Teams versus Individuals in Pre-play Cheap Talk Communication

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Abstract

In a lab experiment, we compare team and individual play in a coordination game with incomplete information, with and without pre-play cheap talk communication. We found that teams and individuals behave significantly differently in some situations. Specifically, when both agents are of middle types, teams perform better than individuals without communication but worse than individuals with communication, in terms of both payoffs and coordination rates. As to strategies used, teams are more strategic than individuals: for middle types, with communication teams exaggerate their types significantly more and are more likely to choose their preferred action conditional on messages sent. We also conduct chat analysis, which sheds light on subjects' underlying motives in decision making.

JEL Classification: *D23, D74, D82*
Keywords: Coordination game, Pre-play communication, Cheap talk, Experiment, Teams

1. Introduction

This paper studies how *teams* and *individuals* behave differently in cheap talk communication in lab experiments. The existing experimental papers on the Crawford-Sobel (1982, CS hereafter) cheap talk model all use individuals as subjects, and one main result from those papers (e.g., Cai and Wang, 2006) is that subjects tend to be honest in communication relative to theoretical predictions. Departuring from those papers, we use *teams* as subjects, and then compare teams' behavior to that of individuals.

Our motivation for studying team play is twofold. First, many decisions of this sort are made by teams in real-life situations. In order to shed light on players' actual behavior in the real world, it is important to extend laboratory studies to teams. In the experimental literature, many studies (e.g., Kagel, 2018; Nielsen et al., 2018) have shown that team play and individual play could be significantly different in strategic situations. Second, analysis of within-team discussions provides an opportunity for us to understand what motivates agents' behavior.

The game that the subjects play is a coordination game with incomplete information, with and without pre-play communication (in the form of cheap talk). It was developed by Li et al. (2019; hereafter LYZ), which is a variation of a two-player battle-of-the-sexes (BOS) game. In

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particular, there are costs of miscoordination so that agents have incentives to coordinate their actions. On the other hand, each agent prefers to coordinating on his own preferred action, and the intensity with which a player prefers his favored action (type) is private information. Theory predicts that pre-play communication can enhance coordination, but each player also has a tendency to exaggerate his own type in order to achieve coordination on his preferred action. This game has broad applications in the real world.[3]

In the team treatment of our experiment, each player consists of a two-person team. We run two treatments with team plays, one with communication and one without. In the communication treatment, agents have a restricted set of messages – Low (L), Middle (M), or High (H) - that can be sent regarding their types before choosing actions. Whenever there is a decision to make for a team, the two team members can discuss freely beforehand via a private chat box. The results obtained in the two team treatments are then compared to those of the individual treatments, which were conducted by Hu et al. (2020).

We first compare the performance of teams to that of individuals, in terms of payoffs and coordination rates. For the whole sample, there is no significant difference with regard to performance between teams and individuals, though in the no-communication treatments the performance with teams is slightly better and in the communication treatments the performance with individuals is slightly better. We then separate the data into six subsamples according to type pairs (types are grouped into low, middle, and high types, with six type pairs in total). We find that for the subsample with type pair mm (both agents are of middle types), teams perform significantly better than individuals without communication, but with communication teams perform significantly worse than individuals.

Between the two team treatments, communication significantly improves the performance for the full sample. A result similar to the one obtained in Hu et al. between the two individual treatments. However, for the subsample of type pair mm, communication does not improve performance under team play, which stands in contrast to individual play where communication significantly improves performance.

Next we compare subjects' strategies between individuals and teams. In the no-communication treatments, relative to individual play, under team play the types who have a dominant strategy play the dominant strategy more frequently, and the first significant jump in the probability of playing the preferred action occurs at a lower type. Both changes contribute to the slightly better performance for teams over individuals.

In the communication treatments, in the communication stage teams on average send higher messages than individuals. This is mainly due to the difference in middle types' behavior. Specifically, for middle types teams exaggerate their types significantly more than individuals, while the behaviors of low and high types are similar between teams and individuals. In the action stage, for the whole sample there is no significant difference between individuals and teams in

[3] See LYZ and Hu et al. (2020) for such examples.

their action choices conditional on the messages sent. However, for the type pair mm sample, teams are significantly more likely to choose preferred action A than individuals conditional on sending message H or the message pair being HH. This, in conjunction with middle types' tendency to exaggerate more in the communication stage under team play, explains why teams' performance is significantly inferior to that of individuals for type pair mm. Overall, our results suggest that teams are more strategic than individuals to some extent, especially for middle types.

To understand subjects' underlying motives in making choices, we investigated the chat messages within team members. Our chat analysis yields the following results. First, in the no-communication treatment, subjects with low types mainly chat about the probabilities of their opponents' action choices, while middle types mainly talk about using the MaxMin strategy.[4] In contrast, in the communication treatment, before making action choices both low types and middle types mainly talk about opponents' messages. This shows that communication fundamentally impacts subjects' decision-making process in choosing actions.[5] Second, in the communication stage of the communication treatment, both low types and high types mainly talk about being honest, while middle types mainly chat about exaggerating their types, which is consistent with the results with middle types. Moreover, we also found that subjects tend to believe opponents' L and M messages (truly indicating opponents' types), but are suspicious of opponents' H message (aware of the possibility of exaggerating).

Related literature

As mentioned earlier, our paper is related to the experimental literature on the role of cheap talk in various settings. To name a few, some papers investigate the CS cheap talk model in principal-agent settings (Blume et al., 1998, 2001; Cai and Wang, 2006; Battaglini and Makarov, 2014). Others explore the effects of pre-play communication in a public good contribution game when players' costs of contribution are private information (Palfrey and Rosenthal, 1991; Palfrey et al., 2017).[6] In all these papers, subjects are individuals; and one main result emerged from the literature is that subjects tend to be honest about their types (e.g., Cai and Wang, 2006). To the best of our knowledge, our paper is the first experimental paper on CS type of cheap talk models using teams as subjects. Our result clearly indicates that teams and individuals behave differently in cheap talk communication (at least for some types), with teams being more strategic and exaggerating more about their types. Given that in many real-world situations decisions are made by teams, our result suggests that the main result in the existing literature, namely players' tendency to be honest in cheap talk communication, should be interpreted with caution.

Two earlier papers, Sutter (2009) and Cohen et al. (2009), also ran experiments about a cheap talk game with team subjects. However, the game is based on Gneezy's (2005) deception

[4] In the MaxMin strategy, a player chooses the action maximizing his payoff in the worst possible scenarios.
[5] For high types, subjects mainly chat about using dominant strategies in both treatments.
[6] Crawford (1998) and Ochs (2008) provide excellent surveys on the experimental literature on pre-communication via cheap talk.

game, which is quite different from CS type of cheap talk models. Specifically, in the deception game there are only two states and two actions, and the sender and the receiver have completely opposite preferences. As a result, the only equilibrium is the babbling one in which no information is transmitted. Sutter (2009) finds that for senders teams are more honest than individuals in sending messages, while for receivers teams trust less about senders' messages relative to individuals. Similar results are obtained in Cohen et al. (2009). Due to the possibility of sophisticated deception in the deception game,[7] Sutter (2009) concludes that his experiment is inconclusive about whether teams are more strategic or honest than individuals.

Our paper is also related to a small literature using laboratory studies to investigate the effect of cheap talk in coordination games (Cooper et al., 1989; Cooper et al., 1992). For instance, Cooper et al. (1989) study a complete information BOS game (Farrell, 1987) under several communication structures. Later papers study the effect of pre-play communication in other complete-information coordination games (Duffy and Feltovich, 2002; Burton et al. 2005; Blume and Ortmann, 2007). In all these papers, since players have no private information, communication consists of messages regarding players' intended actions, and they all use individuals as subjects. As mentioned earlier, our paper is most closely related to Hu et al. (2020), as both papers study the same game and share very similar experimental designs. The major difference is that the current paper examines team play while their paper studies individual play.

There has been a growing experimental literature using teams as subjects. Just to name a few, Cooper and Kagel (2005) study signaling games and Cox and Stoddard (2018) investigate games of public goods contribution. These papers found that in general teams are more strategic than individuals, which is broadly consistent with our result. Kagel (2018) investigates pre-communication in a repeated prisoners-dilemma game with teams. But in his experiment players' cheap talk is about intended actions.

The remainder of the paper is organized as follows. Section 2 introduces the game and presents theoretical predictions. Section 3 describes the experiment design. The experimental results are reported in Sections 4 and 5, with the former comparing performances and the latter comparing strategies between individuals and teams. Section 6 conducts chat content analysis, and Section 7 concludes the paper.

2. Theoretical Model

Figure 1 illustrates a modified version of the BOS game with private information, developed by LYZ. Choices are made simultaneously between options, A and B. If player i chooses his preferred action A he gets benefit θ_i, where θ_i is private information (player i's type),

[7] In this game with binary states and binary actions, if the sender anticipates that the receiver is more likely to choose the opposite of his recommended action, the sender is better off by recommending the action that is better for the receiver, which appears to be the honest recommendation in the data.

distributed (i.i.d.) uniformly on [0, 10]. Agents' types, θ_1 and θ_2, are independent from each other. If both agents choose the same action, then both suffer a miscoordination loss $C > 0$.

Player 1\ Player 2	A	B
A	θ_1-C, θ_2-C	θ_1,0
B	0, θ_2	-C, -C

Fig.1 Illustration of the coordination game

For outcomes (A, B) and (B, A) coordination is achieved. There are two miscoordination outcomes, (A, A) and (B, B), where (A, A) dominates (B, B) as the players get their intrinsic benefit θ_i under the former. Because of this (A, A) will be referred to as "positive miscoordination", with (B, B) referred to as "negative miscoordination." Note that when $\theta_i > C$, it is a dominant strategy for player i to choose A.[8]

The game in Figure 1 with no communication serves as a control treatment. There are multiple equilibria, and we focus on the unique symmetric Bayesian Nash Equilibrim (BNE) in which both players adopt the same cutoff strategy: player i chooses A if and only if $\theta_i \geq C/(2C+1)$.

The game with communication has two stages. In the first stage, the two agents simultaneously communicate with each other by sending cheap talk messages regarding their types. In the second stage, they simultaneously choose their actions in the coordination game.

With communication the game has multiple Perfect Bayesian Equilibria (PBE). For the purpose of the experiment, we focus on a class of equilibria which is referred to as three-partition symmetric PBE. Specifically, in the first stage both players adopt the same partitional communication rule, where the type space [0, 10] is partitioned into three connected intervals, which correspond to three different messages. In the second stage, if two players send different messages, the player sending the higher message chooses A, with the other player choosing B. If both players send the same message, then each player chooses A if and only if his type is higher than a cutoff (this cutoff is message specific).

The main prediction of LYZ is that, compared to the benchmark case without communication, pre-play communication helps agents to coordinate and achieve higher expected payoffs. The intuition behind this result is that with pre-play communication, players may be able to coordinate their actions when they send different messages, which is not feasible without communication. In terms of communication strategies, LYZ predict that in equilibrium higher messages are noisier in the sense that the corresponding partition elements (in the type space) are larger.

In the experiment, the type space is discrete: each type must be an integer between 0 and 10 (11 types in total). Moreover, the miscoordination cost is set at C=6.[9]

[8] See Hu et al. (2020) and LYZ for real-world applications of this game.

[9] Hu et al. (2020) has a detailed characterization of the equilibria for the discrete type model.

3. Experimental design

We begin with describing the procedures for the team treatment with cheap talk, followed by a brief description of the no-communication team treatment. The two individual treatments will be discussed later. Specifically, in the team treatment each player consists of a two-person team. At the beginning of an experimental session, subjects were randomly matched to form two-person teams, and teams remained the same throughout the session. Teams played against teams throughout each session. We sometimes use the term agent to refer to a team.

Each treatment was conducted in three sessions. Each session has 17 or 18 rounds with the first round being trial. After each round, teams were randomly re-matched. Two teams form a market and each session consisted of six markets (24 subjects) operating simultaneously. Instructions were read out loud with subjects having copies to follow. Subjects were provided with a calculator, a pen and a piece of sketch paper. Each session lasted between 1.5 to 2 hours. Subjects were paid the sum of their earnings from the paid periods plus a participation fee. Each member of a team received his team's total earnings.

All subjects were shown the game matrix on the top of their screens throughout the session. In the beginning of each round, new private values θ_i's were drawn i.i.d. by computer.[10] To facilitate learning, the same pair of types was assigned to all markets in each round.

Subjects in the communication treatment make decisions in two stages: the communication stage and the action stage. Specifically, after learning their types, each team must decide together which message to send within 120 seconds.[11] The four alternatives are "My type is low", "My type is medium", "My type is high", and "I don't want to provide information". There is a chat box for team members to discuss their choices, and subjects were told that the discussion would be strictly private communication between team members.

Subjects are given a warning near the end of this stage – with 15 seconds left – to make the choice. If time expires and the two team members have not agreed on which message to send, the computer will check which of the following three cases applies. If the two team members have made different choices, the computer will randomly pick one of them as the team's choice. If only one team member has made a choice, then that choice is picked as the team's choice. If neither of the team members has made a choice, the computer will automatically send the message that the team used in the last round.

Messages were sent simultaneously only after both teams have made their choices.[12] They then entered into the action stage in which each team must decide which action to take (A or B) within 120 seconds.[13] Similar to the communication stage, team members exchange their opinions regarding which action to take via a chat box, and the rules of determining team action is the same

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[10] These type pairs are the same as in the individual treatments; see details later.
[11] 150 seconds for the first five rounds.
[12] This was done to prevent subjects from inferring something about the other agent's type from how quickly the message was sent.
[13] Again 50 seconds for the first five rounds.

as that of determining team message. After all decisions were made, feedbacks for all six markets were provided, including subjects' types, messages sent, action choices, and payoffs. In addition, each team was provided with a complete history of this information for its own market.

The no-communication treatment is the same as the cheap talk treatment except that the communication stage is eliminated. Each subject was provided a sufficient starting capital balance. Any profit earned was added to this, with losses subtracted. The end-of-experiment balances were converted into Chinese yuan at a pre-specified rate. End-of-experiment balances, along with a 10 Yuan participation fee, averaged 54 Yuan ($8.3), ranging from 47 to 66 Yuan ($7.3 to $10.3). This is higher than the average student wage which, for local college students with a standard work load, averages between 10 and 20 yuan per hour.

The two individual treatments were conducted in Hu et al. (2020), which has two sessions. The experimental designs are similar to those in the team treatments, except that each team is replaced by an individual. Each individual session consists of five markets (10 subjects), and has 28 rounds, with the first three rounds being trial. Thus, each individual treatment has 50 rounds in total, and each team treatment has 50 rounds as well (though are separated into three sessions).

Since the individual treatments were conducted before the team treatments, to facilitate the comparison between individuals and teams, type pairs used in team treatments were borrowed from their corresponding individual treatments. In particular, the type pairs used in the team communication treatment are exactly the same as those generated in the individual communication treatment. There are 50 type pair realizations in total,[14] and they appear in the same order in both treatments. For the no-communication treatments, again the type pairs generated in the individual treatment were applied to the team treatment.

The experiment was programmed using z-Tree, with all sessions conducted in the experimental economics lab at Southwestern University of Finance and Economics in Chengdu, Sichuan Province, China. Subjects were predominantly undergraduate students with a few graduate students from various departments as well.

4. Experiment Results: Performance Comparison between Teams and Individuals

In the experiment, since there are five simultaneous markets in each round of individual play and six simultaneous markets in each round of team play, we obtain 250 observations for individual play and 300 observations for team play, respectively. In the ensuing analysis, outcomes are either averaged across all rounds, or averaged across the last 8 rounds. Recall that A is a dominant strategy for types >= 6. Those types are called *Dominant strategy types*. If both players' types are dominant strategy types, they will be referred to as a *dominant strategy (type) pair*.

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[14] In each individual treatment, the 50 type pair realizations were divided into two sessions with 25 rounds in each session. In the corresponding team treatment, they were divided into three sessions, with two sessions having 17 rounds each and one session having 16 rounds.

Next we compare the performance between individual and team play, for both with and without cheap talk. The outcomes of interest are payoffs, probability of coordination, and probability of negative miscoordination (B, B). Two sets of results are reported - first with the dominant strategy pairs included and then without them. Dominant strategy types choose the dominant strategy (A) over 90% of the time. Therefore, eliminating the dominant strategy pairs gives a truer picture of behavior.

The comparison results are reported in Table 1. As we observe, relative to individual play, with team play market payoff is slightly worse and coordination rates is slightly lower with communication, but they are slightly better or higher with no communication. However, all the differences are not statistically significant. Table A1 in the Appendix reveals a similar pattern using the last 8 rounds of the data. We thus conclude that, for the whole sample, in terms of performance there is no significant difference between individual and team play, for both with communication and without.

Table 1: Individual vs. Team Play (full sample)

	With Communication			Without Communication		
Index	Individuals	Teams	Diff: Indvds-Teams (test-statistics)[a]	Individuals	Teams	Diff: Indvds-Teams (test-statistics)
Market Payoff	2.236 (5.81)[b]	1.91 (5.95)	0.326 (0.649)[c] N/A	2.232 (5.94)	2.71 (5.63)	-0.48 (0.382) N/A
Prob. of Coor.	0.556 (0.03)	0.517 (0.03)	0.039 (0.357) (0.043)	0.436 (0.03)	0.46 (0.03)	-0.024 (0.573) (0.043)
Prob. of Neg. Miscoor. [d]	0.052 (0.01)	0.05 (0.01)	0.002 (0.915) (0.019)	0.072 (0.02)	0.05 (0.01)	0.022 (0.279) (0.021)

a. Tests are based on market level observations; b. Standard error; c. p-value; d. Both players choose B.

To account for the slight differences in the performance between teams and individuals, we break down the whole sample according to type pairs. Specifically, types are separated into three categories: l (low types 0-2), m (middle types 3-6), and h (high types 7-10). Correspondingly, there are six type pairs in total: ll, mm, hh, lm, lh, and mh. For each type pair, we compare the market payoffs between teams and individuals, with and without communication. The results are reported in Table 2.

From the table we observe that, for type pair mm, the market payoffs are significantly different between teams and individuals, and those of all other type pairs are not significantly different. Interestingly, for type pair mm teams perform significantly better than individuals without communication, but with communication teams perform significantly worse. This pattern explains why overall teams perform slight better than individuals without communication but slightly worse with communication.

Table 2: Individual vs. Team Play: Market Payoffs by Type Pair

type pair	Obs. of individual	Obs. of team	individual	team	diff	*p*-value
			Without Communication			
ll	20	24	-7.30	-6.67	0.63	0.526
lh	60	72	5.25	6.42	1.17	0.411
hh	25	30	4.28	4.47	0.19	0.620
lm	40	48	0.53	0.06	-0.46	0.847
mm	25	30	-0.48	1.93	2.41	**0.079**
mh	80	96	3.41	3.29	-0.12	0.648
			With Communication			
ll	45	54	-2.82	-4.35	-1.53	0.567
lh	50	60	6.08	6.40	0.32	0.932
hh	20	24	4.45	4.25	-0.20	0.760
ml	50	60	-0.64	0.35	0.99	0.346
mm	20	24	3.00	0.46	-2.54	**0.046**
mh	65	78	4.08	3.72	-0.36	0.595

Table 3: Coordination Rates for Type Pair mm

	individual	team	diff	p-value
	Without Communication			
Prob. of Coor.	0.28	0.53	0.25	**0.058**
Prob. of Pos. Miscoor.[a]	0.68	0.47	-0.21	0.112
Prob. of Neg. Miscoor.	0.04	0	-0.04	0.269
	With Communication			
Prob. of Coor.	0.70	0.46	-0.24	0.107
Prob. of Pos. Miscoor.	0.30	0.50	0.20	0.179
Prob. of Neg. Miscoor.	0	0.04	0.04	0.356

a. Both players choose A.

To better understand the payoff differences, Table 3 reports various coordination rates for type pair mm. As we observe, without communication the probability of achieving coordination is significantly higher under team play than under individual play. However, the pattern is reversed with communication (the difference is almost statistically significant at 10% level). Another observation is that, relative to individual play, the probability of negative miscoordination is lower under team play without communication, while it is higher with communication. Although the differences are not statistically significant, since negative miscoordination is very damaging in terms of payoffs, they contribute to the payoff differences between teams and individuals.

The main reason for the above observed pattern is that teams tend to be more strategic than individuals, and the difference in behaviors is more pronounced for middle types (see Section 5 for details). In particular, relative to individuals, in the no-communication treatments with teams the middle types choose A more often when types are relatively high and less often when types are relatively low, which increases the probability of achieving coordination.[15] On the other hand, relative to individuals, in the communication treatments teams with middle types exaggerate more about their types in the communication stage and are more likely to choose action A conditional on sending message H in the action stage, which reduces the rate of coordination.

In the communication treatments, given that for middle types teams exaggerate more in communication, one may conjecture that the performance for type pair mh should also be significantly different between teams and individuals. Yet Table 2 shows that is not the case. To understand the reason, Table 4 reports various coordination rates for type pair mh.

Table 4: Coordination Rates for Type Pair mh with Communication

	individual	team	diff	p-value
Prob. of Coor.	0.38	0.33	-0.05	0.524
Prob. of Pos. Miscoor.	0.62	0.67	0.05	0.524
Prob. of Neg. Miscoor.	0	0		

As we observe, for type pair mh the probability of coordination is slightly lower with teams than with individuals, but the difference is not significant. The slight decrease in the coordinate rate is due to middle types' more exaggeration under team play. The reason for the difference not being significant is that for type pair mh, the behavior of high types is almost the same between teams and individuals (send message H and choose A). In contrast, for type pair mm, since both agents behave quite differently between teams and individuals, the resulting coordination rates are significantly different between teams and individuals.

Conclusion 1: Relative to individual play, for the whole sample, with team play mean payoffs and coordination rates are slightly lower with communication and slightly higher without communication. Neither difference is statistically significant, with or without communication. However, for type pair mm (both agents are of middle types), without communication teams perform significantly better than individuals, but with communication teams perform significantly worse.

With teams, we can also compare outcomes with communication to those without. For the whole sample, we reach the conclusion that communication significantly improves performance. Since this result is similar to the corresponding result under individual pay (Hu et al. 2020), the analysis is relegated into the Appendix.

Earlier analysis suggests that for type pair mm the effect of communication might be different from the general pattern. Table 5 reports the comparison of outcomes for type pair mm. Clearly, with individuals communication significantly improves payoffs and reduces the probability of negative miscoordination. However, with teams it is not clear whether communication improves payoffs (the two 90% confidence intervals overlap). To get clear results, we conduct t-tests. For individuals the test rejects the hypothesis that the market payoffs with and without communication are equal (p-value is 0.0015). However, for teams the test cannot reject

[15] Relative to individuals, under team play types 3-4 choose A less often and types 5-6 choose A more often (see Figure 2 in the Section 5).

the hypothesis (p-value is 0.5140). We thus conclude that for type pair mm, under team play communication does not improve payoffs. As mentioned earlier, the main reason is that with communication teams of middle types exaggerate too much which makes communication less effective.

Table 5: The Effect of Communication for Type Pair mm
(90% confidence intervals in parentheses.)

	Payoffs		Prob. of Coor.		Prob. of Neg. Miscoor.	
Type Pair	No Comm.	Comm.	No Comm.	Comm.	No Comm.	Comm.
Individual						
mm	-0.39 (-1.55, 0.85)	3 (1.42, 4.58)	0.33 (0.2, 0.45)	0.7 (0.11, 0.52)	0.03 (0, 0.1)	0
Team						
mm	-0.17 (-1.33, 0.96)	0.46 (-1.17, 2.09)	0.34 (0.21, 0.46)	0.46 (0.28, 0.64)	0.02 (0, 0.08)	0.04 (0, 0.11)

Conclusion 2: Under team play, for the whole sample communication significantly improves payoffs. However, for type pair mm ((both agents are of middle types) communication does not improve payoffs.

5. Strategy Comparison between Teams and Individuals

5.1. Treatments without communication

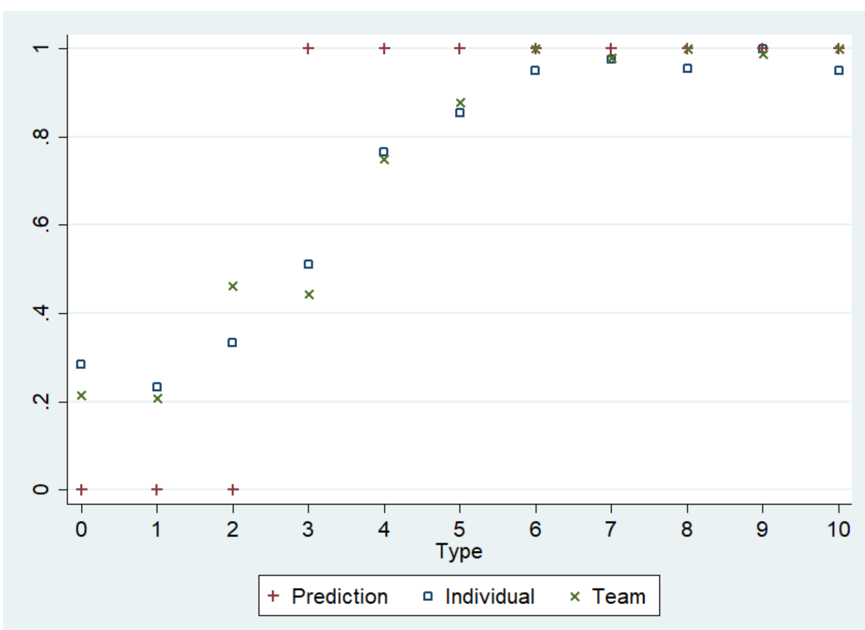

Fig. 2: Observed and Predicted Action Choices with No Communication

In this subsection we examine the difference in action choices between teams and individuals without communication. Figure 2 plots the probabilities of choosing A conditional on subjects' type. As we observe, dominant strategy types in both treatments overwhelmingly choose A. Their propensities of doing so are very close, averaging 97% and 99% for individuals and teams, respectively. Using each individual or each team as an observation, the p value of the proportion test (a t-test between the two percentages) is 0.103. This means that the two percentages are statistically (marginally significantly) different. On the other hand, for types below 6, the percentages of playing A for teams are almost statistically the same as those for individuals (the p value is 0.778). However, type 2 is an exception: teams play A considerably more often than individuals (0.463 vs 0.333), and the difference is close to be marginally significantly different (the p value is 0.16). Overall, compared to individuals, teams play A slightly more often.

From Figure 2, we also observe that in the team treatment types 2 and 3 have similar frequencies of choosing A, while in the individual treatment type 2's behavior is similar to type 1's. This suggests that in the two treatments subjects play different cutoff strategies, with the first significant jump in the probability of playing A occurring at a lower type in the team treatment. Proportion tests verified these observations. In the individual treatment the p value between types 1 and 2 is 0.257, and that between types 2 and 3 is 0.088. By contrast, in the team treatment the p value between types 1 and 2 is 0.002, and that between types 2 and 3 is 0.847.

Table 6: Panel Probit Estimation for Cutoffs in NC treatments

Coefficients	Individual		Team	
	All	Excl Dom Types	All	Excl Dom Types
NC2– (<2)				
NC2 (2)	0.211	0.187	0.712***	0.713***
	(0.240)	(0.253)	(0.230)	(0.232)
NC3 (3)	0.768***	0.869***	0.684***	0.696***
	(0.223)	(0.247)	(0.240)	(0.241)
NC3+ (>3)	2.405***	2.059***	2.488***	1.825***
	(0.357)	(0.415)	(0.207)	(0.237)
Constant	-0.751***	-0.930***	-0.816***	-0.823***
	(0.235)	(0.331)	(0.126)	(0.128)
N	500	270	600	324
Log pseudolikelihood	-183.9	-135.4	-208.1	-178.4

Robust standard errors in parentheses are clustered at the individual level.

*** p<0.01, ** p<0.05, * p<0.1

We also ran a panel probit to formally test the cutoffs, the results of which are reported in Table 6, with and without dominant strategy types. In the estimation we include four dummy variables: NC2- = 1 for types 0 and 1, NC2 =1 for type 2, NC3 =1 for type 3, and NC3+ =1 for types strictly above 3. From the table, we observe that in the individual treatment the coefficient for NC2 is not significant, meaning that type 2's behavior is statistically the same as that of types 0 and 1. By contrast, in the team treatment, the coefficient for NC2 is significant. Moreover, a

Wald test cannot reject the hypothesis that the coefficients between NC2 and NC3 are equal ($p > 0.90$). These results imply that in the team treatment type 2's behavior is statistically the same as type 3', which is different from that of types 0 and 1.

Conclusion 3**:** In the no-communication treatments, types predicted to play the dominant strategy do so overwhelmingly, but teams do so slightly more frequently than individuals. For the rest of the types, teams and individuals play A almost with the same probabilities, except for type 2. With teams the first significant jump in the probability of playing A occurs at a lower type (type 2) than with individuals (type 3).

5.2. Treatments with communication

Communication Strategy

We first compare agents' communication strategies between teams and individuals. The following figure depicts the distribution of messages sent conditional on types, for both individuals and teams. The first observation is that there is a sizable proportion of agents sending no information in both treatments. Moreover, this proportion under the team treatment (16.8%) is slightly higher than that under the individual treatment (12%). However, they are not statistically different (the p value is 0.25). Our reading of the chat scripts indicates that there is learning in the team treatment: some teams first chose sending no information, and then learned that it did not help and switched to sending other messages.[16]

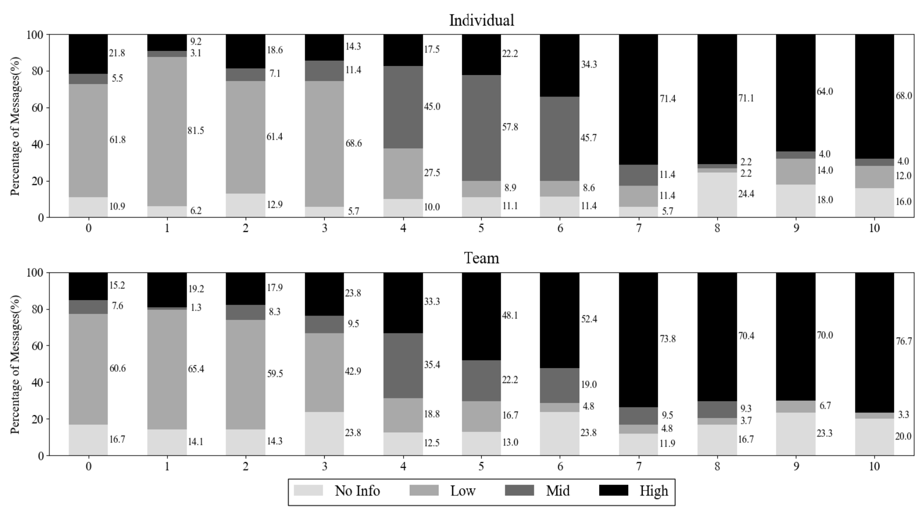

Fig. 3. Distribution of Messages across Types

[16] Scripts of the within team discussions reveal the following motivations for agents sending "no information" when they are dominant strategy types. Some subjects start with a wrong strategic thinking: messages do not matter, or sending no information can make themselves appear to be mysterious to their opponents and induce them to play B. Overtime, however, they realized that sending message H is a better choice. This learning effect is reflected in the sharp decrease in the proportion of sending no information in the subsample of the last 8 rounds. Type 9 is an exception, with the percentage of sending no information increases sharply in the last 8 rounds. One reason is that this type occurs less frequently than other types in later rounds (12 observations verses 24 observations for type 8 or type 10).

To rule out this effect of learning under the team treatment, we graph the message distribution using the sample of the last 8 rounds, which is shown in Figure 4.[17] In this subsample, the percentage of providing no information in the team treatment (11.8%) is slightly lower than that in the individual treatment (12.2%). Test shows that these two percentages are not statistically different (the p value is 0.93).

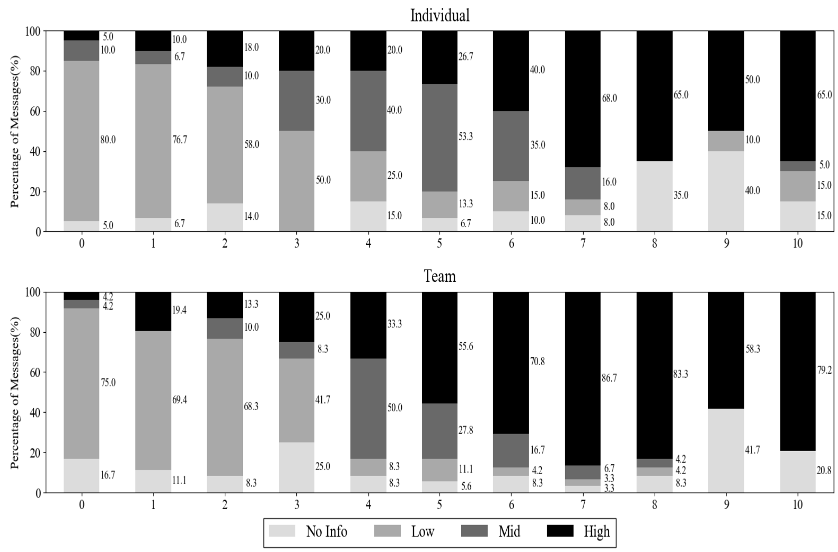

Fig. 4. Distribution of Messages in the Last 8 Rounds

An important observation from Figures 3 and 4 is that teams tend to send higher messages than individuals. To see this pattern more clearly, Figure 5 reports a weighted average of messages sent for each type (of the whole sample). In constructing the weighted average, messages L, M, and H are indexed by 1, 2, and 3, respectively, and then weighted by their observed frequencies.[18]

[17] The last 8 rounds refer to those in the three team sessions. For the individual sessions, we pick those rounds corresponding to the same type pairs in the team sessions (recall that there are 3 team sessions but only two individual sessions with longer rounds). This selection of rounds for the individual sessions is reasonable, since there is little learning going on in the individual treatment, as shown in Hu et al. (2020).

[18] The "no messages" have been dropped as there are relatively few of them.

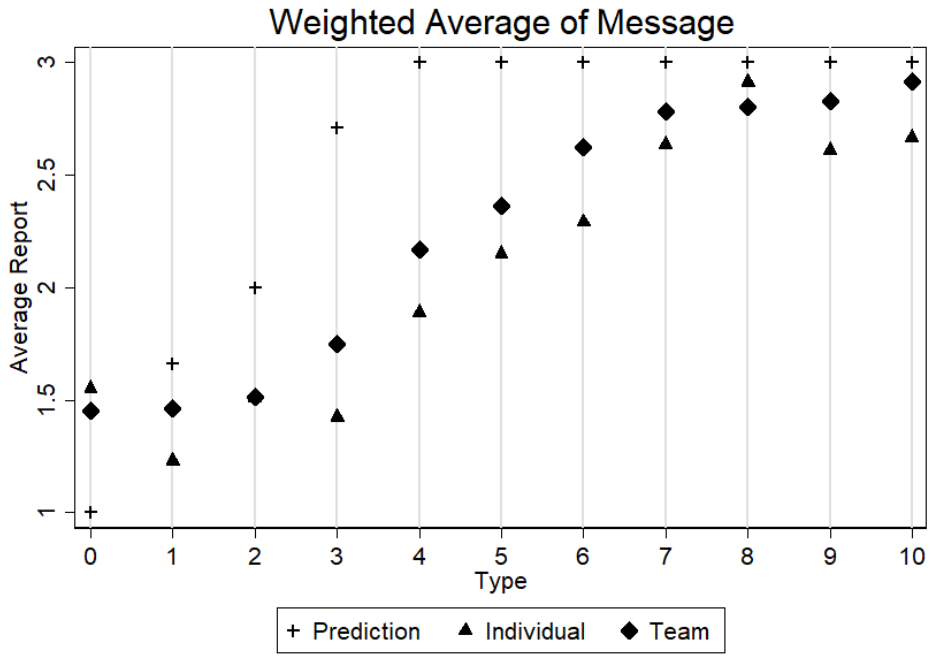

Fig. 5: Weighted Average of Messages

As we observe in Figure 5, for both individuals and teams, subjects' behavior is different from theory predictions.[19] However, overall teams' behavior is closer to what theory predicts than individuals' behavior is. Specifically, for types 3-6 the average messages are significantly higher for teams than for individuals (the p-value is 0.001). For types 7-10, the average message is slightly higher for teams than for individuals, though the difference is not statistically significant (the p value is 0.137). For types 0-2, the average messages are similar between teams and individuals (the p value is 0.472). We also examine types 3-6 individually. For type 3, the average message is not significantly different between individuals and teams (the p value is 0.133). For types 4, 5, and 6, the difference is statistically significant (the p values are 0.099, 0.075, and 0.025, respectively).

To decompose the average messages for types 3-6, we go back to Figures 3 and 4. For type 6, the percentage of sending message H with teams is 68.8% (excluding the sample of providing no information), which is significantly higher than that of individuals, 38.7% (the p value is 0.017). The same pattern holds for types 4 and 5: for type 4, the percentages are 38.1% vs 19.4% with p value 0.072; for type 5, the percentages are 55.3% vs 25% with p value 0.004.[20] For type 3, the percentages are not significantly different (31.3% versus 15.2%, and the p value is 0.124).[21]

[19] For the predicted communication strategies, see Hu et al. (2020) for details.

[20] For types 4-6, the dominant message in individual sessions is message M. With teams these types are much less likely to send message M.

[21] There is no significant difference in the messages sent by types 0 and 2 between team and individual play. For type 1, teams send message L significantly less often than individuals.

In the Appendix, we also empirically estimated subjects' communication strategy under team play, and then compare it with the one under individual play (by Hu et al., 2020). With individuals, the identified partition elements (types are grouped according to messages sent) are, 0-3, 4-6, and 7-10, which are almost of equal size, meaning that subjects tend to be more honest about their types compared to theory predictions. Under team play, the identified partition elements are 0-3, 4-5, and 6-10. Note that this partition is uneven, with the highest partition being larger in size. Compared to individuals, with teams the partition becomes closer to theory predictions.

The result that teams are more strategic than individuals in communication could be important. In standard CS cheap-talk experiments (e.g., Cai and Wang, 2006), one main result is that subjects tend to be more honest than what theory predicts. Our result suggests that if the subjects change from individuals to teams in those experiments, probably subjects will also exaggerate more about their types, and the resulting communication strategy will be closer to theory predictions.

Scripts of within team chats reveal the motivation for the middle types (types 3-5) to send message H (and then play A). If the opponent's type is high and plays A, then these agents lose either 3, 2, or 1 by adopting the proposed strategy. On the other hand, if the opponents' type is low, then sending message H can induce them to play B, and these agents will get 3, 4, or 5. Thus, by weighing the expected losses and gains, they think it is better to send message H. For example (own type is 5):

P2 (partner 2): Take a bet?
P1: You mean sending H?
P2: Yes. After all, if we win then we get 5, and only lose 1 otherwise.

Another example provides a more detailed thought process (own type is 5):

P2: Just always send H?
P2: Haha.
P2: This time we will play A no matter what.
P1: Okay.
P2: If we induce the opponent to play B, then we win.
P1: Yes, let's send H.
P2: Yes. If the opponent plays A, we won't lose much.
P1: Let's scare them a little.
P2: Let's see what our opponent does.

The last example provides a slightly different perspective due to a relatively low own type (3):

P2: Our type is a bit low.
P1: Yes, don't know what type our opponent has. Shall we send L, M, or H?
P2: How about sending H to deceive our opponent?
P2: If our opponent also sends H, we'll play B; otherwise, we'll play A.
P1: I don't have better ideas, so let's do as you suggested.
P2: Okay. If we send M, it's very likely for both sides to play A and then we'll suffer a loss.
P1: Alright.

Conclusion 4: Teams on average send higher messages than individuals. This tendency is most pronounced for the middle types 3-6. That is, with teams the middle types are much more likely to exaggerate their types than with individuals. In terms of estimated communication strategies, while with individuals the partition is almost even, with teams the partition becomes uneven and closer to theory predictions: the partition element for the highest message gets larger.

Action choices

We first examine how messages sent affect agents' action choices. We start with the cases in which agents send different messages. Figure 6 reports the action choices under message pairs HL, HM, and ML, for both teams and individuals. The first action in the action pairs below the bars represents the higher-message subject's action. For instance, AB indicates that the higher-message subject chooses A and the lower-message subject chooses B, which represents successful coordination. In the data, the dominant strategy types overwhelmingly choose to play their dominant strategy A (regardless of the message pairs), averaging 95% and 100% for individuals and teams, respectively (the p value is 0.027). To provide a sharper comparison, we focus on the subsample with dominant strategy pairs excluded.

As we observe, for message pair HL, the predominant outcome is AB, averaging 87.7% and 80.9% for individuals and teams, respectively; but they are not statistically different (the p value is 0.282). For message pair ML, the predominant outcome for both teams and individuals is still AB, averaging 69.6% and 82.6% for individuals and teams, respectively; and again they are not statistically different (the p value is 0.30). For message pair HM, under both treatments the coordination rates are low (slightly below 60%) and not statistically different (the p value is 0.831), but the coordination rate for teams is slightly better than that for individuals.

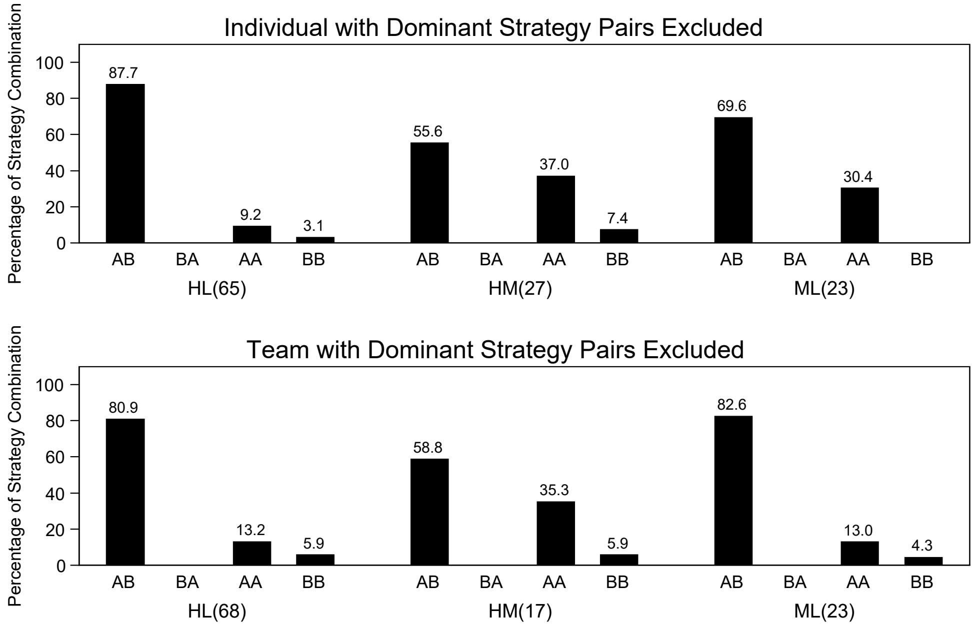

Fig. 6: Action Choices When Two Agents Send Different Messages.

The analysis of the action choices when both agents send the same message are provided in the Online Appendix. The pattern is that for message pair LL there is no much difference between teams and individuals for action choices. For message pair HH, teams' behavior is more consistent with theoretical predictions: for types 4-5, the percentage of agents choosing A is about 85% for teams, while it is 63% for individuals. But this should be interpreted with caution, as the sample size for individuals is relatively small.[22]

Since for mm type pairs there is significant difference in performance between teams and individuals, here we take a closer look at their action choices conditional on messages sent. The results are reported in Table 7.

[22] The sample size for message pair MM is too small.

Table 7: The Probabilities of Choosing A for Type Pair mm

	Obs. of individual	Obs. of team	individual	team	diff	p-value
Conditional on own message sent						
H	11	21	0.73	0.95	0.23	**0.067**
M	19	10	0.74	0.70	-0.04	0.833
Conditional on message pair (own, opponent)						
HH	6	10	0.50	1	0.50	**0.013**
HM	4	4	1	1		
MM	8	4	0.75	1	0.25	0.273
MH	4	4	0.25	0.50	0.25	0.465
Conditional on the relative ranking of messages (excluding no information)						
>	9	7	1	1		
=	14	16	0.64	0.94	0.29	**0.044**
<	9	7	0.33	0.29	-0.05	0.839

The sign > denotes that own message is strictly higher than opponent's message.

From the table we observe several patterns. First, conditional on middle types sending message H, teams choose A significantly more often than individuals; conditional on middle types sending message M, there is no difference between teams and individuals in the probabilities of choosing A. Second, conditional on message pair, teams choosing A significantly more often than individuals only in the case that the message pair is HH.[23] Actually, this difference is so significant that, even if we restrict attention to the subsample in which players send the same message (HH, MM, and LL), teams' probability of choosing A is still significantly higher than that of individuals. Taken together with the fact that for middle types teams send message H more often than individuals, this explains why in the communication treatments for mm type pairs the performance and coordination rates of teams are worse than those of individuals.

Finally, between individuals and teams we compare agents' unconditional action choices (unconditional on messages sent). In Figure 7, we plot the observed probability of choosing A as a function of subjects' type.

[23] For types 3-6, some teams play A even if their opponents sent a higher message (say the message pair is MH). Scripts within team discussions reveal that they do so because they think their opponents might have exaggerated their types.

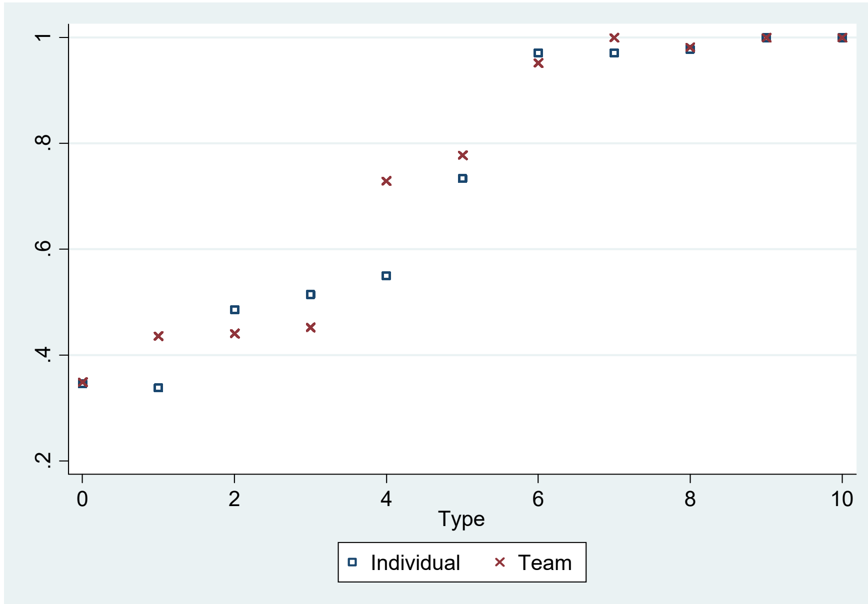

Fig. 7: Unconditional Probabilities of Choosing A across Types

As we observe, the probability of playing A does not differ significantly for the dominant strategy types between individuals and teams, averaging 98.0% and 98.8% for individuals and teams, respectively (the p value is 0.4786). On the other hand, for types below 6 the combined probability of playing A is slightly higher for teams (51%) than that for individuals (48%), but statistically they are not different (the p value is 0.613). Among those types, the only type whose behavior is significantly different between teams and individuals is type 4. Specifically, for this type the probability of playing A with teams is about 20% higher than that with individuals, and the two probabilities are significantly different (the p value is 0.09). This difference can be mainly attributed to type 4's higher average message (exaggerating his type) in the communication stage in the team treatment.

Conclusion 5: In the communication treatments, conditional on the messages sent, there does not exist much difference in terms of action choices between individual and team play. For mm type pairs, conditional on sending message H or the message pair being HH, teams are significantly more likely to choose A than individuals. Taken together with the pattern that for middle types teams send message H more often than individuals, this explains why the performance and coordination rates of teams are worse than those of individuals for mm type pairs. The unconditional probability of choosing A is not significantly different between teams and individuals for any given type, except for type 4 (teams are significantly more likely to choose A).

6. Chat analysis

To understand the motivations behind subjects' choices, we conduct chat analysis between members of the same team. Table 8 describes chat categories for chat messages, which are suggested by the theory in Section 3 as well as the authors' reading of the chats. Two research assistants (RAs) were hired to code the chats according to the pre-specified categories.[24] First, the RAs independently coded a session, and then a co-author met with them to review the codes. After that the RAs independently coded the rest of the sessions, and in the end there was a meeting to reconcile obvious discrepancies. Note that coding is at the level of a team in a period, and multiple categories could be coded for a given team in a given period, as the categories are not mutually exclusive.

6.1 Chat categories

It is useful to look at examples of some chat categories. In the no-communication treatment, CutStrat (A1) is coded for explicit mentions of cutoff strategies when the cutoff point is less than (type) 6. For example:

Let us choose B if it is under 4. We can make a bet by choosing A if it is 5.

Relatedly, DominAware (A2) is coded for explicit mentions of cutoff strategies when the cutoff point is at least 6. For example:

As long as it is greater than or equal to 6, choose A.

Maxmin (A3) is coded when subjects compare the worst outcomes between choosing A and B and then choose the one that yields the better outcome (implying that A is always better than B). The following is a clear example:

How about choosing A? Lose 1 at most if choosing A.

OppProb (A4) is coded for discussions of assessing opponents' probability of choosing A or B, as in the following example (P stands for partner):

P1: Type is 1. No money to earn. Choose B?

P2: What if the opponent chooses B?

P1: Choose B. I remember in the past our type was high when the opponent's type was 1.

For OppProb (A4), two subcategories, FalseNegCorr (A4.a) and FalsePosCorr (A4.b), are coded when team members (falsely) think that their type is negatively (positively) correlated to the opponent's type. The previous example is also an example for FalseNegCorr.

[24] One RA is a graduate student from Tsinghua University majoring in management and the other is an undergraduate student from Beijing Normal University majoring in economics.

Table 8: Chat Categories

	Treatment	Category	Description
			Action
A1	Nocom/Com	CutStrat	Choose A if own type is above some cutoff, otherwise choose B
A2	Nocom/Com	DominAware	Aware that choosing A is a dominant strategy when own type is at least 6
A3	Nocom/Com	MaxMin	Compare the worst outcomes between choosing A and B, and then choose the action leading to the better outcome
A4	Nocom/Com	OppProb	Assess opponent's probability of choosing A or B
A4.a	Nocom/Com	FalseNegCorr	When own type is low, conjecture that opponent's type is probably high, or vice versa
A4.b	Nocom/Com	FalsePosCorr	When own type is low, conjecture that opponent's type is probably low too
A5	Com	OppMess	Account for the opponent's message in choosing actions
A5.a	Com	Believe	Believe the opponent's message truly reflecting his type
A5.b	Com	NotBelieve	Suspect the opponent exaggerated his type
A5.c	Com	OppoNoInfo	Uncertain about what to do when the opponent sends no information
A6	Com	OwnMess	Recognize own message's impact on the opponent's action
			Message
M1	Com	Honest	Send an honest message about own type
M2	Com	Exagg	Exaggerate own type to induce the opponent to choose B
M3	Com	NoInfo	Choose sending no information
M3.a	Com	Mystery	Create mystery to make the opponent guess
M3.b	Com	Unaware	Unaware of the impact of own message on the opponent's action

In the communication treatment, additional chat categories about action choices are coded. OppMess (A5) is coded for interpreting opponents' message in deciding what to do. It has four subcategories. The subcategory Believe (A5.a) is coded for believing opponents' message (truly indicates opponents' type). For example (own type is 4, own message is L, and the opponent's message is H):

P1: So what do we choose?

P2: A?

P1: Since the opponent sent H, they will probably choose A. (We should choose B).

The subcategory NotBelieve (A5.b) is coded for not believing opponents' message (opponents exaggerated). For instance (own type is 5, own message is M, and the opponent's message is H):

P1: Alas, I'm afraid they are tricking us again.

P2: Choose A.

P1: OK.

OwnMess (A6) is coded for discussions about subjects' own message before choosing actions (recognize own message's impact on the opponent's action). For example (own type is 4, own message is H and the opponent's message is M):

P2: Do we choose B?

P1: What do you think our opponent will choose?

P2: Oh, I guess they think we would choose A.

P1: Yes. Yes. Yes.

P2: So we choose A?

P1: OK.

In the communication treatment, there are several chat categories about choosing messages. Honest (M1) is coded for sending an honest message about subjects' own type to facilitate coordination. For example (own type is 7):

P1: Send H?

P2: OK. We are honest.

P1: Just want to be an honest man.

Exagg (M2) is coded for exaggerating own type to induce the opponent to choose B. For example (own type is 1):

P1: Want to send H. Haha.

P2: Let's have a try.

P1: OK. Pretend (to be high types) so that we can deter the opponent.

NoInfo (M3) is coded for explicit mentions of providing no information. For example:

P1: How about choosing the last choice (no information)? Hahaha.

P2: OK.

P1: OK. Let our opponent guess and guess.

6.2 Coded chat contents

Table 9 reports summary statistics for the chat codes.[25] The first column reports Cohen's kappa (Cohen, 1960), which measures the degree of between-rater agreement about coding, with a score of kappa=1 indicating perfect agreement. In the literature (e.g., Landis and Koch, 1977), codes with kappa >= 0.4 are considered to be reliable. From the table, we observe that for most chat categories the values of kappa are above 0.4, indicating that the coding is reliable for most categories.

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[25] In the pooled data, the coding frequency for all action categories in the no communication treatment is 0.36. In the communication treatment, the coding frequency for all message categories is 0.46, and that of all action categories is 0.53. Overall, teams talk about actions more often in the communication treatment. This makes sense because the strategic environment with communication is more complex than in the case of no communication.

Table 9: Chat Code Frequencies by Type

	Category	Cohen's kappa	Nocom Low (0-2)	Nocom Mid (3-6)	Nocom High (7-10)	Com Low (0-2)	Com Mid (3-6)	Com High (7-10)
A1	CutStrat	0.65	1.17%	2.50%	2.50%	0.58%	0.67%	0.33%
A2	DominAware	0.56	1.08%	0.92%	**3.92%**	0.25%	3.25%	**8.83%**
A3	MaxMin	0.57	2.00%	**5.92%**	0.83%	1.67%	2.17%	0.25%
A4	OppProb	0.50	**4.58%**	3.67%	1.08%	2.50%	1.75%	0.17%
A4.a	FalseNegCorr	0.58	1.92%	1.75%	0.33%	0.67%	0.08%	0.08%
A4.b	FalsePosCorr	0.39	1.58%	0.83%	0.17%	0.25%	0.00%	0.08%
A5	OppMess	0.55				**11.17%**	**6.00%**	0.67%
A5.a	Believe	0.60				6.00%	4.58%	0.58%
A5.b	NotBelieve	0.54				0.25%	0.58%	0.08%
A5.c	OppoNoInfo	0.56				1.25%	0.50%	0.00%
A6	OwnMess	0.15				1.33%	1.08%	0.67%
M1	Honest	0.65				**9.33%**	4.17%	**6.25%**
M2	Exagg	0.72				5.17%	**6.00%**	0.33%
M3	NoInfo	0.67				2.75%	2.08%	1.67%
M3.a	Mystery	-0.01				0.42%	0.17%	0.17%
M3.b	Unaware	0.58				0.25%	0.83%	0.33%

Note: The total number of observations is 600, which is 50 rounds time 12 teams per round.

The remaining columns of Table 9 report the chat code frequencies by (own) types. The reason for doing so is that types affect subjects' considerations in making choices, and thus affecting their chat contents. The frequencies reported here are the percentages of periods in which a chat category was coded divided by the number of total observations of 600, averaging over two RAs.

We first investigate chat code frequencies in the no-communication treatment. For low types (0-2) OppProb (A4) is the dominant code (4.58%, consisting of 51.8% of all coded chat categories); that is, team members talk mainly about opponents' probability of choosing A or B. The second most frequent code is MaxMin (2%). Somewhat surprisingly, under the category of OppProb, the proportion of the subcategory FalseNegCorr (A4.a) is 42% and that of FalsePosCorr (A4.b) is 34.5%, indicating that many subjects hold wrong beliefs about their opponents' types. For middle types (3-6), the dominant code is MaxMin (A3) (5.92%, consisting of 45.5% of all coded chats), and OppProb is the distant second (3.67%). Note that, compared to the low types, the two dominant codes switch positions.[26] For high types (>=7), the dominant code is DominAware (A2) (3.92%, consisting of 47% of all coded chats), indicating that a large fraction of subjects are aware of the dominant strategy when their types are high. Across all types, CutStrat (A1) is coded but with moderate frequencies.

[26] For both low and middle types, the dominant code for agents who choose A is MaxMin, and for agents who choose B the dominant code is OppProb.

Next we investigate the code frequencies in the communication treatment. In the communication stage the code frequencies exhibit the following pattern. For low types, the dominant code is Honest (M1), with frequency 9.33% (consisting of 54% of all coded chat categories regarding choosing messages), and Exagg (M2) is the second (5.17%). For middle types, the pattern is the opposite: the dominant code is Exagg, with frequency 6% (consisting of 49% of all coded chats), and Honest is the second (4.17%). For high types, the dominant code is Honest (6.25%, consisting of 76% of all coded chats). If we add the code frequencies of M1 and M2 together, then for middle types 59% of the chats are about exaggerating their types, while for low types this percentage is only 35.7%. For all types, NoInfo (M3) is coded with moderate frequencies. The above results show that middle types have stronger incentives to exaggerate their types than other types, which is consistent with the experimental data in the previous sections.

In the action stage in the communication treatment, for both low types and middle types, OppMess (A6) is the dominant code, with frequencies 11.17% and 6%, respectively. Compared to the no communication treatment, OppProb for low types (2.5% vs 4.58%) and MaxMin for middle types (2.17% vs 5.92%) are coded far less frequently. This shows that communication fundamentally changed subjects' decision process in making action choices, with a big weight given to opponents' messages. For high types, similar to the no communication treatment, DominAware is again the dominant code (8.83%, consisting of 81% of all coded chat categories regarding action choices). Surprisingly, subjects seldom discuss their own messages.[27]

In the communication treatment, we also study how low and middle types interpret opponents' messages: whether higher messages from opponents makes them more suspicious about exaggerating. For that purpose, we examine how the coding frequencies of subcategory Believe (A5.a) are affected by opponents' messages in the last 8 rounds of the data.[28] Table 10 reports the regression results (the default message is M).

[27] This should be interpreted with caution, as the value of kappa for the category OwnMess is very low.

[28] NotBelieve (A5.b) is not included in the regression because its coding frequencies are too low. We use the second half of the data because in earlier rounds the effect is not significant, as agents are still learning about how other agents choose messages.

Table 10: Low and Middle Types' Trust of Opponents' Messages

	(1)	(2)	(3)	(4)
L	0.0376	0.0446	0.0387	0.0447
	(0.0960)	(0.0926)	(0.0966)	(0.0939)
H	-0.155**	-0.151**	-0.136*	-0.132*
	(0.0756)	(0.0726)	(0.0732)	(0.0710)
period	-0.00625	-0.00286	-0.00654	-0.00341
	(0.0186)	(0.0203)	(0.0187)	(0.0206)
own message	-0.0212	-0.0100	-0.0270	-0.0169
	(0.0295)	(0.0349)	(0.0290)	(0.0318)
type		-0.0108		-0.00985
		(0.0196)		(0.0199)
Constant	0.362	0.322	0.370	0.333
	(0.250)	(0.256)	(0.253)	(0.260)
Observations	153	153	153	153
Team RE	No	No	Yes	Yes

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.
The standard errors are clustered at the team level.
For columns (1) and (2) we run simple linear regressions, and for columns (3) and (4) we construct panel data and use a model with random effect. In columns (1) and (3), we do not control for types.

From the table, we observe that subjects tend to trust less if opponents send message H instead of M. Specifically, compared to the benchmark case that opponents send message M, when the opponents send message H the trusting probability decreases by 14.4 percent (average across four columns), and this is statistically significant at 5% or 10% confidence level. On the other hand, when opponents send message L instead of M, the trusting probability increases very slightly and the effect is not statistically significant.

In the Online Appendix, we also study how type and period affect coding frequencies. Our first finding is that in both treatments the coding frequency for all action categories decreases in period, and in the communication treatment the decrease is not as pronounced as in the no-communication treatment. One possible reason for the decreasing trend is that in later periods subjects become familiar with the game (similar situations has been experienced before). The decreasing trend is not pronounced in the communication treatment probably is because with communication the number of possible scenarios increases significantly (adding 9 possible message pairs). The second finding is that the overall coding frequency decreases in type in the no-communication treatment, but it does not change with type in the communication treatment. Without communication, low types chat more because in the game low types' action choice is involved with higher risks. With communication subjects of all types chat about how to interpret the messages before choosing actions, which makes the frequency of chatting depend less on type.

Finally, in the communication treatment the coding frequency for all message categories also decreases in period. This is probably also due to the familiarity of situations in later periods. Moreover, in later periods the coding frequency of NoInfo (M3) and so is the probability of sending no information. This indicates that gradually subjects learn that sending no information has no benefit.

Conclusion 6: In the no-communication treatment, subjects with low types mainly chat about their opponents' probabilities of choosing actions, and middle types mainly talk about the MaxMin strategy. In contrast, in the communication treatment, both low types and middle types mainly talk about opponents' messages when subjects make action choices. In the communication stage of the communication treatment, both low types and high types mainly talk about being honest, while middle types mainly chat about exaggerating their types. Compared to the case that opponents send message M, the level of trust for messages for both the low and middle types is significantly reduced when opponents send message H.

7. Conclusion

This paper introduces team play in a lab experiment on pre-play cheap talk communication in a coordination game with incomplete information. To the best of our knowledge, our paper is the first experimental study on CS cheap talk communication about types using teams as subjects. We compare team play with individual play, both in terms of performance and strategies.

Between teams and individuals, there is no significant difference in terms of performance for the whole sample. However, for type pair mm (both agents are of middle types), without communication teams perform significantly better than individuals, but with communication teams perform significantly worse than individuals. For type pair mm, while communication significantly improves performance under individual play, with teams communication does not improve performance.

In terms of strategies used, teams are more strategic than individuals in some situations. In the no-communication treatments, relative to individuals, with teams types having a dominant strategy play the dominant strategy more often, and the first significant jump in the probability of playing the preferred action occurs at a lower type. For middle types, in the communication treatments teams exaggerate significantly more about their types than individuals, and teams choose their preferred action more often than individuals conditional on messages sent. The latter result indicates that using teams as subjects could qualitatively change the results in CS type of cheap talk experiments.

Our analysis of the chat contents between team members sheds light on subjects' underlying motives in making choices. In the no-communication treatments, low types mainly chat about their opponents' probabilities of choosing actions, while middle types mainly talk about using the MaxMin strategy. In contrast, in the communication treatments both low types and middle types mainly chat about opponents' messages before choosing actions. In the communication stage in the communication treatments, both low types and high types mainly talk about being honest, while middle types mainly chat about exaggerating their types. We also found that subjects are more suspicious of opponents' higher messages.

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Appendix

Table A1. Performance Comparison (subsample with the last 8 rounds of data)

	With Communication			Without Communication		
Index	Individuals	Teams	Diff: Indvds-Teams (test-statistics)[a]	Individuals	Teams	Diff: Indvds-Teams (test-statistics)
Market payoff	2.18 (5.73)[b]	2.13 (5.99)	0.05 (0.99)[c] N/A	3.38 (4.55)	3.73 (4.68)	-0.35 (0.391) N/A
Prob. of coor.	0.54 (0.05)	0.53 (0.04)	0.01 (0.822) (0.062)	0.40 (0.04)	0.43 (0.04)	-0.03 (0.616) (0.06)
Prob. of neg. mis. coor.	0.05 (0.02)	0.042 (0.02)	-0.008 (0.746) (0.026)	0.025 (0.01)	0.021 (0.01)	0.004 (0.821) (0.018)

a. Tests are based on market level observations; b. Standard error; c. p-value

The effect of communication under team play

To control for the difference in type realizations between the treatments with communication and without, outcomes with cheap talk are compared to simulated outcomes for the same type pairs in the no cheap talk sessions. In particular, each pair of realizations in the cheap talk sessions are randomly assigned the action actually played by the same types in the no cheap talk sessions. This is reasonable, because in the no cheap talk sessions a player's action only depends on his own type. This process is repeated 1000 times for each pair of types in the cheap talk sessions, with the 90% confidence interval for what would have occurred in the no cheap talk sessions calculated. Table A1 compares these to the mean values and the 90% confidence interval for the cheap talk sessions.

Table A2 shows that in all cases, mean outcomes with communication lie outside the 90% confidence interval for the no communication sessions, with these differences consistently larger when the dominant strategy pairs are dropped. We thus established a result similar to Hu et al. (2020): cheap talk helps coordination.

Table A2: Communication versus No-Communication Outcomes for Team Play

(90% confidence intervals in parentheses.)

	Payoffs		Prob. of Coordination		Prob. of Neg. Miscoor.	
	No Comm.	Comm.	No Comm.	Comm.	No Comm.	Comm.
All Pairs	0.68 (0.24 - 1.16)	1.91 (1.63 - 2.19)	0.41 (0.37 - 0.45)	0.52 (0.49 - 0.54)	0.13 (0.11 - 0.16)	0.05 (0.04 - 0.06)
Dominant Pairs Dropped	-2.88 (-3.40 - -2.35)	1.69 (1.37 - 2.01)	0.29 (0.24 - 0.33)	0.58 (0.56 - 0.61)	0.25 (0.21 - 0.28)	0.06 (0.05 - 0.07)

Estimate subjects' communication strategies

To identify the partition elements under team play, we first conduct proportional tests regarding the average message sent for adjacent types. We found that type 6's average message is not significantly different from type 5's or type 7's (the p values are 0.151 and 0.165, respectively), while with individuals type 6's behavior is the similar to type 5's (p value 0.30), but different from type 7's (p value 0.013). This suggests that with teams type 6 might be grouped with higher types.[29]

To formally test this, we run a panel ordered probit regression model. Results are reported in Table A3. Specifically, we use dummy variables CL, C4, C5, C6, C7, and CH to capture type categories, with CL = 1 for types lower than 4 (default), C4 = 1 for type 4, C5 = 1 for type 5, C6 = 1 for type 6, C7 = 1 for type 7, and CH = 1 for types higher than 7.

As we observe, all the dummies are significant in both treatments. We further conduct Wald test to check whether the dummy of C6 is different from those of C5 and C7. For individuals, the p-value of the Wald test between C5 and C6 is 0.32, while that between C6 and C7 is 0.06. These imply that type 6 is grouped with type 5, consistent with Hu et al. (2020). With teams, the result is the opposite: the p-value of the Wald test between C5 and C6 is 0.01, while that between C6 and C7 is 0.40. Therefore, with teams type 6 is grouped with type 7. Based on the above analysis, we conclude that the plausible partition in the team treatment is 0-3, 4-5, and 6-10.

Table A3: Panel Ordered Probit Estimation of Communication Strategy

Coefficients	Individual	Team
CL (<=3)		
C4	0.813***	1.010***
	(0.245)	(0.215)
C5	1.187***	1.463***
	(0.294)	(0.212)
C6	1.406***	1.931***
	(0.323)	(0.221)
C7	2.127***	2.189***
	(0.562)	(0.292)
CH (>=8)	2.277***	2.444***
	(0.609)	(0.249)
N	440	499
Log pseudolikelihood	-340.9	-360.6

Robust standard errors in parentheses are clustered at the individual and team level. *** p<0.01, ** p<0.05, * p<0.1

[29] With teams, type 3's average message is similar to type 2's (p value 0.188) but different from type 4's (p value 0.036). This pattern is the same as with individuals.