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Communication structure and coalition-proofness – Experimental evidence



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ABSTRACT

The paper analyzes the role of the structure of communication—i.e. who is talking with whom—in a coordination game. We run an experiment in a three-player game with Pareto ranked equilibria, where a pair of players has a profitable joint deviation from the Pareto-superior equilibrium. We show that specific communication structures lead to different ‘coalition-proof’ equilibria in this game. Results match the theoretical predictions. Subjects communicate and play the Pareto-superior equilibrium when communication is public. When pairs of players exchange messages privately, subjects play the Pareto-inferior equilibrium. Even in these latter cases, however, players’ beliefs and choices tend to react to messages, despite the fact that these are not credible.

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1. Introduction

This paper investigates in a laboratory experiment the relation between the structure of pre-play communication—i.e., who is talking with whom—and coalition-proofness. A Nash equilibrium is coalition-proof if it is immune to self-enforcing coalitional deviations. If communication is needed to organize a deviation, the structure of communication determines the possibility of different groups of players to coordinate and which equilibrium is coalition-proof. The game under study (the coalitional prisoner's dilemma, see Fig. 1) has two Pareto-ranked pure strategy Nash equilibria, and each pair of players has a profitable joint deviation from the Pareto-superior equilibrium (PSE). We study how the structure of communication influences the choice of messages, the beliefs and the choice of the players in this game, finally determining the possibility to achieve the efficient equilibrium.

Communication may allow players to coordinate on a Nash equilibrium. Furthermore, if the game features Pareto-ranked Nash equilibria, the common perception is that communication helps achieving the Pareto-superior one. Experiments in 2 by 2 stag hunt games have shown that communication indeed leads to higher rate of coordination on the efficient equilibrium (e.g. Charness, 2000; Cooper et al., 1992). However, if communication can allow all players to coordinate, this may also

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	X	Y		X	Y
X	8,8,8	0,0,0	X	0,0,0	0,16,16
Y	0,0,0	16,16,0	Y	16,0,16	4,4,4
	X			Y	

Fig. 1. The coalitional prisoner's dilemma.

hold for smaller coalitions organizing a deviation. This consideration is at the heart of the coalition-proof Nash equilibrium (Bernheim et al., 1987).¹ The game we study is similar to the example used to motivate that concept. In that example, Bernheim et al. (1987, p. 4) argue that if players have “unlimited opportunities to communicate”, the PSE is an implausible outcome even if players agreed on playing it, because two players could agree on a self-enforcing and improving deviation from it. The coalition-proof Nash equilibrium sets out to analyze games where every group of players may communicate.

Milgrom and Roberts (1996) recognize that players may not always have unlimited opportunities to communicate with everyone, and propose a coalition-proof equilibrium notion that is sensitive to the “coalition communication structure”, which specifies coalitions that are allowed to communicate. A coalition-proof Nash equilibrium under a communication structure is a strategy profile that is immune to deviations that are self-enforcing and improving under that communication structure.² In this paper, we design a laboratory experiment that tests the mechanics of coalition-proofness – i.e., that coalitions and subcoalitions use communication to organize joint deviations – under different communication structures.

Our experimental design manipulates the structure of pre-play communication across treatments. Communication takes the form of structured messages, by which players reveal their intended action.³ In a baseline treatment, players do not communicate (*NoCom*). Each of the other treatments implements one of the possible symmetric communication structures. These are: (i) *Public*: each player sends a public message to both of the other group members; (ii) *Private*: each player sends a private message to each of the other group members; (iii) *Both*: each player sends both the private and the public messages to the other group members. In all treatments we elicit beliefs to check if and when does communication affect them.

The coalition-proof Nash equilibrium under communication structure *Public* is the PSE since pairs of players cannot deviate from it. The coalition-proof Nash equilibrium under communication structure *Both* is the Pareto-inferior equilibrium (PIE). The PSE is not coalition-proof under that structure as it is not immune to the joint deviation by two players. This also implies that the deviation by three players from the PIE to the PSE is not self-enforcing. The same holds in *Private*. Thus, the theory predicts that the PSE will be played only under *Public*, and that the PIE will be played in *Private* and *Both*.

To reach the PSE in *Public*, players must first agree to play it in the communication phase. In *Private* and *Both*, an agreement to play the PSE is not self-enforcing, and as such should not be believed. Indeed, a player should recognize that the other players could coordinate privately to deviate from the PSE even if others reveal their intention to play according to it. Thus, the messages observed in the communication phase affect beliefs in *Public*, but not in *Private* and *Both*.

We find that the impact of the communication structure on play is in line with the theoretical predictions. Absent communication, miscoordination is initially high, and play quickly converges to the PIE. Coordination on pure strategy Nash equilibria is higher in the first rounds with communication. In *Public*, the PSE is played by more than half of the groups, steadily across rounds. A vast majority of the players announce their intention to play the action corresponding to the PSE, and play accordingly only when others do so as well. When private communication is allowed, the PIE ends up being played by most groups in the last rounds. Lying is prevalent: players try to convince one of their partners to play the PSE, while agreeing on a deviation with the other. This strategy is frequently successful because some subjects trust messages that are not credible, especially in earlier rounds. As a result, and contrary to our hypothesis, the outcome of communication affects beliefs also in *Private* and *Both*, where messages should be considered uninformative.

In two-player games, the only possible variation to the structure of communication distinguishes one-sided and two-sided communication. Cooper et al. (1992; 1989) find one-sided communication is more effective in the battle of the sexes, where some symmetry-breaking device is needed, while two-sided is more effective in the stag hunt.^{4,5} Relatively few papers have studied the role of pre-play communication in games with more than two-players. Blume and Ortmann (2007)

¹ A number of papers have explicitly modeled pre-play communication in games of complete information, focusing on 2-player games (see Farrell, 1988; 1995; Rabin, 1994; Farrell and Rabin, 1996). A review of this literature can be found in Crawford (1998).

² As discussed in more details in Section 2 and Appendix A, we depart from Milgrom and Roberts (1996) in two aspects. First, their solution concept is a version of coalition-proof correlated equilibrium. Moreno and Wooders (1996) and Ray (1996) also propose notions of coalition-proof correlated equilibrium. While we acknowledge that, in general, communication may lead to correlated play, our design is not suited to address correlation. Second, our communication structures are special cases of their “coalition communication structures”.

³ We focus on the communication of intentions of play. A different, though related, literature addresses communication about the state of the world in sender–receiver games with incomplete information (see Crawford and Sobel, 1982; Blume et al., 1993). Within this literature, a number of studies have investigated information revelation under different communication structures. Farrell and Gibbons (1989) compared private and public communication in sender–receiver games with multiple audiences. Battaglini and Makarov (2014) provided an experimental test of the model.

⁴ Related to this result, it has been pointed out that, in situations where subjects face strategic risk, mutual communication of intentions may have a reassuring effect (see Charness and Dufwenberg, 2006; 2011; Brandts et al., 2015).

⁵ Andersson and Wengström (2012) instead, allow for pre-play and intra-game communication, and show how this can work, through renegotiation, against efficient coordination in dynamic settings.

find that communication improves coordination and efficiency in the weak-link and the median game, which both feature Pareto-ranked equilibria and perfectly aligned interests. In [Moreno and Wooders \(1998\)](#), two players with common interests are opposed to those of the third one. Any subgroup of players can freely chat, and it is shown this allows players to use correlated strategies. [Castillo and Leo \(2007\)](#) also allow both public and private free chat. Some subjects use communication to organize complex deviations, betting on the partial sophistication of their partners.

[Choi and Lee \(2014\)](#) study a multi-player battle of the sexes, where structured communication takes place on different network structures.⁶ They show that the level of coordination and the equilibria that are reached depend on the network structure. While theirs is the only other paper comparing different communication structures in a coordination game with more than two players, they do not allow players to send different messages to different audiences. They find groups tend to coordinate on the equilibrium that is preferred by players that occupy more central positions in the network. Thus, they focus on ‘influence’, while this paper is the first to study the role of the communication structure on its credibility and coalition-proofness.

The paper is organized as follows. [Section 2](#) introduces our notion of coalition-proof Nash equilibrium under communication structure. [Section 3](#) presents the experimental design and procedures. Hypotheses are drawn in [Section 4](#). [Section 5](#) presents the results. [Section 6](#) concludes.

2. The coalition-proof Nash equilibrium under communication structure

We here introduce formally the notion of coalition-proof Nash equilibrium under communication structure for a game in strategic form.⁷ A game in strategic form is given by $G = \langle N, \{A_i\}_{i \in N}, \{u_i\}_{i \in N} \rangle$, where $N = \{1, 2, \dots, n\}$ is a finite set of players and, for each player $i \in N$, A_i is her nonempty set of actions and u_i is her von Neumann–Morgenstern utility function, $u_i: A \rightarrow \mathbb{R}$, where $A = \times_{j \in N} A_j$. The set of mixed strategies of player $i \in N$ is denoted by $\Delta(A_i)$. Payoffs are extended to mixed strategies in the usual way. Coalitions are nonempty subsets of players (J such that $J \subseteq N$ and $J \neq \emptyset$). Let $A_J = \times_{j \in J} A_j$, and denote an action profile for coalition J by $a_J \in A_J$. For $J \subseteq N$ and $J \neq \emptyset$, $\times_{j \in J} \Delta(A_j)$ is the set of probability distributions α_J over A_J , such that $\alpha_J(a_J) = \times_{j \in J} \alpha_j(a_j)$ for all $a_J \in A_J$, where $\alpha_j(a_j)$ is the weight of action a_j in player j ’s mixed strategy $\alpha_j \in \Delta(A_j)$.

Given an agreement $\alpha \in \times_{j \in N} \Delta(A_j)$, the set $D(\alpha, J)$ of feasible mixed deviations by coalition $J \subseteq N$ from α are the mixed strategies obtained when each player $j \in J$ randomizes according to some mixed strategy $\alpha'_j \in \Delta(A_j)$ while each player m outside of J sticks to his part of the agreement α_m . Formally, for some $\alpha \in \times_{j \in N} \Delta(A_j)$ and $J \subseteq N$, let $D(\alpha, J) = \{\alpha' \in \times_{j \in N} \Delta(A_j) \mid \alpha' = (\alpha'_J, \alpha_{-J})\}$.

A communication structure specifies the coalitions that are allowed to communicate prior to play. We assume a communication structure always include each singleton. The set of communication structures is $\mathcal{C} = \{C \subseteq 2^N \text{ such that } \{l\} \in C \text{ for each } l \in N\}$. For a given communication structure $C \in \mathcal{C}$, a mixed strategy α' is a self-enforcing mixed deviation by coalition $J \in C$ from α to α' if α' is a feasible mixed deviation, and if no proper communicating subcoalition J' of J has a further self-enforcing and improving mixed deviation from α' .⁸

Definition 1. Let $C \in \mathcal{C}$, $\alpha \in \times_{j \in N} \Delta(A_j)$ and $J \in C$. The set of self-enforcing mixed deviations by coalition J from α , $SED(\alpha, J, C)$, is defined recursively, as

- (i) If $|J| = 1$, then $SED(\alpha, J, C) = D(\alpha, J)$;
- (ii) If $|J| > 1$, then $SED(\alpha, J, C) = \{\alpha' \in D(\alpha, J) \mid \nexists J' \subsetneq J \text{ with } J' \in C \text{ and } \alpha'' \in SED(\alpha', J', C) \text{ such that } U_j(\alpha'') > U_j(\alpha') \text{ for all } j \in J'\}$

The notion of coalition-proof Nash equilibrium under communication structure $C \in \mathcal{C}$, $CPNE(C)$, is then defined as follows.

Definition 2. Let $G = \langle N, \{A_i\}_{i \in N}, \{u_i\}_{i \in N} \rangle$ be a game in normal form and $C \in \mathcal{C}$ be a communication structure. A strategy profile $\alpha \in \times_{j \in N} \Delta(A_j)$ is a $CPNE(C)$ if no coalition $J \in C$ has a feasible and self-enforcing deviation $\alpha' \in SED(\alpha, J, C)$ such that $U_j(\alpha') > U_j(\alpha)$ for all $j \in J$.

When every coalition may communicate, our notion is, by construction, equivalent to the notion of mixed strategy coalition-proof Nash equilibrium of [Moreno and Wooders \(1996, Definition B.3, p. 108\)](#). It is thus also equivalent to the notion of mixed strategy coalition-proof Nash equilibrium of [Bernheim et al. \(1987\)](#), since [Moreno and Wooders \(1996, Proposition B.1, p. 109\)](#) show the equivalence between their notion and the notion of [Bernheim et al. \(1987\)](#).

⁶ See [Choi et al. \(2016\)](#) for a review of network experiments, including a section on communication.

⁷ This section adapts the definitions in Appendix B of [Moreno and Wooders \(1996\)](#) to accommodate different communication structures. [Milgrom and Roberts \(1996\)](#) follow [Moreno and Wooders \(1996\)](#) definition of coalition-proofness in terms of self-enforcing deviations, as we do.

⁸ In [Milgrom and Roberts \(1996\)](#), a “coalition communication structure” can be any set of sequences of subsets of players that are decreasing with respect to set inclusion. We consider a special case of that notion.

3. Experimental design and procedures

3.1. The game

The game we investigate is depicted in Fig. 1. The set of players is $N = \{i, j, k\}$, and the action space of any player $l \in N$ is $A_l = \{X, Y\}$. We denote by x, y the message announcing a player's intention to play X and Y . Let YYY be a shortcut notation for the profiles of actions where one player chooses X , and the others choose Y , and let XXX , XXY , and YYY be defined accordingly.

There are two pure strategy Nash equilibria: XXX and YYY . The game belongs to the class of coordination games with Pareto-ranked equilibria: XXX is the *PSE*, YYY the *PIE*. There also exists a mixed strategy Nash equilibrium where all players play X with probability $\frac{1+\sqrt{2}}{3} \cong .805$, leading to an expected payoff of 5.18.⁹

In the experiment, subjects communicate in coalitions by selecting their intended action which are then revealed to the other coalition members. A communication structure describes the communication opportunities of the players. The four communication structures analyzed in this paper are (i) $C_{NoCom} = \{\{i\}, \{j\}, \{k\}\}$, when no group of players communicates, (ii) $C_{Pub} = \{\{ijk\}, \{i\}, \{j\}, \{k\}\}$, when only the grand coalition communicates, (iii) $C_{Priv} = \{\{ij\}, \{jk\}, \{ik\}, \{i\}, \{j\}, \{k\}\}$, when each pair of players communicates, and (iv) $C_{Both} = \{\{ijk\}, \{ij\}, \{jk\}, \{ik\}, \{i\}, \{j\}, \{k\}\}$, when both the grand coalition and each pair of players communicates.

When communication among players is not possible, our notion is the Nash equilibrium. We have $CPNE(C_{NoCom}) = \{PSE, MSE, PIE\}$.¹⁰

When pairs of players communicate, the *PSE* and the *MSE* are not coalition-proof since the joint deviation by two players from these Nash equilibria to YY is payoff-improving and self-enforcing. Deviating players would indeed get 16 instead of 8 when they deviate from the *PSE*, and they would get 13.66 instead of 5.18 when they deviate from the *MSE*. In both cases, a deviating player would get strictly less by further deviating by playing X with positive probability, since playing X is the worst option when at least one other player picks the action Y . We conclude that $PSE \notin CPNE(C_{Priv}) \cup CPNE(C_{Both})$, and $MSE \notin CPNE(C_{Priv}) \cup CPNE(C_{Both})$.

The *PIE* is coalition-proof when pairs of players communicate since deviations from this profile are either not profitable for the deviating players, or not self-enforcing. First, the deviations by pairs of players from the *PIE* are never profitable since the third player is playing Y . Second, even if the three players may communicate, the deviations by the three players from the *PIE* lead to outcomes that are not coalition-proof, and as such they are not self-enforcing: if the joint deviation is not a Nash equilibrium, a player has a profitable (and trivially self-enforcing) deviation from it, while if the deviation is a Nash equilibrium, we have established that it is not immune to a further profitable and self-enforcing deviation by pairs of players to YY . It follows that $CPNE(C_{Both}) = CPNE(C_{Priv}) = PIE$.

When the three players communicate but pairs of players cannot, deviations by three players are self-enforcing if they constitute a Nash equilibrium of the game. The Pareto dominated equilibria are not coalition-proof since the deviation by the three players from the *MSE* (*PIE*) to the *PSE* is profitable, and self-enforcing since the *PSE* is a Nash equilibrium. On the other hand, the *PSE* is coalition-proof since the only deviations by the three players from the *PSE* that are self-enforcing (i.e. the *PIE* or the *MSE*) are not profitable for the players. We conclude that $CPNE(C_{Pub}) = PSE$.¹¹

3.2. Design and treatments

We run four treatments. In each treatment, subjects played eight rounds of the coalitional prisoner's dilemma depicted in Fig. 1. Payoffs, in experimental currency units (ECU), were rescaled by a factor of ten. The treatment variable was the structure of pre-play communication. Each treatment implemented one of four symmetric communication structures. Each subject took part only in one treatment.

In a baseline condition (*NoCom*), there was no pre-play communication. In *Public*, each player sent a single message to both of the other group members. In *Private*, each player sent a message to each of the other group members. In *Both*, each player sent a message to both, and a message to each of the other group members. The subjects had to send a message when given the opportunity – i.e. they could not opt out from communication.

When pre-play communication was allowed, each round included four communication stages. In every stage, the players exchanged structured messages. Each message was in the form “I intend to choose action X (Y)”. All messages were received

⁹ When groups of two players may coordinate their moves, agreeing on XY or YX does not make sense since the player playing X is sure of getting his worst payoff. Among the other possible strategies, the two players are strictly better off by playing YY over XX . Iterated elimination of ‘coalitionally dominated strategies’ leads to the selection of the *PIE*. Because this feature recalls the prisoner's dilemma, except for defection being defined over coalitions rather than individuals, we label this game the *coalitional prisoner's dilemma*. See Ambrus (2006) for a noncooperative solution concept based on this procedure.

¹⁰ We abuse notation here and let *PSE*, *PIE*, and *MSE* denote the strategy profiles XXX , YYY , and the profile associated to the mixed strategy Nash equilibrium, respectively.

¹¹ Both Moreno and Wooders (1996) and Milgrom and Roberts (1996) study coalition-proof correlated equilibria. In Appendix A we characterize the coalition-proof correlated equilibria under the communication structures of our game. The predictions for *Private* and *Both* are similar to those obtained absent correlation. The predictions for *Public*, instead, are different. In particular the *PSE* is not a coalition proof correlated equilibrium under communication structure *Public*. We believe that the structured communication protocol that we implement is not suited to allow for correlated strategies.

Table 1
Sessions.

Session	Date	Participants	Matching groups (Ind. Obs)	Treatment
1	June 2013	18	3	Public
2	June 2013	18	3	Private
3	June 2013	18	3	Both
4	June 2013	18	3	Private
5	June 2013	18	3	Both
6	June 2013	12	2	Public
7	June 2013	18	3	Private
8	June 2013	18	3	Both
9	June 2013	18	3	NoCom
10	June 2013	18	3	NoCom
11	June 2013	18	3	NoCom
12	June 2013	18	3	Public

Notes: Subjects were assigned to matching groups of six people. Each matching group is one independent observation. In Session 6 only 17 subjects showed up and we had to give up one matching group.

simultaneously. At the end of the communication phase, the subjects had to choose a pure action between X and Y . Subjects could see the exchanged messages in that round when choosing a message or an action.

We elicited first order beliefs, asking the following question: “Co-player 1 and Co-player 2 will choose between X and Y . What do you think they are going to choose? Please enter a number between 0 and 100, representing the probability that Co-player 1(2) chooses X .”

After answering, they were asked the following question, eliciting second order beliefs: “Co-player 1 and Co-player 2 also answered the same question as you did. Regarding you, what number do you think they entered? Please enter a number between 0 and 100, representing the probability with which Co-player 1(2) thinks you are choosing X .” Thus, we elicit probabilistic first order beliefs, and point second order beliefs.¹²

Beliefs were incentivized using a quadratic scoring rule.¹³ Let b_{ij}^{1st} and b_{ij}^{2nd} be the first and second order belief stated by player i relative to player j , and taking value in $[0, 1]$. The chosen action of player j is $a_j \in \{0, 1\}$, where $a_j = 0$ indicates that player j 's choice is Y , while $a_j = 1$ indicates that player j 's choice is X . The payoff for the belief tasks, expressed in ECU, were: $25 \cdot (1 - (a_j - b_{ij}^{1st})^2)$ and $25 \cdot (1 - (b_{ji}^{1st} - b_{ij}^{2nd})^2)$, for the first and second order beliefs, respectively.¹⁴

In *NoCom*, belief tasks were taken after choosing the action, before receiving feedback on the game. In all communication treatments we elicited beliefs twice. Subjects took the tasks once before the communication phase, and a second time after they had chosen an action, before receiving feedback on the game. As beliefs were stated before and after communication, we will refer to the first as prior beliefs, to the second as posterior beliefs. In total the players completed four belief tasks in each round in *NoCom*, eight tasks in the other treatments.

Summing up, the players stated their prior beliefs, communicated for four stages, chose their action, stated their posterior beliefs, and received feedback on the game and on the belief tasks. Only the last three steps were implemented in *NoCom*.

This procedure was repeated eight times. We refer to these repetitions as rounds. We used a constrained stranger matching. The subjects were informed that they were being re-matched in every round with a new group of players. They were guaranteed they would not play twice in the same group with the same two co-players. We formed matching groups of six people (at random). In every new round players were re-matched with others in their own matching group. The sequence of matching was predetermined to ensure that no group appeared twice in the sequence. The assignments of subjects to terminals, of terminals to matching groups, and of labels within the matching group were random. As a consequence, so was the sequence of groups for each individual subject.

This procedure allowed us to collect one independent observation every six subjects, while preventing repeated game effects. We point out that all the information given to the subjects was correct.

3.3. Procedures

The computerized experiment was run at the WZB-TU Experimental Lab in Berlin, in June 2013, and involved 210 subjects, distributed over 12 experimental sessions. Fifty-four subjects took part in *NoCom*, *Private* and *Both*; forty-eight subjects took part in *Public*. Sessions took on average 45 min. The computerized program was developed using Z-tree (Fischbacher, 2007). Table 1 summarizes sessions' details.

¹² Second order beliefs are expressed as probabilities, but not as a probability distribution over probabilities.

¹³ As shown by Savage (1971) the quadratic scoring rule is proper, meaning that the (risk-neutral) expected utility is uniquely maximized when the stated probabilities are equal to the true probabilities. See Schotter and Trevino (2014) for a broader perspective on belief elicitation methods.

¹⁴ The subjects were not provided with these formulas, but with tables reporting the possible payoffs from different combinations of choices and stated beliefs. A copy of the tables can be found in online Appendix B.

All sessions followed an identical procedure. After subjects were allowed to enter into the lab, instructions were read aloud.¹⁵ Participants were asked to fill in a control questionnaire. The experiment started only when all the subjects had correctly completed the task.

After completing the eight rounds, subjects filled in a questionnaire. We gathered qualitative information about the expectations from the game, the opponent, and the strategy followed. We recorded their assessment on the credibility of communication, and its role in the game. Finally, we elicited self-reported quantitative measures of trust and risk preferences, using the questions of the SOEP German Panel.¹⁶

Subjects were told they would be paid according to the ECU earned in one stage game, and in one belief task, selected at random by the computer. At the end of each round the computer selected one of the belief tasks to be relevant for payment in case that round was selected. After the last round the computer drew two numbers for each individual, between 1 and 8, without replacement. The stage game and the relevant belief task in the corresponding rounds were paid to the subjects, according to the exchange rate: 10ECU = 1 Euro. Subjects could earn between 0 and 16 Euros from the stage game, and between 0 and 2.50 Euros from the belief task. They knew that either the stage game or the belief task from the same round could be paid, but not both. This prevents them from hedging their action using the belief tasks. The average payment, including 5 Euros of show-up fee, was around 13.70 Euros.

4. Hypotheses

In [Section 3.1](#) we have shown that, in *Public*, only the *PSE* is coalition-proof, because pairs of players cannot organize deviations from there, and the deviation by the grand coalition from the *PIE* is self-enforcing. If there is private communication, any pair of players has a self-enforcing deviation from the *PSE*, so that this cannot be coalition-proof. The *PIE* is, instead, coalition-proof: even when the grand coalition is allowed to deviate to the *PSE*, as in *Both*, this deviation is not self-enforcing.

Hypothesis 1. Coordination on the *PSE* is higher in *Public* than in any other treatment.

When communication is allowed, every structure selects one of the two pure-strategy Nash equilibria as coalition-proof. Thus, we expect high coordination rates, because communication allows beliefs to converge. Absent communication, the theory is silent on what equilibrium is selected. As a consequence, players are expected to have heterogeneous beliefs on the play of others, resulting in frequent miscoordination, at least in the initial rounds.

Hypothesis 2. Coordination on pure strategy Nash equilibria is higher with communication than without.

In *Public* players can agree on playing the *PSE* by announcing they are going to play *X*. This agreement is credible, because no feasible and self-enforcing deviation can be organized from it. However, if they agree to play the *PIE* they should also consider this agreement credible. The message profiles corresponding to the *PSE* and the *PIE* are both self-committing, in the sense that each player's best response corresponds to his own message when he believes the others will play as they said they would.^{17, 18} Indeed, when a player receives at least one message *y* and believes the messages, his best-response is to play *Y*. This implies that the messages a player observes during the communication phase affect his beliefs.

In *Private* and *Both* players can agree on playing the *PIE*, and this agreement is credible. Indeed, a single private agreement between two players to play *Y* is self-committing for any belief about the play of the third player. Agreements to play the *PSE*, instead, are not credible. Consider a player that only observes *x* messages (including public messages in *Both*). To play *X*, he must believe that the other two also agreed to play *X* and intend to do so with high probability. Holding such a belief, however, gives the other players the incentive to organize a self-enforcing deviation to *YY*. Even a player receiving only messages *x* should not believe that the other players will play the *PSE*. Players should play *Y* independently of the observed messages, and messages are uninformative about intended play.

Hypothesis 3. Communication affects beliefs only in *Public*.

In *Public* we expect players try to agree on playing the *PSE* by sending *x*. In *Private* and *Both*, messages are uninformative, and players are indifferent between communication strategies. Some constraints on those can be recovered if players believe some opponents are naive—i.e., they trust messages even when these are uninformative. Naive players would play *X* with positive probability after observing only *x* messages. If a player thinks there is a chance that his opponents are naive, sending *y* to both other players, either with a public and/or with two private messages, is dominated. It is always better for him to

¹⁵ The experiment was conducted in German. An English version of the experimental instructions is available in online [Appendix B](#), together with screenshots of the user's interface.

¹⁶ For the use of the risk questions to measure risk preferences, see [Dohmen et al. \(2011\)](#).

¹⁷ The notion of self-committing messages is common in the literature on communication to assess the credibility of messages (e.g. [Farrell and Rabin, 1996](#)). It is useful here, because coalition-proofness sidesteps communication, in the sense that communication choices and strategies conditional on exchanged messages are modeled implicitly.

¹⁸ [Aumann \(1990\)](#) noted that a player may have incentives to send a self-committing message even if he is planning to play something else. In that case, the message is not self-signaling and should not be credible. In our game, this tension does not occur. See [Charness \(2000\)](#) and [Clark et al. \(2001\)](#) for experimental tests of Aumann's conjecture.

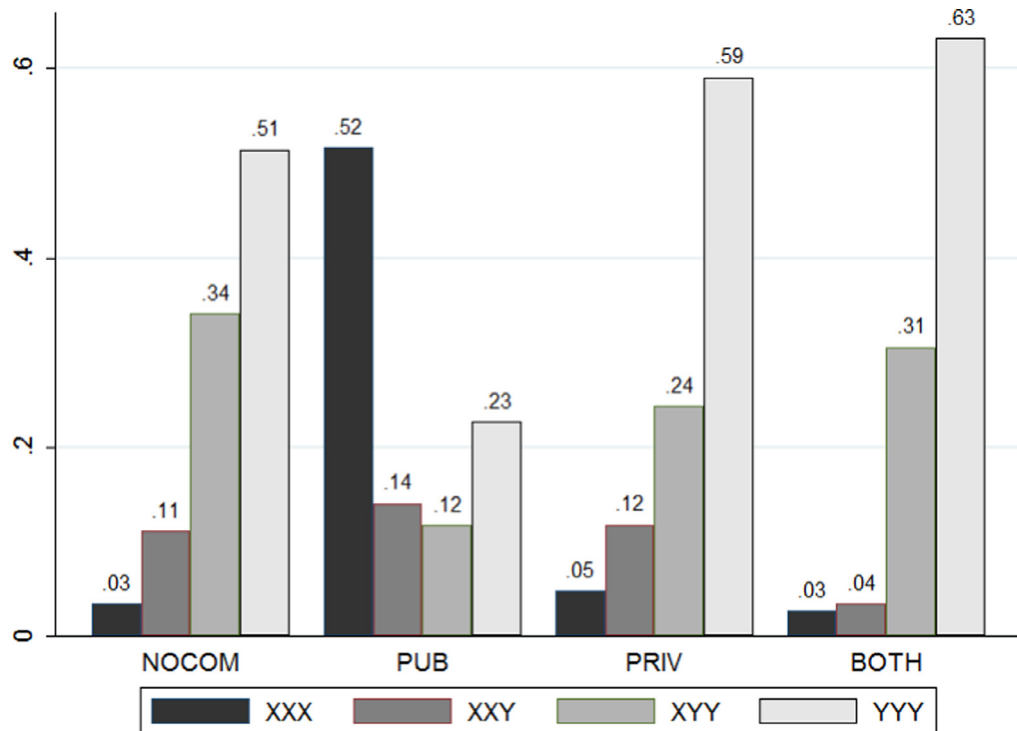


Fig. 2. Aggregate outcomes.

Table 2
Across treatment tests.

Test	Variable	Pub vs. Priv	Pub vs. Both	Pub vs. NoCom	Priv vs. Both	Priv vs. NoCom	Both vs. NoCom	Com vs. NoCom
KS	Outcome	0.778 (.00)	1.000 (.00)	0.889 (.00)	.222 (.96)	0.333 (.59)	0.222 (.96)	
WRS	PSE	3.518 (.00)	3.552 (.00)	3.552 (.00)	0.607 (.54)	−0.506 (.62)	0.053 (.96)	
WRS	NE all rounds	1.27 (.20)	1.10 (.27)	−2.79 (.01)	−0.10 (.92)	−1.59 (.11)	−1.91 (.05)	−2.58 (.01)
WRS	NE rounds 7–8	−0.76 (.45)	−1.40 (.16)	0.90 (.37)	−0.54 (.59)	−0.10 (.92)	−0.462 (.64)	0.226 (.82)
WRS	Bel. spread	−3.468 (.00)	−3.466 (.00)	0.915 (.360)	−2.250 (.024)	−3.401 (.00)	−3.311 (.00)	

Notes: Each cell reports a test statistic, with *P*-val in parentheses. Bold indicates significance at the .05 level. H_0 is always equality across treatments vs. two-sided alternative. KS is the Kolmogorov–Smirnov statistic on the distribution of outcomes. WRS is the Wilcoxon rank-sum test on the fraction of PSE outcomes (PSE), of Nash equilibrium outcomes (NE), and on the individual spread in first order beliefs (Bel. spread). Tests are run on averages over rounds for each matching group—i.e., using one independent observation per matching group. These averages are continuous, which makes the reported tests applicable (the variable ‘outcome’ is categorical, the variables for ‘PSE’ and ‘NE’ are binary). COM refers to the aggregation of all treatments with pre-play communication.

send *y* to one player and *x* to the other, and try to agree with only one other player to play *Y*, or to send *x* to both (and send *x* publicly in either case in *Both*). Thus, we expect these ‘weakly dominated’ messages are not sent.

5. Results

Fig. 2 shows the aggregate outcomes for each treatment. Subjects coordinate more than half of the time on the PSE in *Public*, whereas they virtually never play it in the other treatments. On the other hand, the PIE is played 23 percent of the time in *Public*, but more than half of the time in the other treatments. A Kolmogorov–Smirnov test confirms that the distribution of aggregate outcomes is different only when comparing *Public* with each of the other treatments. A Wilcoxon rank-sum test (WRS) confirms that the fraction of groups playing the PSE is higher in *Public* than in any other treatment (Table 2, first and second rows).¹⁹

¹⁹ All the tests that will be shown are based on one independent observation for each matching group.

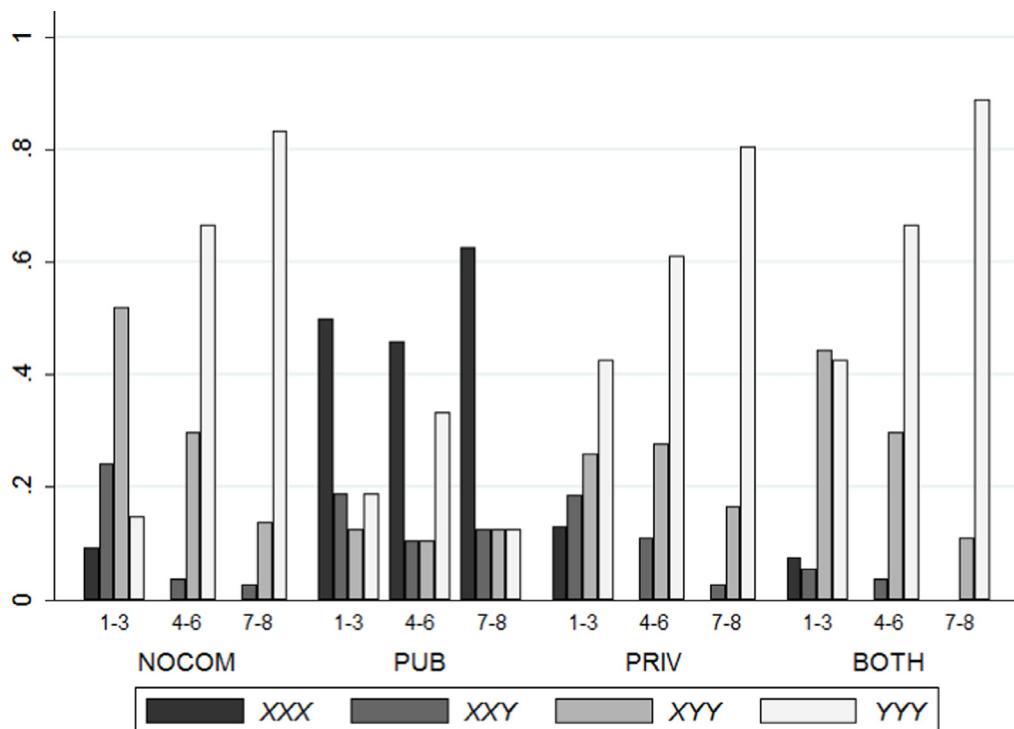


Fig. 3. Distribution of outcomes over rounds.

Coordination on pure strategy Nash equilibria is higher when subjects communicate. The fraction of equilibrium outcomes ranges from 75 percent in *Public* to 55 percent in *NoCom*. Using a WRS test, the fraction of Nash equilibrium outcomes in *NoCom* is significantly different than in *Public*, *Both*, and the aggregation of communication treatments. Coordination rates in any two communication treatments are not significantly different (Table 2, third row).

In Fig. 3 the outcomes are decomposed in initial (1–3), intermediate (4–6) and final rounds. In *NoCom*, *Private* and *Both*, coordination on the *PIE* increases over rounds, peaking above 80 percent in the final rounds. In *Public*, the proportion of groups playing the *PSE* slightly increases from 50 percent in the initial rounds to 63 percent in the final rounds. Thus, the difference in the distributions between *Public* and the other treatments persists.

The lower coordination rate on pure strategy Nash equilibria in *NoCom* is explained by large miscoordination in the initial periods. In the final rounds, there are no statistical differences of coordination rates between any two treatment (Table 2, fourth row).²⁰

Result 1. Coordination on the *PSE* is sustained only in *Public*. In the other treatments, play converges to the *PIE*.

Result 2. Coordination on pure strategy Nash equilibria is higher with communication than without, but this difference shrinks with experience.

These results match the implications of Hypotheses 1 and 2.

Action X is chosen 65 percent of the time in *Public*, 22, 21, and 15 percent in *NoCom*, *Private*, and *Both*, respectively. Fig. 4 displays the fraction of X actions conditional on the observed messages in the last stage of communication, and for initial, intermediate and final rounds.

In *Public*, subjects play X more than 80 percent of the time following an agreement to do so, which, in turns, happens 69 percent of the time. In one out of five games, only two players send x. Initially, around one third of the subjects chooses X in these cases, but this fraction drops below 15 percent in the last rounds. When at least two players send y, everyone plays Y.

In *Private* and *Both*, if at least one y message is exchanged with at least one group member, that is sufficient to induce action Y.²¹ Thus, when every player observes at least one y message—as it is the case in more than half of the games in *Private* and *Both*—the group almost certainly plays the *PIE*. When players observe only message x, in the initial rounds they

²⁰ The results of the tests also hold against a permutation test on means, as well as a binomial test on the original data – i.e. not averaging within each matching group.

²¹ For treatment *Both* we do not condition on the observed public messages. The reason is that, when it is observed in public, some message y is observed also in private.

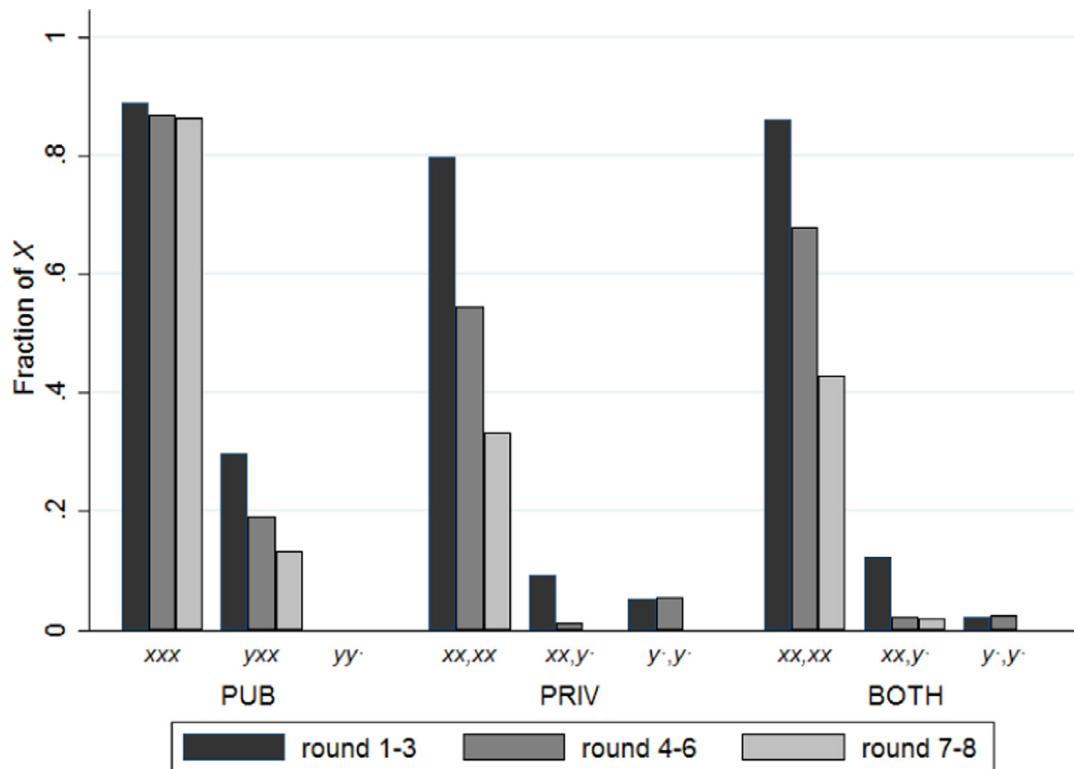


Fig. 4. Fraction of X actions conditional on observed messages.

Notes: xxx means everybody send x publicly; yxx means two send x and one sent y publicly; yy· means at least two sent y publicly. Similarly, xx, xx means sending and receiving only x with both partners privately; xx, y· means sending and receiving only x with one partner and sending and/or receiving y with the other, and so on. That is, we do not condition on sending versus receiving y (or both). In *Both* we do not condition on public messages.

Table 3
Last message sent in each treatment.

Round	Pub		Priv			Both					
	x	y	xx	xy	yy	x – xx	x – xy	x – yy	y – xx	y – xy	y – yy
1	.85	.15	.65	.26	.09	.44	.43	.02	.00	.02	.09
2	.90	.10	.48	.39	.13	.37	.50	.00	.00	.02	.11
3	.77	.23	.33	.52	.15	.20	.46	.06	.02	.09	.17
4	.77	.23	.46	.41	.13	.30	.61	.00	.00	.00	.09
5	.83	.17	.41	.52	.07	.19	.57	.04	.02	.06	.13
6	.83	.17	.35	.52	.13	.22	.61	.04	.00	.06	.07
7	.96	.04	.28	.63	.09	.13	.63	.09	.00	.04	.11
8	.94	.06	.30	.54	.16	.20	.52	.03	.02	.02	.20
All	.86	.14	.41	.47	.12	.27	.54	.03	.01	.04	.12

Notes: The table reports the distributions of messages sent in the last stage of the communication phase. For instance, xx means sending x to both partners in *Private*, x – xy sending publicly x, and privately x to one partner and y to the other.

respond by playing X around 80 percent of the time, as in *Public*. As they gain experience, they learn not to trust these messages, but more than one third of the subjects still chooses X in the final rounds.

One third of the time, two players exchange at least one y message between them and only x messages with the third player in *Private* and *Both*. Those messages profiles give two players the opportunity to let the third down by reaching the *YYY* outcome. Indeed, the probability of the *YYY* outcome conditional on these message profiles is .51 in *Private* and .7 in *Both*. While these figures decline over rounds, they are remarkably high. The difference between *Private* and *Both* is significant (WRS: $z = -3.4$ $P\text{-val} < .01$), and suggests that public communication may reinforce trust in private messages for relatively naive players.

Table 3 shows how communication decisions evolved over rounds. It reports, for each treatment, the distribution of messages in the last stage of communication, round by round. In *Public*, x prevails across all rounds. In *Private* and *Both*, the fraction of private messages xx—i.e., sending x to both partners—declines over rounds, while the converse happens to xy.

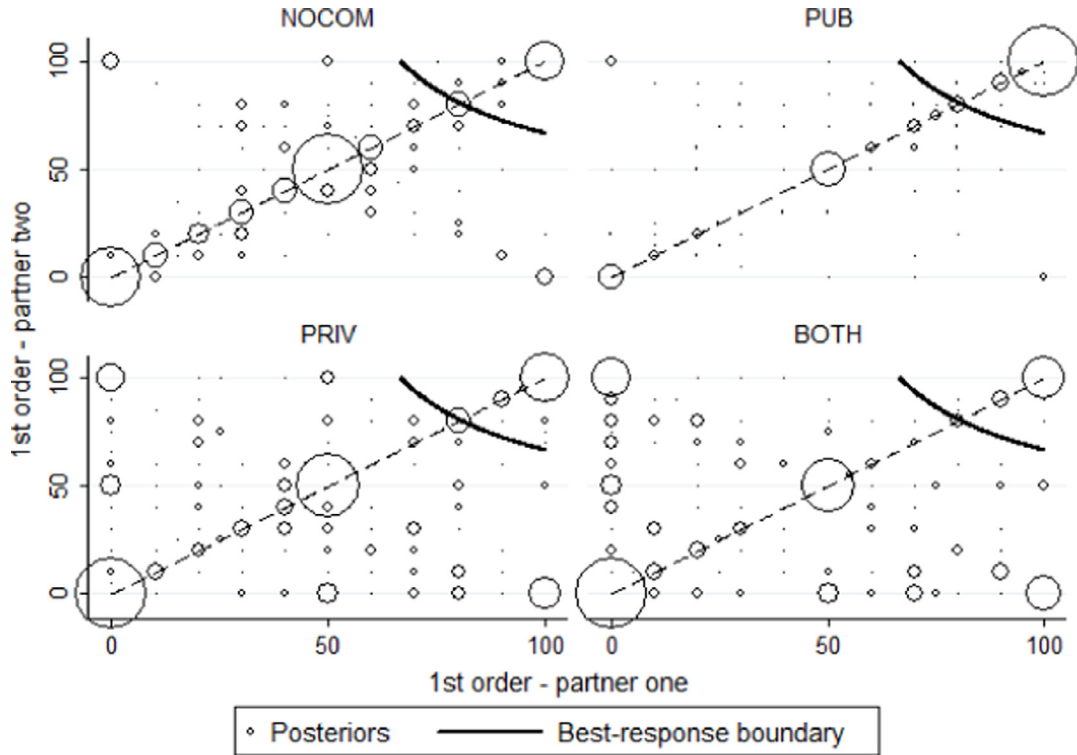


Fig. 5. Distribution of first order beliefs.

Players rarely send y to both players, either with a public message or with two private ones. The overall percentage ranges between 12 percent in *Private* and 19 percent in *Both*, with no significant difference across treatments, and no clear pattern across rounds. Since these messages are ‘weakly dominated’, we may interpret their presence as an instance of preferences for promise keeping. This motivation appears minor for our subjects, especially when one considers that half of the time subjects send different messages to their partners, thus necessarily lying to one of them.²²

That communication strategies reflected an attempt to affect partner’s actions is confirmed by the distributions of first order beliefs.²³ In Fig. 5 each circle represents a couple of beliefs, one for each partner. Beliefs are stated as the probability that a partner chooses X . The dimension of the circles represents the frequency of each pair of beliefs. We overimpose the frontier of beliefs where the best response switches from Y (below the solid black line) to X (above it).²⁴

As it should be expected at this point, in *Public* beliefs are concentrated on higher values for each partner with respect to the other treatments. A more subtle difference is present between *Public/NoCom*, on one side, and *Private/Both*, on the other. While in the former two beliefs mainly fall on the bisector, where the same belief is reported for the two partners, in the latter a substantial share of players have divergent expectations regarding their partners.²⁵ In particular, the highest off-the-diagonal frequencies correspond to expecting one partner to play Y , the other to play X , both with probability one. We check for the significance of this result by testing across treatments for the difference in the absolute spread between each subject’s first order beliefs (Table 2, last row). A WRS rejects the null of equal differences in all pairwise comparisons, except for *Public* and *NoCom*.

The previous estimates suggest that communication affects beliefs in all treatments. We run a GLS panel regression model with random effects to formally assess the effect of communication on beliefs in the different treatments. The model can be written as:

$$B_{it} = \gamma_0 + \gamma_y y_{it} + \gamma_{Treat} Treat_{it} + \gamma_{int} y_{it} * Treat_{it} + \gamma_W W_{it} + \gamma_t t + u_i + \epsilon_{it}$$

²² The fact that messages are structured may contribute to inhibit preferences for promise keeping (Charness and Dufwenberg, 2010). For experimental investigations of preferences for promise keeping and pure lie aversion see Vanberg (2008), Erat and Gneezy (2012) and Vanberg (2016).

²³ For brevity, further analyses on beliefs, including second-order beliefs, are reported in online Appendix C.

²⁴ In each treatment the fraction of best response to beliefs is above 80 percent.

²⁵ All joint distributions show a high frequency of beliefs around 50–50. The attraction toward such intermediate reports may be explained by risk aversion: 50–50 is a risk-free report. However, reporting a higher risk propensity does not correlate with reporting beliefs closer to 50 ($\rho = 0.07$, P -val = .298 – no substantial variation across treatments).

Table 4

First order beliefs: across-treatment GLS estimates.

	(1) B_{ij}	(2) ΔB_{ij}	(3) B_{ij}	(4) ΔB_{ij}
t	−1.40*** (0.505)	−0.334 (0.425)	−1.42*** (0.511)	−0.311 (0.435)
$\bar{Y}_{\{j,k\}PAST}$	−14.11*** (1.692)	6.326** (2.493)	−13.69*** (1.592)	6.07** (2.510)
observes_y	−27.67*** (4.060)	−24.54*** (4.163)	−26.90*** (4.045)	−24.69*** (4.459)
Public	18.08*** (5.956)	−2.393 (4.311)	13.75** (6.272)	−3.535 (5.506)
Both	8.038 (6.282)	0.201 (5.882)	7.416 (5.581)	1.584 (5.487)
observes_y*Public	−18.58** (8.538)	−13.685** (6.982)	−18.92** (8.754)	−13.96** (6.794)
observes_y*Both	−7.21 (6.807)	−5.124 (6.777)	−8.22 (6.620)	−6.190 (6.538)
γ_0	86.18*** (4.379)	7.77 (4.603)	75.35*** (9.104)	2.852 (9.176)
N	2184	2184	2184	2184
Matching groups	26	26	26	26
Additional controls	No	No	Yes	Yes
R-squared	0.397	0.114	0.417	0.123

Notes: The dependent variable is the posterior belief B_{ij} , or the difference between the prior and posterior belief (ΔB_{ij}). $\bar{Y}_{\{j,k\}PAST}$ is the average number of Y 's observed in past rounds. Variable 'observes_y' is a dummy where 1 means the subjects observed at least one y message. In parentheses we report robust standard errors, clustered at the matching group level. *, **, ***: statistically significant at the 10 percent, 5 percent and 1 percent level, respectively. Additional controls include gender, age, field of study, and self-reported measures of risk aversion and trust.

where B_{it} is the first order posterior belief of individual i in round t , y_{it} represent the outcome of communication, W_{it} is a set of controls, including individual characteristic, such as attitudes toward trust and risk aversion, and statistics on the past observed play, u_i is the individual-specific random effect, and ϵ_{it} is the error term.²⁶

Messages are different objects in different treatments. We collapse the communication variables into one dummy regressor (y_{it}), taking value one whenever player i has observed at least one y in the last stage of communication of round t , and we interact this dummy with the treatments (base treatment: *Private*; see Table 4).²⁷

One may be concerned that posteriors are the result of self-fulfilling priors: players' belief that induce communication strategies that end up confirming the prior. In this case the causality would move from beliefs to communication, rather than the other way around. To address this concern we run a similar model where we use as dependent variable the change in first order beliefs, as measured by the difference between the posterior and the prior. A positive (negative) difference indicates that the subject is more (less) confident in his partner choosing action X after communication than he was before.

Coefficients show communication affects beliefs in all treatments, with a stronger effect in *Public*. In particular the posterior belief is on average 18 percentage points higher in *Public* with respect to *Private* after observing only message x , while *Both* does not differ significantly from the base. Observing at least one y , shifts beliefs downward of about 27.7 percent in *Private* and *Both*. The same figure is 46.3 percent in *Public* (−27.7–18.6). Summing up the effects, the average belief for those that observe y messages in *Public* is similar as in the other treatments.²⁸ When looking at changes in beliefs, the main effect of *Public* is insignificant. Thus, there is no difference in how players update their beliefs after observing only x messages, and the corresponding positive coefficient found in model (1) can be ascribed to higher priors in *Public*. As before, observing y results in a larger revision of the beliefs in this treatment, but a significant revision happens in *Private* and *Both* as well. All results hold to the introduction of additional controls (models (3) and (4)).

Result 3. Communication affects beliefs in all treatments. The effect is stronger in *Public*.

Thus, despite the comparative statics across treatments are in line with Hypothesis 3, we reject the hypothesis that communication is disregarded in *Private* and *Both*.

²⁶ Standard errors are clustered at the matching group level.

²⁷ In web Appendix C we report treatment-by-treatment regressions that include a richer set of communication regressors as well as specifications where we assess the impact of earlier versus later stages of communication.

²⁸ (+18.1 − 26.7 − 18.6) − (−26.7).

6. Conclusion

When equilibria are Pareto-ranked, coordination problems can lead to inefficient outcomes. The fact that everybody would be happy to coordinate on Pareto-superior equilibria suggests communication could help players reach the Pareto-superior outcome. Results in two-by-two games support this view. The paper presents an experiment on pre-play communication in a three-player coordination game with Pareto-ranked equilibria.

We implement different communication structures and find communication sustains the Pareto-superior equilibrium when only public communication is allowed, but not when private communication is. If private messages are allowed, players end up in the dominated equilibrium. Thus, that efficient coordination may be reached through communication depends not only on equilibria being Pareto-ranked, but also on the alignment of the interests of various groups outside equilibrium, and on whether they can communicate to coordinate their actions. While we find strong support for the rationale behind the coalition-proof Nash equilibrium, our experiment suggests an appropriate solution concept should be sensitive to the communication structure that is in place.

Despite this, the mechanics of credibility are not straightforward to grasp, and subjects do not realize immediately when they should trust messages. In the first rounds, players respond similarly to the observed messages in all treatments, even when these are uninformative. This widespread and persistent tendency to believe to messages is hardly matched by subjects' preferences for truth-telling: groups of players use communication to cheat on their partners, and exploit naivety for their own interests.

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Supplementary material

Supplementary material associated with this paper can be found, in the online version, at [10.1016/j.eurocorev.2017.02.007](https://doi.org/10.1016/j.eurocorev.2017.02.007).

References

- Ambrus, A., 2006. Coalitional rationalizability. *Q. J. Econ.* 903–929.
- Andersson, O., Wengström, E., 2012. Credible communication and cooperation: experimental evidence from multi-stage games. *J. Econ. Behav. Organ.* 81 (1), 207–219.
- Aumann, R., 1990. Nash Equilibria are not Self-Enforcing. In: Gabszewicz, J.J., Richard, J.-F., Wolsey, L.A. (Eds.), *Economic Decision-Making: Games, Econometrics and Optimisation*. Elsevier, Amsterdam, pp. 201–206.
- Battaglini, M., Makarov, U., 2014. Cheap talk with multiple audiences: an experimental analysis. *Games Econ. Behav.* 83, 147–164.
- Bernheim, B.D., Peleg, B., Whinston, M.D., 1987. Coalition-proof Nash equilibria I. concepts. *J. Econ. Theory* 42 (1), 1–12.
- Blume, A., Kim, Y.-G., Sobel, J., 1993. Evolutionary stability in games of communication. *Games Econ. Behav.* 5 (4), 547–575.
- Blume, A., Ortmann, A., 2007. The effects of costless pre-play communication: experimental evidence from games with Pareto-ranked equilibria. *J. Econ. Theory* 132 (1), 274–290.
- Brandts, J., Ellman, M., Charness, G., 2015. Let's talk: how communication affects contract design. *J. Eur. Econ. Assoc.* 14 (4), 943–974.
- Castillo, M., Leo, G.C., 2007. From coordination to double-crossing: experiments on the strategic behavior of groups. *Mimeo*.
- Charness, G., 2000. Self-serving cheap talk: a test of Aumann's conjecture. *Games Econ. Behav.* 33 (2), 177–194.
- Charness, G., Dufwenberg, M., 2006. Promises and partnership. *Econometrica* 74 (6), 1579–1601.
- Charness, G., Dufwenberg, M., 2010. Bare promises: an experiment. *Econ. Lett.* 107 (2), 281–283.
- Charness, G., Dufwenberg, M., 2011. Participation. *Am. Econ. Rev.* 101 (4), 1211–1237.
- Choi, S., Gallo, E., Kariv, S., 2016. Networks in the laboratory. In: Bramoullé, Y., Galeotti, A., Rogers, B.W. (Eds.), *The Oxford Handbook on the Economics of Networks*. Oxford University Press, pp. 440–478.
- Choi, S., Lee, J., 2014. Communication, coordination, and networks. *J. Eur. Econ. Assoc.* 12 (1), 223–247.
- Clark, K., Kay, S., Sefton, M., 2001. When are Nash equilibria self-enforcing? an experimental analysis. *Int. J. Game Theory* 29 (4), 495–515.
- Cooper, R., Dejong, D.V., Forsythe, R., Ross, T.W., 1992. Communication in coordination games. *Q. J. Econ.* 107 (2), 739–771.
- Cooper, R., Dejong, D.V., Forsythe, R.E., Ross, T.W., 1989. Communication in the battle of the sexes game: some experimental results. *RAND J. Econ.* 20 (4), 568–587.
- Crawford, V., 1998. A survey of experiments on communication via cheap talk. *J. Econ. Theory* 78 (2), 286–298.
- Crawford, V.P., Sobel, J., 1982. Strategic information transmission. *Econometrica* 50 (6), 1431–1451.
- Dohmen, T., Falk, A., Huffman, D., Sunde, U., Schupp, J., Wagner, G.G., 2011. Individual risk attitudes: measurement, determinants, and behavioral consequences. *J. Eur. Econ. Assoc.* 9 (3), 522–550.
- Erat, S., Gneezy, U., 2012. White lies. *Manag. Sci.* 58 (4), 723–733.
- Farrell, J., 1988. Communication, coordination and Nash equilibrium. *Econ. Lett.* 27 (3), 209–214.

- Farrell, J., 1995. Talk is cheap. *Am. Econ. Rev.* 85 (2), 186–190.
- Farrell, J., Gibbons, R., 1989. Cheap talk with two audiences. *Am. Econ. Rev.* 79 (5), 1214–1223.
- Farrell, J., Rabin, M., 1996. Cheap talk. *J. Econ. Perspect.* 10 (3), 103–118.
- Fischbacher, U., 2007. z-tree: zurich toolbox for ready-made economic experiments. *Exp. Econ.* 10 (2), 171–178.
- Milgrom, P., Roberts, J., 1996. Coalition-proofness and correlation with arbitrary communication possibilities. *Games Econ. Behav.* 17 (1), 113–128.
- Moreno, D., Wooders, J., 1996. Coalition-proof equilibrium. *Games Econ. Behav.* 17 (1), 80–112.
- Moreno, D., Wooders, J., 1998. An experimental study of communication and coordination in noncooperative games. *Games Econ. Behav.* 24 (1), 47–76.
- Rabin, M., 1994. A model of pre-game communication. *J. Econ. Theory* 63 (2), 370–391.
- Ray, I., 1996. Coalition-proof correlated equilibrium: a definition. *Games Econ. Behav.* 17 (1), 56–79.
- Savage, L.J., 1971. Elicitation of personal probabilities and expectations. *J. Am. Stat. Assoc.* 66 (336), 783–801.
- Schotter, A., Trevino, I., 2014. Belief elicitation in the laboratory. *Ann. Rev. Econ.* 6 (1), 103–128.
- Vanberg, C., 2008. Why do people keep their promises? an experimental test of two explanations. *Econometrica* 76 (6), 1467–1480.
- Vanberg, C., 2016. Who never tells a lie? *Exp. Econ.*