

THREE-PLAYER TRUST GAME WITH INSIDER COMMUNICATION

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We examine behavior in a three-player trust game in which the first player may invest in the second and the second may invest in the third. Any amount sent from one player to the next is tripled. The third player decides the final allocation among three players. The baseline treatment with no communication shows that the first and second players send significant amounts and the third player reciprocates. Allowing insider communication between the second and the third players increases cooperation between these two. Interestingly, there is an external effect of insider communication: the first player who is outside communication sends 54% more and receives 289% more than in the baseline treatment. As a result, insider communication increases efficiency from 44% to 68%. (JEL C72, C91, D72)

I. INTRODUCTION

Trust and reciprocity play important roles in economic interactions. The most frequently used measure of trust and reciprocity in economics is based on a two-player trust game, proposed by Berg, Dickhaut, and McCabe (1995). In this game, the first player (trustor) sends any part of his endowment to the second player (trustee). The amount sent is tripled and the second player decides how much to return. Berg et al., as well as many replications, show that most participants display trust and trustworthiness contrary to self-interested profit-maximizing behavior (Burks, Carpenter, and Verhoogen 2003; Glaeser et al. 2000; McCabe, Rassenti, and

Smith 1998; McCabe, Rigdon, and Smith 2003; McCabe and Smith 2000). However, the bilateral relation in the two-player trust game rules out the multiple levels of trust that often emerge in real life when more than two agents are involved. For example, customers trust that the retailer will link them to a reliable producer. Safari travelers rely on their domestic travel company to match them with a high-quality foreign travel agent in Africa. Web businesses connect people with hotels, houses, condominiums, and other accommodations for rent. In all these relationships, the retailer, the domestic travel company, and the web businesses serve as a middleman linking users to goods and services. Whether to purchase via a middleman depends on the degree to which users are willing to accept vulnerability based on positive expectations of both the middleman and the provider. The redistribution of the benefits in these types of transactions is mainly controlled by the last player in the chain who provides goods or services to the customer and pays a commission to the middleman for making the linkage.

Multilevel trust interactions are also common in financial markets. For example, a person investing in a bond fund must trust the fund manager to correctly represent the bonds in the fund. The fund manager, in turn, must trust the

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ABBREVIATION

FOF: Fund of Funds

bond issuers. The same intuition applies in the fund of funds (FOF) industry, where the manager of a hedge fund company invests in other funds instead of individual securities. Thus, multiple (direct and indirect) levels of trust are required between the individual investor, the hedge fund manager, and the FOF manager. Finally, multilevel trust is crucial in workplaces where the workers must not only trust their managers to report their performance truthfully to the CEO, but also trust that the CEO will appropriately reward their performance.

This study provides a framework for understanding multilevel trust interactions in complex environments involving direct and indirect interactions among multiple players. We depart from the conventional two-player trust game of Berg, Dickhaut, and McCabe (1995) by introducing the third player. In our three-player trust game, the three players move sequentially. (1) The first player sends any portion of his endowment to the second player, with the amount being tripled. (2) The second player then decides how much to send to the third player, with the amount being tripled again. (3) Finally, the third player decides the final allocation among three players. The three-player trust game captures the essential elements of complex multilevel trusting and reciprocal behavior in a simplified setting.

Moreover, trust in multilevel interactions depends on the thickness and the pattern of the links between players. One of the indispensable social lubricants for the network of trust and reciprocity is communication. The multilevel interactions introduced by adding the third player provide us a useful platform to explore our second research question: what are the internal and external effects of communication on trust and reciprocity? There are many potential channels of communication that one can investigate in the three-player trust game, but the considerable complexity that arises with the introduction of communication is nontrivial. As a first step, we focus on studying communication between the second and the third player which resembles insider communication in a group when only a subgroup is allowed to communicate (as far as we know, this is the first laboratory study of insider communication).¹ In the FOF example, there is a potential

for privileged insider communication between the FOF manager and the managers of the hedge funds. Similarly, in the workers-manager-CEO example, the detailed discussions CEO and managers have in the board room are often not revealed to workers.

We conducted treatments with and without insider communication. The results of our experiment indicate that even in the baseline treatment with no communication, the first and second players send significant amounts and the third player reciprocates. When we allow communication between the second and the third player, the amounts sent and returned between these two increase. The new interesting finding is that there is an external effect of insider communication: the first player who is outside communication sends 54% more and receives 289% more than in the baseline treatment. As a result, insider communication increases efficiency from 44% to 68%. Content analysis of the communication reveals that what drives the most efficient outcomes are the proposals of equal split among three players made by either the second or the third player. The effect of these types of proposals is strong enough to overcome tendencies toward collusion between the second and the third player.

Our three-player trust game is related to a three-player centipede game of Rapoport et al. (2003) and Murphy, Rapoport, and Parco (2004).² The three-player centipede game is a multistage game which can be used to address some aspects of indirect trust (Camerer 2003). However, the strategy space of each player in the three-player centipede game is restricted to a binary choice, whether to end the game and take some percentage of the available surplus, or to increase the surplus and allow other players a chance to end the game. Thus, it allows observing only whether indirect trust exists but not the magnitude of indirect trust. The three-player trust game proposed in this study is general enough to capture both the degrees of

on both the insiders' and outsiders' behavior. Third, as we discuss in Section III, predictions about the effects of insider communication are not trivial, and thus conducting a laboratory experiment is important.

2. In a repeated three-player centipede game, Rapoport et al. (2003) find that neither full cooperation nor full non-cooperation is supported. In a mixed population of human players and robots, Murphy, Rapoport, and Parco (2004) find that there is an increase in the propensity of human players to cooperate over time when a handful of cooperative robots are added while adding a handful of non-cooperative robots does not change the cooperation rate.

1. We chose to study insider communication between players 2 and 3 for several reasons. First, full communication among all players is less feasible in reality and easier to break down as the size of the communicating group grows. Second, restricting communication between insiders allows us to examine the impact of such asymmetric communication

direct and indirect trust and reciprocity by using a continuous strategy space for each player. Moreover, our game gives us the flexibility to analyze different communication channels and, in this paper, we focus on the external effect of insider communication which is new to the communication literature.

II. THREE-PLAYER TRUST GAME

We introduce a novel three-player trust game, where player 1 acts as a trustor, player 2 embodies both the trustor's and trustee's characteristics, and player 3 always acts as a trustee. All players 1, 2, and 3 are endowed with e_1 , e_2 , and e_3 . Player 1 can send a portion α_{12} of his endowment e_1 to player 2. The amount sent by player 1 is multiplied by factor k_1 . Then player 2 can send a portion α_{23} of his total income to player 3. The amount sent by player 2 is multiplied by factor k_2 . Then player 3 can reciprocate to players 1 and 2 by returning portions of the total money received ($\alpha_{31} > 0$ and $\alpha_{32} > 0$). It is important to emphasize that, in returning to player 1, player 3 may be motivated by direct reciprocity and two types of indirect reciprocity, that is, observation-based and experience-based.³ Moreover, being reciprocal only requires returning positive amounts, while being trustworthy requires returning at least as much as the amount received (McCabe, Rigdon, and Smith 2003).

The unique subgame perfect Nash equilibrium in the three-player trust game, which assumes that all players maximize their earnings, is for all players to send nothing. By backwards induction, player 2 knows that a rational player 3 will not return anything ($\alpha_{32} = \alpha_{31} = 0$) and therefore player 2 should send nothing ($\alpha_{23} = 0$). Anticipating this, player 1 should send nothing to player 2 ($\alpha_{12} = 0$). In this setting, if player 1 sends any positive amount ($\alpha_{12} > 0$), it means he is willing to take a risky bet that both players 2 and 3 will reciprocate. In other words, player 1 exhibits direct trust in player 2 and indirect trust in

player 3. It is riskier to trust in this game than in the two-player game because player 1 is repaid by player 3 and not by player 2. Therefore, player 1 has to trust that player 2 will pass the money to player 3 and also trust that player 3 will be trustworthy. The most efficient outcome is when both players 1 and 2 fully trust player 3 by sending all of their incomes.

III. EXPERIMENTAL DESIGN AND HYPOTHESES

A. Experimental Design

We conducted an experiment in which each session had two treatments: a no communication treatment (NC) and a communication treatment (C). Both treatments lasted for ten periods. We used a random stranger protocol with fixed roles. In the NC treatment, all subjects were randomly assigned to a specific role, designated as player 1, player 2, or player 3. Each subject remained in the same role throughout the experiment. At the beginning of each period, each player was endowed with $e_1 = e_2 = e_3 = 100$ experimental francs and was randomly regrouped with two other players to form a three-player group, with each player in a different role. Player 1 made a decision on how many francs between 0 and 100 to send to player 2 and how many francs to keep. Each franc sent by player 1 was tripled ($k_1 = 3$). After players 2 and 3 learned the amount of francs sent by player 1, player 2 then made a decision on how many francs to send to player 3. The amount sent by player 2 was also tripled ($k_2 = 3$). Finally, player 3 made a decision on how many francs to return to player 1, how many francs to return to player 2, and how many francs to keep. All subjects were told that player 1, player 2, and player 3 can send some, all, or none of the francs available to them. At the end of each period, the amounts sent and returned by all players were reported for everyone to see. Instructions, available in Appendix S1 (supporting information), explain the structure of the game in detail.

To study the effects of insider communication we conducted a treatment C. The design of the C treatment closely followed the design of the NC treatment except that, after player 1 made his decision, players 2 and 3 were able to communicate for 90 seconds in a text-based "chat room." Communication took place only after players 2 and 3 learned the decision made by player 1. Subjects were told that only players 2 and 3

3. In the terminology of Nowak and Sigmund (2005) there is direct reciprocity and two types of indirect reciprocity, i.e., upstream or observation-based ("A helps B because B helped C") and downstream or experience-based ("A helps B because C helped A"). In our experiment, player 3 may reciprocate to player 1 because player 1 indirectly helped player 3 (direct reciprocity), because player 1 helped player 2 (observation-based indirect reciprocity), and because player 2 helped player 3 (experience-based indirect reciprocity). We report the evidence of the two types of indirect reciprocity in Section IV.

would see the messages. In sending messages back and forth, we requested subjects to be civil to each other and not to reveal their identities.

A total of 72 undergraduate student subjects from Purdue University participated in our experiment. The computerized experimental sessions were run using z-Tree (Fischbacher 2007). We ran two NC-C sessions, in which a total of 36 subjects were engaged in ten interactions with no communication and then ten interactions with communication (NC-C sessions). The other 36 subjects participated in the C-NC sessions, where we reversed the order of the treatments.⁴ After completing all 20 decision periods, four periods were randomly selected for payment (two periods for each treatment). The earnings were converted into U.S. dollars at the rate of 100 francs to \$1. On average, subjects earned \$16 each and the experiment session lasted for about 90 minutes.

B. Hypotheses

Previous studies have shown that subjects care about treating others fairly (Fehr and Gächter 2000a), they display trust and trustworthiness contrary to self-interested profit-maximizing behavior (Berg, Dickhaut, and McCabe 1995; McCabe, Rassenti, and Smith 1998), they are concerned about efficiency (Engelmann and Strobel 2004), and they have unconditional other-regarding preferences (Bolton and Ockenfels 2000; Cox 2004; Fehr and Schmidt 1999). In evolutionary literature it is found that people exhibit direct and indirect trust in other people (Buchner et al. 2004; Greiner and Levati 2005).⁵ On the basis of these observations we provide the following hypothesis.

Hypothesis 1: Players 1 and 2 trust player 3 by sending positive amounts, and player 3 reciprocates.

It is also documented in a two-player trust game that the levels of direct trust and reciprocity are higher than the levels of indirect

4. Two sessions (one NC-C and one C-NC) had 12 subjects and two other sessions had 24 subjects.

5. Greiner and Levati (2005) use a variant of a trust game in order to implement a cyclical network of indirect reciprocity where the first individual may help the second, the second help the third, and so on until the last, who in turn may help the first. Like in a two-player trust game, the authors find that pure indirect reciprocity enables mutual trust in the multi-player environment. Buchner et al. (2004) compare the trust-reciprocity regimes with the explicit incentive schemes in the context of a three-person ultimatum game. They find that mutual trust is as good as incentive contracts in inducing costly actions by employees.

trust and reciprocity (Dufwenberg et al. 2001; Guth et al. 2001; Seinen and Schram 2006; Wedekind and Milinski 2000).⁶ Therefore, we expect that:

Hypothesis 2: Player 2 trusts more than player 1, and player 3 reciprocates to player 2 more than to player 1.

We base our hypothesis about the effects of insider communication in the three-player trust game on previous findings in the communication literature. Several experimental studies of one-shot two-player trust games show that communication increases cooperation between trustor and trustee (Ben-Ner and Putterman 2009; Ben-Ner, Putterman, and Ren 2011; Buchan, Croson, and Johnson 2006; Charness and Dufwenberg 2006; Glaeser et al. 2000).⁷ Communication also improves cooperation in prisoner dilemma games (Wichman 1972), public good games (Isaac and Walker 1988), common-pool resource games (Hackett, Schlager, and Walker 1994), voting experiments (Schram and Sonnemans 1996; Zhang 2012), and contests (Cason, Sheremeta, and Zhang 2012; Sheremeta and Zhang 2010). Social psychologists have

6. Dufwenberg et al. (2001) allow trustees to reciprocate toward the other trustors, and find that indirect reciprocity induces only insignificantly smaller donations than direct reciprocity and that trustees are more rewarding in the case of indirect reciprocity. Guth et al. (2001) find that indirect reward reduces significantly mutual cooperation compared to the direct reward. In the same line of research, Seinen and Schram (2006) and Wedekind and Milinski (2000) provide experimental evidence on indirect reciprocity in the "repeated helping game" developed by Nowak and Sigmund (1998). In this game, donors decide whether or not to provide costly help to the recipients they are matched with, based on information about the recipients' behavior in encounters with third parties.

7. Glaeser et al. (2000) allow face-to-face communication before playing the trust game. They find that when individuals are closer socially, both trust and trustworthiness increase. They conclude that trusting behavior in the experiments is predicted by past trusting behavior outside of the experiments. Buchan, Croson, and Johnson (2006) allow subjects to engage in personal but not task-relevant communication before playing the trust game and find significant increase of trust and trustworthiness. Charness and Dufwenberg (2006) allow either trustor or trustee, but not both, to send free-form messages in a binary trust game. They find that the messages sent by trustees increase both trust and trustworthiness. However, no such effect is found when only trustors can send messages. Ben-Ner and Putterman (2009) allow two-way communication and find that verbal communication helps subjects to reach agreement even without visual or auditory contact. Similarly, Ben-Ner, Putterman, and Ren (2011) allow two-way communication and find that trust and trustworthiness increase when verbal communication is allowed.

identified several means by which communication can increase cooperation: communication creates group identity, thus improving group welfare, and communication elicits commitments, creating a promise-keeping norm (Bicchieri 2002; Bornstein 1992; Kerr and Kaufman-Gilliland 1994). In our three-player trust game, insider communication occurs between players 2 and 3. Therefore, we expect that:

Hypothesis 3: With insider communication, player 2 trusts player 3 more, and player 3 reciprocates more.

According to the social identity theory (Chen and Li 2009; Tajfel and Turner 1979), individuals may put themselves and others into different categories based on perceived similarities and differences (categorization), identify others as in-group or out-group members (identification), and discriminate in favor of the in-group and against the out-group members (comparison). Various methods have been used to induce saliency of group identity, including communication between group members (Cason, Sheremeta, and Zhang 2012; Sutter 2009). As in our experiment insider communication occurs only between players 2 and 3, these players should identify each other as in-group members, while categorizing player 1 as an out-group. Such categorization would imply collusion between players 2 and 3, and thus less trust from player 1. On the other hand, as discussed previously, communication should enhance trust and trustworthiness between players 2 and 3, thus increasing their payoffs (Ben-Ner, Putterman, and Ren 2011). Given that some individuals have preferences for equal distribution of payoffs (Bolton and Ockenfels 2000; Fehr and Schmidt 1999), it is likely for players 2 and 3 to share their higher payoffs with player 1, which in turn may increase the trust level of player 1. In summary, depending on whether the “equal distribution” effect or the “collusion” effect dominates, player 1 will either trust more, less, or the same. This is an empirical question for us to test against the following null hypothesis.

Hypothesis 4: With insider communication, player 1 trusts the same.

IV. RESULTS

Our analysis in Section III.A focuses on the first ten-period data before switching to a

different treatment. We discuss the order effect in details using all 20-period data in Section III.B. We mainly use parametric tests and multilevel mixed-effects linear regressions to analyze individual decisions.⁸ The regression models have random effects at both the individual level and the session level to control for correlations that may arise between individuals due to the random regrouping within a session over time. The within-subject residuals are estimated as being autoregressive of order 2 to account for the repeated measurement for each individual.

A. Trust and Trustworthiness

Table 1 summarizes the average amount sent and the profit earned by all players in the C and NC treatments. Among three players, player 1 earns the lowest profit while player 3 earns the highest profit in the experiment. In line with Hypothesis 1, in the NC treatment, players 1 and 2 trust player 3 by sending significant amounts, and player 3 reciprocates. Moreover, in line with Hypothesis 2, the level of indirect trust exhibited by player 1, which is represented by 39 francs sent to player 2 (39% of income), is significantly lower than the level of direct trust by player 2, which is represented by 96 francs sent to player 3 (43% of income). The reciprocal behavior of player 3 is also in agreement with Hypothesis 2, with player 3 returning more to player 2 than to player 1 (57 vs. 35 francs, 10% vs. 7% of income) but the difference is only marginally significant.⁹ On the other hand, on average, player 3 returns

8. For a robustness check, we also estimated panel models with individual subjects representing the random effects (to control for individual effects), standard errors clustered at the session level (to control for possible correlation within a session), and a period trend (to control for learning and experience). The estimation results confirm our main conclusions and are available from the authors upon request. All p values reported in the paper are two-sided unless otherwise stated.

9. To formally test Hypothesis 2, we estimated the two-level mixed-effects model where the dependent variable is the amount sent per period by players 1 and 2 and the independent variables are a constant, a period variable, and a player-type dummy. Based on the estimation, the amount sent by player 1 to player 2 is significantly lower than the amount sent by player 2 to player 3 (p value $< .01$). The significance disappears when we regress on the share of income sent which accounts for the amount received by player 2 before sending to player 3. A similar model regressing the amount player 3 returns to players 2 and 1 on the same set of independent variables reports that player 3 sent back marginally more to player 2 than to player 1 (one-sided p value = .10). No significant difference is found based on the relative amount sent by player 3.

TABLE 1
Summary of Average Amount Sent and Profit

Decision	Amount Sent		Share of Income Sent		Player	Profit		Share of Total Profit	
	NC	C	NC	C		NC	C	NC	C
P1 to P2	39 (39)	60 (40)	0.39 (0.39)	0.60 (0.40)	P1	96	176	0.20	0.20
P2 to P3	96 (107)	231 (143)	0.43 (0.40)	0.82 (0.32)	P2	178	297	0.33	0.35
P3 to P1	35 (61)	136 (172)	0.07 (0.11)	0.14 (0.15)	P3	296	410	0.47	0.45
P3 to P2	57 (111)	247 (189)	0.10 (0.15)	0.30 (0.18)	Efficiency (%)	43.8	67.9		

Note: Standard deviations are in parentheses.

90% of the amount received from player 1 but only 59% of the amount received from player 2. Thus, in terms of trustworthiness, neither player 1's nor player 2's trust pays off. On average, player 2 passes on 82% of the tripled amount received from player 1 without risking his own endowment. Without communication, efficiency is 44%.

When insider communication is allowed between players 2 and 3, efficiency increases significantly from 44% to 68%. This is because on average player 2 sends to player 3 the entire tripled amount received from player 1 plus 50% of his own endowment. As we will show in Section V, player 1 correctly anticipates the increase in trust player 2 places on player 3 and sends 60% of his endowment to player 2 (54% more than in the NC treatment). Player 3 is trustworthy—player 1 receives twice the amount sent and player 2 receives 107% of the amount sent. Interestingly, the increased trust and trustworthiness do not change the distribution of payoffs among three players.

Table 2 reports the estimation results of the mixed-effects linear regressions, where the dependent variable is the amount sent by each player in each period and the independent variables are a treatment dummy-variable and a period trend.¹⁰ As we expected, when communication is allowed, player 2 exhibits more trust in player 3 (specification 2). Controlling for the amount player 2 receives from player 1, the share of income sent by player 2 is significantly higher in the C treatment (specification 6). Anticipating this increase, player 1 sends more to player 2 (specifications 1 and 5). Comparing to the NC treatment, player 3 returns

higher absolute and relative amounts to players 1 and 2 in the C treatment (specifications 3, 4, 7, 8). The two panels in Figure 1 show that the distribution of return ratio is shifted toward more generous behavior of player 3 in the C treatment as compared to the NC treatment. These findings are consistent with Hypothesis 3.

Although only players 2 and 3 were allowed to communicate, we find that the amount player 1 sends to player 2 in the C treatment is increased by 54%. This finding rejects the null Hypothesis 4. We conjectured that the trust level of player 1 would fall in the C treatment if communication would serve as a collusion device between players 2 and 3. In fact, we do find evidence that insider communication increases the collusion between players 2 and 3. Table 3 categorizes player 3's decisions conditional on positive amounts sent by players 1 and 2. In the C treatment, player 3 returns roughly half of his income to player 2 and nothing to player 1 in around 11% of the time. This did not happen once in the NC treatment. Communication also significantly decreases the percentage of players 3 who are trustworthy to player 1 but not to player 2 and increases the percentage of players 3 who are trustworthy to player 2 but not to player 1. Then the question is why would communication increase trust of player 1? The answer turns out to be very simple. In the NC treatment, player 3 almost never splits the income equally between three players. In the C treatment, this happens 28% of the time. Also, there is a significant decrease of the proportion where player 3 keeps everything to himself from 24% in the NC treatment to 12% in the C treatment and an increase of the proportion where player 3 is trustworthy to both players 1 and 2. Therefore, in the C treatment, player 1 receives 288% more than in the NC treatment. This means that insider communication has two opposite effects on the amount player 3 returns

10. The use of non-parametric tests is not feasible in our analyses, as the observations are not independent. Instead we reserve to regressions which control individual effects (since the same subject makes multiple choices), session effects (since all subjects interact in the same session), and a time trend (since the trust game is repeated).

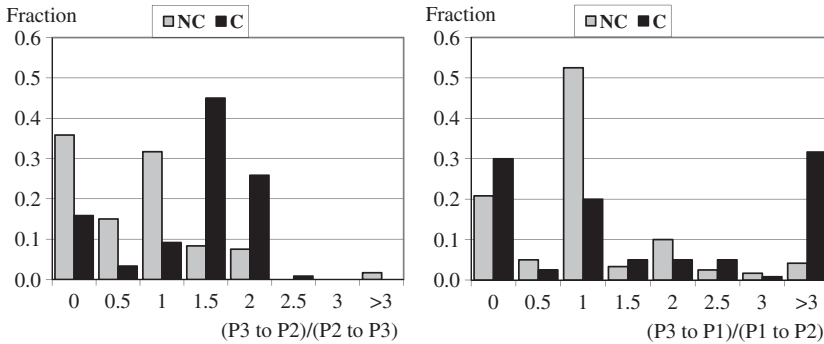
TABLE 2
Treatment Effects

Regression	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Amount Sent				Amount Sent Relative to Income			
Dependent variable	P1 to P2	P2 to P3	P3 to P1	P3 to P2	P1 to P2	P2 to P3	P3 to P1	P3 to P2
C-treatment	18.29*	131.57***	100.11***	189.22***	0.18*	0.39***	0.07**	0.20***
[1 if C treatment]	(10.32)	(30.95)	(27.38)	(36.28)	(0.10)	(0.10)	(0.03)	(0.04)
Period	0.11	5.71*	-0.72	5.04	0.00	0.02**	-0.01**	0.00
[period trend]	(1.08)	(3.33)	(2.88)	(3.91)	(0.01)	(0.01)	(0.00)	(0.00)
Constant	41.18***	66.50**	39.55	29.66	0.41***	0.33***	0.10***	0.08**
	(9.58)	(28.53)	(25.02)	(33.46)	(0.10)	(0.09)	(0.03)	(0.04)
Observations	240	240	240	240	240	240	240	240

Notes: All regressions are estimated using mixed-effects. The models have random effects at both the individual level and the session level and account for second-order autocorrelation in the within-individual residuals. Standard errors are in parentheses.

*Significant at 10%; **significant at 5%; ***significant at 1%.

FIGURE 1
Distribution of Return Ratio in the NC and C Treatments



to player 1: (1) insider communication enhances collusion between players 2 and 3, and (2) it also activates fairness norms and thus increases cooperation between all players. The cooperation effect dominates the collusion effect leading to significant efficiency gains.¹¹ The efficiency in the NC treatment is about 44% while in the C treatment it is 68% (see Table 1). Moreover, as a result of communication, all players earn higher payoffs (see Table 1).¹²

To better understand the determinants of trust and trustworthiness, Table 4 reports estimation

results of different regression models, where the dependent variable is the amount sent by players 1, 2, and 3. To control for endogeneity we use three-stage estimation for systems of simultaneous equations with individual subject dummies. Besides a treatment dummy-variable and a period trend, we also include the observable decisions in the current period and the average amounts sent or received by each player across all past periods.¹³ Although we randomly re-grouped all players with fixed roles after each

11. A two-sided proportion test indicates that the number of cases where player 3 splits equally between all three players is significantly higher than the number of cases where player 3 splits only between players 2 and 3 in C treatment (p value < .01).

12. Based on the estimation of mixed-effect models where the dependent variables are the period profits for each player and the independent variables are a treatment dummy

and a period trend, we find that profits are significantly higher in the communication treatment for all player types (p value < .01 for players 1 and 2, p value = .01 for player 3). A similar model regressing total earnings of three players per period on a treatment dummy and a period trend reports significantly positive communication effect (p value < .01).

13. Each subject can see the decisions of all three participants in the group made at each stage from the

TABLE 3
Player 3's Reciprocal Behavior

Classification of player 3's behavior	NC treatment	C treatment	Z-stat
P3 sent nothing to P1 and split (almost) equally between P2 and P3	0.0%	11.3%	
P3 split (almost) equally between P1, P2, and P3	0.0%	27.8%	
P3 kept everything	23.5%	12.4%	-1.88*
P3 was trustworthy both to P1 and P2	16.2%	26.8%	1.61*
P3 was trustworthy to P1 but not to P2	45.6%	7.2%	-5.76***
P3 was trustworthy to P2 but not to P1	2.9%	9.3%	1.61*
P3 was trustworthy neither to P1 nor to P2	11.8%	5.2%	-1.55
Observations	68	97	4.04***

Notes: We only included cases where both players 1 and 2 sent a positive amount. The amount differs less than 10% is counted as almost equal. The Z-stat reflects the two sample test of proportions.

*Significant at 10%; ***significant at 1%.

period, from specification 1 we see that the amount player 1 sends to player 2 depends on the average amount player 1 received from all previous players 3. This finding suggests that player 1 is learning about the general level of trustworthiness exhibited by player 3. Similarly, the amount player 2 sends to player 3 depends on the average amount player 3 returned to player 2 in all past periods (specification 2).

Besides the past observable decisions, specifications 2, 3, and 4 show that the current period's observable choices are significant determinants of the trusting and reciprocal behavior. Specifically, the more player 1 sends to player 2, the more player 2 passes on to player 3 and the more player 3 returns to player 1. More interestingly, for a given amount that player 2 sends to player 3, the more player 1 sends to player 2, the less player 3 returns to player 2 (specification 3) and the more player 3 returns to player 1 (specification 4). Thus, player 3 reciprocates to player 2 accounting for the decisions made by player 1. In other words, consistent with Nowak and Sigmund (2005), we find evidence for both the observation-based indirect reciprocity (the amount player 3 returns to player 1 increases when player 1 sends more to player 2) and the experienced-based indirect reciprocity (the amount player 3 returns to player 2 increases when player 2 sends more to player 3).

B. Order Effects

We conducted both C-NC sessions and NC-C sessions to examine if there is a significant order

effect. Specifically, one interesting question is whether cooperation which subjects achieve during the C treatment could be sustained in the NC treatment when communication is removed. Figure 2A and B displays the time trend of average amount sent by all players in different sessions. Figure 2A suggests that communication in the C treatment indeed influences the behavior of players in the consecutive NC treatment. The average amount sent by each player in the NC treatment is higher in the C-NC session (Figure 2A) than in the NC-C session (Figure 2B).

To further account for order effects, Table 5 reports mixed-effects regressions of the amount all players sent on treatment and order variables. Four dummy variables that capture the treatment and order variations are included. The variable $C\text{-treatment} \times NC\text{-C}$ is equal to 1 if treatment is C and the session is NC-C. The variable $C\text{-treatment} \times C\text{-NC}$ is equal to 1 if treatment is C and the session is C-NC. We use the Wald test comparing these two variables to measure the significance of the order effect for the C treatment (see the second to the last line in Table 5). Similarly, two variables for the NC treatment in the NC-C session and C-NC session are included and the corresponding Wald tests are reported in the last line of Table 5. Clearly, order has a significant effect on the absolute amount sent by all players in both treatments. Particularly, communication is more effective in the NC-C sessions than in the C-NC sessions. A possible explanation is that in the NC-C sessions, after ten periods of the NC treatment, subjects understand better the efficiency cost of poor cooperation, and thus they significantly increase cooperation in the

outcome screen and we asked subjects to write down all the decisions for each period in the personal record sheet.

TABLE 4
Determinants of Trust and Trustworthiness

Regression	(1)	(2)	(3)	(4)
Dependent variable	P1 to P2	P2 to P3	P3 to P2	P3 to P1
P1 to P2		1.77***	-0.75***	0.41***
[P1 to P2 in the current period]		(0.11)	(0.14)	(0.13)
P2 to P3			0.89***	0.51***
[P2 to P3 in the current period]			(0.04)	(0.04)
P1 to P2 lag	-0.09	-0.75***	-0.24	0.09
[P1 to P2 average over all past periods]	(0.11)	(0.28)	(0.32)	(0.29)
P2 to P3 lag	0.00	0.23**	-0.09	-0.08
[P2 to P3 average over all past periods]	(0.03)	(0.11)	(0.11)	(0.10)
P3 to P1 lag	0.06***	-0.02	-0.04	0.18***
[P3 to P1 average over all past periods]	(0.02)	(0.06)	(0.07)	(0.07)
P3 to P2 lag	0.00	0.14**	0.24***	0.06
[P3 to P2 average over all past periods]	(0.02)	(0.06)	(0.07)	(0.06)
C-treatment	30.69***	52.92***	77.93***	-9.97
[1 if C treatment]	(5.14)	(15.39)	(15.99)	(14.73)
Period	-1.97***	-2.23	-4.29**	-5.79***
[period trend]	(0.57)	(1.60)	(1.81)	(1.67)
Constant	50.71***	49.08***	32.42*	-4.62
	(6.01)	(16.40)	(18.63)	(17.16)
Observations	648	648	648	648
R-squared	0.30	0.59	0.68	0.53

Notes: All regressions are estimated using a system of simultaneous equations (SE). In each regression we also control for period, subject, and session effects. Standard errors are in parentheses.

*Significant at 10%; **significant at 5%; ***significant at 1%.

following C treatment. Although there is a decay of cooperation after we disable communication in the C-NC sessions, the level of cooperation is still significantly higher than in the first half of the NC-C sessions.¹⁴

V. BELIEFS AND MESSAGES

A. Beliefs

In both C and NC treatments, after making the decision on how much to send to player 2, we asked player 1 to make a prediction about the actions of players 2 and 3 before seeing the outcome screen.¹⁵ Player 1 was asked to guess

14. The increase of cooperation when communication is introduced in NC-C sessions and the decay of cooperation when communication is removed in C-NC sessions are similar to the findings with respect to the effect of costly punishment in repeated public goods game with stranger protocol (Fehr and Gächter 2000b). More interestingly, we find the communication is less effective in C-NC sessions than in NC-C sessions. Such order effect is not observed with the punishment mechanism. Thanks to an anonymous referee for pointing out this analogy.

15. We chose to elicit the beliefs of only player 1 for several reasons. First, the most interesting questions of the

how much player 2 would send to player 3, how much player 3 would return to player 2, and how much player 3 would return to player 1. Subjects were financially motivated to make correct predictions. They were paid 10 francs for each prediction if the prediction differed by no more than 5% from the actual decision made.¹⁶ We chose this belief-elicitation protocol instead of the quadratic-scoring rule mainly because it is simple and rather easy for subjects to understand.

current paper are about player 1's behavior, so eliciting player 1's belief was a natural choice. Second, player 1 had the most "free" time in the experiment. After making the decision, player 1 would have to wait for about 5 minutes before players 2 and 3 communicated and made their decisions. The fact that players 2 and 3 were more occupied in our experiment also motivated us not to elicit players 2's and 3's beliefs. Finally, we felt that subjects assigned as player 1 had the least interesting roles, in a sense that they had to make the same unconditional decisions over and over again. So, we decided to provide player 1 with an additional "productive" task.

16. It is also important to emphasize that eliciting beliefs may cause risk-averse subjects to hedge between choices made in the experiment and incentivized belief statements. However, Blanco et al. (2010) find no evidence of such hedging.

FIGURE 2
Average Amount Sent Over the Periods in (A) C-NC Sessions and (B) NC-C Sessions

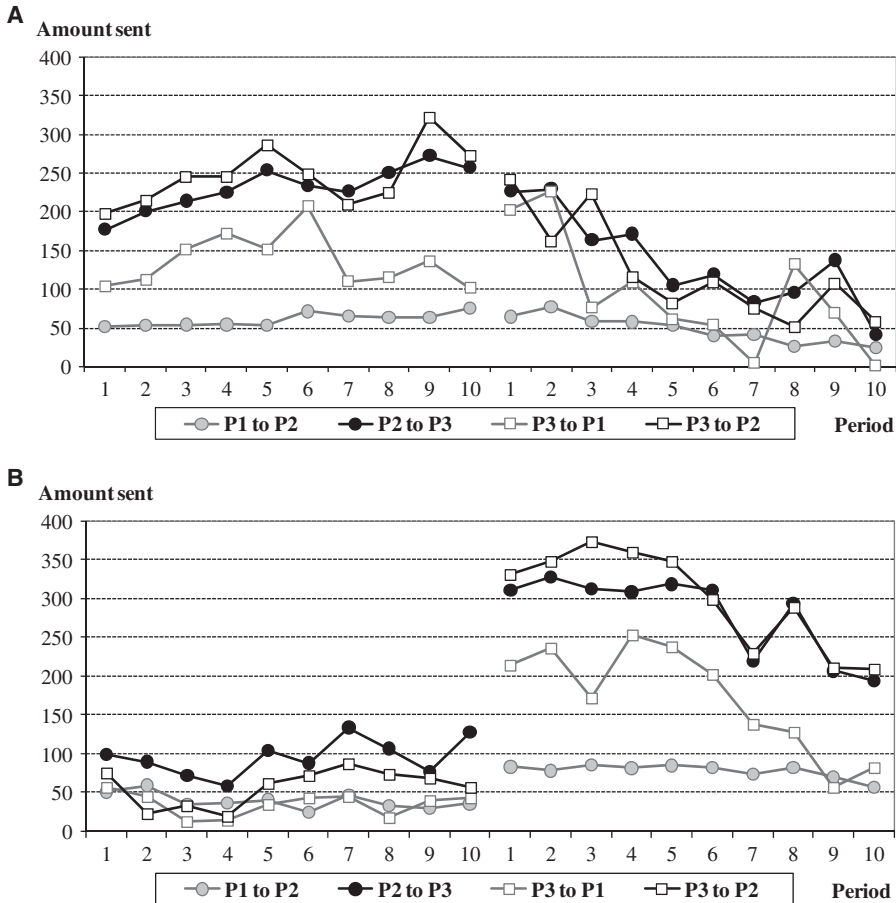


Table 6 reports the average predictions of player 1 on the amounts sent by player 2 and returned by player 3 and the average percentage differences from the actual decisions made from the first ten periods. On average player 1 makes good predictions on the amount player 2 sends to player 3 and the amount player 3 returns to player 2 in both C and NC treatments.¹⁷ However, in both treatments,

17. Based on the estimation of random effect models, where the dependent variable is the amount predicted minus the actual amount sent, we find that the difference between predicted and actual behavior of player 2 is not significantly different from zero neither in the NC treatment (p value = .14) nor in the C treatment (p value = .92). Similarly, the difference between predicted and actual behavior of player 3 toward player 2 is not significantly different from zero neither in the NC treatment (p value = .34) nor in the C treatment (p value = .83).

player 1 significantly overestimates the amount player 3 returns to player 1.¹⁸ This overestimation may partially explain the high level of trust exhibited by player 1 in the three-player trust game.

B. Content Analysis of Communication

At this point we know that insider communication enhances cooperation in the group of three people although only a subgroup of two people is allowed to communicate. This brings

18. Based on the estimation of random effect models, where the dependent variable is the amount predicted minus the actual amount sent, we find that the difference between predicted and actual behavior of player 3 toward player 1 is significantly different from zero both in the NC treatment (p value < .01) and in the C treatment (p value = .02).

TABLE 5
Treatment and Order Effects

Regression	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Amount Sent				Amount Sent Relative to Income			
Dependent variable	P1 to P2	P2 to P3	P3 to P1	P3 to P2	P1 to P2	P2 to P3	P3 to P1	P3 to P2
C-treatment × NC-C [1 if C treatment and NC-C session]	38.71*** (9.73)	171.62*** (32.20)	130.86*** (32.37)	175.25*** (37.57)	0.39*** (0.10)	0.25** (0.11)	0.01 (0.04)	0.12*** (0.04)
C-treatment × C-NC [1 if C treatment and C-NC session]	-2.57 (8.35)	37.16 (29.11)	-54.31 (33.82)	62.15 (37.85)	-0.03 (0.08)	0.13 (0.08)	-0.10*** (0.03)	0.10*** (0.04)
NC-treatment × NC-C [1 if NC treatment and NC-C session]	-13.74 (11.12)	-56.45 (37.53)	-99.17** (41.38)	-125.72*** (46.74)	-0.14 (0.11)	-0.19* (0.11)	-0.17*** (0.05)	-0.10** (0.05)
NC-treatment × C-NC [1 if NC treatment and C-NC session]	68.00*** (11.60)	207.39*** (39.79)	222.81*** (46.40)	215.88*** (51.66)	0.68*** (0.12)	0.67*** (0.11)	0.30*** (0.05)	0.21*** (0.05)
Period [period trend]	-1.68*** (0.64)	-5.10** (2.21)	-9.49*** (2.61)	-6.08** (2.90)	-0.02*** (0.01)	-0.00 (0.01)	-0.01*** (0.00)	-0.00 (0.00)
Observations	480	480	480	480	480	480	480	480
Wald test for order effect on C-treatment	0.000	0.000	0.000	0.016	0.000	0.278	0.016	0.711
Wald test for order effect on NC-treatment	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001

Notes: All regressions are estimated using a random effects error structure with the individual subject effects. In each regression we also include dummy variables (not shown in the table) to control for session effects. Standard errors are in parentheses.

*Significant at 10%; **significant at 5%; ***significant at 1%.

TABLE 6
Summary of Average Expected Amount Sent and Percentage Difference

Decision	Expected Amount Sent		Actual Amount Sent		Percentage Difference from Actual Decisions	
	NC	C	NC	C	NC (%)	C (%)
P2 to P3	80	233	96	231	16.8	0.9
P3 to P2	71	251	57	247	24.6	1.6
P3 to P1	60	191	35	136	71.4	40.4

us to the question of what kinds of messages cause this cooperation. We use content analysis to answer this question.

The procedure that we used to quantify the recorded messages is as follows. First, we randomly selected a session to develop a coding scheme. We classified the messages into 18 categories, shown in Table 7. Then we employed two undergraduate students to code all messages into the coding categories independently. The unit of observation for coding was all messages sent out in a given period before subjects made decisions. Coders were asked not to start coding until they had finished reading all messages in a given period. If a unit of observation

was deemed to contain the relevant category of content, it was coded as 1 and 0 otherwise. Each unit was coded under as many or few categories as the coders deemed appropriate. The coders were not informed about any hypotheses of the study.¹⁹

We use Cohen's Kappa K as a reliability measurement of the between-coder agreement. This measurement determines to which extent the coders agree that a certain message belongs to a particular coding category. Cohen's reliability measurement accounts for the between-coder

19. The instructions for coders are available in Appendix S2.

TABLE 7
Coding Table, Reliability Indexes, and Frequency of Coding

Code	Description	Cohen's Kappa K	Frequency of Coding
<i>Messages sent by player 2</i>			
1a	P2 proposed to send nothing to P1 and (almost) equal split between P2 and P3	0.53	21.7%
1b	P2 proposed (almost) equal split between P1, P2, and P3	0.75	20.4%
1c	P2 proposed to send some to P1 and (almost) equal split between P2 and P3	0.81	0.4%
1d	P2 made a positive comment or showed concern for well-being of P1	0.76	3.8%
1e	P2 made a negative comment about P1	0.50	7.1%
1f	P2 made any promises or showed trust in P3	0.39	4.6%
1g	P2 used threat	0.39	1.3%
1h	P2 pleaded or appealed to P3	0.53	10.8%
<i>Messages sent by player 3</i>			
2a	P3 proposed to send nothing to P1 and (almost) equal split between P2 and P3	0.74	32.5%
2b	P3 proposed (almost) equal split between P1, P2, and P3	0.77	24.6%
2c	P3 proposed to send some to P1 and (almost) equal split between P2 and P3	0.77	1.7%
2d	P3 made a positive comment or showed concern for well-being of P1	0.50	5.8%
2e	P3 made a negative comment about P1	0.49	6.3%
2f	P3 made any promises or showed trustworthiness	0.72	9.6%
2g	P3 mentioned about his or her good qualities	0.32	0.8%
<i>Messages indicating agreement or disagreement between players 2 and 3</i>			
3a	Agreement was reached on the first proposal	0.70	69.2%
3b	Agreement was reached on a different proposal than the first proposal	0.67	22.9%
3c	Agreement was not reached	N/A	0.0%

Note: The amount differs less than 10% is counted as almost equal.

agreement by chance (Hayes 2005).²⁰ Reliability K greater than zero indicates that the proportion of agreements exceeds the proportion of agreements expected by chance. According to Landis and Koch (1977), K between 0.4 and 0.6 corresponds to a moderate agreement level and K greater than 0.6 corresponds to full agreement. Table 7 displays the coding scheme along with Cohen's reliability indexes and the frequency of coding for the C treatment. For the vast majority of categories, K is greater than 0.5. As a result of infrequent coding there are few categories that have unsatisfactory agreement levels. In further discussions of categories we use the average of the two independent codings. Specifically, the value of coding is treated as 1 if two coders agree that a message belongs to a given category, 0 if two coders agree that a message does not belong to a given category, and 0.5 if the two coders disagree with each other.

Table 8 reports the estimation results of mixed-effects models which have random effects

on both the subjects and session levels and account for second-order autocorrelation in the within-subject residuals. The dependent variables are the absolute (specifications 1 to 3) and relative (specifications 4 to 6) amounts sent and returned by players 2 and 3 and the independent variables are various categories of messages. In all regressions, we include a trend variable equals the period number and a constant. The first four independent variables code the cases when only one proposal was made and differ by who made the proposal and whether the proposal was to share the profit equally between players 2 and 3 or among all three players. The next two variables quantify the cases when both players 2 and 3 proposed the same strategy. The seventh and eighth variables capture the cases when the two exchanged different proposals—to collude versus to cooperate. The last two message variables are the most frequently coded categories besides making proposals.

There are a number of notable findings. When either player 2 (1a) or player 3 (2a) or both (1a + 2a) propose to collude between themselves, player 3 returns significantly less

20. For binary 0 or 1 coding, agreement by chance is 50%.

TABLE 8
Multilevel Mixed-effects Regression on Categories of Messages

Regression		(1)	(2)	(3)	(4)	(5)	(6)
		Amount Sent			Amount sent Relative to Income		
Dependent variable		P2 to P3	P3 to P2	P3 to P1	P2 to P3	P3 to P2	P3 to P1
<i>Only one player made a proposal</i>							
1a	P2 proposed to send nothing to P1 and (almost) equal split between P2 and P3	-2.37 (37.13)	42.48 (55.22)	-124.17*** (39.64)	0.07 (0.08)	0.11** (0.05)	-0.13*** (0.03)
1b	P2 proposed (almost) equal split between P1, P2, and P3	109.46** (44.19)	141.29** (65.76)	150.30*** (48.03)	0.14 (0.10)	0.05 (0.06)	0.10** (0.04)
2a	P3 proposed to send nothing to P1 and (almost) equal split between P2 and P3	-16.89 (29.01)	-42.50 (43.57)	-142.32*** (31.67)	0.12* (0.06)	0.05 (0.04)	-0.15*** (0.03)
2b	P3 proposed (almost) equal split between P1, P2, and P3	133.98*** (29.87)	65.21 (45.17)	139.74*** (33.06)	0.16** (0.06)	-0.06 (0.04)	0.10*** (0.03)
<i>The same proposal made by players 2 and 3</i>							
1a + 2a	Both P2 and P3 proposed to send nothing to P1 and (almost) equal split between P2 and P3	66.34* (35.07)	-0.78 (56.56)	-126.98*** (39.87)	0.27*** (0.08)	0.06 (0.05)	-0.15*** (0.03)
1b + 2b	Both P2 and P3 proposed (almost) equal split between P1, P2, and P3	173.87*** (57.67)	149.93* (81.90)	246.40*** (59.79)	0.23* (0.12)	0.00 (0.07)	0.11** (0.05)
<i>Two different proposals made by players 2 and 3</i>							
1a + 2b	P2 proposed to send nothing to P1 and (almost) equal split between P2 and P3 while P3 proposed (almost) equal split between P1, P2, and P3	61.12 (51.56)	35.90 (79.20)	31.41 (58.36)	0.09 (0.11)	-0.05 (0.07)	0.11** (0.05)
1b + 2a	P3 proposed to send nothing to P1 and (almost) equal split between P2 and P3 while P2 proposed (almost) equal split between P1, P2, and P3	85.11 (67.07)	117.72 (97.58)	211.53*** (72.88)	-0.06 (0.15)	-0.03 (0.08)	0.13** (0.06)
<i>The most frequently used messages</i>							
1h	P2 pleaded or appealed to P3	67.17 (50.44)	56.99 (76.70)	4.68 (55.92)	0.21* (0.11)	0.04 (0.07)	0.01 (0.05)
2f	P3 made any promises or showed trustworthiness	25.51 (35.21)	71.86 (51.97)	33.61 (36.53)	0.07 (0.07)	0.00 (0.05)	0.00 (0.03)
	Period [period trend]	6.98 (4.49)	8.47 (7.53)	2.63 (4.51)	0.01 (0.01)	0.00 (0.01)	-0.00 (0.00)
	Constant	129.78*** (36.25)	153.63*** (54.68)	134.59*** (32.57)	0.59*** (0.09)	0.25*** (0.06)	0.18*** (0.03)
	Observations	120	120	120	120	120	120

Note: Standard errors are in parentheses.
*Significant at 10%; **significant at 5%; ***significant at 1%.

absolute and relative amounts to player 1 (specifications 3 and 6). The collusion proposal significantly increases the amount player 2 sends to player 3 only when both of them proposed it (1a + 2a) and has much less effect on the amount player 3 returns to player 2. When either player 2 (1b) or player 3 (2b) or both (1b + 2b) propose to share equally among all three players, both the absolute and relative amounts player 2 sends to player 3 and player 3 returns

to player 1 significantly increase. The cooperative proposal significantly increases the absolute amount player 3 sends to player 2 only when player 2 proposes it and has no effect on the relative amount.

Interestingly, when a collusion proposal is challenged by a cooperative proposal, the negative effect of collusion proposals on the amount player 3 returns to player 1 is offset (1a + 2b, specification 3) or even reversed

(1b + 2a, specifications 3 and 6). The positive effect of cooperative proposals on the amount exchanged between players 2 and 3 also disappears.

Finally, promises made by player 3 and appeals made by player 2 do not seem to influence the final decisions.

Therefore, content analysis reveals that the proposals of equal split among three players, especially when such proposals were made by both players or used to challenge the collusion proposal, significantly increase cooperation between all players, and thus efficiency.

VI. CONCLUSIONS

This paper presents an experimental study of a novel three-player trust game. In this game, player 1 acts as a trustor, player 2 embodies both the trustor's and trustee's characteristics, and player 3 always acts as a trustee. We also investigate the internal and external effects of insider communication on direct and indirect trust and reciprocity. Although the three-player trust game requires additional layers of trust than the standard two-player trust game, we still find a substantial level of direct and indirect trust even when there is no communication. Consistent with other studies, we find that the level of direct trust and reciprocity is higher than the level of indirect trust and reciprocity.

Regarding insider communication, we find that players 2 and 3 who are engaged in communication exhibit more trust and trustworthiness. The most unexpected and positive result of our experiment is the effect insider communication has on player 1's behavior. Although only players 2 and 3 are allowed to communicate, we find that player 1's trust increases by 54%. This is because communication activates stronger preference for fairness than collusion between players 2 and 3. Expecting that, player 1 exhibits more trust in players 2 and 3. In response, player 3 returns higher absolute and relative amounts to player 1. Belief elicitation reveals that player 1 persistently overestimates the trustworthiness of player 3, which may also account for the high level of trust exhibited by player 1. We also find that the social norms developed during the communication stage carry over to the no communication stage.

Finally, we use content analysis to study what kinds of messages enhance cooperation. In the multivariate analysis of communication, we find that the messages that significantly

increase cooperation are the ones that indicate willingness to split all earnings equally.

Our study provides evidence that economic agents exhibit direct and indirect trust in multilevel interactions among strangers. One mechanism that can further promote trust and reciprocity is communication even when only a subgroup of agents can afford to communicate with each other. Since communication between insiders may raise the concerns of forming collusion at the cost of the outsiders, to better use this mechanism, insiders should deliver the idea that communication activates more fairness norms toward the outsiders. This suggests that to build trust with individual investors in FOF, managers have to send clear signals to investors that their interests of obtaining cooperative, fair, and efficient outcomes from the investment are perfectly aligned.

As a first attempt to use simplified laboratory experiments to explore trusting behaviour and effect of communication in multilevel interactions, caution would be suggested in drawing direct inferences from our results. Nevertheless, our findings may shed some light on the important causal factors affecting the emergence of many web-based auctions and other forms of online businesses which are built on trust and reciprocity among strangers (Resnick and Zeckhauser 2002). For example, in the wholesale eBay online auction, as a consumer wholesale distributor, you can buy products at an unbeatable wholesale price from suppliers and then set your sale price in online auctions. Advertising fair trade between you and the wholesale suppliers may help to attract more buyers.

There are many interesting extensions to our research. Future work can investigate how trust and reciprocity are affected by different channels of communication, other interactions between players (e.g., player 2 can also directly return to player 1), and factors such as the size of the endowment and multipliers in the three-player trust game.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Appendix S1. The Instructions for the NC-C Session.

Appendix S2. Instructions for Coders.