the bias configuration is $(2, 2)$, there is no information transmission in both private and public modes.

(ii) *Mutual discipline.* When the receivers' preferences differ from those of the sender in opposite directions $(-2, 2)$, there is no information transmission in the private mode. In the public mode, there is mutual discipline and the sender reveals the true state of the world.

(iii) *One-sided discipline / subversion.* When the receivers' preferences differ from the sender's in the same direction but to a different extent, $(0, 2)$, in the private mode the sender communicates truthfully with the receiver of bias 0 and does not communicate with the one of bias 2. In the public mode the quality of communication is intermediate and can be either closer to a one-sided discipline or subversion.

2.4 Level-k model of strategic thinking

The level-k model of strategic thinking has successfully explained out-of-equilibrium behavior in many classes of games including cheap talk games.[11] It is a non-equilibrium model of strategic thinking, which assumes that each player follows a rule drawn from a common distribution over a particular hierarchy of decision rules. Type *Lk* anchors its beliefs in a nonstrategic *L0* type (for cheap talk games, this is the truth-telling sender type), which is meant to describe *Lk*'s model of others' instinctive reactions to the game. *Lk* then adjusts its beliefs via thought experiments with iterated best responses: *L1* best responds to *L0*, *L2* to *L1*, etc. More precisely, in a cheap talk game, an *L0* sender tells the truth, and an *L0* receiver best responds to an *L0* sender by following the message. An *L1* sender best responds to an *L0* receiver by inflating the message (stating his/her preferred states), and an *L1* receiver best responds to an *L1* sender by discounting the message. And so on. Table 1 summarizes the *Lk* type behavior for both senders and receivers.

Following Costa-Gomes and Crawford (2006), we also define a sophisticated type as the one which best responds to the probability distribution of other subjects' decisions (denoted *SOPH*), see Table A1 in Appendix A. The messages and actions of the equilibrium type of senders and receivers, respectively, are specified in Proposition 1. For senders, any message for any state when $b = 2$ and any message above 2 for any state above 2 when $b = 1$ is compatible with the equilibrium. The identification of the equilibrium type has to be based on a very small subset of data—on which it coincides with the L0 type. For receivers, there are very few equilibrium types and we do not look at them separately.[12]

Besides computing the level-k distribution of our subjects, our within-subject design allows us to track the individuals' level across treatments. The private mode does not really add complexity to the game so we anticipate that the subjects will play according to the same level-k as in the one-receiver mode (and in the previous literature). However, making the sender communicate publicly naturally increases the complexity of the game significantly as the subjects now need to take into account both biases when sending and interpreting the message. Accordingly, we expect that the subjects decrease their level-k.

[11] See Nagel (1999) for an early overview and Crawford, Costa-Gomes and Iriberri (2013) for a more recent one.

[12] Cai and Wang (2006) bunch equilibrium and *L2* receiver types together while Wang, Spezio and Camerer (2010) perform all their analysis only for senders.

Table 1: Level-k messages and actions

Sender message (condition on state)						Receiver action (condition on message)					
State	1	2	3	4	5	Message	1	2	3	4	5
$b = 0$ (in one-receiver and private modes) or $b_i = -2$ and $b_j = 2$ (in public mode)											
All types	1	2	3	4	5	All types	1	2	3	4	5
$b = 1$ (in one-receiver mode) or $b_i = 0$ and $b_j = 2$ (in public mode)											
L0 sender	1	2	3	4	5	*L0* receiver	1	2	3	4	5
L1 sender	2	3	4	5	5	*L1* receiver	1	1	2	3	4,5
L2 sender	3	4	5	5	5	*L2* receiver	1	1	1	2	4
$b = 2$ (in one-receiver and private modes) or $b_i = 2$ and $b_j = 2$ (in public mode)											
L0 sender	1	2	3	4	5	*L0* receiver	1	2	3	4	5
L1 sender	3	4	5	5	5	*L1* receiver	1	1	1	2	4
L2 sender	4,5	5	5	5	5	*L2* receiver	1	1	1	1	3
$b = -2$ (in private mode)											
L0 sender	1	2	3	4	5	*L0* receiver	1	2	3	4	5
L1 sender	1	1	1	2	3	*L1* receiver	2	4	5	5	5
L2 sender	1	1	1	1	1,2	*L2* receiver	3	5	5	5	5

Hypothesis 2 *Level-k behavior.*

(i) Subjects play according to the same level-k in the one-receiver and private modes.

(ii) Subjects decrease their level-k in the public mode as compared to the private mode.

3 Experimental design

We ran twelve sessions with 168 subjects (56 senders and 112 receivers) at a major Spanish university. Subjects were recruited from undergraduate and graduate students for a three-hour experiment, though the real time was closer to two hours and a half. We excluded those who had participated in any experiment during the previous few weeks. Each session had only new subjects.

All the sessions contained the three communication modes. First, subjects played the one-receiver mode for 10 rounds; they then played the private mode for 20 rounds and, finally, they played the public mode for 20 rounds. Before starting the one-receiver and private modes, subjects were given instructions with detailed explanations about the one-receiver and two-receiver games, respectively. After reading the instructions, subjects took a test to ensure that they understood the instructions and the layout of the payoff matrices (see Appendix B). Subjects were not allowed to continue to the next question unless they were answering the previous one correctly.

Subjects received no feedback during play to suppress experience-based learning and experimentation.[13] Clearly, introspective learning could still have occurred and receivers, upon seeing a lot of messages $m = 5$, could deduce that senders were not truthful. We tested for within mode learning effects by comparing how subjects play in the first half and in the second half of the same mode and found no significant difference in the play. Roles were kept fixed and subjects were randomly matched in each round to avoid repeated-game effects. States were randomly generated in each round and we used a pre-specified composition of different biases in each mode.

At the end of the experiment, subjects did the Cognitive Reflection Test (Frederick, 2005) and answered a standard questionnaire on their background. The payment consisted of an attendance fee, plus a performance part that was computed using the subjects' total payoff from all the rounds. The average subject payment was 18.60€, including the

[13]This design aims at disentangling learning from sophistication by eliciting initial responses and has been used in a large number of studies before. See, for instance, Stahl and Wilson (1994, 1995), Costa-Gomes, Crawford and Broseta (2001) and Costa-Gomes and Crawford (2006). In the words of Costa-Gomes, Crawford and Broseta (2001), in order to study "sophistication in its purest form" it is needed to elicit "subjects' initial responses to a series of (...) games, with different partners and no feedback to suppress learning and repeated-game effects as much as possible." (p. 1198). Note that although Wang, Spezio and Camerer (2010) did provide feedback, the results of our one-receiver mode are very close to theirs, see Table 2.

attendance fee 5€.

4 Results

4.1 Information transmission

The experimental literature has measured information transmission in terms of correlations. The correlation between the states (S) and the messages (M) shows the informativeness of the sender's messages. The correlation between the messages and the actions (A) measures how "trusting" the receiver is. Overall, the information transmission is measured by the correlation between the states and the actions. Table 2 reports these correlations for the one-receiver mode. In particular, the correlations between states and actions for all the possible biases are all statistically different from the ones predicted by the theory. We find that when the bias is 2 there is more information transmission even though only a babbling equilibrium exists. Conversely, when the bias is either 0 or 1, there is less information transmission as compared to the theoretical predictions. These results are in line with those of Wang, Spezio and Camerer (2010), which are reported in squared brackets.

Table 2: One-receiver mode^{+}

Bias	r(S,M)	r(M,A)	r(S,A)	Predicted r(S,A)
0	0.85 [0.94]	0.82 [0.94]	0.68** [0.88]	1
1	0.53 [0.51]	0.58 [0.61]	0.31** [0.35]	0.71
2	0.30 [0.23]	0.44 [0.63]	0.18** [0.28]	0

* (**) – statistically different from predicted at 5% (1%). The standard errors are clustered at the level of sender-receiver pair. Only column r(S,A) is tested against its theoretical counterpart.
\+ Non-eyed tracked correlations from Wang, Spezio and Camerer (2010) in squared brackets.

In Table 3, we compare the correlations of the one-receiver mode, when the bias is 2, with the correlations of the private and public modes with biases $(2, 2)$. Hypothesis 1(i) says the correlations should be the same in all three modes. Our results are in line with the theory, in that the correlation between the state and the action in the one-receiver mode is not statistically different from the one in the private mode (*p-value 0.3*). The same is true for the comparison between the private and public modes (*p-value 0.13*). Our results thus support Hypothesis 1(i).

Interestingly, unlike in the one-receiver mode, information transmission in the private and public modes is in line with the theory as the correlation is not significantly different from zero (it is significantly different from the one in the one-receiver mode (*p-value* = 0.01)). The change in the information transmitted between the two modes is driven by the senders, i.e., the correlations between the messages and actions are almost the same in both modes, while the correlation between states and messages decreases significantly in the public mode. One possibility is that, even though the players receive no feedback, the senders learn to play more in line with equilibrium as they go through the different modes.[14]

Table 3: Mode equivalence

Biases (2,2)	r(S,M)	r(M,A)	r(S,A)	Predicted r(S,A)
Private mode	0.27	0.37	0.09	0
Public mode	0.20	0.43	0.02	0
One-receiver mode ($b = 2$)	0.30	0.44	0.18**	0

* (**) – statistically different from predicted at 5% (1%). The standard errors are clustered at the level of sender-receiver pair. Only column r(S,A) is tested against its theoretical counterpart.

We now turn to Hypothesis 1(ii). According to the theoretical prediction, when the biases are $(-2, 2)$, the sender does not transmit any information to either receiver in the private mode. In the public mode, however, there is "mutual discipline" and the sender sends a message as if he/she was facing a single receiver with the bias equal to the average of -2 and 2, which is 0. Thus, the sender should reveal the truth and the receivers should believe it. The results of our experiment are displayed in Table 4. We observe that no information transmission in the private mode as predicted by the theory; the correlations are not significantly different from zero. We find some evidence of mutual discipline arising with public communication, the correlation being 0.32; however, it is much weaker than the full information transmission predicted by the theory. Surprisingly, we observe much less information transmission in the public mode than in the theoretically equivalent one-receiver mode with bias 0.[15] This suggests that subjects fail to fully understand the mutual discipline effect.

[14] This is in line with our level-k analysis, see Section 4.2.

[15] They are significantly different with a *p-value* < 0.001.

Table 4: Mutual Discipline

Biases $(2, -2)$	r(S,M)	r(M,A)	r(S,A)	Predicted r(S,A)
Private mode, $b = 2$	0.22	0.26	0.03	0
Private mode, $b = -2$	0.19	0.48	0.05	0
Public mode	0.55	0.59	0.32**	1
One-receiver mode $(b = 0)$	0.85	0.82	0.68**	1

* (**) – statistically different from predicted at 5% (1%). The standard errors are clustered at the level of sender-receiver pair. Only column r(S,A) is tested against its theoretical counterpart.

Finally, we turn to Hypothesis 1(iii) regarding the case of one-sided discipline / subversion in Table 5. The correlation between states and actions for the private mode (0.16 for the receiver with bias 2 and 0.73 for the one with bias 0) are in line with what we find in the one-receiver mode in Table 2 (0.18 and 0.68, respectively). As predicted by the theory, the sender communicates more truthfully with the receiver of bias 0 than with the one of bias 2. In the public mode, the quality of the communication is intermediate (0.51) and less than predicted by the theory (0.71). Surprisingly, we observe more communication than in the theoretically equivalent one-receiver mode with bias equal to 1.[16]

Table 5: One-sided discipline/Subversion

Biases $(0, 2)$	r(S,M)	r(M,A)	r(S,A)	Predicted r(S,A)
Private mode, $b = 2$	0.23	0.46	0.16**	0
Private mode, $b = 0$	0.85	0.85	0.73**	1
Public mode	0.72	0.71	0.51**	0.71
One-receiver mode $(b = 1)$	0.53	0.58	0.31**	0.71

* (**) – statistically different from predicted at 5% (1%). The standard errors are clustered at the level of sender-receiver pair. Only column r(S,A) is tested against its theoretical counterpart.

The comparison between the public and the one-receiver mode allows us to test the prediction of Goltsman and Pavlov (2011). They predict that under public communication a sender only takes into account the average bias of the receivers and acts as if there were a unique receiver with this "effective" bias. We find that the behavior of the senders

[16] They are significantly different with a *p-value* < 0.001.

is different. The senders under-communicate relative to the communication in the one-receiver mode when the "effective" bias is 0 and 2.[17] In contrast, when the average bias is 1, the senders over-communicate with respect to the one-receiver mode.

One possible explanation for this non-monotonic behavior is the presence of bias 0 with one of the receivers. This only happens when the average bias is 1.[18] In this case it is possible that the sender thinks that he cannot convince the receiver with bias 2 and puts an effort into at least convincing the one with bias 0. The sender effectively places a larger weight on the receiver with bias 0; the receivers correctly anticipate it and, as a result, there is more information transmission.

4.2 Level-k analysis

In assigning a level-k to subjects, we use the "spike-logit" error structure introduced by Costa-Gomes and Crawford (2006). It is assumed that each subject plays a certain level-k with probability $1 - \varepsilon$ (the "spike" of probability) while they make mistakes with probability ε. In case of the senders, the mistakes follow this logit error density:

$$d^k(m, \lambda|s) = \frac{\exp[\lambda U_S^k(m|s)]}{\sum_{\mu \neq t^k} \exp[\lambda U_S^k(\mu|s)]},$$

where $U_S^k(m|s)$ is the expected payoff of the sender when the underlying state is s and the message sent is m and λ is a parameter reflecting the relative cost of different mistakes. $U_S^k(m|s)$ is equal to $\sum_{a=1}^5 u_S(s,a) f^k(a|m)$ in one-receiver mode and to $\sum_{a_1=1}^5 \sum_{a_2=1}^5 u_S(s, a_1, a_2) f^k(a_1|m) f^k(a_2|m)$ in the private and public modes, where $f^k(a|m)$ is the belief of the level-k sender about receiver's actions upon seeing message m. The density in the case of receivers $d^k(a, \lambda|m)$ is defined analogously.

Tables 6 and 7 and Figures 1 and 2 present the level-k distribution for senders and receivers, respectively. Tables A3, A4, A5 and A6 in Appendix A report transition matrices between the modes.

In order to test Hypothesis 2 (subjects play according to the same level-k in the one-receiver and private modes but decrease it in the public mode), we first run the non-parametric Wilcoxon signed-rank test.[19] We then regress the level-k on modes, performance on the Cognitive Reflection Test (Frederick, 2005) and demographic variables.

[17] See Tables 3 and 2, respectively.

[18] In the other two cases the biases of the receivers are either 2 or -2.

[19] More standard Kolmogorov-Smirnov and Wilcoxon–Mann–Whitney tests cannot be used because they assume independent samples.

Table 6: Senders' level-k distribution

Level/Mode	One receiver	Private	Public
L0	16%	14%	21%
L1	32%	23%	38%
L2	38%	59%	23%
SOPH	14%	4%	18%
Total	100%	100%	100%

Table 7: Receivers' level-k distribution

Level/Mode	One receiver	Private	Public
L0	20%	22%	28%
L1	40%	14%	33%
L2	20%	30%	11%
SOPH	21%	33%	29%
Total	100%	100%	100%

Hypothesis 2(i) predicts that the levels-k do not change between the one-receiver and private modes. Among 56 senders, a majority (31 or 55%) were classified with the same level-k, 13 senders (23%) were classified as a higher level-k in the private mode than in the one-receiver mode, and 12 senders (21%) were classified as a lower level-k in the private mode, see Table A3. The Wilcoxon signed-rank test also points that there is no significant difference between the two modes (*p-value* 0.8681).

Among 112 receivers, 45 (i.e., 40%) were classified with the same level-k in the one-receiver and private modes; 41 (37%) were classified as a higher level-k in the private mode as compared to the one-receiver mode, and 26 (23%) were classified as a lower level-k in the private mode, see Table A4. The Wilcoxon signed-rank test shows a significant difference between the two modes (*p-value* 0.0244).

In Table 8, we present the regression results of the effect of modes on the level-k which confirm the results above. The excluded mode is the private mode. For senders the dummy for the one-receiver mode is statistically insignificant while for the receivers

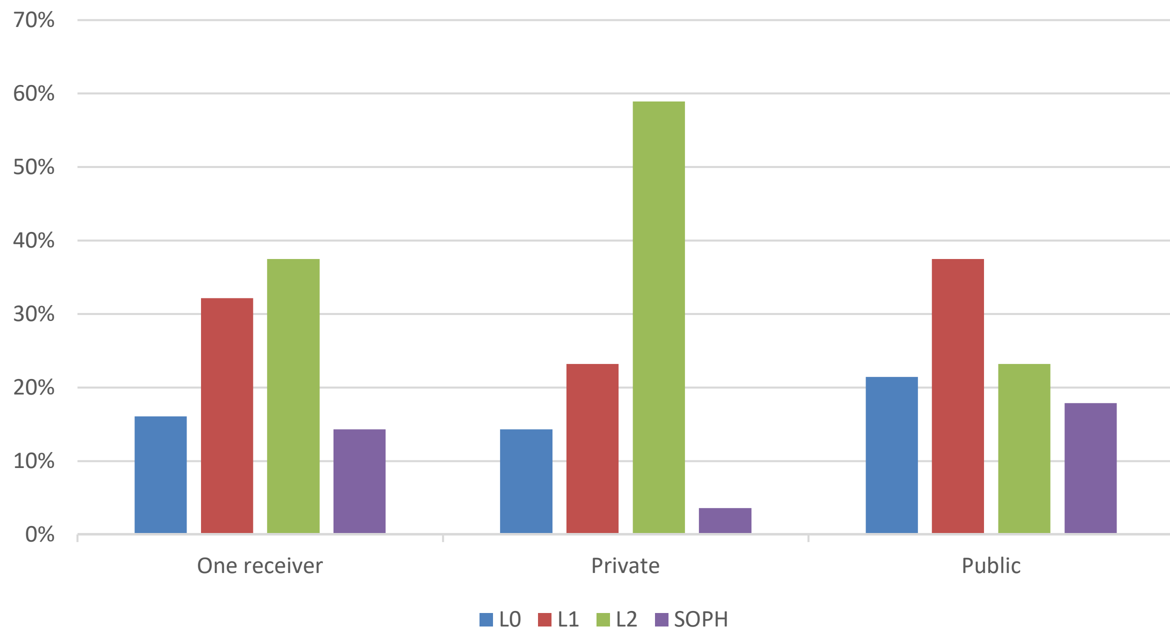

Figure 1: The distributions of the senders' levels-k in the three modes.

it is significant and negative.[20] Thus, Hypothesis 2(i)—that the level-k does not change between the one-receiver and private modes—is rejected for receivers and not rejected for senders. The level-k of receivers is on average higher in the private mode than in the one-receiver mode although no feedback was given and theoretically there are no differences between these two modes.

Let us now turn to Hypothesis 2(ii)—that subjects decrease their level of strategic thinking in the public mode relative to the private mode. Among 56 senders, 19 (i.e., 34%) did not change their level-k, 16 (29%) increased the level-k and 21 (38%) decreased their level-k, see Table A5. The Wilcoxon signed-rank test shows that there is no significant difference between the two modes (*p-value* 0.8339).

[20]Table A2 presents the ordered logit specification of the same regression with qualitatively similar results, for both senders and receivers. The only difference is that the performance on the CRT test (The Cognitive Reflection Test, Frederick, 2005) is not significant in the OLS specification in Table 8 while it is in the logit specification in Table A2. The latter speaks to the findings in the literature (e.g., Brañas-Garza, García-Muñoz and Hernán González, 2012; Carpenter, Graham and Wolf, 2013; Gill and Prowse, 2016) that higher cognitive abilities lead to a more strategic play. We prefer the standard OLS specification of Table 8 because ordered logit imposes more structure on the data and its coefficients are harder to interpret.

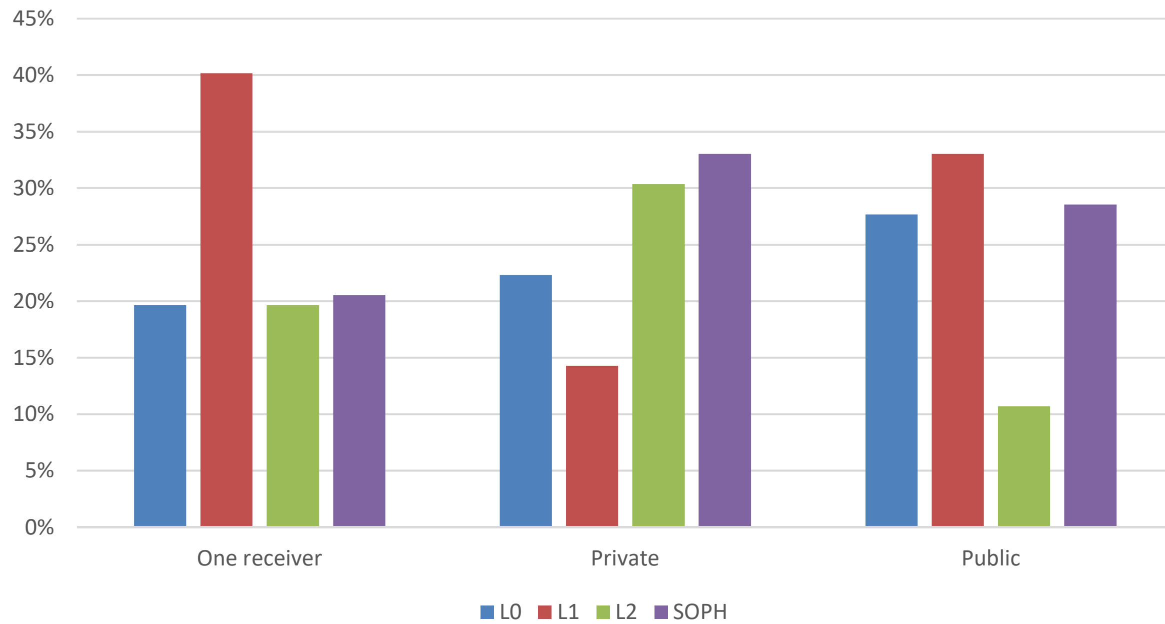

Figure 2: The distributions of the receivers' levels-k in the three modes.

Among 112 receivers, 36 (i.e., 32%) were classified with the same level-k in the private and public modes; 20 (18%) were classified as a higher level-k in the public mode as compared to the private mode, and 38 (34%) were classified as a lower level-k in the public mode, see Table A6. The Wilcoxon signed-rank test shows a significant difference between the two modes (*p-value* 0.0211).

The regression in Table 8 shows the same result. For senders the dummy for the public mode is statistically insignificant while for the receivers it is significant and negative. Thus, Hypothesis 2(ii)—that the level-k decreases from the private to the public mode—is rejected for senders and not rejected for receivers. The level-k of receivers is on average lower in the public mode than in the private mode.

Hence, in our experiment senders play the same level-k in the three modes while receivers first increase it from the one-receiver mode to the private one and then decrease it in the public mode. Our preferred explanation for this difference between senders and receivers is the following. For senders, the game is entirely in their head. Since there is no feedback, they do not see any actions of the receivers and hence, they do not adjust their strategies much. For the receivers the situation is different. First, they have to

Table 8: The effect of modes, performance on the CRT and demographic variables on the level-k

	(1)	(2)
VARIABLES	Senders	Receivers
One-receiver mode	0.304	-0.673**
	(0.288)	(0.022)
Public mode	0.286	-0.482*
	(0.349)	(0.066)
CRT	0.121	0.342
	(0.709)	(0.288)
Understanding test	-0.00212	0.0310
	(0.966)	(0.382)
Age	0.0459	0.0125
	(0.247)	(0.814)
Male	0.478	-0.0988
	(0.139)	(0.753)
Constant	0.259	2.199*
	(0.763)	(0.063)
Observations	168	330
R-squared	0.038	0.022

Robust p-values in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% levels. Standard errors are clustered at the subject level. The base mode is the private mode. CRT is a dummy variable that takes value 1 if the subject has answered at least one CRT question correctly. "Understanding test" is the number of mistakes in the understanding test.

make a choice based on the message deliberately sent by a sender—somebody in the same room. This naturally makes them think more "in the opponent's shoes". As can be seen in Figures 1 and 2 there are many more receivers playing sophisticated than senders. Second, they see the messages sent by the senders and after seeing a lot of high messages such as 4 and 5 they realize—if they did not understand it before—that senders do not send messages truthfully. Facing the public mode, however, their strategic thinking gets naturally less deep as this is a more complex setting.

While it seems intuitive that subjects should play according to a lower level-k in a more complex game, our experiment is the first one to test this in the same game, to the best of our knowledge. Comparing different experiments in terms of complexity can be difficult as it is not clear how this is to be measured. In our experiment the public mode is objectively more complex than the private one and yet it is similar enough to make a comparison meaningful.

Finally, our experiment highlights that comparing the one receiver mode with the public mode (as it is done in BM14) it is not an accurate test of the cheap talk game with multiple audiences. In particular, receivers behave differently in the one-receiver and in the private modes. Perhaps because in the private mode they are prompted with 4 payoff tables (as opposed to 2), they end up thinking more strategically even if theoretically this should not be the case. Our experiment, by running the three specifications, allows us to understand these differences.

5 Conclusion

In this paper we experimentally tested the two-receiver cheap talk model, building on the models of Farrell and Gibbons (1989) and Goltsman and Pavlov (2011). Using the design and specification of a standard (one-receiver) cheap talk experiment by Wang, Spezio and Camerer (2010) as the first mode, we are able to check the consistency of our experiment with the previous literature and, having established it, be sure that our results are not driven by some unusual design features.

We find that subjects behave in a way which is broadly consistent with the theoretical predictions. In particular, talking to two receivers with opposing preferences improves communication due to the so-called "mutual discipline" effect. When the preferences of one receiver are aligned with the sender, while the preferences of the other differ greatly, talking publicly produces communication at an intermediate level as compared to private communication; this corresponds to the one-sided discipline / subversion case.

We then turned to the level-k analysis of the subjects' behavior. While the senders did not change their level-k across the three modes the receivers did. First, they played a higher level-k in the private mode even though it is theoretically the same as the standard one-receiver mode. Second, in the public mode they decreased their level-k. Our explanation is that the public mode is unambiguously more complex and, therefore, achieving the same level-k is more cognitively difficult.

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Appendix A

Table A1: Sophisticated (*SOPH*) players' messages and actions*

Sender message (condition on state)						Receiver action (condition on message)					
State	1	2	3	4	5	Message	1	2	3	4	5
One-receiver mode											
$b = 0$	1	2	3	4	5		1	2	3	4	5
$b = 1$	1	4	5	5	5		2	2	3	3	4
$b = 2$	4	5	5	5	5		2	2	3	3	3
Private mode											
$b = 0$	1	2	3	4	5		1	2	3	4	5
$b = 2$	4	5	5	5	5		2	3	3	2	3
$b = -2$	1	1	1	1	4		3	3	3	4	3
Public mode											
$b = 0$	1	2	3	4	5		2	2	3	4	4
$b = 1$	2	4	4	5	5		1	2	3	4	5
$b = 2$	4	5	5	5	5		2	3	2	2	3

* We compute this type using the best available predictions of the probability distribution, that is, the population frequencies of our own subjects' choices. In the public mode b stands for the average bias.

Table A2: The effect of modes, performance on the CRT and demographic variables on the level-k (ordered logit specification) (marginal effects are reported)

	(1)	(2)
VARIABLES	Senders	Receivers
One-receiver mode	-0.103	-0.482**
	(0.727)	(0.020)
Public mode	-0.400	-0.565***
	(0.224)	(0.005)
CRT	0.0815	0.614**
	(0.832)	(0.034)
Understanding test	-0.0358	0.0307
	(0.517)	(0.284)
Age	0.0581	-0.00152
	(0.247)	(0.980)
Male	0.575	-0.134
	(0.134)	(0.614)
Constant cut1	-0.211	-1.229
	(0.850)	(0.348)
Constant cut2	1.346	0.123
	(0.229)	(0.925)
Constant cut3	3.482***	1.032
	(0.003)	(0.430)
Observations	168	330

Robust p-values in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% levels. Standard errors are clustered at the subject level. The base mode is the private mode. CRT is a dummy variable that takes value 1 if the subject has answered at least one CRT question correctly. "Understanding test" is the number of mistakes in the understanding test.

Table A3: Transition matrix one-receiver/private mode for senders

Type in the one-receiver mode	*Type in the private mode*				
	L0	*L1*	*L2*	*SOPH*	Total
L0	4	0	5	0	9
L1	1	10	6	1	18
L2	2	1	17	1	21
SOPH	1	2	5	0	8
Total	8	13	33	2	56

Table A4: Transition matrix one-receiver/private mode for receivers

Type in the one-receiver mode	*Type in the private mode*				
	L0	*L1*	*L2*	*SOPH*	Total
L0	11	2	2	7	22
L1	10	11	9	15	45
L2	2	0	14	6	22
SOPH	2	3	9	9	23
Total	25	16	34	37	112

Table A5: Transition matrix private/public mode for senders

Type in the private mode	*Type in the public mode*				
	L0	*L1*	*L2*	*SOPH*	Total
L0	3	4	0	1	8
L1	5	5	2	1	13
L2	4	10	11	8	33
SOPH	0	2	0	0	2
Total	12	21	13	10	56

Table A6: Transition matrix private/public mode for receivers

Type in the private mode	*Type in the public mode*				
	L0	*L1*	*L2*	*SOPH*	Total
L0	18	3	2	2	25
L1	2	10	1	3	16
L2	5	12	8	9	34
SOPH	6	12	1	18	37
Total	31	37	12	32	112

Appendix B

Instructions

Introduction:

Welcome! This is a study of decision-making. The funds for this project have been provided by a public funding agency. If you follow these instructions, and make decisions carefully, you could earn a considerable amount of money in addition to the attendance fee of 5 euros. You will be paid in cash at the end of today's experiment.

Experimental Instructions:

The experiment in which you are participating consists of 3 parts. Part 1 has 10 rounds, while parts 2 and 3 each have 20 rounds. In each round of Part 1, you will be randomly matched with one other participant and in Parts 2 and 3 with two other participants. At the end of Part 3, you will be asked to fill out a questionnaire and will be paid the total amount you have accumulated during the course of the entire experiment.

During the experiment all the earnings are denominated in ECU (experimental currency unit). Your earnings in euros are determined by the ECU/$ exchange rate: 350 ECU = 1 euro.

You will be informed about your role (A or B) at the beginning of the experiment. You will have the same role for the entire duration of the experiment.

Part 1:

In this part, player A is randomly matched with another player, B1.

In each round, the computer randomly chooses a secret number that can be 1, 2, 3, 4 or 5 and all these numbers are equally likely. The secret number is displayed only on player A's screen and it is the same secret number for players A and B1.

After seeing the number, player A will send the message to player B1 with whom he/she is matched: “Player A sent you the message saying that the secret number is X”.

After receiving the message from player A, player B1 will choose an action. Specifically, player B1 can choose one of the following actions: 1, 2, 3, 4 or 5.

Earnings of both players depend on the secret number and player B1’s action.

Earnings are determined in the following manner:

Player B1’s earnings are higher when his/her action is closer to the secret number. Player A’s earnings are higher when the action of player B1’s is closer to the secret number **plus the preference difference** (represented by a number). The preference difference is either 0, 1 or 2, and will be determined by the computer in each round. The preference difference will be displayed and announced to everyone at the beginning of each round.

An example: If the preference difference is 2 and the secret number is 3, player B1’s earnings are higher if his or her action is closer to 3. However, player A’s earnings are higher when player B1’s action is closer to $3 + 2 = 5$.

To summarize, in each round the computer will display the secret number only on player A’s screen. The secret number will not be revealed to player B1. Both players will be informed about the preference difference. Player B1 will receive a message “Player A sent you the message saying that the secret number is X” from player A and will then choose an action. The earnings will be determined according to the actual value of the secret number and player B1’s action.

If the explanation above is not clear, please raise your hand and the experimenter will answer your questions.

Please answer now a few questions to ensure that you understand the instructions.

Part 2:

In this part, player A is randomly matched with two other players, B1 and B2. In each round, the computer randomly chooses a secret number that can be 1, 2, 3, 4 or 5 and all these numbers are equally likely. The secret number is displayed only on player A's screen and it is the same secret number for players A, B1 and B2.

After seeing the secret number, player A sends a separate **private message** to each of the two players, B1 and B2, with whom he or she is matched "Player A sent you a PRIVATE message (only for you) saying that the secret number is X".

Players B1 and B2, after receiving the respective messages from player A, will choose an action. Specifically, players B1 B2 can choose one of the following actions: 1, 2, 3, 4 or 5.

Earnings of all the players depend on the secret number and actions of players B1 and B2.

Now player A has two different **preference differences**: One with B1 and one with B2. The preference differences can take values -2, 0, or 2. Furthermore, the preference differences may not be the same for players B1 and B2. The preference differences will be displayed and announced to all players in the beginning of each round.

Earnings are determined in the following manner:

As in Part 1, player B1's and B2's earnings are higher when their own action is closer to the secret number, while player A's earnings are higher when players B1's and B2's actions are closer to the secret number **plus the preference differences** that player A has with B1 and B2, respectively.

Example 2: If A's **preference difference with B1 is 2** and the **secret number is 3**, player B1's earnings are higher if his or her action is closer to 3. However, **player A's earnings are higher when B1's action is closer to 3 + 2 = 5**. A's **preference difference with B2 be $-$2**. In this case player B2's earnings are higher if his or her action is closer to 3 (the secret number). However, **player A's earnings are higher when player B2's action is closer to 3 + ($-$2) = 1**.

To summarize, in each round the computer will display the secret number only on player A's screen. All the players will be informed about preference differences. Players B1 and B2 will each receive separate private messages from player A "Player A sent you a PRIVATE message (only for you) saying that the secret number is X". Players B1 and B2 will then each choose an action. The earnings are determined according to the actual value of the secret number and B1's and B2's actions.

If the explanation above is not clear, please raise your hand and the experimenter will answer your questions.

Please answer now a few questions to ensure that you understand the instructions.

Part 3:

In this part, player A is randomly matched with two other players, B1 and B2.

In each round, the computer randomly chooses a secret number that can be 1, 2, 3, 4 or 5 and all these numbers are equally likely. The secret number is displayed only on player A's screen and it is the same secret number for players A, B1 and B2.

The only difference with Part 2 is that player A now sends a **public message** (the same) to players B1 and B2 "Player A sent you a PUBLIC message (the same to both players) saying that the secret number is X".

Players B1 and B2, after receiving the respective messages from player A, will choose an action. Specifically, players B1 B2 can choose one of the following actions: 1, 2, 3, 4 or 5.

Earnings of all the players depend on the secret number and actions of players B1 and B2.

As in Part 2, player A has two different preference differences: One with B1 and one with B2. The **preference differences** can take values –2, 0, or 2. Furthermore, the preference differences may not be the same for players B1 and B2. The preference differences will be displayed and announced to all players in the beginning of each round.

The earnings will be determined exactly in the same way as in Part 2.

Recall that player B1's and B2's earnings are higher when their action is closer to the secret number, while player A's earnings are higher when players B1 and B2 actions are closer to the secret number **plus the respective preference difference.**

To summarize, in each round, the computer will display the secret number only on player A's screen. All the players will be informed about preference differences. Players B1 and B2 will receive a common message "Player A sent you a PUBLIC message (the same to both players) saying that the secret number is X" from player A, and then each choose an action. The earnings are determined according to the actual value of the secret number and B1's and B2's actions.

If the explanation above is not clear, please raise your hand and the experimenter will answer your questions.

Thank you for your participation.

Understanding test

You will now start an understanding test. You must answer each question correctly before being allowed to continue to the next question.

Questions regarding Part 1 of the experiment:

Please look at the example of earning tables below for a case of preference difference equal to +1.

Suppose that the secret number is 2.
Which action is it optimal for player B to undertake? [ANSWER: 2]
Which action does player A want player B to undertake? [ANSWER: 3]

Suppose now that the secret number is 5.
Which action is it optimal for player B to undertake? [ANSWER: 5]
Which action does player A want player B to undertake? [ANSWER: 5]

Questions regarding the part of the experiment with two players B1 and B2 (parts 2 and 3):

Jugador A

Diferencial con B1: **+1**

El número secreto

Acciones	1	2	3	4	5
1	94	53	21	-33	-84
2	114	86	53	21	-25
3	94	114	94	53	13
4	61	94	106	94	61
5	13	53	86	114	86

Jugador B1

El número secreto

Acciones	1	2	3	4	5
1	106	94	53	21	-33
2	94	106	94	53	13
3	61	94	114	94	61
4	13	53	86	106	94
5	-25	21	53	86	114

Please look at the example of earning tables below for a case of preference difference equal to -2 for player B1 and equal to +2 for player B2.

Jugador A

Diferencial con B1: **-2**

El número secreto

Acciones	1	2	3	4	5
1	61	94	106	86	61
2	21	61	86	114	86
3	-33	21	53	86	114
4	-76	-33	13	61	86
5	-140	-84	-25	13	61

Jugador A

Diferencial con B2: **+2**

El número secreto

Acciones	1	2	3	4	5
1	61	21	-25	-84	-132
2	86	53	13	-33	-76
3	106	94	61	21	-25
4	86	114	86	61	21
5	53	94	106	94	61

Jugador B1

El número secreto

Acciones	1	2	3	4	5
1	114	86	53	13	-33
2	86	114	94	53	21
3	61	86	106	86	53
4	21	53	86	106	86
5	-25	13	53	86	106

Jugador B2

El número secreto

Acciones	1	2	3	4	5
1	114	94	61	13	-33
2	94	106	94	61	21
3	61	94	106	86	61
4	21	61	94	114	94
5	-33	13	61	94	114

Suppose that the secret number is 3.

Which action is it optimal for player B1 to undertake? [ANSWER: 3]
Which action is it optimal for player B2 to undertake? [ANSWER: 3]
Which action does player A want player B1 to undertake? [ANSWER: 1]
Which action does player A want player B2 to undertake? [ANSWER: 5]

You have completed the understanding test.

Screenshots

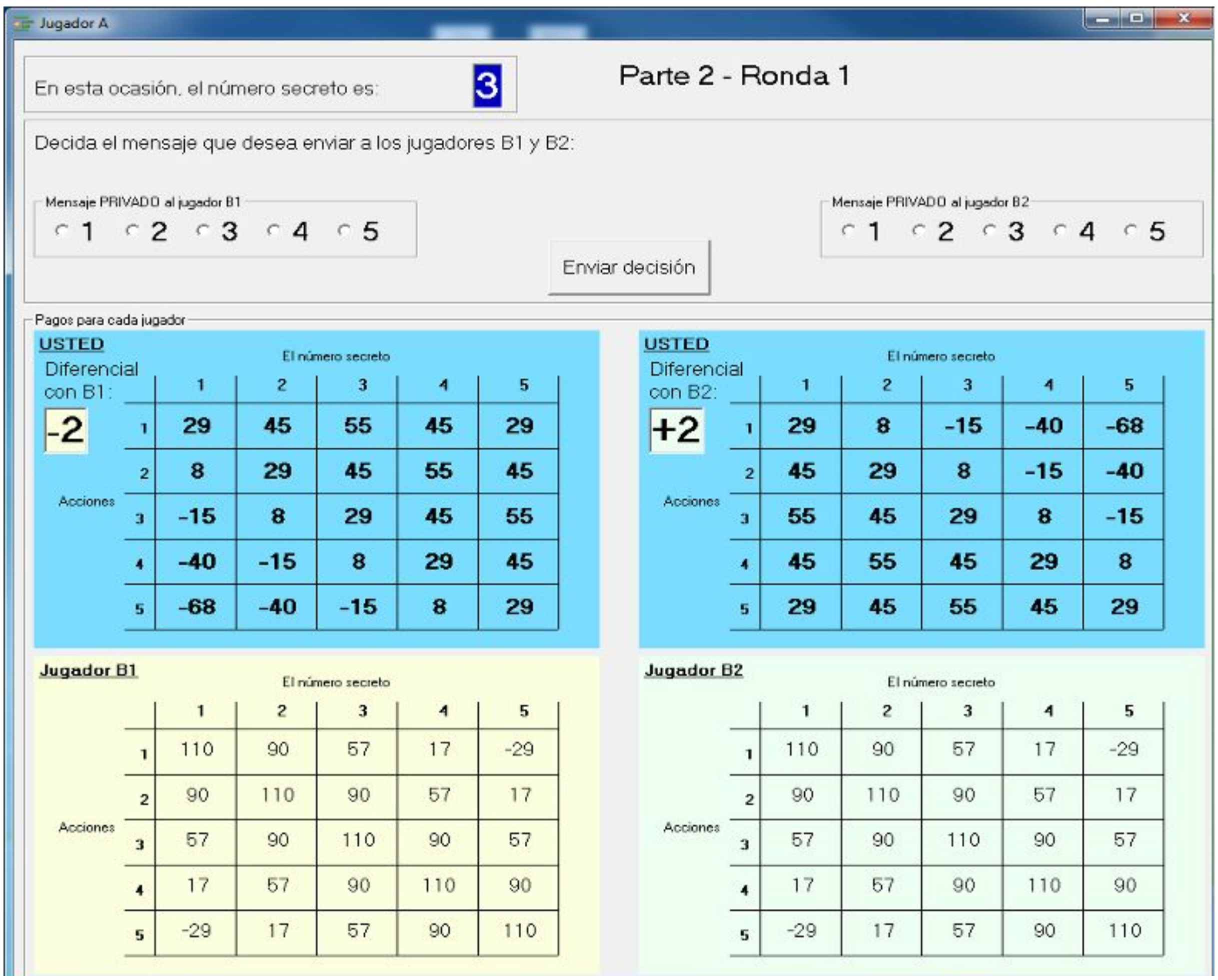

Figure B1: Sender Screen

Figure B1 shows a typical sender's screen for the private mode. In this particular case, the state of the world ("número secreto") is 3 and it appears in the top left of the

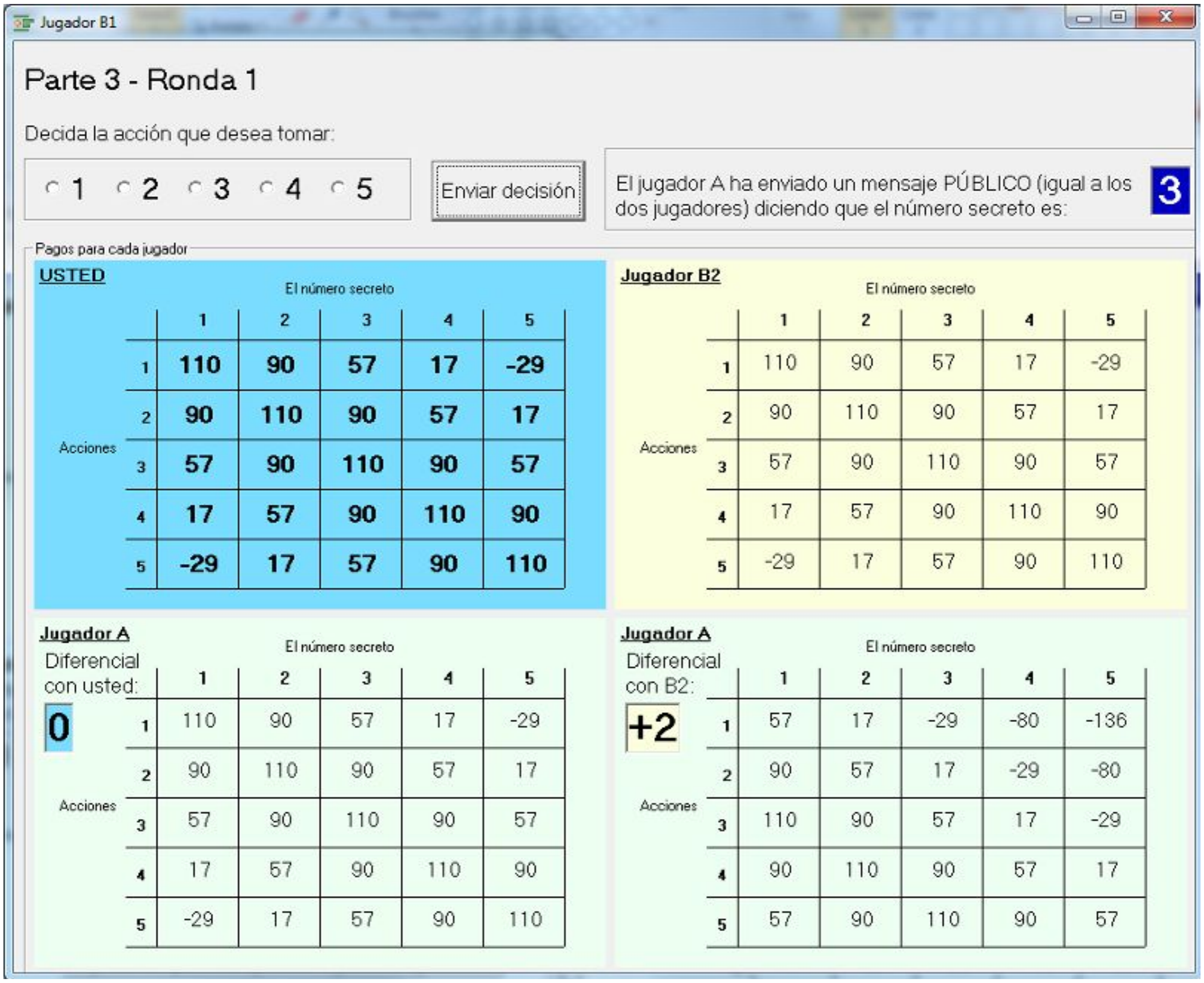

Figure B2: Receiver Screen

screen. The sender needs to decide which private message ("mensaje privado") to send to receivers 1 and 2, by respectively choosing a number from each of the left and right top panels. The two top (blue) matrices represent the sender's payoffs, depending on the actions taken by receivers 1 and 2, respectively. Next to each of these matrices, there is the bias ("diferencial") that the sender has with this particular receiver. Finally, the bottom matrices are the payoffs of receivers 1 and 2, respectively. The sender's screen in the public mode looks the same, the only difference being that he can send just one message that will be observed by both receivers.

Figure B2 shows a typical screen for a receiver in the public mode. In this particular screen, the public message sent by the sender is 3 and is in the top right corner. In the left top corner, the receiver decides which action ("acción") to take by selecting one of the five options. The payoffs of this receiver (B1) are in the top left (blue) matrix. The payoffs of the other receiver (B2) are in the top right matrix. Finally, the payoffs of the sender with respect to the receivers B1 and B2 are in the bottom left and right matrices, respectively. The bias that the sender has with each receiver is next to his payoff matrix corresponding to that receiver. The receiver's screen in the private mode looks the same, the only difference being that the message is said to be private.