Demanding or Deferring?
The Economic Value of Communication with Attitude

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Abstract We present and test a formal framework for expressing the idea that taking account of the multiple meanings conveyed by natural language may help economists to better understand the impact of pre-play free-form communication. We model coordination games where each player simultaneously requests others to take a particular action. We assume requests include two independent features: the desired action as well as the request's "attitude". We show that, in relation to one-dimensional signals, communication with attitude increases the rate of coordination on actions. We test our model both in Shanghai and Washington D.C. using laboratory implementations of complete information coordination games with pre-play communication. Consistent with our model, we find (i) natural language action requests are made with attitude; (ii) people consider both the requested action and attitude when making action decisions; and (iii) the use of attitude improves coordination. We also find evidence of gender differences. Although males and females recognize and respond to attitude equally well, females are more likely to send more demanding action recommendations than males, while males generally focus more on which action request to send rather than which attitude to use. Our results imply that, when requesting actions of another, it is important to be clear not only about the action but also the attitude with which the request is made. Knowing that transparent attitude can improve economic outcomes can benefit conversational and social media strategies in any social, economic or political environment.

Keywords two-way communication; coordination; attitude; gender; culture

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1. INTRODUCTION

Language is a powerful and complex human tool facilitating social and economic decisions. Over the last decades there has been significant theoretical and empirical progress towards understanding how free-form communication improves coordination. While much of this early progress has occurred within the context of one-dimensional signaling models, natural language communication has a more richly detailed structure that can convey multiple meanings in concisely. That this structure has evidently survived an evolutionary process has led some economists to argue for its importance not only to understanding grammar (see, e.g. Selten and Warglien 2007) but also for understanding human decisions (see, e.g. Rubinstein 2000). Consequently, it has been long-argued that the existence of a rich language should play a more prominent role in game theory (see, e.g., Farrell, 1993), while empirically others have demonstrated that, in relation to constrained signaling, efficient economic outcomes emerge more readily when players can communicate using rich natural language (see Ledyard 1995; Charness and Dufwenberg 2006, 2010).

Our aim here is to present and test a formal framework for expressing the idea that taking account of the multiple meanings conveyed by natural language may help economists to better understand the impact of pre-play free-form communication. We model coordination games where each player simultaneously requests others to take a particular action. This type of quick multi-way communication is essential for solders in the battle, athletes of football, and video game players, among others. We assume requests include two independent features: the desired action as well as the request's "attitude". We show theoretically that communication with multi-dimensional meanings improves economic coordination.

Consider routine discussions over where to dine or which film to view. If all report an attitude of indifference, by stating that it's "Up to you", or "I really do not care", the conversation is likely to be long and inefficient. At the same time, the same is true if all report a preferred option without a clear attitude. For example, one person's "I feel like French" combined with another's "I'm thinking Indian" creates inefficiencies. Of course, in natural environments these problems are typically solved by making statements that combine preference information with attitude, that is, by indicating strength of preference. For example, one person's, "I really want French tonight" meeting another's "I'm thinking Indian, but it's up to you" will lead to immediate agreement. Intuitively, it makes good sense to communicate in a way that allows any common ground to be rapidly found. Our model shows this can be done when communication includes multiple independent meanings, and in particular when requests are made with attitude.

In our model, players play a two-stage game in which they simultaneously communicate in the first stage and simultaneously take actions in the second stage. We assume the language space players communicate with is common and complete, that is, that players understand each others' messages and that every message includes a recommended *Equilibrium* action action (so-called *E-meaning* by Rabin 1991, 1994*)* as well as an *attitude* (which we denote an *A-meaning*) that indicates the strength of preference for this recommendation. We demonstrate the existence of two perfect Bayesian equilibria with a *Credibility* condition. One is an *agreement equilibrium* where players reach coordination success by suggesting the same *E-meaning* in the first stage and choosing that action in the second stage. The other is a *negotiated equilibrium* where players' messages have the different *E-meanings* and different *A-meanings* (*Attitudes).* In this case coordination occurs by choosing the action of the player who made a stronger recommendation.

We test our model both in Shanghai and Washington D.C. using laboratory implementations of complete information coordination games with pre-play communication. Consistent with our model, we find (i) natural language action requests are made with attitude; (ii) people consider both the requested action and attitude when making action decisions; and (iii) the use of attitude improves coordination. Our analysis also reveals gender effects. Although males and females recognize and respond to attitude equally well, they write different types of messages. We find females are more likely to make stronger (more demanding) action recommendations than males, and that males generally focus more on which action request to send rather than which attitude to use.

Economic theory has long conjectured that natural language communication facilitates efficient economic outcomes because it includes a rich, multi-meaning structure that people use and to which people respond (e.g. Marschack, 1965). To our knowledge, this paper is the first direct test of this conjecture, and our findings lend support to the related body of theory. Moreover, our results have valuable implications. For example, leadership in any social, economic or political environment will benefit by knowing the importance of making requests with transparent attitude.

The remainder of this paper is organized as follows. Section 2 reviews the theoretical and experimental literature on pre-play communication. Section 3 models free-form two-way simultaneous communication with attitude. Section 4 describes the design of our experimental test. Section 5 summarizes and discusses our main findings. Section 6 offers concluding remarks and further discussion.

2. LITERATURE REVIEW

The modern theory of communication and coordination originates with Aumann (1974), which introduces "cheap-talk" communication where agents engage in costless, non-binding, pre-play talk before choosing their actions. Aumann argues that players will reach some agreement, and that since no external enforcement is available they can only consider self-enforcing Nash outcomes. Farrell and Maskin (1987) confirms that cheap-talk can generate a selection of self-enforcing agreements. Aumann (1990) adds subtlety to the discussion by noting that the effectiveness of communication in promoting coordination can depend crucially on the payoff structure of the game (see also Farrell and Rabin, 1996).

Farrell (1987, 1988) took another important step by studying signaling intentions in simple sequential games of complete information, where an underlying game is preceded by one more round of structured pre-play communication in which players make nonbinding announcements about their intended decisions in the underlying game. (Farrell (1987) studies the Battle of the Sexes and Farrell (1988) considers a finite n-person matrix game.) Rabin (1991, 1994) extended the analyses of Farrell (1987, 1988). He assumes that players make repeated, simultaneous statements before they play a simple coordination game. He made it possible to combine the assumptions that players maximize expected payoffs given beliefs with a variety of behaviorally motivated restrictions on beliefs. He generalized Farrell's (1987) result for an unlimited number of rounds of communication and generated considerable additional insights. As will become clear below, the model in this paper builds closely on the previous work of Farrell and Rabin.

Another advance was made by Crawford (2003), which relaxes equilibrium assumptions in a way that imposes more structure on behavior. His model allows for the possibility of bounded strategic rationality and rational players' responses to the misrepresentation of intentions. Next, Ellingsen and Östling (2010) used level-k model of strategic thinking to describe players' beliefs in both one-way and two-way communication of intention game. They find that communication facilitates coordination in common interest games with positive spillovers and strategic complementarities. Blume and Board (2013) introduced language barriers into standard common-interest games. They find that lack of common knowledge of language can generate substantial efficiency losses.

Empirically, many experimental studies have shown that cheap talk can facilitate coordination on efficient equilibria in experimental games with Pareto-ranked equilibria (e.g. Cooper et al. 1989, 1992; Holt and Davis 1990; Van Huyck et al. 1993; Charness 2000; Clark et al. 2001; Charnes and Grosskopf, 2004; Duffy and Feltovich 2002, 2006, Blume and Ortman 2007). For instance, Cooper et al. (1989) showed one-way communication resolves coordination problems in the Battle of Sexes game. On the other hand, two-way communication is of less value in solving coordination problems. For example, Cooper et al. (1992) found that two-way communication does not always decrease the frequency of coordination failure. Clark et al. (2001) tested Aumann's conjecture with two-way signals and show, consistent with theory, informative communication does not necessarily lead to Pareto-efficient equilibrium outcomes. Blume and Ortman (2007) showed costless pre-play communication can be effective in coordination games with more than two players. It is worthwhile to point out that cheap-talk communication in these experiments occurs not in the form of natural language but rather a constrained-form signal.

Economic experiments allowing subjects to communicate using natural language have also appeared (e.g. Ledyard 1995). Natural language communication has been shown to improve efficiency in games including prisoners' dilemmas (Dawes, MacTavish, and Shaklee 1977), sealed bid auctions (Isaac and Walker 1985), as well as games of signaling (Cooper and Kagel 2005) and coordination (Brandts and Cooper 2007). A relatively early contribution was Ledyard (1995), which compared face-to-face communication, verbal communication through chat room and numerical cheap talk through computer terminals in public provisions environment, and found while face-to-face and verbal communication both have equally strong effect on increasing contributions, numerical cheap communication had no effect.

Many studies implement pre-play cheap-talk as free-form written messages (e.g. Cooper and Kagel 2005; Xiao and Houser 2005, 2009, 2011; Charness and Dufwenberg 2006; Brandts and Cooper 2007; Schotter and Sopher 2007; Kimbrough et al. 2008; Ellingsen and Johannesson 2007; Sutter and Strassmair 2009; Heinnig Schmidt et al. 2008; Lundquist et al. 2009, Cason et al. 2012). Some studies also use face-to-face communication (Isaac, Ramey and Williams 1984; Daughety and Forsythe 1987a, 1987b; Binger et al. 1990; Valley et al. 1998).

In broad brush-stroke, the message of the empirical literature is that the efficiency of economic outcomes is surprisingly high in the presence of pre-play communication, and all the more so when communication includes natural language. As pointed out by Ledyard (1995, p. 158) the question left unanswered is: why? Our paper, building on economic theory that points to the importance of richly-structured multi-meaning free-form messages, is a step towards answering this question.

3. MODEL

Our model incorporates commonly known language into two-stage games in which players simultaneously communicate in the first stage C and simultaneously take actions in the second stage G. We denote this two-stage game as G* (C, G). All players $i = 1, \dots, k$ make decisions in both stages.

Beginning with the second (or action) stage, players play a complete information game G. Each player i takes an action $a_i \in \mathcal{A}_i$, where each players action set $\mathcal{A}_i$, $i = 1, \dots, k$, is finite. We denote $\boldsymbol{\mathcal{E}}$ as the set containing all Nash equilibrium of G. We focus on coordination games, where multiple pure strategy Nash equilibria exist. Suppose a subset $\mathrm{E} \in \boldsymbol{\mathcal{E}}$ includes at least two elements E, E' $(\, or\ more, denote\ as\ E, E', E'', \dots)$ which Pareto-dominate all other elements (if any) in $\boldsymbol{\mathcal{E}}$, while at the same time no element in E Pareto-dominates the other(s). This payoff structure ensures any improvement from communication is sustained. The set of all the strategies Player i can play is denoted by S_i. Let $(s_i^E, s_{-i}^E) \in S_i \times S_{-i}$ be the strategies that constitute equilibrium $E \in \mathrm{E}$. Let $U_i(s_i, s_{-i})$ and $U_{-i}(s_i, s_{-i})$ denote players' strategy-dependent payoffs.

Turning now to the first (or communication) stage, each player sends a message m_i simultaneously from a publicly known set *M*. Messages are cheap-talk in that they are neither binding nor costly. Consequently, behavioral assumptions must underlie claims about the effects of pre-game communication on expectations.

In day-to-day life, people use different words and have different ways to construct sentences. As a result, natural language is not a limited space. For this reason the impact of free-form communication can be challenging to model. We circumvent this by assuming that the set of action-relevant information conveyed by natural-language messages is finite. We make this idea precise by defining a common and complete language space in the next subsection.

3.1. Language Space

In the spirit of Rabin (1994), we assume players share a common language *M*. A common language consists of (1) a meaningful vocabulary; (2) a shared understanding among players that it is appropriate to interpret statements according to their literal meaning. Common language is important not only because it eliminates the inessential multiplicity of equilibria in cheap-talk games, but also it restricts the plausible interpretations of out-of-equilibrium messages, which could otherwise be anything needed to support equilibrium[1].

First, we define the *E-meaning* and *A-meaning* (attitude) of messages.

DEFINITION 1*. The E-meaning of a message refers to the equilibrium that the message suggests. We denote the set of messages that suggest equilibrium E as* $Q(E)$.

DEFINITION 2*. The A-meaning of a message indicates how strongly players indicate their preference to achieve a certain equilibrium. We denote set of messages conveying attitude D as* $A(D)$.

Attitude (*A-meaning*) is a linear ordering of the strength of preference to achieve a certain equilibrium. Since players communicate in a common language space, we assume that all players express and interpret *attitude* with the same linear ordering. For example, we assume that everyone in the game should agree that a message like "I choose X no matter what" expresses a stronger preference than a message like "It's up to you, if you have no strong opinion, let's choose X", even though they have the same *E-meaning*.

Next, extending Rabin (1991, 1994), we define a complete language space[2] both in *E-meaning* and *A-meaning*.

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[1] See Crawford (1998) for more details.
[2] Rabin (1991, 1994) defines a complete and common space for the E-meaning of language.

DEFINITION 3. *The E-meaning of language M is complete with respect to game G iff:*

(1)For all $m_i \in M$, there exists an equilibrium $E \in \boldsymbol{\mathcal{E}}$ of G such that $m_i \in Q(E)$;

(2)For every two equilibria $E \in \boldsymbol{\mathcal{E}}, E' \in \boldsymbol{\mathcal{E}}$ and $E \neq E'$ of G, $Q(E) \cap Q(E') = \emptyset$.

DEFINITION 4. *The A-meaning of language M is complete with respect to game G iff*

(1)For all $m_i \in M$, there exists attitude $D \in \boldsymbol{\mathcal{D}}$ such that $m_i \in T(D)$;

(2)For all $D \in \boldsymbol{\mathcal{D}}, D' \in \boldsymbol{\mathcal{D}}$ and $D \neq D'$, $T(D) \cap T(D') = \emptyset$.

Definition *3* assumes all messages suggest some equilibrium, and that no message can simultaneously request to play two different equilibria. Analogously, Definition *4* assumes that every message conveys an *A-meaning*, and that no single message can convey more than one attitude.

3.2. Equilibria

3.2.1. Agreement Equilibrium

We now discuss how players form an "agreement" in this language space. Rabin (1991, 1994) defines players to have an "agreement" when they mention the same equilibrium in the pre-played communication stage. Proposition 1 and Definition 5 in this subsection extend the notion of "agreement" into a communication environment where both *E-meaning* and *A-meaning* of messages exist, and then proceeds to define the concept of an *agreement equilibrium*.

ASSUMPTION 1 (CREDIBILITY) *If it is optimal for any player to honor the E-meaning of her message when all other players honor the E-meaning of their messages, then all players' messages' E-meanings will be honored.*

This assumption extends the idea of *credibility*[3] to a n-way communication environment. Because talk is cheap it should not matter, in the sense that *any* first-stage communication followed by second-stage Nash play in G is an equilibrium of the extended game G*. Nevertheless, communication can improve coordination under certain conditions, which makes *credibility* important. In particular, Assumption 1 implies that when all players send messages with the same *E-meaning*, the players will coordinate and play that equilibrium in G.

PROPOSITION 1. *For each Nash Equilibrium $E \in \mathcal{E}$, players play E if players make proposal set $m = (m_1, \ldots, m_k)$, where $m_i \in Q(E)\ \forall i \in (1, \ldots, k)$.*

[3] See Farrell (1988, 1993)

Proof. *$\forall i \in (1, \ldots, k)$, given $m_i \in Q(E)$, if Player i believes other players will honor their announcements, it is optimal for Player i to honor her announcement as well, since $U_i(s_1^E, \ldots, s_i^E, \ldots, s_k^E) \geq U_i(s_1^E, \ldots, s_i', \ldots, s_k^E)$, $\forall s_i' \in S_i$ and $s_i' \neq s_i^E$ (by definition of Nash Equilibrium). Consequently, by Credibility (Assumption 1), Player i will honor her announcement by playing E.*

If all the players suggest the same equilibrium in the first stage C, by the *Credibility* condition, they have an implicit agreement to play that equilibrium.

DEFINITION 5. A set $(\sigma_1, \ldots, \sigma_k)$ where $\sigma_i \equiv (m_i, s_i)$, is called *agreement equilibrium* of game G*(C, G) iff

(1)Players make proposal set $m = (m_1, \ldots, m_k)$ in stage C, where $m_i \in \mathrm{Q(E)}$ $\forall i \in (1, \ldots, k)$

(2)Players play $E = (s_1^E, \ldots, s_k^E)$ in stage G.

3.2.2. Negotiated Equilibrium

In this subsection, we consider how a message's *A-meaning* can be used to communicate and help players achieve an alternative equilibrium.

ASSUMPTION 2. *If in a set of k messages there exist at least two different E-meanings, and there exists a unique message with the strongest A-meaning, then all players will honor the E-meaning of the message with the strongest A-meaning, while all others' messages will be ignored.*

To ignore a message means to treat it as if it had never been expressed. Assumption 2 means players are able to use *A-meaning* to resolve the conflicts between *E-meanings*. Based on this assumption, we can deduce how a simultaneous "negotiated agreement" can occur within one round of simultaneous multi-way communication.

DEFINITION 6. *A set $(\sigma_1, \ldots, \sigma_k)$, where $\sigma_i \equiv (m_i, s_i)$, is called negotiated equilibrium of game G*(C, G) if*

(1)One player makes a proposal which satisfies $m_i \in T(D) \cap Q(E)$ in stage C, where D is the highest ranked A-meanings players can send;

(2)Players play $E = (s_1^E, \ldots, s_k^E)$ in the second stage G.

3.2.3. Communication-failure

In this subsection, we describe what happens if neither *agreement* nor *negotiated Equilibrium* is achieved in the communication stage.

ASSUMPTION 3. *If the conditions of neither agreement equilibrium nor negotiated equilibrium can be achieved, all messages will be ignored.*

PROPOSITION 2. *Action stage G will be played as if there is no communication if for* $m = (m_1, \ldots, m_k)$, $\exists\, m_i \in Q(E) \cap T(D)$ *and* $m_j \in Q(E') \cap T(D)$, $\forall E \in \mathcal{E}, E' \in \mathcal{E}$ *and* $E \neq E'$ *and* $D \in \boldsymbol{\mathcal{D}}$ *is ranked highest among attitudes matched players send.*

Proof. *Given* $m_i \in Q(E) \cap T(D)$ *and* $m_j \in Q(E') \cap T(D)$, *neither the conditions of agreement equilibrium nor negotiated equilibrium can be formed. So all the messages will be ignored given Assumption 3. As a result, players play G as if there was no communication.*

When multiple players' messages all convey the same A-meaning, then neither Assumption 1 nor Assumption 2 hold, so that players are unable to base their play in G on the sent messages. Further, if all players choose to honor the *E-meanings* of their own messages, then coordination necessarily fails. With Assumption 3, the coordination rate with communication is assured to be at least as high as when there is no pre-play communication.

DEFINITION 7. *A set* $(\sigma_1, \ldots, \sigma_k)$, *where* $\sigma_i \equiv (m_i, s_i)$, *is called communication-failure for game G*(C, G) if*

(1)For $m = (m_1, \ldots, m_k)$, $\exists\, m_i \in Q(E) \cap T(D)$ *and* $m_j \in Q(E') \cap T(D)$, $\forall E \in \mathcal{E}, E' \in \mathcal{E}$ *and* $E \neq E'$ *and* $D \in \boldsymbol{\mathcal{D}}$ *is ranked highest among attitudes matched players send*

(2)Players play the game as if there is no communication stage.

Note that given Assumption 3, communication-failure does not necessarily result in coordination failure. The reason is players may coordinate without communication.

In these equilibria subsection we illustrate the possible equilibria players can achieve in this two-stage game. Players are guaranteed to achieve payoffs at least as high as when there is no communication as long as all of them respond to each communication situation based the model in previous subsection. However, one presumably wants to avoid Pareto-dominated outcomes that result from communication failure. This can be done by optimally use E-meaning and A-meaning of messages based on beliefs over the distribution of message types. For ease of exposition, and consistent with the game we study below, in the following we focus on two-person games. It is straightforward to generalize the model to a k-player environment.

3.3. Communication Strategies

PROPOSITION 3. Given any beliefs about the distribution of E-meanings and A-meanings expected to be received from counterparts' messages, players maximize their expected utility by sending messages that include the E-meaning they are most likely to receive, and the A-meaning they are least likely to receive.

Proof. Denote $p^i_{E_j}$ as the belief player i has about counterpart j sending $m_j \in Q(E), \forall E \in$ Ɛ, and $p^i_{D_j}$ is the belief of counterpart sending $m_j \in A(D), \forall D \in \boldsymbol{\mathcal{D}}$.

EU($m_i \in Q(E) \cap A(D)$)= $p^i_{E_j} + (1 - p^i_{E_j})(1 - p^i_{D_j})$=*1*+$p^i_{D_j}(p^i_{E_j} - 1)$

Given $p^i_{E_j}$ *and* $p^i_{D_j}$*are belief of probabilities, we know* $0 \leq p^i_{E_j} \leq 1$ & $0 \leq p^i_{D_j} \leq 1$.

If $0 \leq p^i_{E_j} < 1$ & $0 \leq p^i_{D_j} \leq 1$, *EU*($m_i \in Q(E) \cap A(D)$) *decreases with* $p^i_{D_j}$ *and increases with* $p^i_{E_j}$. *If* $p^i_{E_j} = 1$, then Corollary 1 follows.

COROLLARY 1. If there exists a focal point in second stage game G, players will send the messages with E-meaning of the focal point to confirm in the communication stage.

3.4. Modified Holm (2000) Pink-Blue Game

Our interest is in determining whether people use and respond to natural language messages in a way that is consistent with the model above. To do this, following Holm (2000) [4], we design a "Pink-Blue" Game, where options are labeled as Pink and Blue, and counterparts' genders are revealed to players at beginning. We use an announcement to ensure it common knowledge that, for the purpose of this game, "pink is a color preferred by females, and blue is a color preferred by males". To the Holm (2000) environment we added a pre-play free-form communication stage C, where players are able to send each other simultaneous messages. After the message exchange, players make decisions in the Pink-Blue game, the payoff matrix for which is described by (Fig.1). As indicated by the Figure, players earn x>0 if they choose the same color, and zero otherwise.

Player 1 \ Player 2			
		BLUE	PINK
	BLUE	x, x	0, 0
	PINK	0, 0	x, x

FIGURE 1

[4] Holm (2000) discusses the idea that introducing Pink and Blue labels into Battle of Sexes Game where gender is revealed information might improve coordination rate.

The Pink-Blue game has three Nash equilibria: two pure-strategy equilibria (PINK, PINK), (BLUE, BLUE) as well as a mixed strategy equilibrium where each player plays each action with probability 0.5. Neither pure-strategy equilibria Pareto-dominates the other, but both dominate the mixed strategy equilibrium. Given that Pink-Blue is a complete information game, players can use pre-play communication exclusively to make claims about intended moves (as compared to, for example, using this stage to reveal private information[5]).

Next, we map the Pink-Blue game to the framework described above. We begin by specifying the language space Ɛ={B, P} and $\boldsymbol{\mathcal{D}} = \{Dm,\ Df\}$ where $Dm > Df$.

HYPOTHESIS 1. Players communicate with one of four types of messages in game G*(C, G): Demanding Blue (*DmB*), Demanding Pink (*DmP*), Deferring Blue (*DfB*), Deferring Pink (*DfP*). i.e. $\mathrm{m}_i \in M = \{DmB,\ DmP,\ DfB,\ DfP\}$.

DmB refers to the case where the sender intended to play BLUE, and requests the other player also play BLUE; *DfB* refers to the case where the sender intended play BLUE, but is ultimately deferring the choice to the player, and analogously for *DmP* and *DfP*. Hypothesis 1 is built on Definition 1-4. It states that players in Pink-blue Game communicate in this well-defined common and complete space with both *E-meaning* and *A-meaning*.

3.4.1. Equilibria of Pink-Blue

Based on Assumption 1-3 and Definition 5-7, we obtain following three hypotheses and summarized all connections between messages and actions in Fig. 2. When two players suggest the same color, they can achieve an *agreement equilibrium*. When two players suggest different colors with different attitudes, they achieve a *negotiated equilibrium*. Communication failure occurs when the two players suggest different colors with same Attitude. In this case, they ignore the messages and play a mixed-strategy Nash equilibrium.

HYPOTHESIS 2. *If paired players send messages requesting the same color, they will play that color.*

HYPOTHESIS 3. *If paired players send messages requesting different colors with one Demanding one Deferring attitude, both the demanding player and the deferring players will play the color the demanding player announced.*

[5] Farrell (1987, 1988) and Rabin (1991, 1994) provide formal analysis of communication as a means to convey intentions and thereby improve coordination among rational players. Farrell (1987, 1988) studies signaling intentions in simple sequential games of complete information, where an underlying game is preceded by one or more rounds of structured pre-play communication. Rabin (1991, 1994) extends analysis of Farrell (1987, 1988) and studies coordination in a more general class of games with multiple rounds of communication.

HYPOTHESIS 4. *If paired players send messages requesting different colors but with the same attitude, they will play mixed strategies with half chance choosing Blue,and half choosing Pink.*

Player *i* \ Player *j*	*DmB*	*DfB*	*DmP*	*DfP*
DmB	(BLUE, BLUE)	(BLUE, BLUE)	$((\frac{1}{2}, \frac{1}{2}), (\frac{1}{2}, \frac{1}{2}))$	(BLUE, BLUE)
DfB	(BLUE, BLUE)	(BLUE, BLUE)	(PINK, PINK)	$((\frac{1}{2}, \frac{1}{2}), (\frac{1}{2}, \frac{1}{2}))$
DmP	$((\frac{1}{2}, \frac{1}{2}), (\frac{1}{2}, \frac{1}{2}))$	(PINK, PINK)	(PINK, PINK)	(PINK, PINK)
DfP	(BLUE, BLUE)	$((\frac{1}{2}, \frac{1}{2}), (\frac{1}{2}, \frac{1}{2}))$	(PINK, PINK)	(PINK, PINK)

FIGURE 2

3.4.2. Communication Strategies in the Pink-Blue game

In the previous subsection we built a matrix (Fig.2) to illustrate links between all 16 possible paired communication situations and response actions. In Pink-Blue game, a pair of players is guaranteed to coordinate on a Nash equilibrium in the second stage as long as both of them respond to each communication situation in first stage based the model in previous subsection. However, one presumably wants to avoid Pareto-dominated outcomes that result from communication failure. This can be done by optimally use E-meaning and A-meaning of messages based on beliefs over the distribution of message types. Hypothesis 5 is implied directly from Corollary 1, while Hypothesis 6 is derived from Proposition 3.

HYPOTHSIS 5. *With a focal point of (Blue, Blue) in the second stage game, players will send messages with Blue E-meaning, and with a focal point of (Pink, Pink) in the second stage game, players will send messages with Pink E-meaning.*

HYPOTHESIS 6. *Absent a focal point in the second stage game, players will send messages including what they believe will be the most likely color they will receive, and the least likely attitude.*

4. EXPERIMENTAL TEST

We conduct the Pink-Blue game both without (baseline treatment) and with (communication treatment) two-way simultaneous free-form communication. The game proceeds as follows. We begin by randomly assigning people to pairs. We then reveal the gender of each person in each pair to both players. In the communication treatment, there is then simultaneous pre-play free-form communication (they send a written message to each other). Finally, the players simultaneously choose a color. If they choose the same color, then both earn the same amount of money in addition to their show-up payment. Otherwise, both earn only the show-up amount.

To avoid menu effects (i.e. the possibility that participants will coordinate on the first listed option), we use a presentation without focal points. In particular, we use a square payoff figure (Fig. 3) that ensures no option is more salient than any other.

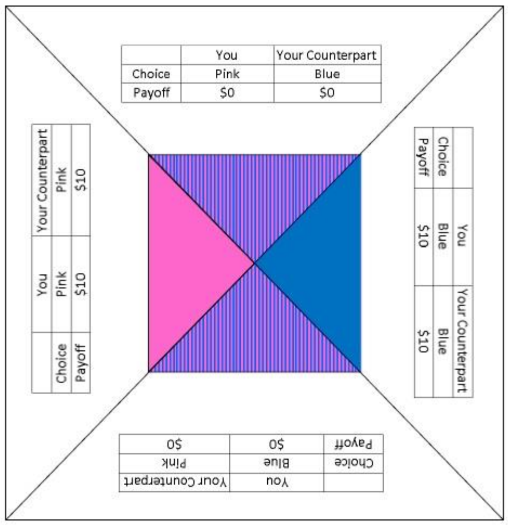


FIGURE 3. Instruction Table

To ensure color-labels were treated the same way across sessions and cultures, in all instructions subjects were informed: "Pink is a color preferred by females, and blue is a color preferred by males".

4.1. Baseline Treatment

In the baseline, subjects are randomly paired with anonymous counterparts and provided with information of each other’s gender. Then each subject chooses a color-label option simultaneously.

4.2. Communication Treatment

The treatment with communication proceeds just as in baseline, with the exception that subjects are able to write any message they like to each other simultaneously. Messages are written and delivered after the gender of the counterpart has been revealed and prior to subjects’ Pink/Blue choices. In each round, each player has one chance to write a note to her counterpart. They are not able to read the counterparts’ notes until they have finished writing their own messages.

4.3. Procedures

We use a between-subject design. That is, each subject experiences exactly one treatment, either with communication or without communication. In both treatments, each subject plays three rounds of the same game and faces different counterparts each round. At the beginning of each round, subjects are randomly and anonymously paired. The randomization was not constrained by gender, though nearly all subjects experienced games with both genders. At the end of the experiment, one of the three rounds was randomly selected to determine subjects' payoffs.

During the experiment players were seated at separated computer terminals and were given a copy of the experiment's instructions. These instructions were also read aloud, as we wanted to ensure subjects understood that the information contained in them is common knowledge. The experiment was conducted at George Mason University, Washington, D.C., and Shanghai Jiao Tong University, Shanghai. Subjects interacted only with people from their same university. At Mason, subjects were paid \$5 for showing up and \$10 for coordination success. At SJTU, subjects were paid 10 RMB for showing up and 40 RMB for coordination success (1 US dollar ≈ 6.14 RMB and 1 US dollar ≈ 6.06 RMB when we conducted the experiment in Shanghai, May 2013 and Dec. 2013) The experiment lasted about 40 minutes and the average payoff was designed to be slightly above the local hourly wage for subjects from the two subject pools.

5. RESUTLS

Subjects were recruited from undergraduate populations at George Mason University (GMU) and Shanghai Jiao Tong University (SJTU). Each of the 228 participations made 3 decisions, for a total of 684 observations. Table 1 summarizes our subjects' demographics.

TABLE 1 - DEMOGRAPHICS OF SUBJECTS IN TWO POOLS

	George Mason Univ. Washington D.C., U.S.	Shanghai Jiao Tong Univ. Shanghai, China
Number of Subjects	94	134
Percentage of Males	54.26%	64.18%
Average Age	21.17	21.83
Average GPA	3.21	3.35
Date of Experiment	Match 21st – April 11th, 2013	May 16th, 2013, Dec 18th-19th, 2013

There are few things need to be mentioned about our subjects pool. First, both subject pools include more males than females; the gender ratio of SJTU is more unbalanced than GMU. This reflects the unbalanced gender ratio in SJTU, which is probably due to that SJTU is an engineering University. Second, Seventy-eight percent of participants at GMU were born in

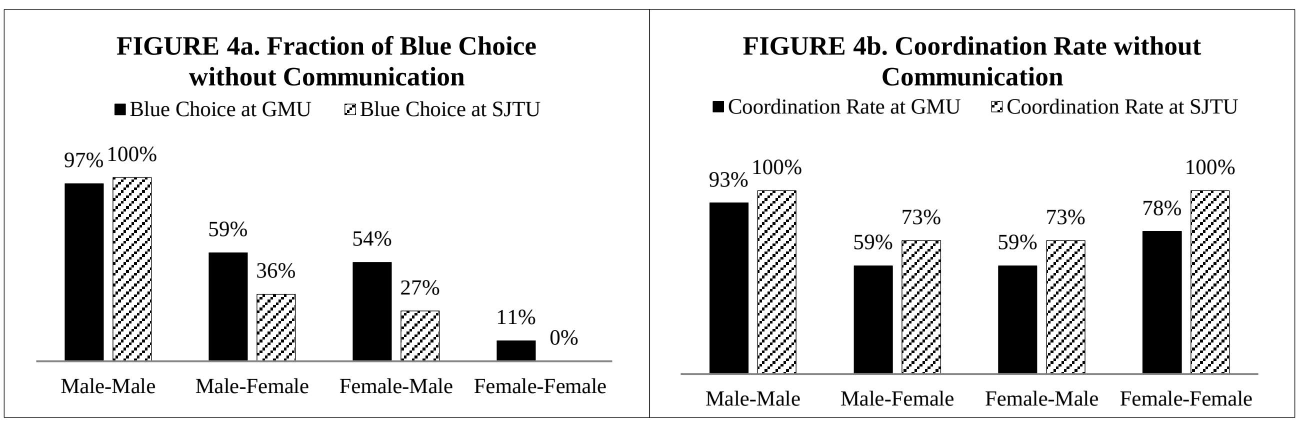
United States, and all of the SJTU participants were born in China. Finally, the age and GPA of GMU and SJTU are comparable to each other.

5.1. Baseline

In the absence of communication, as discussed in Holm (2000), if both players are females, (Pink, Pink) is focal, while if both are males (Blue, Blue) is focal**.** In a mixed-gender group, they would coordinate on Pink if both male and female consider females' color preference should be more respected, coordinate on Blue if both male and female consider males' color preference should be more respected, and coordinate on the mixed strategy (1/2, 1/2) if there is no clear social pressure regarding this matter. Table 2 and Fig. 4 illustrate the empirical results we collected from baseline treatment.

TABLE 2 – CHOICE AND COORDINATION RATE WITHOUT COMMUNICATION

		GMU	SJTU	GMU	SJTU
		Male		Female	
Number of Observation	Male	30	90	39	33
Blue Choice (%)		96.7	100	59	36.4
Coordination Rate (%)		93.3	100	59	72.7
Number of Observation	Female	39	33	18	18
Blue Choice (%)		53.8	27.3	11.1	0
Coordination Rate (%)		59	72.7	77.8	100



RESULT 1a. *Single-gender groups coordinated well both in D.C. and Shanghai.*

Ninety-seven percent of GMU players in male-male groups choose blue and the coordination rate is as high as 93%. In SJTU, players in the male-male group coordinated on blue with 100% probability. About 11% of GMU female players choose blue and coordination success is 78%, no female player in SJTU choose blue and coordination success is 100%.

As noted, with mixed-gender groups, players may simply mix (effectively ignoring gender information), or they may adopt strategies that depend on gender-based expectations, possibly influenced by a shared sense of social pressure to choose in favor of one gender or another. Regardless, one expects it would be more difficult to coordinate in mixed- than single-gender groups.

RESULT 1b. *Mixed-gender groups coordinated less well than same-gendered groups.*

When facing a counterpart of the opposite gender, 73% of females and 64% of males in Shanghai chose pink. Mixed-gender groups in Shanghai achieved 73% rate of coordination success. While in Washington, D.C., 46% of the females and 41% of the males chose pink. The coordination rate of mixed-gender groups in D.C. is about 59%. Apparently, mixed-gender groups coordinated less well than same-gendered groups (Wilcoxon Mann-Whitney test: z = -4.956, P<0.001, two-sided test, $n_1 = 44, n_2 = 56$[6]) Furthermore, the coordination rate of mixed-gender groups in Shanghai is not higher than D.C. (WMW test: z=0.783, P=0.434, two-sided test, $n_1 = 22, n_2 = 43$). However we can see from Fig. 4, that both Shanghai males and females tend to choose pink more often. In D.C., it seems people are playing a mixed-strategy between pink and blue.

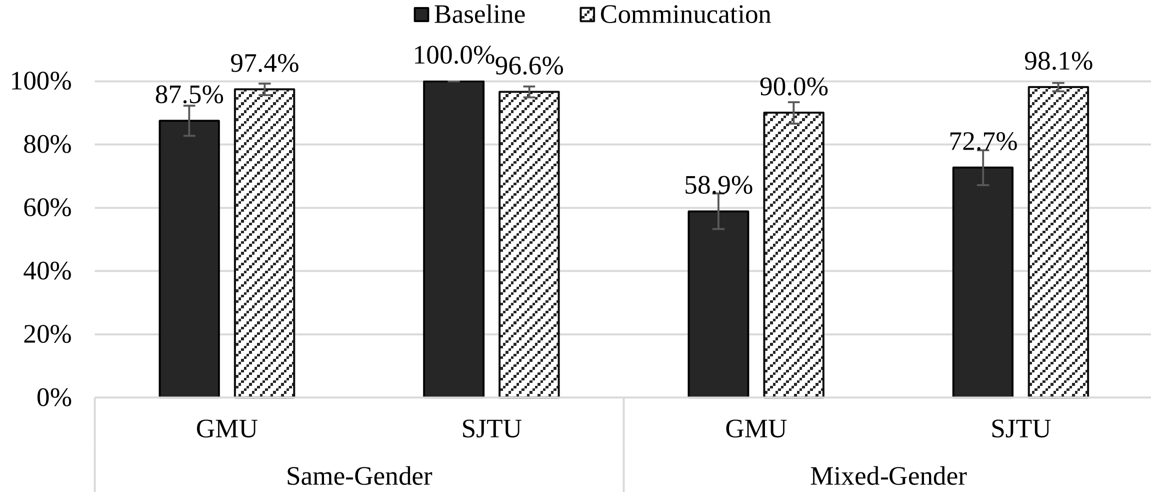
5.2. Communication and Coordination

RESULT 2. *Communication significantly improved coordination rates in both subject pools.*

Here we compare the coordination rates between the baseline treatment where there is no communication and the communication treatment where paired subjects can send two-way simultaneous free-form messages to each other. The coordination rate is significantly increased under communication (WMW test: z = -4.271, P<0.001, two-sided test, $n_1 = 100, n_2 = 128$). This result holds if we test the hypothesis respectively in the two subject pools (WMW test: z = -4.173, P<0.001, two-sided test, $n_1 = 42, n_2 = 52$ in GMU; z = -1.707, P=0.088, two-sided test, $n_1 = 58, n_2 = 76$ in SJTU). However, while the coordination rate is increased significantly in mixed-gender groups (Wilcoxon Mann-Whitney test: z = -4.796, P<0.001, two-sided test, $n_1 = 56, n_2 = 66$), the change in same-gender groups is insignificant (WMW test: z =1.197, P=0.23, two-sided test, $n_1 = 44, n_2 = 62$). The reason, of course, is that coordination rates are already very high in same-gender groups in the baseline treatment.

[6] For the purpose of satisfying the assumptions for nonparametric tests, subjects do not receive any feedback until the end of the experiment, and only the first observation from each individual in each comparison category is included. However, it doesn't change the basic results if all the observations are included. Note that the Wilcoxon Mann-Whitney test is abbreviated as WMW below.

FIGURE 5. Coordination Rate with and without Communication



Next we investigate reasons for communication's success in promoting coordination. In particular, we are interested in discovering whether our participants both use and respond to messages that include both *E-meaning* and *A-meaning*.

5.3. Nature of Communication

In order to analyze the content of messages objectively, we use the Houser and Xiao (2011)[7] procedure to classify our messages. We recruit 32 evaluators from SJTU and 37 from GMU to categorize the messages written by our subjects. All the messages are translated into both Chinese and English and classified by these third party evaluators from both pools. Evaluators read messages and place them into five categories: "Demanding Pink", "Deferring Pink", "Demanding Blue", "Deferring Blue" and "None of Above". In the instructions, they were told: "you should choose 'Demanding Pink' if you believe the message writer suggests pink, and requests that her or his counterpart also chooses Pink. You should choose 'Deferring Pink' if you believe the message writer suggests Pink, but is ultimately deferring the choice to her or his counterpart." Similarly for "Demanding Blue" and "Deferring Blue". Evaluators are paid based on whether their categorizations of three random chosen messages are consistent with most popular categorizations for that session.

[7] While some previous literature on communication uses research assistants as evaluators, Houser and Xiao (2011) discuss the advantage of using a coordination game classify message content. This classification method is increasingly used to classify messages from free-form communication studies (e.g. Xiao and Houser, 2005; Gachter et al. 2013; Deck et al. 2013; Ong et al. 2012; Chen et al. 2013)

To provide a sense for the nature of messages in each category, in the following we provide one sample message from each category (see all 384 messages and their classifications at authors' website).

One message was, “Pick Blue no matter what”. 97.30% of American evaluators and 87.50% of Chinese evaluators classified this message as “Demanding Blue”.

Other subjects wrote: “Hi, I will follow what you wrote on this paper. If you suggested Pink, I will choose Pink, if you wrote Blue, I will choose Blue. If you didn't suggest any color, please choose Blue.” 94.59% American evaluators and 96.87% Chinese evaluators classify this message as “Deferring Blue”.

“Pink! Girl's Rule! No if ands or but! I will NOT change! 100% Pink!! I will not choose otherwise even if you 100% say different or tell me to change! I will NOT change! Go Pink!” 89.19% of American evaluators and 93.75% of Chinese evaluators classify this message as “Demanding Pink”.

“Going with whatever color you say. (If you don't mention a color I will go with Pink.)” 91.89% of American evaluators and 96.88% of Chinese evaluators classify this message as “Deferring Pink”.

A final example is: “The point of coming to these experiments is to make money. I don't care about the colors and what-not. So let's try and choose the same option.” 97.30% of American evaluators and 96.88% of Chinese evaluators classify this message as “None of Above”.

We classify a message as one of the four categories in our model only if more than 50% of the evaluators from both pools place it in that same category. We classify a message as “None of Above” if either more than half of evaluators from both pools believe it belongs to “None of above”, or fewer than 50% of evaluators agree on any of the four named categories.

RESULT 3. *95.83% of cases players are classified consistently by evaluators from the U.S. and China as communicating with one of the four types of messages: Demanding Blue, Deferring Blue, Demanding Pink or Deferring Pink.*

FIGURE 6. Number of Messages Classified as Each Communication Style (By Culture)

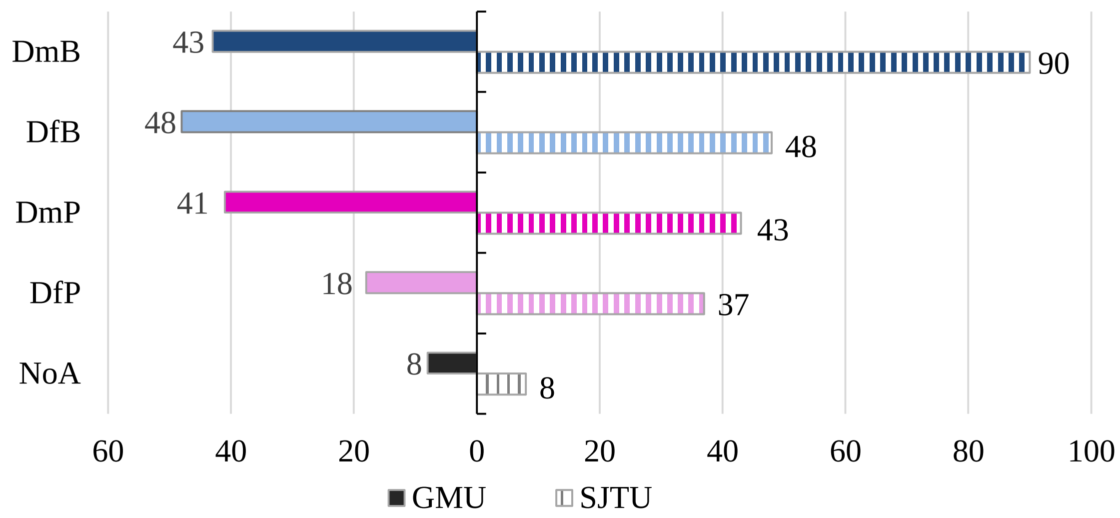


Fig.6 shows the distribution of classifications among all the messages we collected from the two subjects pools. Among the 384 messages collected, only ten messages were categorized differently between Shanghai subjects and D.C. subjects, and only six messages were not classified within one of the four named classifications. Thus, 95.83% of messages were classified consistently by evaluators from both pools as one of the four named communication types. Result 3 is a direct test of Hypothesis 1.

It is important to emphasize that messages were classified based on message content only. Evaluators were provided no other information. In particular, evaluators did not know which messages were paired and knew neither the gender nor the choices of the message writers. Because evaluations are independent of participants' choices, we are able to use the classified E-meanings and A-meanings to test whether people wrote and responded to messages as our theory predicts.

5.4. Responses to Messages

In this subsection, we focus our attention on cases where both messages from a pair of players are classified as one of the four named types. We do this as a direct test of our model.

RESULT 4. *When paired players requested same colors, in 99.6% of cases they chose to honor the color in messages. There is neither significant cultural nor gender differences in how people responded in this case. Overall, the coordination rate is as high as 99.2%.*

Result 4 confirms the validity of Hypothesis 2. Overall, in 99.6% of cases players chose to honor their messages when both players suggested the same pure-strategy equilibrium. As a result, players achieved agreement-equilibrium in 99.2% of the cases. As shown in Fig. 7a and Fig. 7b There is no difference in how many people chose to honor their words between genders[8].

FIGURE 7a. Fraction of Players Chose to Honor the E-meaning (Color) of Messages (By Culture)

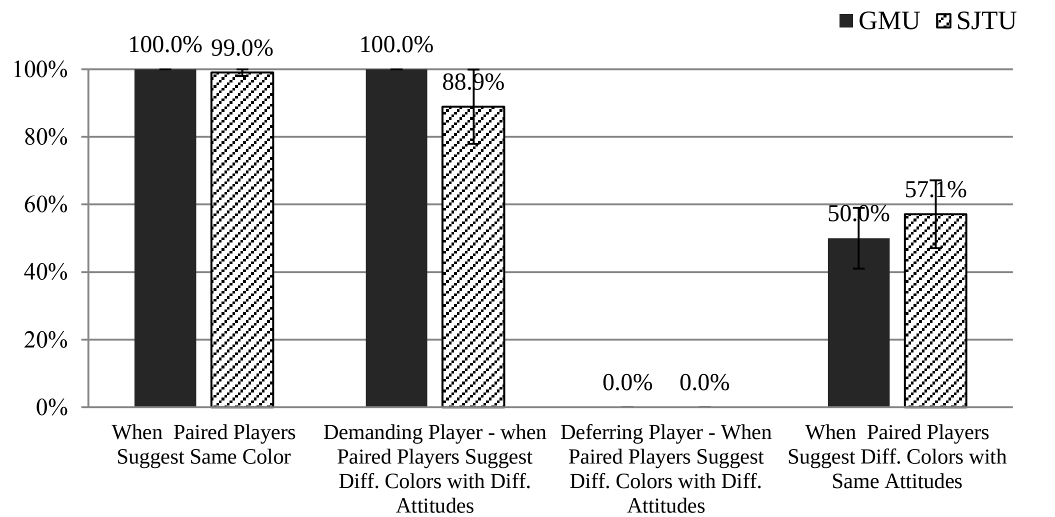
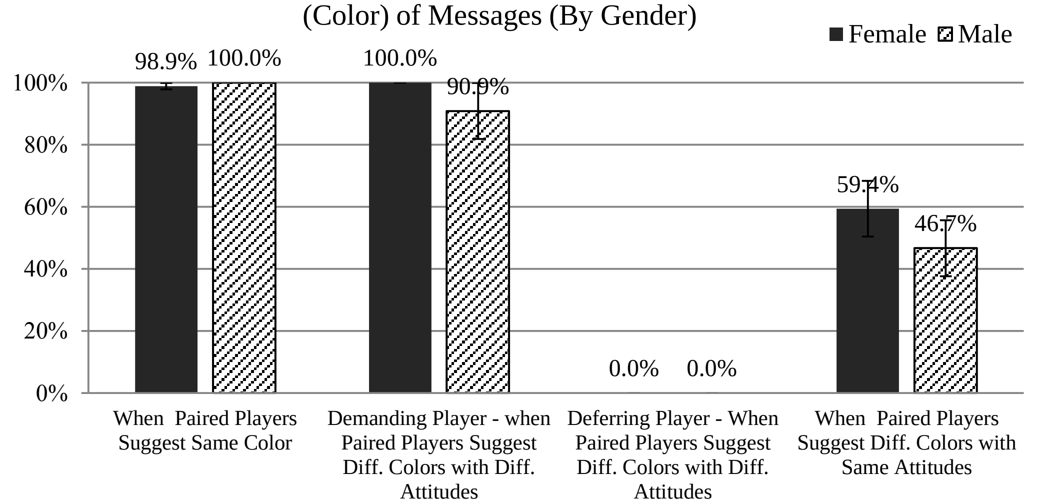


FIGURE 7b. Fraction of Players Chose to Honor the E-meaning (Color) of Messages (By Gender)



RESULT 5. *When paired players request different colors, and one of them sends a demanding message, and the other sends a deferring message, in 95.7% of cases demanding players chose*

[8] As noted in footnote 7, for the purpose of satisfying the assumptions for nonparametric tests, subjects do not receive any feedback until the end of the experiment, and only the first observation from each individual in each comparison category is included. For both between-culture and between gender comparisons, the rate of honoring the color is 100% for each pool respectively. Consequently, no P-value can be offered.

to honor their the color in the messages, while no deferring player chose to honor the color in their message. Further, GMU players respond to attitude as well as SJTU players, and male players respond to attitude as well as female players.

Hypothesis 3 describes how players can take advantage of *A-meanings* (*attitudes*) to resolve conflicts between E-meanings in Pink-Blue game. From this, we can infer how a "negotiated equilibrium" can emerge within a single round of simultaneous two-way communication. It requires that when there is one demanding and one deferring A-meaning from paired players, the demanding announcement will be honored, while the deferring announcement will be ignored.

Empirically, pooled across locations, in 95.7% of 232 cases demanding players chose to honor their words and 100% of deferring players switched to demanding players' announced option. As a result players reached *negotiated-equilibrium* in 95.7% of the cases where it was possible. This is strong evidence people do take advantage of and respond to the A-meaning of language. As depicted in Fig.7, the cultural difference of neither how demanding players respond (WMW test: z=1.173, P=0.241, two-sided test, n_1=11, n_2=8) nor how deferring players respond in this case is not significant (WMW test[9]: z=., P=., two-sided test, n_1=12, n_2=6). The gender difference of neither how demanding players respond (WMW test: z=0.949, P=0.343, two-sided test, n_1=9, n_2=10) nor how deferring players respond in this case if not significant (WMW test: z=., P=., two-sided test, n_1=12, n_2=6).

RESULT 6. *When paired players suggested different colors with same attitude, in 53.2% of cases players chose to honor the color in the messages, and this fraction is not different across cultures or genders.*

The result states that, consistent with Hypothesis 4, communication failed in those cases where paired players' messages included different *E-meanings* and the same *A-meaning*. In only 53.2% of these cases our subjects chose to honor the color in their messages. Specifically, the overall coordination rate was still as high as 87.1% because they find other ways to coordinate just as the case when there is no communication.

As is shown in Fig. 7, the fraction of people who chose to honor their words when paired players requested different colors with same attitude is around 50%, and this number is consistent across cultures (WMW test: z=-0.602, P=5474, two-sided test, n_1=27, n_2=22) and gender (WMW test: z=704, P=481, two-sided test, n_1=25, n_2=24).

[9] For both between-culture and between-gender comparisons of deferring players' responses, all players chose to honor demanding players' E-meanings. Consequently, no P-value can be offered.

RESULT 7. *When the conditions of agreement equilibrium or negotiated equilibrium are achieved in the first stage, coordination success in the second stage is significantly higher than otherwise.*

Given that conditions of which equilibrium players have reached after the first stage is a result of their own communication style as well as their counterpart's communication style rather than a randomly assigned independent variable, we should not perform non-parametric tests. To accommodate the non-independence issue with respect to individuals, we ran OLS econometric models which control for random effects at individual level. The dependent variable in the model is coordination success, which takes value of 1 if two matched players choose the same option, while takes a value of zero otherwise. The independent variables included in the regressions are: *negotiated equilibrium* condition dummy, which takes value of 1 if the subjects have achieved the conditions for *negotiated equilibrium* in the first stage, and 0 otherwise; *communication-failure* condition dummy, which takes value of 1 if subjects face the condition of communication failure in the first stage, and 0 otherwise; Culture dummy, which takes a value of one for GMU subjects, and 0 for SJTU subjects; Gender dummy, which takes a value of 1 for male subjects, and 0 for female subjects; Gender of counterpart dummy, which is equal to 1 for the subjects who interact with male counterparts in the round, and 0 for the subjects who interact with female counterparts; age, year of staying the current location, GPA, and relationship status, which takes a value of 1 if subjects are committed in a relationship, takes a value of 2 if subjects has a relationship but not committed to it, takes a value of 3 if single.

Model 1 of Table 3 includes data from both males and females and both locations. The first regression shows that the coordination rate under baseline of agreement *equilibrium* condition, after controlled for culture, gender, gender of counterpart, age, year of staying current location, GPA, relationship status, the coordination rate is significantly lower in communication failure cases, while not significantly different in *negotiated equilibrium* cases.

Model 2-4 pairwise compare when conditions of different Equilibria are achieved. Model 2 only includes data from cases when the conditions of either *agreement equilibrium* or *negotiated equilibrium* have been achieved. Model 3 only includes data from cases when the conditions of either *agreement equilibrium* or *communication-failure equilibrium* have been achieved. Model 4 only includes data of cases when the conditions of either *negotiated equilibrium* or *communication-failure equilibrium* have been achieved.

These regressions show that (i) the coordination rate in cases when *agreement equilibrium* conditions have been achieved is higher than when *negotiated equilibrium* conditions have been achieved; (ii) the coordination rate in cases when either *agreement equilibrium* conditions or *negotiated conditions* have been achieved is significantly higher than when *communication-failure* conditions have been achieved.

TABLE 3 - Effect of Achievement of Equilibrium Conditions on Coordination Rate

Dependent Variable: Coordination Success				
Model	1	2	3	4
Negotiated Equilibrium Conditions	-0.02	-0.04**		
	(0.03)	(0.02)		
Communication-failure Conditions	-0.11***		-0.12**	-0.11***
	(0.03)		(0.06)	(0.03)
Culture	0.03	-0.06*	-0.04	-0.00
	(0.03)	(0.03)	(0.07)	(0.03)
Gender	0.02	-0.00	0.16**	0.03
	(0.02)	(0.02)	(0.07)	(0.02)
Gender of Counterpart	0.02	-0.01	0.16**	0.03
	(0.02)	(0.01)	(0.07)	(0.02)
Age	0.00	0.00	0.00	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Year	-0.00	0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)
GPA	-0.03	-0.02	-0.15*	-0.02
	(0.02)	(0.03)	(0.08)	(0.02)
Relationship Status	0.01	0.02	0.01	0.01
	(0.01)	(0.01)	(0.04)	(0.01)
Constant	0.99***	1.01***	1.28***	0.91***
	(0.16)	(0.02)	(0.41)	(0.16)
Number of Observations	343	283	104	299

*** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Note: Standard errors robust to heteroskedasticity are shown in parentheses. All models include a random effects, with individual subject effects.

5.5. Communication Strategies

In this subsection, we investigate the communication styles players actually used as their strategies in different gender pairings and across cultures. Figure 8 partitions the distribution of communication styles into the four possible pairings (Male-Male, Female-Female, Male-Female, Female-Male) and two cultures (GMU, SJTU).

RESULT 8. *Male-Male matched players send messages with DmB and DfB communication styles more frequently than DmP and DfP. Female-Female matched players send message with DmP and DfP communication style more frequently than DmB and DfB.*

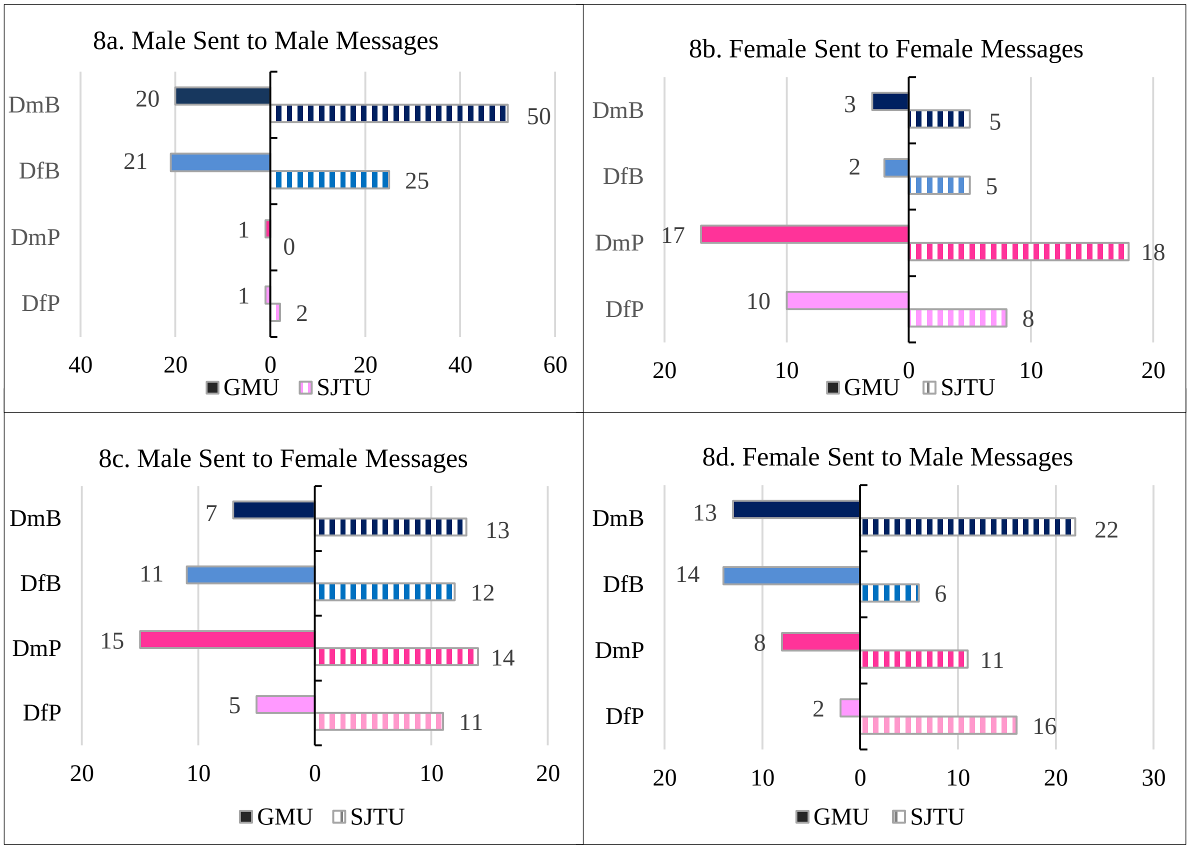


FIGURE 8. Communication by Matching Type and University

As Fig. 8a shows, in only 4.7% of cases in GMU and 2.6% of cases in SJTU Male-Male matched players choose communication style with Pink *E-meaning*. Slightly more Blue E-meaning messages are sent by females, but still much less than Pink *E-meaning* messages. 15.6 % of cases in GMU and 27.7 % of cases in SJTU Female-Female players choose communication styles with Blue *E-meaning* (see Fig. 8b). Comparing part c and part d of Fig. 8, one can observe some gender differences in communication styles in the mixed-gender environment. We cannot reject the hypothesis that male players are randomly choosing one of the four communication styles in both the GMU and SJTU populations (Chi-square (3)=6.21, P=0.102 in GMU; Chi-square(3)=0.4, P=0.940 in SJTU). On the other hand, female players' communication styles are significantly different from random choice regardless the culture (Chi-square (3)=9.81, P=0.020 in GMU; Chi-square (3)=10.24, P=0.017). Only 5.4% of females in a mixed-gender group at GMU choose DfP, while only 10.9% of females in a mixed-gender group at SJTU choose DfB.

RESULT 9. *Coordination rates are not only affected by the E-meaning of the messages, but also by their A-meaning. When only males included, coordination rate is only affected by E-meaning. While when only females included, coordination rate is only affected by A-meaning.*

Table 4 shows five OLS regressions all of which control for random effects at the individual level. The dependent variable is coordination success, which takes value of 1 if two matched players choose the same option, and is zero otherwise. In addition to the controls included in Table 3, we also include an *E-meaning* dummy, taking value of 1 (0) if a player requests Blue (Pink), and an *A-meaning* dummy taking value 1 (0) if a player is demanding (deferring).

As model 1 of Table 3 shows, when all messages[10] are included, both the *E-meaning* and *A-meaning (attitude)* impact coordination rates significantly after controlling for culture, gender, gender of counterpart, age, year, GPA, and relationship status. Generally speaking, both sending messages with Pink *E-meaning* and communicating with a demanding attitude increase the chance of coordination success. For males (Model 2), only *E-meaning* has an effect, while for females (Model 3), only *A-meaning* has an effect. With mixed-gender pairs (Model 4 for males, Model 5 for females), only Demanding messages from females seem to improve coordination.

TABLE 4 - Effect of Communication Strategies on Coordination Rate

Dependent Variable: Coordination Success					
Model	1	2	3	4	5
E-meaning of messages	-0.05**	-0.05*	-0.06	-0.04	0.02
	(-0.03)	(-0.03)	(0.04)	(0.05)	(0.05)
A-meaning of messages	0.06***	0.01	0.14***	0.01	0.11**
	(0.02)	(0.02)	(0.04)	(0.05)	(0.05)
Culture	0.01	-0.01	-0.02	0.03	-0.12*
	(0.03)	(0.04)	(0.06)	(0.08)	(0.07)
Gender	0.06**				
	(0.02)				
Gender of Counterpart	0.05**	0.65***	-0.76**		
	(0.02)	(0.12)	(0.35)		
Age	0.01	0.01	-0.00	0.02*	-0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Year	-0.00	-0.00	-0.00	-0.01	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
GPA	-0.01	-0.03	0.00	-0.05	-0.06
	(0.03)	(0.03)	(0.05)	(0.06)	(0.06)
Relationship Status	0.02	0.02	0.02	0.02	0.08**
	(0.01)	(0.01)	(0.03)	(0.03)	(0.03)
Constant	0.81***			0.70**	1.24***
	(0.17)			(0.34)	(0.39)
Number of Observations	356	205	151	86	88

*** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

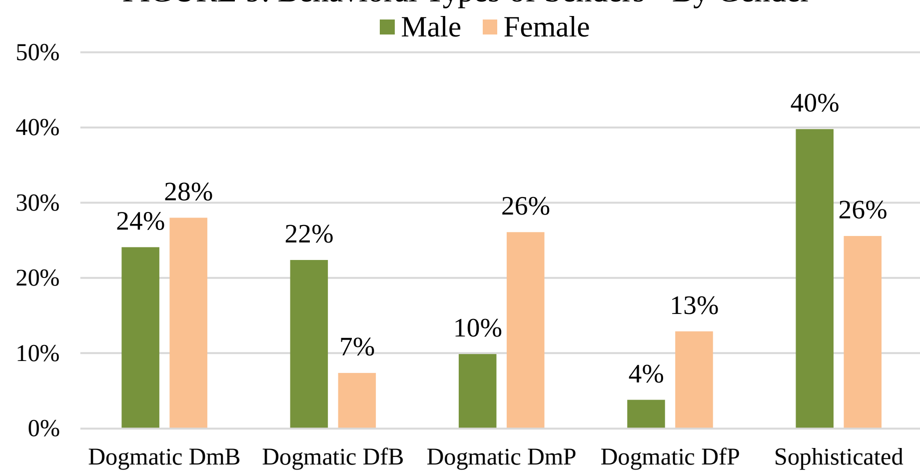
Note: Standard errors robust to heteroskedasticity are shown in parentheses. All models include a random effects, with individual subject effects.

[10] 28 observations do not show in the regression because we are lack of some of the control dummies (mostly GPA).

The above analyses are at the level of the message. Next we investigate the communication strategies which players use at the individual level. We find some subjects always to send the same style of message regardless the gender of the counterpart, while the others vary the *E-meaning* or *A-meaning* according to their counterpart's gender. To provide formal evidence on this we adopt a statistical classification procedure proposed by El-gamal and Grether(1995) to classify each player's behavioral type as a sender. We assume that players in the game include exclusively behavioral types chosen randomly from separate distributions, each assigning positive prior probability to four "dogmatic" types, as well as to a sophisticated type[11].

Specifically, we restrict attention to following types of players: *dogmatic DmB* sender, *dogmatic DfB* sender, *dogmatic DmP* sender, *dogmatic DfP* sender and *sophisticated* sender. *dogmatic DmB* sender always sends *DmB* message; *dogmatic DfB* sender always sends *DfB* message; *dogmatic DmP* sender always sends *DmP* message; *dogmatic DfP* sender always sends *DfP* message; and *sophisticated* sender sends the messages with focal point color as *E-meaning* if there is a focal point, while sends messages with more popular color and less popular *attitude* among the counterparts' population if there is no focal point[12]. The population distribution can be summarized as $r_{Dogmatic\ DmB} \equiv Prob\{Player\ always\ sends\ DmB\ message\}$, $r_{Dogmatic\ DfB} \equiv Prob\{Player\ always\ sends\ DfB\ message\}$, $r_{Dogmatic\ DmP} \equiv Prob\{Player\ always\ sends\ DmP\ message\}$, $r_{Dogmatic\ DfP} \equiv Prob\{Player\ always\ sends\ DfP\ message\}$, $r_{Sophisticated} \equiv Prob\{sophisticated\ senders\}$, where $r_{Dogmatic\ DmB} + r_{Dogmatic\ DfB} + r_{Dogmatic\ DmP} + r_{Dogmatic\ DfP} + r_{Sophisticated} = 1$.

FIGURE 9. Behavioral Types of Senders - By Gender



[11] Crawford (2003) assumed players' roles in a sender-receiver game is filled by players chosen randomly from four possible mortal types (boundedly rational types), as well as to a sophisticated type.

[12] Given our experiment design, we assume that(Blue, Blue) is focal if two male subjects are matched, while (Pink, Pink) is focal if two female subjects are matched, and there is no focal point for mixed-gender matches.

Following El-Gamal and Grether (1995), we assume different subjects may use different rules and the error rate is same for all subjects and for all tasks. We introduce the possibility that subjects make errors with probability ε. This allows each of our decision rules to give a positive probability (likelihood) to all possible patterns of behavior.

RESULT 10. *Males are more likely be dogmatic senders who always send Blue messages; while Females are more likely to be dogmatic senders who always send demanding messages.*

Fig. 9 summarizes our basic results of classification of senders' behavioral type by adopting El-gamal and Grether (1995) method. While 46% of male players are either dogmatic *DmB* senders or *DfB* senders, only 14% of male players are dogmatic senders who always send PINK. Such a color pattern is not observed among female dogmatic senders. However, 52% of females are dogmatic demanding senders while only 19% of females are dogmatic deferring senders. And attitude pattern is not observed among male dogmatic players.

6. CONCLUSION

In this paper, we have proposed a way to model rich, multi-meaning natural language communication with *E-meanings* and *A-meanings* (*attitudes*). In theory, the A-meaning of messages increases the chance of coordination when the E-meaning of messages don't match. This model allows us to answer two questions relevant to a well-structured language space: will people send rich messages that include multiple meanings, and will people respond as theory predicts to those multiple meanings?

As a step towards answering these question we conducted laboratory experiments at George Mason University, Washington DC and Shanghai Jiao Tong University, Shanghai. We find that people write messages including both *E-meaning* and *A-meaning (attitude),* and that people respond to both of these meanings when they make decisions and in a way that is broadly consistent with theory.

Talk is the game that almost everyone plays everyday. In majority of those games, talk is "cheap-talk". That is, we cannot attach credible threat, promises or cost to it. People choose how to structure communication for a specific problem within the constraints of incentives. The study of cheap talk is based on how people skeptically, but reasonably and most conventionally interpret language. Fundamentally, we argue that economists may want to construct environment specific language space in order to understand how people communicate in an ordinary way. But we face the tradeoff of how limited we want the analytical language space to be. Being specific about every possible vocabulary, the analysis will lose generalizability and feasibility; while being too broad and ignoring the details, we might forfeit precious opportunities to fully understand why economic results were changed so much by cheap-talk. We also encounter the challenge that the interpretation of free-form communication is subjective, which can be solved by taking advantage of double-blind third party evaluators. This article is a small step towards that type of investigation. Further studies of free-form communication would be profitable.

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