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Communication and Competition

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Abstract

Charness and Dufwenberg (*American Economic Review*, June 2011, 1211-1237) have recently demonstrated that cheap-talk communication raises efficiency in bilateral contracting situations with adverse selection. We replicate their finding and check its robustness by introducing competition between agents. We find that communication and competition act as "substitutes:" communication raises efficiency in the absence of competition but lowers efficiency with competition, and competition raises efficiency without communication but lowers efficiency with communication. We briefly review some behavioral theories that have been proposed in this context and show that each can explain some but not all features of the observed data patterns. Our findings highlight the fragility of cheap-talk communication and may serve as a guide to refine existing behavioral theories.

JEL Code: C92
Keywords: *cheap talk, adverse selection, competition, guilt aversion, lie aversion, inequality aversion, reciprocity*

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1. Introduction

It is well known that efficient contracting may be hampered by adverse selection problems that arise when outputs depend on privately known talents or types. Besides an impressive theoretical literature that addresses the design of optimal contracts in the presence of adverse selection (see, e.g., Bolton and Dewatripont, 2005), alternative solutions based on insights from behavioral economics and laboratory experiments have recently been proposed (see, for instance, Fehr et al., 2007). In particular, experimental studies have demonstrated that "cheap talk," i.e. non-binding and costless communication, can enhance efficiency (Charness and Dufwenberg, 2006, 2011) and can be more effective than monetary incentives (Brandts and Cooper, 2007). Plausible explanations that have been put forth are that cheap talk messages contain implicit promises that are costly to break when agents get disutility from lying (Vanberg, 2008) or from letting others down (Battigalli and Dufwenberg, 2009).

Much of this recent literature, however, focuses on bilateral relationships between a single principal and a single agent. This is obviously different from many real-world settings, e.g. when multiple job applicants compete for a single job (especially in times of a recession). It is conceivable that competition will change the nature of the messages exchanged, or the propensity with which promises are kept. In addition, implicit promises may have less impact when a principal receives similar messages from more than one agent. It is, therefore, natural to ask whether cheap-talk communication is still effective in promoting efficient contracting when competition exists.

To address this question, we vary the possibility of communication in the one-shot principle-agent game studied by Charness and Dufwenberg (2011) and in an extension where the principle selects one of two agents before playing the game. This variation of the game defines our competition treatments.[1] Our experiment replicates the main finding of Charness and Dufwenberg (2011). We find that in the "no-competition" treatments, communication raises efficiency. We also find that in the "no-communication" treatments, competition raises efficiency. Thus, by themselves, communication and competition positively affect efficiency. However, compared to treatments with competition or communication only, efficiency is *lower* in a treatment with both communication and competition. In other words, competition and communication act as substitutes. Communication raises efficiency without competition but lowers efficiency with competition. Likewise, competition raises efficiency without communication but lowers efficiency with communication.

[1] Stigler (1987, p. 531) defines competition as "a rivalry between individuals ... that arises whenever two or more parties strive for something that all cannot obtain." Our design captures the essence of this definition.

We discuss the extent to which several recently proposed behavioral models can explain the observed comparative statics patterns. We find that lie aversion (Vanberg, 2008), guilt aversion (Charness and Dufwenberg, 2011), inequality aversion (e.g., Fehr and Schmidt, 1999), and reciprocity (Rabin, 1993) all capture some but not all features of the data. We expressly do not propose an alternative theory. Rather we hope our novel empirical findings will stimulate further theoretical work in this exciting area.

The remainder of the paper is organized as follows. Section 2 describes our experimental design based on the principle-agent game with hidden information. In Section 3 we report the effects of communication and competition. We also correlate messages with outcomes to provide additional insights into behavior. Section 4 briefly discusses several behavioral theories. Section 5 concludes and the Appendix contains the instructions for the experiment.

2. Experimental Design

2.1. A Simple Principal-Agent Game

The experiment employs simple variations of the principal-agent game with hidden information as proposed by Charness and Dufwenberg (2011). The principal needs to hire an agent to complete a project, which can be either a simple project at a wage of 14, or a difficult project at a wage of 20. Agents can be either of "Low" type (with probability 2/3) or of "High" type (with probability 1/3). Both types of agents can complete the simple project while only the high-type agent can successfully complete the difficult project. The contract cannot be conditioned on the agent's type, which is private information; the principal only knows the *ex ante* probabilities that an agent is of low or high type.

The game tree is summarized in Figure 1.[2] If the principal chooses not to hire ("Out") then both the principal and the agent get their outside-option payoffs of 10. When the principal chooses to hire ("In") the outcome depends on who accepts the difficult project. If a low-type agent selects the difficult project ("Roll") then he fails and the principal gets 0. If a high-type agent selects the difficult project then in the with-die-roll ("WDR") version of the game the project is completed successfully with probability 5/6 and the principal receives 24, otherwise the principal gets nothing. In the no-die-roll ("NDR") version of the game the principal gets (the expected value) 20 for sure. (These two versions are introduced to test different models of guilt, as explained in Section 4 below.) Finally, if the simple project is selected ("Don't Roll")

[2] We doubled the payoffs in Charness and Dufwenberg (2011) to make the monetary incentives more salient.

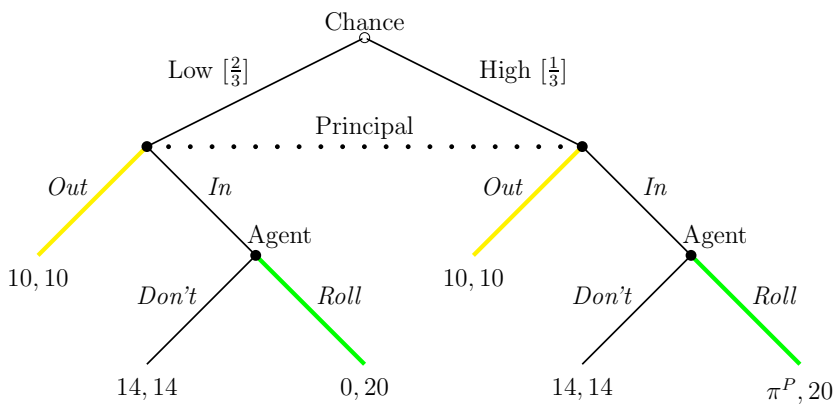

Figure 1. *A principal-agent game with hidden information. In the no-die-roll ("NDR") version $\pi^P = 20$ for sure while in the with-die-roll ("WDR") version $\pi^P = 24$ with probability $5/6$ and $\pi^P = 0$ with probability $1/6$.*

by either type of agent then the principal receives 14.

Socially optimal contracts are possible when information is complete, i.e. when the contract can be conditioned on the agent's type. In this case, the principal hires a low-type agent to complete the simple project or a high-type agent to complete the difficult project. It will be useful to compare the outcomes observed in the experiment to this efficient benchmark.

Definition. *The efficient outcomes are ("In", "Don't Roll") when the agent is of low type and ("In", "Roll") when the agent is of high type. All other outcomes are inefficient.*

When contracts are efficient, the *ex ante* expected payoffs are readily computed to be 16 for the principal and 16 for the agent. These payoffs are higher than those that result when contracts cannot be conditioned on the agent's private information. With selfish agents, the prediction is that both low-type and high-type agents will choose "Roll," and, hence, the best response for the principal is to choose "Out," resulting in payoffs of 10 for both the principal and the agent.[3] The setting of Figure 1 therefore captures the adverse selection problem that hinders efficient contracting (e.g., Bolton and Dewatripont, 2005).

2.2. Design and Procedures

Table 1 summarizes the different treatments of the experiment, which vary by whether or not there is agent competition (group size two or three), whether or not communication is allowed ("C" or "NC"), and whether or not the principal's payoff when a high-type agent chooses

[3]Choosing "In" yields an expected payoff of only $1/3 \times 5/6 \times 24 = 20/3$ for the principal.

Treatment	Competition	Communication Channel	Group Size	# of Groups	# of Subjects
2NC-WDR	No	none	2	24	48
2C-WDR	No	B → A	2	24	48
2NC-NDR	No	none	2	25	50
2C-NDR	No	B → A	2	23	46
3NC-WDR	Yes	none	3	24	72
3C-WDR	Yes	B1 → A, B2 → A	3	37	111

Table 1. The experimental design varies whether there is competition between agents and whether one-sided communication from the agent(s) to the principle is possible. In addition, in the no-competition treatments the principal's payoff is 20 for sure in the no-die-roll treatments and it is 24 with chance 5/6 and zero otherwise in the with-die-roll treatments.

"Roll" is uncertain ("NDR" or "WDR"). Communication is one-way, e.g. in "2C-NDR" or "2C-WDR" the agent can send free-form messages to the principal but not vice versa. In the no-competition treatments with group size equal to two the principal is paired with a single agent while in the competition treatments with a group size of three there is an additional agent. In the competition treatments the principal has to select one of the two agents prior to playing the game shown in Figure 1. The agent that is not selected receives a low payoff of 5. In "3C-WDR" both agents can send free-form messages to the principal to influence the principal's selection while this is not possible in treatment "3NC-WDR". Communication is again one-way so that agents cannot observe or influence each other's messages.

We recruited a total of 375 subjects from the University of Zürich and the neighboring ETH. The sessions without communication typically took about half an hour and the sessions with communication took about an hour, including the instruction and payment phases. The reason that the experiments were quick is that there was only a single period of play. Average earnings were 23 CHF including a 10 CHF show-up fee at an exchange rate of roughly 1 CHF for $1. The experimental instructions closely follow those of Charness and Dufwenberg (2011), see Appendix A.[4]

3. Results

We first discuss the aggregate outcomes in the different treatments and then provide an analysis of the messages that were sent in the communication treatments.

[4]One difference is that our experiments were computerized using zTree (Fischbacher, 2007).

3.1. Outcomes

We start by comparing the outcomes of our no-competition treatments (with group size two) to those of Charness and Dufwenberg (2011) to check whether we replicate their findings. The left and middle panels of Figure 2 show the fraction of "In" choices made by the principal and the fraction of "Don't Roll" choices made by the low-type agent respectively. We do not separately show the percentage of "Roll" choices for the high-type agents, which, like in the Charness and Dufwenberg (2011) study, was 100% in all treatments. Each panel shows the results for the with-die-roll ("WDR") and no-die-roll ("NDR") treatments separately and combined ("Pooled") as well as the results from the Charness and Dufwenberg (2011) study (labeled "C&D"). For each data set, the left bar ("NC") pertains to the no-communication treatment and the right bar ("C") to the communication treatment. The right panel in Figure 2 shows the predicted fraction of efficient outcomes based on the choice data and, in the communication treatments, the messages sent. We use the predicted rather than the observed fraction of efficient outcomes to correct for any differences in outcomes unrelated to the subjects' decisions.[5]

As can be seen from Figure 2, the "In" rates, "Don't Roll" rates, and predicted percentages of efficient outcomes are very similar for the "NDR" and "WDR" treatments, whether or not communication is allowed. Furthermore, they are all similar to the corresponding rates for the Charness and Dufwenberg (2011) study. Indeed, formal statistical tests reveal no significant differences (at the 10%-level) for either the "In" rate, "Don't Roll" rate, or the predicted percentage of efficient outcomes with or without communication.[6]

Finding 1. *Our no-competition treatments replicate the results of Charness and Dufwenberg (2011) for both the communication and no-communication treatments.*

Finding 2. *The no-die-roll and with-die-roll treatments yield identical results for both the communication and no-communication treatments.*

Since there are no significant differences between the "NDR" and "WDR" treatments we will

[5]For instance, agents' types were randomly determined by the program and the fraction of high-type agents varied from 28.6% to 41.7% across treatments. To correct for this variability, the predicted fraction of efficient outcomes, $p^{In}(\frac{1}{3} + \frac{2}{3}p^{DR})$, uses the ex ante probabilities for each type. Here p^{In} denotes the principal's "In" rate and p^{DR} the low-agent's "Don't Roll" rate. In the communication treatments, the "In" and "Don't Roll" rates may depend on the agent's message, m, which, in turn, may depend on the agent's type. The predicted fraction of efficient outcomes now becomes $\sum_m p^{In}(m)(\frac{1}{3}P_H(m) + \frac{2}{3}P_L(m)p^{DR}(m))$ where $P_L(m)$ and $P_H(m)$ are the probabilities that a low-type or high-type agent sends message m respectively. See Section 3.2 for a more detailed discussion and an extension to the case with agent competition.

[6]More specifically, a two-sided proportion test shows no significant difference at the 10% level between the "In" rates in "NDR" vs "WDR", "NDR" vs "C&D", "WDR" vs "C&D", and "pooled" vs "C&D." The same no-difference result holds for the "Don't Roll" rate and the percentage of efficient outcomes.

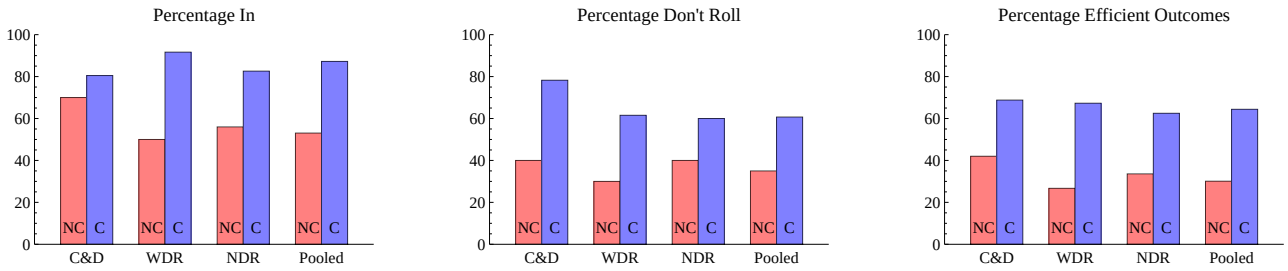

Figure 2. The left panel displays the "In" rates, the middle panel the "Don't Roll" rates, and the right panel the predicted fraction of efficient outcomes for the no-competition treatments. In each panel, the "NC" bar refers to the no-communication treatment and the "C" bar to the communication treatment. The data from the Charness and Dufwenberg (2011) study are labeled "C&D" and the data of the with-die-roll and no-die-roll treatments are labeled "WDR" and "NDR" respectively. The "Pooled" data represent the combined data of the with-die-roll and no-die-roll treatments.

consider only the pooled data in the remainder of this section. To avoid confusion, we drop the "NDR" and "WDR" labels and refer to the pooled data from the two-person communication treatments as "2C" and to those from the no-communication treatments as "2NC." Figure 3 shows the "In" rates, "Don't Roll" rates, and percentage of efficient outcomes for these pooled data sets and the corresponding rates for the competition treatments, which are now labeled "3NC" and "3C."[7]

Note that the three panels of Figure 3 show a similar pattern: the "In" rate, the "Don't Roll" rate, and the percentage of efficient outcomes are high for the "2C" and "3NC" treatments and low for the "2NC" and "3C" treatments. Importantly, Figure 3 shows that competition raises efficiency without communication but it lowers efficiency with communication.[8] Likewise, communication raises efficiency in the absence of competition but it lowers efficiency with competition.[9] In other words, communication and competition act as "substitutes."

Finding 3. *Communication raises efficiency without competition but lowers efficiency with competition.*

Finding 4. *Competition raises efficiency without communication but lowers efficiency with communication.*

[7]The "In" rate, "Don't Roll" rate, and predicted percentage of efficient outcomes are (26/49, 7/20, 30.1%) for treatment 2NC, (41/47, 17/28, 64.4%) for treatment 2C, (19/24, 7/11, 60.0%) for treatment 3NC, and (22/37, 6/12, 37.5%) for treatment 3C.

[8]A two-sided proportion test shows that the predicted percentage of efficient outcomes is higher in "3NC" than in "2NC" ($p = 0.0143$). However, the percentage of efficient outcomes is lower in "3C" than "2C" ($p = 0.0142$).

[9]A two-sided proportion test shows that the predicted percentage of efficient outcomes is higher in "2C" than in "2NC" ($p = 0.0008$). However, the percentage of efficient outcomes is lower in "3C" than "3NC" ($p = 0.0852$).

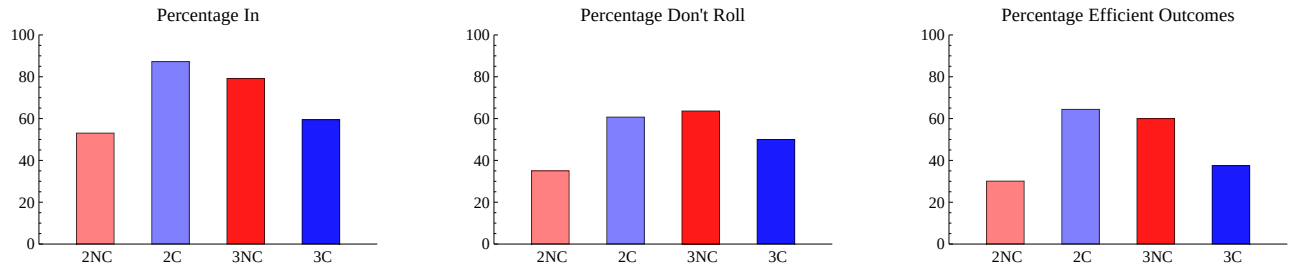

Figure 3. The left panel displays the "In" rates, the middle panel the "Don't Roll" rates, and the right panel the predicted fraction of efficient outcomes for all treatments.

This substitute relationship may result from the fact that competition affects the messages sent or the extent to which the principal relies on the messages, or possibly both. To explore this issue, we next provide a detailed analysis of the messages exchanged in the different treatments.

3.2. Messages

The coding of the free-form messages sent in our experiments follows the classification scheme used by Charness and Dufwenberg (2011). In particular, we focus on three basic message types: "NP" for no promise, "LD" when a low-type agent discloses her type and promises to choose "Don't Roll," and "HR" when a high-type agent discloses her type and promises to choose "Roll."[10]

Table 2 provides an overview of the messages sent by each agent type in our no-competition treatments and compares them with those from the Charness and Dufwenberg (2011) study. In each box in Table 2, the row labeled "Total" shows the total number of times each message was used, while the percentage below the box expresses this as a frequency. Using the Fisher's exact test reveals no significant differences (at the 10% level) between the "NDR" and "WDR" messages nor are there significant differences between the pooled messages and the messages from the Charness and Dufwenberg (2011) study.

Finding 5. *The frequencies with which the different message types occurred in our communication treatment without competition are not significantly different from those observed by Charness and Dufwenberg (2011).*

[10] As in Charness and Dufwenberg (2011) most, but not all, messages can be captured with this coding scheme. Other types of messages are "L" when a low-type agent only discloses her type with no promise about the action she will take, "R" when the agent only promises to "Roll" without disclosing her type, "H" when the agent claims to be of high type with no promise about the action, and "DR" when the agent promises to choose "Don't Roll" without disclosing her type. The first two messages were classified as "NP," the third message as "HR" and the fourth message as "LD."

C & D (2010)		NP	LD	HR	Total
Low	Out	4	1	0	5
	In, R	0	0	5	5
	In, DR	4	13	1	18
	Total	8	14	6	28
		28.6%	50.0%	21.4%	100.0%
High	Out	2	0	1	3
	In, R	0	2	8	10
	In, DR	0	0	0	0
	Total	2	2	9	13
		15.4%	15.4%	69.2%	100.0%

2C (pooled)		NP	LD	HR	Total
Low	Out	2	2	1	5
	In, R	4	2	5	11
	In, DR	3	13	1	17
	Total	9	17	7	33
		27.3%	51.5%	21.2%	100.0%
High	Out	0	0	1	1
	In, R	1	0	12	13
	In, DR	0	0	0	0
	Total	1	0	13	14
		7.1%	0.0%	92.9%	100.0%

2C-WDR		NP	LD	HR	Total
Low	Out	1	0	1	2
	In, R	1	2	2	5
	In, DR	2	5	1	8
	Total	4	7	4	15
		26.7%	46.7%	26.7%	100.0%
High	Out	0	0	0	0
	In, R	1	0	8	9
	In, DR	0	0	0	0
	Total	1	0	8	9
		11.1%	0.0%	88.9%	100.0%

2C-NDR		NP	LD	HR	Total
Low	Out	1	2	0	3
	In, R	3	0	3	6
	In, DR	1	8	0	9
	Total	5	10	3	18
		27.8%	55.6%	16.7%	100.0%
High	Out	0	0	1	1
	In, R	0	0	4	4
	In, DR	0	0	0	0
	Total	0	0	5	5
		0.0%	0.0%	100.0%	100.0%

Table 2. Messages and outcomes in the communication treatments without competition. The data from the Charness and Dufwenberg (2011) study are labeled "C&D" and the data from the with-die-roll and no-die-roll treatments are labeled "WDR" and "NDR" respectively. The "Pooled" data represent the combined data of the with-die-roll and no-die-roll treatments.

Finding 6. *The frequencies with which the different message types occurred in the no-die-roll and with-die-roll communication treatments without competition are not significantly different.*

Table 2 also lists the resulting outcomes by message and agent type. A test of our coding scheme is whether the messages capture everything that the principal knows about the agent, i.e. whether, conditional on the message, the principal's choice is independent of the agent's type. Using a simple proportion test reveals that, conditional on the message received, there are no significant differences (at the 10% level) between the principal's "In" rate when the message is sent by a low or a high-type agent. This is true for the "2C-NDR" and "2C-WDR" messages as well as for the pooled messages and the messages from the Charness and Dufwenberg (2011) study.

We next compare the messages from the pooled no-competition treatments (labeled "2C") with those from the competition treatment ("3C"), see the top panels of Table 3. First, with or without competition, messages sent by low-type agents differ significantly from those sent by high-type agents.[11] Moreover, messages differ significantly between the no-competition and

[11] The Fisher exact test yields $p < 0.001$ for treatment "2C" and $p = 0.010$ for treatment "3C."

2C	NP	LD	HR	Total
Low	9	17	7	33
High	1	0	13	14
Total	10	17	20	47
In	8/10	15/17	18/20	41/47
DR	3/7	13/15	1/6	17/28
Select Low	18.2%	34.3%	14.1%	66.6%
Select High	2.4%	0.0%	31.0%	33.4%
Total	20.6%	34.3%	45.1%	100.0%
Efficiency Low	6.2%	26.2%	2.1%	34.6%
Efficiency High	1.9%	0.0%	27.9%	29.8%
Total	8.2%	26.2%	30.0%	64.4%

3C	NP	LD	HR	Total
Low	24	16	13	53
High	8	1	12	21
Total	32	17	25	74
In	3/9	5/10	14/18	22/37
DR	0/1	5/5	1/6	6/12
Select Low	20.1%	22.3%	21.9%	64.3%
Select High	8.4%	1.8%	25.5%	35.7%
Total	28.5%	24.1%	47.4%	100.0%
Efficiency Low	0.0%	11.2%	2.8%	14.0%
Efficiency High	2.8%	0.9%	19.8%	23.5%
Total	2.8%	12.0%	22.7%	37.5%

Table 3. A comparison of the communication treatments with and without competition. The top panels show the messages sent by each type of agent as well as the low-type agent's and principal's choice frequencies. The top parts of the lower panels show the frequencies with which low-type and high-type agents were selected given the message they sent. The bottom parts of the lower panels show how much low-type and high-type agents contributed to the total percentage of efficient outcomes given the messages they sent.

competition treatments.[12] In particular, for both types of agents there is a shift from the message they predominantly use in the absence of competition ("LD" for a low-type agent and "HR" for a high-type agent) to the "NP" message. The rows labeled "Total" in the top panels of Table 3 show that while the "NP" message is least used (10) without competition it is the most frequently used message (32) with competition.

Finding 7. *When competition is introduced there are fewer messages that signal the agent's ability.*[13]

The preponderance of "NP" messages make it harder for the principal to select high-type agents and may negatively affect her decision to choose "In." We first discuss the selection issue. In treatment "2C," given the frequency $P_L(m)$ with which a low-type agent sends message m, the chance that the principal is matched with a low-type agent who sent message m is $P_L^{select}(m) = \frac{2}{3}P_L(m)$. Similarly, the chance that the principal is matched with a high-type agent who sent message m is $P_H^{select}(m) = \frac{1}{3}P_H(m)$. These match or selection probabilities are shown in the top part of the lower-left panel. Together with the "In" and "Don't Roll" rates they determine the predicted fraction of efficient outcomes by agent and message type[14] and

[12]For low-type agents the difference is close to being significant with $p = 0.124$, for high-type agents $p = 0.073$, and for the pooled messages $p = 0.041$ using the Fisher exact test.

[13]The fraction of "LD" plus "HR" messages drops from 78.7% to 56.8% when competition is introduced. This difference is significant ($p = 0.013$).

[14]When a low-type agent sends message m, predicted efficiency is $P_L^{select}(m)p^{In}(m)p^{DR}(m)$ and when a

the overall fraction of efficient outcomes:

$$\sum_{m \in \{\text{NP,LD,HR}\}} p^{In}(m)\big(P_H^{select}(m) + P_L^{select}(m)p^{DR}(m)\big) \tag{1}$$

which yields 64.4% for treatment "2C," see the bottom-left panel of Table 3.

In treatment "3C," the principal can use the messages received to improve the chances of selecting a high-type agent. To analyze this issue we simply record which message was selected by the principal from each of the 37 pairs of messages received. If we order the messages ("NP", "LD", "HR") then the empirical selection frequencies can be conveniently summarized by the following 3×3 matrix

$$P^{select} = \begin{pmatrix} 0.50 & 0.20 & 0.21 \\ 0.80 & 0.50 & 0.29 \\ 0.79 & 0.71 & 0.50 \end{pmatrix}$$

where each entry represents the probability the row message is selected.[15] Note that "better" messages are more likely chosen: "LD" and "HR" are more frequently selected when matched with "NP," and from the pair ("LD","HR") the "HR" message is more frequently selected.

Given the above selection probability matrix we can compute the predicted frequency with which the principal is matched with a low or high-type agent, for each of the three message types. The chance that a low-type agent who sent message m is selected is given by

$$P_L^{select}(m) = \sum_{m' \in \{\text{NP,LD,HR}\}} \tfrac{2}{3}P_L(m)\big(\tfrac{2}{3}P_L(m') + \tfrac{1}{3}P_H(m')\big)2P^{select}(m,m')$$

where the 2 appears because there are two agents that could have sent the selected message. Analogously, for a high-type agent the probability of being selected after sending message m is

$$P_H^{select}(m) = \sum_{m' \in \{\text{NP,LD,HR}\}} \tfrac{1}{3}P_H(m)\big(\tfrac{2}{3}P_L(m') + \tfrac{1}{3}P_H(m')\big)2P^{select}(m,m')$$

These selection frequencies are shown in the bottom-right panel of Table 3. With competition the overall frequency with which a high-type agent is selected goes up from 33.4% to 35.7%, which is not significant.

high-type agent sends message m it is $P_H^{select}(m)p^{In}(m)$.

[15] For example, the second entry in the top row indicates that 20% of the time the principal selects the "NP" message from the pair ("NP","LD"). The first entry in the second row shows the "LD" message is selected from such a pair with complementary probability. More generally, summing the upper and lower part of the selection matrix yields 1 since one of the two messages is selected. For the same reason the diagonal elements are 1/2.

Finding 8. *The possibility of communication does not improve the principal's ability to select the high-type agent in the competition treatment.*

Besides hampering the selection process, the many "NP" messages also affect the principal's decision to choose "In." Comparing the numbers in the top panels of Table 3 shows that the "In" rate drops from 80% to 33% for the "NP" message, from 88% to 50% for the "LD" message, and from 90% to 78% for the "HR" message.[16] The overall "In" rate drops from 87.2% in "2C" to 59.5% in "3C," which is significant ($p = 0.0035$).

Finding 9. *In the communication treatments, the principal chooses "In" significantly less often when competition is introduced.*

Interestingly, low-type agents that sent "LD" messages are trustworthy and never "Roll," as in the treatment without competition. Also, the frequency with which selected low-type agents lie (either about their actions or types) is not significantly higher in the treatment with competition.[17]

The selection probabilities together with the observed "In" and "Don't Roll" rates determine the predicted fraction of efficient outcomes, see (1). These are shown in the bottom-right panel of Table 3. In particular, the overall predicted fraction of efficient outcomes in treatment "3C" is 37.5%.[18] This is significantly lower than the corresponding percentages for treatments "3NC" and "2C" (Findings 3 and 4). To summarize, the lower efficiency observed in the treatment with competition and communication is because there are fewer messages that signal ability (Finding 7). This precludes the principal from selecting a high-type agent more frequently than the ex ante probability of 1/3 (Finding 8). In addition, the many "NP" messages cause the principal to be more cautious and she chooses "In" less frequently (Finding 9).

4. Behavioral Explanations

4.1. Guilt Aversion

With selfish agents the subgame-perfect equilibrium predicts only inefficient outcomes. The principal chooses "Out" because there is a high chance (2/3) that choosing "In" will result in

[16] For the "NP" and "LD" messages these differences are significant ($p = 0.04$ and $p = 0.03$ respectively.

[17] The percentages of lies are 37.5% and 27.3% in treatments with and without competition respectively. The difference is not significant ($p = 0.412$).

[18] An interesting extension is to let the principal's "In" rate depend on both messages received. In this case, the predicted fraction of efficient outcomes drops to 34.2% and the difference between "2C" and "3C" is significant at the 5% level ($p = 0.0475$).

a zero payoff since selfish agents choose to "Roll" independent of their type. The flip side of this argument is that for the principal to choose "In," low-type agents would have to choose "Don't Roll" sufficiently often. Charness and Dufwenberg (2011) suggest that one reason why low-type agents might choose "Don't Roll" is to avoid feelings of guilt associated with letting the principal down.

There are two ways to model guilt. One version, called "simple guilt," assumes that a low-type agent's guilt is proportional to the payoff loss she knows she caused. A different version, called "guilt-from-blame," assumes that a low-type agent's guilt is proportional to the payoff loss she can be blamed for by the principal. To illustrate the differences between these two guilt theories, consider the "NDR" and "WDR" versions of no-competition treatments. According to the simple guilt theory, the amount of guilt incurred by a low-type agent who chooses "Roll" is the same in both versions of the game. In contrast, guilt-from-blame predicts that feelings of guilt are less pronounced in the "WDR" version of the game, since a low-type agent cannot be fully blamed for a zero payoff for the principal. Guilt-from-blame thus predicts higher "Don't Roll" rates and, in equilibrium, higher "In" rates in the "NDR" version of the game. Since we find no differences in behavior between "NDR" and "WDR" (see Finding 2), our data are best explained by the simple-guilt theory.

Neither guilt theory, however, can explain the positive effect of competition on efficiency (see Finding 4) since for the selected agent in treatment "3NC" the amount of guilt is the same as in treatment "2NC." In addition, as noted by Charness and Dufwenberg (2011), the reason for the increased efficiency when communication is introduced in the no-competition treatment is "outside the scope" of the simple guilt and guilt-from-blame models.

4.2. Lie Aversion

Lie aversion (Vanberg, 2008) relies more directly on the possibility of communication. The basic idea underlying the theory is that an agent who makes a promise incurs a cost $k \geq 0$ when breaking it. In other words, lie aversion transforms cheap talk into costly talk once promises are made. As a result, lie aversion allows for the possibility of a fully efficient equilibrium where low-type agents promise "LD," high-type agents promise "HR," and the principal chooses "In" when faced with an "LD" or "HR" message and "Out" when faced with an "NP" message.[19,20] Lie aversion can thus explain the increase in efficiency when communication is introduced in the no-competition treatment ("2C" versus "2NC"). However, it cannot explain the *decrease*

[19]For the payoffs of Figure 1, it is trivial to verify that this is an equilibrium when the cost of lying $k \geq 6$.

[20]Of course, there is always the possibility that communication does not produce any promises ("babbling") in which case only the inefficient equilibrium is possible.

in efficiency when communication is introduced in the competition treatment ("3C" versus "3NC"), see Finding 3. Also, it cannot explain the increase in efficiency when competition is introduced in the absence of communication ("2NC" versus "3NC").

4.3. Inequality Aversion

When low-type agents are inequality averse they value the "Roll" option less because of the disutility they get from being ahead in terms of payoffs. For example, according to the Fehr and Schmidt (1999) model a low-type agent's utility from choosing "Roll" would be $20 - 20\beta$ where $\beta \geq 0$ is the inequality-aversion parameter that multiplies the difference between the agent's and the principal's payoff. The low-type agent's utility from choosing "Don't Roll" is simply 14. When $\beta \geq 0.3$, agents would thus have an incentive to choose "Don't Roll" and the principal should choose "In."

Now consider what happens if there is competition between agents. The selected agent now compares her payoff to that of the principal and to that of the agent who was not selected. A low-type agent's utility from choosing "Roll" is now $20-\frac{1}{2}\beta(20+15) > 20-20\beta$ while the utility from choosing "Don't Roll" is $14-\frac{1}{2}\beta(9) < 14$. In other words, the introduction of competition makes the "Roll" option more attractive and the "Don't Roll" option less attractive, resulting in *less* efficient outcomes. Inequality aversion therefore predicts a reduction of efficiency due to competition, which is the opposite of the first part of our Finding 4. Moreover, this outcome-based theory cannot explain the effects of communication in the no-competition ("2C" versus "2NC") and competition treatment ("3C" versus "3NC").

4.4. Reciprocity

Rabin's (1993) reciprocity model is centered around the idea that kind actions trigger kind responses while unkind actions are retaliated. For example, for the extensive-form game in Figure 1, the principal is kind when she chooses "In" more likely and the low-type agent is kind when she chooses "Don't Roll" more likely. For the high-type agent, "Roll" is the unique Pareto efficient action since it makes both the principal and the agent better off, and the high-type agent's choice is therefore neither kind nor unkind. The notion that kindness is reciprocated is captured by multiplying the kindness levels of the principal and the agent and adding the result to players' material payoffs, weighted by a reciprocity parameter $\xi \geq 0$.

The reciprocity model allows for multiple equilibria. For example, the fully inefficient outcome in which the principal chooses "Out" and both types of agents choose "Roll" is an equilibrium for all levels of ξ. The reason is that the principal's "Out" choice is unkind so a low-type

agent will prefer to "Roll" since this yields higher material payoff and the satisfaction of retaliation. Similarly, the low-type agent's "Roll" choice is unkind and the principal is better off choosing "Out." For high enough reciprocity levels also the fully efficient outcome in which the principal chooses "In," the low-type agent chooses "Don't Roll," and the high-type agent chooses "Roll" is an equilibrium. Now, the principal's choice is kind and the low-type agent prefers to forgo material payoff and respond kindly.

The reciprocity model can thus explain a non-zero fraction of efficient outcomes in the "2NC" treatment. Furthermore, it is the only model that predicts an increase in efficiency when competition is introduced in the no-communication treatments. Since the payoff of not being selected is lower than the payoff of "Out," a low-type agent will want to reciprocate even more when the principal selects her and chooses "In." This results in higher "Don't Roll" rates and, hence, higher "In" rates. As pointed out by Charness and Dufwenberg (2006), however, the reciprocity model may have a hard time explaining the positive effects of communication. Suppose, for example, that in treatment "2C," a low-type agent promises not to "Roll." If the principal believes the promise then her "In" choice is not considered as kind as when this choice is made in the treatment without communication.[21]

5. Conclusions

There are two important messages to take away from our experimental results. One concerns the fragility of cheap-talk communication. We replicate recent findings by Charness and Dufwenberg (2011) that with two people, communication is efficiency improving. However, communication *lowers* efficiency in a treatment with agent competition.[22] The second message concerns the theoretical models, some of which originated to explain the positive effects of communication in bilateral settings. We review several leading alternatives, including lie aversion, guilt aversion, inequality aversion, and reciprocity, and find that each of them captures important aspects of the data that a model with standard preferences cannot. However, none of the models by themselves can explain the substitute patterns between competition and communication that we observe in the experiments.

Of course, this does not imply that the models are wrong – it is only natural to presume that several factors are at work. It does imply, however, that more empirical work is needed

[21]Indeed, if the principal believes that the agent will choose "Don't Roll" with probability one then her "In" choice is the unique Pareto efficient action, which entails zero kindness. As a result, the low-type agent has no incentive to keep the promise.

[22]Communication can be efficiency improving with more than two people if they have a common objective as is the case, for instance, with jury decision making (Goeree and Yariv, 2011).

to gauge the relative importance of the proposed behavioral factors. Our study is only a first step and there are many other directions worth exploring. For instance, do communication and competition act as substitutes in other environments? Preliminary evidence suggests that cheap-talk works well in bilateral bargaining but not in markets with a larger number of traders (Goeree and Zhang, 2012). Another avenue worth investigating is how the communication protocol affects its efficacy. In this paper we considered only one-way communication from the agent(s) to the principal. It would be interesting to explore whether two-way communication would undo or strengthen the substitute effects of competition and communication.

A. Appendix: Instructions (No-Competition, No-Communication Treatment)

Thank you for participating in this session. The purpose of this experiment is to study how people make decisions in a particular situation. Feel free to ask us questions as they arise, by raising your hand. Please do not speak to other participants during the experiment.

You will receive CHF 10, as a show-up fee for participating in this session. You may also receive additional money, depending on the decisions made (as described below). Upon completion of the session, this additional amount will be paid to you individually and privately.

During the session, you will be paired with another person. However, no participant will ever know with whom he or she is paired.

Decision tasks

The amount of money you earn depends on the decisions made in your pair. In each pair, one person will have the role of A, and the other will have the role of B. So half of you have role A and half of you have role B. There are 2 types for B; call these HIGH and LOW. The chance that a B type is LOW is 2/3 and the chance that the B type is HIGH is 1/3.

The computer will roll a six-sided die and show the outcome on B's waiting screen: if the die comes up 1, 2, 3, or 4 then B is LOW and if the die comes up 5 or 6 then B is HIGH. Thus, the chance that in your pair

- B is HIGH is **1/3** (33%)
- B is LOW is **2/3** (67%)

Information about B's type is NOT known by A.

On the decision screen, each person A will indicate whether he or she wishes to choose IN or OUT. If A chooses OUT, each of A and B receives CHF 10 (in addition to the show-up fee).

We will then convey to each B the choice made by the A with whom he or she is paired. If A chose OUT, B has no choice to make. If A has chosen IN, B will indicate whether he or she wishes to ROLL.

If A chooses IN and B chooses DON'T ROLL, A receives CHF 14 and B receives CHF 14. If A chooses IN and B chooses ROLL, the result depends on B's type. If B is the LOW type and chooses ROLL, then A receives CHF 0 and B receives CHF 20. If B is the HIGH type and chooses ROLL, then B receives CHF 20 and the outcome of the roll of a 6-sided die determines A's payoff. If the die comes up 1, A receives CHF 0; if the die comes up 2-6, A receives CHF 24. (All of these amounts are in addition to the CHF 10 show-up fee.)

	A receives	B receives
A chooses OUT	$10	$10
A chooses IN and:		
B is LOW type and chooses DON'T ROLL	$14	$14
B is LOW type and chooses ROLL	$0	$20
B is HIGH type and chooses DON'T ROLL	$14	$14
B is HIGH type and chooses ROLL , die = 1	$0	$20
B is HIGH type and chooses ROLL , die = 2,3,4,5, or 6	$24	$20

Figure A1. *Screen shot of the experimental interface.*

The information is summarized in the chart on the next page:

Are there any questions?

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