Together We Stand? Internal Dynamics of Group Decision Making*

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Abstract

In order to shed light on individuals' financial and social investment decisions in groups, I conduct a laboratory experiment in which subjects play a variant of a public goods game without free-riding incentives. With no private information, the prospect of investment in the experiment involves self-evaluation of uncertain personal and group types, which depend on performance on a pretest. I compare subjects' individual investment decisions with their decisions when in groups. Timing and structure of communication are the two dimensions of controlled treatments. The results strongly suggest that individuals tend to invest more often, and that they increase their subjective beliefs of being a "high" type when in groups, especially when group decisions are made prior to individual decisions. (*JEL*: C91, C92, D71, D81)

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1 Introduction

Many important decisions are made by groups. Despite considerable uncertainties of the returns, people invest time, effort, and money in starting-up businesses, political campaigns, academic co-authorships, religious groups,[1] sports teams, criminal gangs, and more. This study concerns the individual's decision to contribute to a group endeavor.

Theoretically, individual economic agents take everything into account and make their optimal decisions according to their beliefs about uncertainty. Generally, the expected returns to group projects depend on the following elements: 1) nature or random shocks, 2) the total effort made by group members (observable), 3) the quality of the group (not directly observable), and 4) competition.

In this study, in order to focus on individuals' beliefs about the quality of their own group, competition is not considered. For the same reason, without loss of generality, the experimental environment is constructed such that all the uncertainty comes from the unknown quality of one's group. In other words, the only thing determined by nature is the unknown group type.[2]

In order to concretely define the type of a group and link it to the prospect of its investment, I let the subjects take a pretest and keep the score of each subject unrevealed until the end of the subsequent investment decisions. A subject is defined as a "high" type individual if he scores above the median on the test, a "low" type if otherwise. Note that

[1] Iannaccone (1992) provides a model applied to religious groups, in which participation generates positive externalities.

[2] When applying to economic and social phenomena, this unknown shock can be easily interpreted as the quality of the group an agent belongs to, the prospect of a starting-up business, a political campaign's chance of winning an election, or the credibility of a religion or denomination.

an individual does not know his true type. After the pretest, each subject independently makes binary investment decisions in two parts: an individual part and a group part. In the individual part, the gross return entirely depends on the subject's own type and his decision. In the group part, the gross return depends on the average decisions made by all members and the types of all members in the group, i.e., the group type. The costs of investment in both parts vary over rounds and are not shared with group members. Therefore, a subject is expected to form expectations about his own type and the group types.

It remains standard in economic models to treat groups as single agents. Yet, a growing literature documents differences between individual and group decision making. Experimental research that compares the decisions made by individuals and the decisions made by a small group identifies differences in specific settings, including beauty-contest games (Kocher and Sutter, 2005), common value auctions (Cox and Hayne, 2006), simple decisions under risk (Charness et al., 2007; Rockenbach et al., 2007), information cascades (Fahr and Irlenbusch, 2011), and the prisoner's dilemma (Kagel and McGee, 2016). The results are mixed. In these experiments, groups do not seem to be more rational and to make decisions that are more in line with rational predictions all the time.[3] Therefore, whether groups or individuals are better decision makers is inconclusive. Two heads are not necessarily better than one.

[3] Kocher & Sutter (2005) find that groups are not better decision makers per se but they seem to learn faster in games. In Charness et al. (2006), groups are found to be more rational decision makers. Cox & Hayne (2006) find groups less rational compared to individuals when each member of a group has distinct information. The difference disappears when group members have common information. Fahr & Irlenbusch (2011) groups behave more rationally in the information cascade environment.

Some possible explanations for the ambiguous performance of groups compared to individuals come from psychology. The classic experiment of Asch (1956) shows that individuals may conform to the false opinion of the group even when the group is obviously wrong. At the same time, it underlines the importance of the existence of dissent opinion. Janis (1972) indicates that group members may suffer from "groupthink," which describes group members' distorted beliefs about the group's inerrancy or invulnerability.[4] The inner pressure from this false belief shuts down the unpleasant cautionary opinions a group member may express, and thus leads to bad decisions.

In recent decades, economic models have been developed that rationalize people's behavior of forgoing their own opinions and herding (Banerjee, 1992), and the phenomenon of information cascades (Bikhchandani et al., 1992). In these models, an agent with private information observes public information before making an individual decision. The weighted comparison of private and public messages is the crucial part of these models. Experimental work in this branch includes both private and public information as well (McKelvey and Page, 1990; Anderson and Holt, 1997; Bougheas et al., 2015).

More recently, models of "motivated beliefs" describes a mechanism through which individuals cognitively choose beliefs to serve their own utilities. Overconfidence, which is well identified at the individual level (Camerer & Lovallo, 1999), is thought to be the most obvious type of motivated belief (Bénabou and Tirole, 2016). It is also found at the group level (Burks et al., 2013; Proeger and Meub, 2013; Brookins et al., 2014). In

[4] Janis (1972) proposes eight symptoms of groupthink: (1) illusion of invulnerability, (2) belief in inherent morality, (3) collective rationalization, (4) stereotyped views of out-groups, (5) direct pressure on dissenters, (6) self-censorship, (7) illusion of unanimity, and (8) self-appointed mindguards.

addition, asymmetric updating refers to the idea that agents update positive signals more than negative ones (Eli and Rao, 2011). Wishful thinking refers to people choosing to believe what they want to be true (Mayraz, 2011).

Bénabou (2013) constructs a model in which agents in a group face a tradeoff: they can either accept a public signal about a random shock, or hold their own beliefs by ignoring those signals while bearing the risk of making bad decisions out of over-optimism. In his model, the gross return of a group project is determined by a weighted average of an individual's effort and other group members' average effort, with all of this multiplied by a random shock that determines the sign of the gross return. Bénabou's main prediction is that groups are more likely to fall into groupthink: i) when the weight of other group members' effort, i.e., the level of interdependence, is higher; and ii) when the gross return of the random shock is very low in the bad state that rarely happens. One purpose of this paper is to experimentally examine Bénabou's model of groupthink.

How the group type is defined turns out to be one of the most important distinctions between the present work and previous research. Specifically, the impact of a low type individual on the gross return of a group is designed to offset the impact of a high type individual. This provides two advantages. First, the group part of this game is a variant of public goods game without the incentive to free-ride. It is similar to a public goods game in the sense that each individual's payoff is determined not only by his own investment. The difference is that agents do not know the sign of the externalities generated by their investment and thus do not have a direct incentive to free-ride. In particular, the externality is positive only if the group type is positive. Therefore, without information of the group type, an agent does not have an incentive to free-ride or to misreport his prior belief about his type. This feature rules out a free-riding explanation to focus on the group dynamics alone.

Second, for the same reason, for an individual, the prior expectation of the group type equals the expectation of the individuals' own type since the other two members are most likely to offset each other. It allows me to explicitly identify a rational expectation of the group type. At the same time, by varying costs, I can create situations where it is rational to invest and not to invest both in the individual part and in the group part of the game.

Writing a collaborative grant proposal could be an example of this sort of situation this experiment is meant to inform. Suppose an individual is writing a grant proposal with two potential coauthors. The costs include time, effort, and forgone opportunities. The payoff is the grant itself. Suppose there exists an unofficial threshold by which the grant agency looks at each applicant's previous record. If applicants do not know how the funding agency sets the unofficial threshold, then what is known is that the funding will be granted to the project proposed by a research team that has more researchers above the threshold. Thus, an individual applicant has to estimate the number of individuals who pass the threshold, including himself. If, for example, the acceptance rate of funding is 50%, then without any other information, the most reasonable expectation for an applicant to hold is to assume only one of the other two fellow applicants would pass the threshold, and take his evaluation about self as the evaluation about the whole proposal team. In this admittedly unrealistic scenario, co-authors are good ('high' types) or bad ('low' types), and the only thing that matters, as far as getting funding, is how many authors are "above the level." Individual co-authors may vary continuously in their ability, but it only matters if one is "good enough."

Another distinction between this paper and the existing research is that there is no private information in this experiment. This is true in two senses. First, individuals are not informed about their true types. Therefore, each subject has the same public information about the game – the payoff function and the costs – at all stages. Second, for the same reason, what subjects have is merely the private "belief" about the types. Therefore, the resulting beliefs about the group type are endogenously formed by "thinking about what others believe about the group type," not by "learning about the group type," since the exogenous type of each individual remains hidden. Bayesian updating conditional on new information is thus minimal.

In this paper, two dimensions of belief exchange are considered. First, I consider three different communication structures in the group part. In all treatments, subjects are aware of the existence of team members and how the payoff is determined by the joint effort and type of the group. In the benchmark "no-chat" treatment, no communication is allowed. The treatment of "full chat" is similar to open meetings, where subjects can freely talk to all other team members through an on-line chat box. The "one-way leadership" treatment mimics a one-sided communication in which a leader can talk to the non-leaders, who can only receive but cannot send messages.

The other dimension of the belief exchange considers its timing. In particular, in half of the treatments, the individual part is played before the group part. The opposite order is played in the other half of the treatments. The purpose is to check whether the formation of individual beliefs is order-dependent. If being in groups does "bias" an individual's beliefs, I hypothesize the bias is greater when belief formation at the group level occurs before the individual level.

To summarize, the 2×3 experimental design allows me to seek answers to the following questions. Within subjects, I question whether being in a group changes how an individual estimates his performance and that of his own group. Specifically, I compare the beliefs of individuals when they are alone and when they are in groups. Between subjects, I examine how the communication structure and the order of belief formation alleviate or aggravate the effect of group dynamics on individuals' beliefs.

Given the design of the experiment, if group dynamics have no effect on individuals' beliefs, in the group part, subjects should invest as often as in individual part. However, if individuals' belief about the prospect of a group investment had been inflated by the group dynamics, more investments would be made in the group part, especially when they were, optimally, not supposed to make investments. I hypothesize that group dynamics makes an individual believe that the prospect of his own investment and thus the prospect of the group are systematically higher than rationally expected, with an incentive to free-ride and Bayesian updating of the information excluded.

The results of the experiment strongly suggest that the group setting makes individuals more optimistic than they are supposed to be. Subjects are more likely to invest in the group part than in the individual part by 12 to 17 percentage points. On average, an individual's belief of being a high type increases by 33 percentage points. The results are stronger when subjects are communicating with each other before making decisions alone. The results imply that individuals in groups exhibit patterns of decision making that can be interpreted as "groupthink."

The rest of paper proceeds as follows. Section 2 describes the model of the investment environment and its predictions. The experiment design is explained in section 3. Section 4 shows the results. Section 5 concludes.

2 The Model and Theoretical Predictions

There are a total of N subjects in an experiment session. Before being informed about the main investment environment, each subject takes an incentivized pretest consisting of ten true-false common sense questions.[5] The last question in the pretest is an additional incentivized question, which asks the subjects to estimate whether they are in the top half or the lower half of the distribution. After the pretest, the subjects are involved in an individual investment environment and a group investment environment.

The raw score of agent i in group j is denoted by $\theta_{ij}^0, i \in \{1,2,3\}$. In this experiment, the performance on the test is viewed as the type of the each subject. The median score of all N subjects, denoted by $\bar{\theta}$, separates the high type from the low type. θ_{ij} is defined as the performance of a subject relative to all subjects: $\theta_{ij} = \begin{cases} 1 \ \ if\ \theta_{ij}^0 \geq \bar{\theta} \\ -1 \ \ if\ \theta_{ij}^0 < \bar{\theta} \end{cases}$. In other words, an agent is of high type, $\theta_{ij} = 1$, if his score on the pretest is at the top half; an agent is of low type if otherwise. The setting is intuitive in the following sense. The prospect of the investment project depends on the types of team members in the project. A high type agent has a positive impact on the return on

[5] I revise the trivia questions from Biais et al. (2005) and Herz et al. (2014).

investment, and vice versa.[6] The type of an agent is hidden until the final return realizes. Each subject will involve in both individual decision making phase and group decision making phase. In half of the treatments, subjects start the experiments with the individual phase. The other half starts with the group phase.

2.1 Individual decision making

The group subscript j is dropped for the model of individual phase. Each round is independent and thus equally treated in terms of analysis. There is no subscript standing for round. In each round of the individual decision making phase, the profit of investment π_i is equal to an endowment ω plus the gross return R_i minus the cost. Only when the individual chooses to invest do the gross return and the cost occur. In particular,

$$\pi_i = \omega + R_i(\theta_i)e^i - ce^i, \text{ where } e^i = \begin{cases} 1 & if\ invest \\ 0 & if\ not\ invest \end{cases}. \quad (1)$$

The gross return $R_i(\theta_i)$ is a function of individual i's type θ_i:

$$R_i(\theta_i) = \begin{cases} R^+ & if\ \theta_i = 1 \\ R^- & if\ \theta_i = -1 \end{cases}. \quad (2)$$

Let $p_i \equiv p_i(\theta_i = 1)$ be agent i's belief of himself being a high type. Agent i's expected payoff from investing is equal to

$$E_i(\pi_i) = p_i\left[\omega + R^+e^i - ce^i\right] + (1 - p_i)\left[\omega + R^-e^i - ce^i\right]$$

$$= \omega + [p_iR^+ + (1 - p_i)R^-]e^i - ce^i = \omega + E_i[R_i(\theta_i)]e^i - ce^i.$$

Therefore, an agent would invest if

$$p_iR^+ + (1 - p_i)R^- = E_i[R_i(\theta_i)] \geq c. \quad (3)$$

[6] When applying to sports teams, a high type player increases the winning percentage of his team, while a low type decreases it. When applying to small business started by a small group of team members, a high type may help raise the profits by making right decisions, e.g., location, pricing strategies, etc., while the low type may hurt the profits because of wrong judgments.

2.2 Group decision making

In the phase of group decision making, subjects are randomly organized in groups of three. I use the sum of the relative performances of group j to represent group j's type: $\Theta_j = \sum_i \theta_{ij} = \theta_{1j} + \theta_{2j} + \theta_{3j}$, $\Theta_j \in \{3,1,-1,-3\}$ since $\theta_{ij} \in \{1,-1\}$. For example, if all three members of the group belong to the top half of the distribution, $\Theta_j = 3$; if all three members of the group are less talented than median, $\Theta_j = -3$. Θ_j is greater than zero if and only if at least two group members are high type.

After each round in the group part, I do not reveal the true group type to the subjects, but I reveal how many group members invested in the last round. This captures most situations of group decision making where efforts are observable, not real prospects of the group project. One might argue there exists learning underway, which makes individual i's expected group type in round t conditional on the decisions made by every group member in the last round $t-1$. In other words, the solution concept of the group part would be a six-period perfect Bayesian Nash equilibrium.

For the following reasons, I treat each round in the group part independent as in the individual part. First, an individual's decision in the group part only partly reveals what he "believes" about his own type. This belief is far from the true information of the group type and even his own. Second, in this game, individuals do not have an incentive to free-ride, to misreport their types, and to persuade other to make or not to make investments. Therefore, strategic interaction is minimal. Third, the payoff maximization rule for an individual in a group is independent of other teammates' decisions. Fourth, in each round, the payoff maximization problem remains the same, and thus the payoff maximization rule is the same. Except the cost, nothing varies by round. None of these have anything to do with how other individuals believe about their type. Table A1 in Appendix B shows the chat records of a sample round in a session of full-chat treatment. It appears that their primary concern is the cost in each round, not how they have learned about the group type based on previously observed actions. Finally, I control for the realized group type in the econometric models, which absorbs the rest of possibilities of learning the true group type. Nothing statistically significant is explained by the group type. In sum, in the model, no subscript t is needed. Implicitly, Bayesian Nash equilibrium is the solution concept.

Individual's payoff from the group project depends on the group type and each individual member's investment decision $e^{ij} \in \{0,1\}$. An individual subject's payoff in a given round of the group phase is determined by his endowment, ω, the cost of effort if he decides to make investment, ce^{ij}, and the gross return associated with the outcome resulted from the talent and the joint effort of his group, U^{ij}. In particular, the payoff function is given by

$$\pi_{ij} = \omega + U^{ij} - ce^{ij}. \tag{4}$$

The joint gross return function U^{ij} is given by

$$U^{ij} = R_i(\Theta_j)[\alpha e^{ij} + (1-\alpha)e^{-ij}], \tag{5}$$

where R_i is strictly increasing in group talent Θ_j. In particular, $R_i(3) > R_i(1) > 0 > R_i(-1) > R_i(-3)$. The gross return function is borrowed from Bénabou (2013) except the interpretation of the multiplier R_i. In Bénabou (2013), the multiplier θ is a random shock determined by nature. In this paper, without loss of generality, I let nature determine the talent of group j, Θ_j, which further determines the joint gross return of an individual's final payoff. If nature assigns good teammates to a group, they are a plus to the group's payoff.

The other terms in the gross return function follow Bénabou (2013)'s setting. e^{-ij} is the average investment level of the members in group j other than subject i. $1-\alpha$ represents the interdependence level of the group. A higher interdependence level means a larger part of the investment outcome is determined by other group members.

For instance, when $\alpha = 1$, the interdependence level $1-\alpha$ is 0. $U^{ij} = R_i(\Theta_j)e^{ij}$ if subject i's gross return only depends on his own type. The gross return does not depend on the investment decision of his group members, e^{-ij}. When $\alpha = 0$, the interdependence level $1-\alpha = 1$, subject i's gross return entirely depends on the investment decision of his group members, $U^{ij} = R_i(\Theta_j)e^{-ij}$.

In this experiment, the individual phase captures the setting of zero interdependence. The group phase considers the equally distributed interdependence level, $\alpha = \frac{1}{n} = \frac{1}{3}$. In order to make it directly comparable between individual and group settings, I let $R_i(\Theta_j)$ reduce to $R_i(\theta_i)$ in the individual phase. In other words, other team members' types do not affect the individual's gross return when the interdependence level is zero.

Similar to the individual game, agent i's expected payoff in group is

$$E_i(\pi_i) = p_i(\Theta_j = 3)\left[\omega + R_i(3)\left(\alpha e^{ij} + (1-\alpha)e^{-ij}\right) - ce^i\right]$$

$$+p_i(\Theta_j = 1)\left[\omega + R_i(1)(\alpha e^{ij} + (1-\alpha)e^{-ij}) - ce^i\right]$$

$$+p_i(\Theta_j = -1)\left[\omega + R_i(-1)\left(\alpha e^{ij} + (1-\alpha)e^{-ij}\right) - ce^i\right]$$

$$+p_i(\Theta_j = -3)\left[\omega + R_i(-3)(\alpha e^{ij} + (1-\alpha)e^{-ij}) - ce^i\right]$$

$$= \omega + E_i[R_i(\Theta_j)](\alpha e^{ij} + (1-\alpha)e^{-ij}) - ce^i.$$

Therefore, an agent i would choose to invest in group if $E_i[R_i(\Theta_j)] \geq \frac{c}{\alpha}$. Since $\alpha = \frac{1}{3}$, the condition for agent i to invest becomes

$$E_i[R_i(\Theta_j)] \geq 3c. \quad (6)$$

2.3 Identification assumptions

Throughout the paper, I assume that an agent would adopt the neutral prior belief about the other two team members. That is, an agent assumes the type combination of his teammates is one high and one low. Then the group investing condition (6) can be reduced to a form that is directly comparable to the individual part. An agent would invest if

$$p_i R_i(1) + (1-p_i)R_i(-1) \geq 3c. \quad (7)$$

Equation (3) and (7) are the conditions used to directly compare subjects' decision making in the individual and group environments. Because of this, the other identification assumption lies in how the expected value of group gross return, the left hand side of inequality (7) is calculated. I employ two identification assumptions to calculate the expected gross return in group.

2.3.1 Benchmark assumption: $p_i = 0.5$

First, as a benchmark, assume an agent has a prior belief $p_i = p_{-i} = 0.5$. Therefore, $p_i R_i(1) + (1-p_i)R_i(-1) = 0.5 \times R_i(1) + 0.5 \times R_i(-1) = 0$. Agent i would invest if

$$0.5 \times R_i(1) + 0.5 \times R_i(-1) \geq 3c. \quad (7a)$$

In this experiment, I let the impact of each agent in the team symmetric and thus $-R_i(3) = R_i(-3)$ and $-R_i(1) = R_i(-1)$. As a result, an agent with prior beliefs $p_i = p_{-i} = 0.5$ will invest in the group if $c \leq 0$, i.e., when they are subsidized to invest.

2.4 Gross return, costs, and the decision rules in actual parameters

In the individual part, R^+ is set to be 50 and R^- is 20. The costs in six rounds are {10, 25, 30, 35, 40, 60} shown in random orders.

In the group part, the gross returns of different group types are given by

$$R_i(\Theta_j) = \begin{cases} 30 & if\ \Theta_j = 3 \\ 10 & if\ \Theta_j = 1 \\ -10 & if\ \Theta_j = -1 \\ -30 & if\ \Theta_j = -3 \end{cases}. \tag{8}$$

In addition to the formula, Table 1 is provided to make sure subjects understand how the types of the whole group and each member's decision jointly determine the payoff. The costs in six rounds are {-13, -7, -2, 2, 7, 13} shown in random orders.

3 Experimental Design

3.1 Experimental design

The experiment is coded and conducted on the platform of z-Tree (Fischbacher, 2007). Here I briefly describe the design of the experiment. The full instruction, including rules, formula, and examples, are provided in the appendix.

The pretest appears at the beginning of the experiment. Subjects are informed that the score on the test is positively correlated with their final payment. After the pretest, they are asked to predict whether their scores are on the top half among the subjects. They are informed that a correct prediction will be rewarded a bonus of 2.5 U.S. Dollars.

After the pretest comes the investment environment. In half of the experimental sessions, subjects faced the individual phase first, then the group phase. In the other half of sessions, subjects faced the group phase first. At the beginning of each phase, the formula of the payoffs is provided along with examples. They are informed that the currency in the experiment, Experimental Currency Unit (ECU), will be converted into U.S. Dollars at the rate of $1 per 8 ECUs. In each of the two parts, there are six rounds. Subjects have 50 ECUs as endowment in each round. They are informed that the final payment will be equal to their show-up fee of $5 plus the payoff of one random round in each part. Examples and detailed explanation of payoffs are provided. The group members do not change throughout the experiment.

3.2 Communication structures

Presumably, group dynamics could have a more significant effect when the group members are able to affect others' beliefs and thus their decisions, mentally or virtually. Therefore, I hypothesize that the communication structure could make a substantial difference to decisions in the group task.

Three structures of communication are considered. The treatment without communication is the benchmark, in which the group members are not allowed to communicate with anyone.

The other extreme communication structure is a fully connected network. In this treatment, I allow for communication among all three subjects in the same chat room. It captures all "open meeting" communication formats.

Between the two extremes, there are many possibilities to consider. In this paper, the communication structure of interest is "one-way leadership" structure. In this treatment, one randomly assigned subject in each group would be appointed as the leader. The leader can talk to the other two group members, but the group members can only listen. It approximates the scenario in which a strong leader possesses unchallengeable opinions. Figure 1 summarizes the communication structures considered in this paper.

In the treatments with communication, subjects have 90 seconds to communicate before each round of the investment decision. A fixed alias is given to each participant. They are not allowed to reveal their real identities during the communication. Table 2 summarizes the six treatments of the experiment. Within each cell, within-subject effects are observed. Between-subject effects are observed across the cells.

4 Results

The experiment sessions were conducted at Rutgers University – New Brunswick in the Gregory Wachtler Experimental Economics Laboratory in May, June, and September 2016. Subjects were recruited via the Rutgers Economics Experiment Recruiting Site[7] enabled by Sona Systems.[8] The total number of subjects over all sessions

[7] https://rutgers-econ.sona-systems.com/Default.aspx?ReturnUrl=%2f#.
[8] http://www.sona-systems.com/default.aspx.

is 138. Table 3 shows the number of sessions, subjects, and groups in each treatment. Two separate sessions were conducted for each treatment.

4.1 Descriptive Statistics

Table 4 shows the summary statistics of the main variables. Gender is equally distributed. Three-fourths of the subjects have taken economics and statistics, respectively. Sixty-two percent have taken both. The average score on the pretest is 5.01 out of ten points. About 73% of the scores lies between four points and six points, as shown in Figure 2. Sixty percent of the subjects estimated themselves to score on the top half. It suggests the individuals exhibit the “better-than-median” effect.[9] Fifty-five percent of the subjects are high type. Forty-four percent of the subjects correctly estimated their type and thus earned the bonus. Figure 3 shows the distribution of the group type. Because of the randomness of group formation, sixty percent of the groups are positive types.

4.2 Primary results

First, let us look at the average contributions assuming subjects are risk-neutral and have prior beliefs $p_i = 1/2$. Table 5 shows the average contributions of each treatment. By design, an average risk neutral profit maximizer should invest in exactly half of the rounds. Therefore, the average contribution would be 0.5 – one being invest and zero being not invest.[10]

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[9] The one-tail p-value is 0.008.
[10] For the individual part, I exclude the rounds in which the cost equals 25 in order to maintain the theoretical average as 0.5.

Overall, the average contribution is significantly higher when the subjects are involved in groups (0.61 vs. 0.44). This is true in all but one treatment. The tendency that subjects invest more when making group decision is stronger for those who start the experiment with the group phase. It may suggest that if there is any group effect, it is stronger especially when people do not have a chance to solely evaluate themselves. This will be econometrically examined in a later section.

Second, I look at rounds in which the expected payoff is negative, assuming $p_i = 1/2$. The theoretical prediction for each such round is zero, i.e., no one should invest. Table 6 shows the average contributions in such rounds. It is clear that subjects invested much more in groups than they invested alone when the expected payoff is negative. When it was unprofitable to make an investment, individuals made an investment 14% of the time when the investing alone, as opposed to 46% of the time when being in groups. Again, the tendency for subjects to invest more in groups is even stronger for those who encountered the group environment before the individual environment.

4.3 Probit model: probability of making an investment

The first strategy of the econometric analysis is to estimate the probability of making investment using a probit model. The model is given by

$$P\left(e^i = 1 \middle| X^i = x\right) = \Phi(\beta_0 + \beta_1 group_i + \beta_2 groupfirst_i + \beta_3 group_i \times groupfirst_i + \beta_4 chat_i + \beta_5 group_i \times chat_i + \beta_6 chat_i \times groupfirst_i + \beta_7 grouptype_i \times group_i + \gamma' X_i). \quad (8)$$

In equation (8), $P\left(e^i = 1 \middle| X^i = x\right)$ denotes individual i's probability of making an investment, $e^i = 1$, conditional on a set of independent variables X^i. β_1 captures the group effects as $group_i$ is the dummy representing the rounds in the group part. $groupfirst_i = 1$ if the individual starts the game with the group part. Therefore, β_2 is the between-subject effect of starting the experiment with groups, and β_3 would show the effects of being in the group for those who start the experiment with the group part. β_4 is the coefficient of the dummy for communication structure, $chat_i$, with the reference category being the No-chat treatments. So, β_5 shows the effect of being in the group for those who are in the One-way chat and Full-chat treatments. $grouptype_i$ is the realized group type. The interaction term between $grouptype_i$ and $group_i$ will be significant only if some information about the true group type is learned through the group dynamics over the rounds. The vector X_i includes self-evaluation dummy (equals 1 if the individual self-evaluated as a high type), gender, whether the individual has taken economics, and taken statistics courses. The standard errors are clustered at the individual level. The marginal effects are shown in Table 7.

In Table 7, as in Table 5, all models exclude the observations when $c = 25$ in the individual part to ensure equal probability of investment in both parts. In addition, since the theoretical prediction in the group part is that individuals should not invest when the cost is positive, one might worry that the results could be driven by the rounds in which the cost is only slightly larger than the cutoff. Therefore, in model (2) and model (4), I exclude the rounds in which the costs are equal to 2. Consequently, I also exclude the round of $c = -2$ in the group part to maintain the 50% theoretical probability of investing.

The results of the probit estimation show that the group setting increases an individual's probability of making investment by 12 to 17 percentage points. The exclusion of the rounds with costs near the cutoff does not wipe out all the effect. Therefore, the effect of being in the group part is not solely driven by those rounds.

As expected, in all four models, the true group type does not explain the tendency to invest. This may explain why the communication structures do not have a significant impact on the probability of making investments. Individuals communicate, but the learning from the communication is minimal. It justifies the independence assumption.

In model (3), those who self-evaluated themselves as "high" types are 5 percentage points more prone to make investments. However, this seems to be driven by the rounds in which costs near the cutoff are included, since the coefficient is not statistically significant in model (4).

In models (3) and (4), males tend to invest more often than females, which is consistent with previous work that addresses gender differences in overconfidence[11] and risk aversion.[12] Taking economics or statistics does not matter.

4.4 Alternative strategy: lower bound and upper bound of beliefs

Knowing that being in a group increases one's tendency invest, the second econometric strategy is to explicitly examine the belief of being a high type for each individual. An individual's true belief is latent. However, given the cost and the investment decision in a given round, an individual reveals his upper bound of belief of being a high type if he chooses not to invest, and vice versa.

4.4.1 Cutoff beliefs of an individual: individual part

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[11] For example, Barber and Odean (2001).
[12] Borghans et al. (2009).

In the individual part, suppose an agent invested in a given round where the cost is equal to c. His lower bound of belief, p_i, can be inferred by solving for the condition of a profitable investment. That is, $E_i[R_i(\theta_i)] - c \geq 0$, or $p_i R^+ + (1 - p_i)R^- \geq c$. Therefore, the lower bound of belief is given by $p_i = \frac{c - R^-}{R^+ - R^-}$ if the agent invested when the cost is c. Likewise, if an agent chooses not to invest given the cost c, $E_i[R_i(\theta_i)] - c < 0$, or $p_i R^+ + (1 - p_i)R^- < c$. Therefore, the cutoff point of belief is given by $p_i = \frac{c - R^-}{R^+ - R^-}$.

4.4.2 Cutoff beliefs of an individual: group part

In the group part, suppose an agent takes the types of other team members as given. An agent will only have to consider his own type when he compares the expected gross return and the cost.

Suppose an agent has a neutral prior belief about teammates' types (one high and one low.) In particular, his payoff maximization problem is

$$\max_{e^i \in \{0,1\}} E_i(\pi^i) = \omega + E_i[R_i(\Theta_i)] \left(\tfrac{1}{3} e^i + \tfrac{2}{3} e^{-i}\right) - c e^i$$

$$= \omega + [p_i R_i(1) + (1 - p_i) R_i(-1)] \left(\tfrac{1}{3} e^i + \tfrac{2}{3} e^{-i}\right) - c e^i$$

$$= \omega + e^i \left(\tfrac{1}{3}[p_i R_i(1) + (1 - p_i) R_i(-1)] - c\right) + \tfrac{2}{3}[p_i R_i(1) + (1 - p_i) R_i(-1)] e^{-i}.$$

Agent i will invest if $\frac{1}{3}[p_i R_i(1) + (1 - p_i) R_i(-1)] - c \geq 0$, or $p_i R_i(1) + (1 - p_i) R_i(-1) \geq 3c$. So, the lower bound of agent i's belief is given by $p_i = \frac{3c - R_i(-1)}{R_i(1) - R_i(-1)}$ if the agent invested when the cost is c. Likewise, if an agent chooses not to invest given the cost c, $\frac{1}{3}[p_i R_i(1) + (1 - p_i) R_i(-1)] - c < 0$, or $p_i R_i(1) + (1 - p_i) R_i(-1) < 3c$. Therefore, the cutoff point of agent i's belief is given by $p_i = \frac{3c - R_i(-1)}{R_i(1) - R_i(-1)}$.

4.4.3 Evidence from analysis of lower bound and upper bound beliefs

In the individual part, when a subject chooses not to invest, the upper bound belief is $p_i(\theta_i = 1 | e^i = 0) = \frac{c - R^-}{R^+ - R^-} = \frac{c - 20}{50 - 20}$. Out of the six rounds, I choose the smallest $p_i(\theta_i = 1 | e^i = 0)$ and define it to be the least upper bound belief in the individual part, $\overline{p_i}$. If the upper bound belief is greater than 1 or if an individual chooses to invest in all six rounds, the least upper bound belief is replaced by 1.

In the group part, when a subject chooses to invest, I can calculate the lower bound belief by $p_i^g(\theta_i = 1 | e^i = 1) = \frac{3c - R_i(-1)}{R_i(1) - R_i(-1)}$. Out of the six rounds in the group part, I choose the greatest $p_i^g(\theta_i = 1 | e^i = 1)$ and define it to be the greatest lower bound belief in the group part, $\underline{p_i^g}$. Again, negative numbers are recoded as zero, and numbers greater than one are recoded as one.

Table 8 shows the cutoff points given the individual part and group part given the costs in the experiment. Column (2) are the cutoffs in the individual part. Negative numbers are recoded as zero, and numbers greater than one are recoded as one.[13] The cutoffs in the group part are shown in Column (5).

If an individual's least upper bound belief in individual part is less than the greatest lower bound belief in the group part, it gives evidence in the most conservative

[13] Fourteen observations are treated this way. Ten invested in all rounds in the individual part except then the cost was 60, the only cost that would even make a high type lose money. Four invested in all rounds.

way that being in a group enhances individual's belief. Therefore, I define the increase in belief because of group by $\Delta p_i = \underline{p}_i^g - \overline{p}_i$.[14] Figure 4 shows the distribution of Δp_i. The mean of Δp_i is 0.36 (significantly different from zero.) It suggests there is evidence of a within-subject effect of being in a group on individuals' belief of being a high type.

Column (1) and (2) in Table 9 report the OLS estimations on Δp_i. Column (1) suggests that being in the group part before the individual part would increase an individual's belief of being a high type by 24 percentage points, but column (2) seems to suggest this effect is driven by the treatments when communication exists. Those who self-evaluated as high type or those who have taken economics increase beliefs less than others. Those who have taken both economics and statistics increase beliefs more than others. Note that none of the negative coefficients outweigh the statistically significant intercepts in the OLS models, which indicates overall the subjects increase their beliefs of being high type.

Column (3) in Table 9 reports the probit estimation on the probability of having a positive Δp_i. It seems the chat structures do not exhibit significant between-subject differences. The timing of being in a group, however, increases the probability of having a positive change in belief by 14 percentage points.

5 Concluding Remarks

A laboratory experiment of a 2×3 design controlling for group communication structure and its order was conducted to detect the effect of group dynamics on

[14] Of course, the realized Δp_i depends on the chosen gross returns and the costs.

individuals' self-evaluation inferred by a series of investment decisions. In the absence of information leakage through strategic interaction, a subject's best policy is to evaluate the type of the group he belongs to as if he evaluates himself since the most neutral expectation of the other teammates' types is that they offset each other.

Data from the experiment sessions indicate strong evidence of overinvestment in the group settings. Compared to the individual part, subjects are more likely to make investments in the group part by 12 to 17 percentage points (Table 7). Assuming a neutral prior belief about the teammates, a subject's belief of being a high type increases by 33 percentage points on average. Being in the group part first further pushes the increase in beliefs, especially when subjects are communicating with each other. Being in the group part before the individual part makes a subject more likely to have an increase in belief by 14 percentage points (Table 9).

An individual's belief about the group's ability as a whole is clearly inflated simply because of being in a group. The payoff of any individual in the investment project depends on all the group members' efforts and the state of nature, which is the group type in this paper. The group setting makes an individual impose an overoptimistic belief upon the state of nature: a belief he would not hold had he been isolated. Therefore, I interpret the results as experimental evidence of at least some variety of "groupthink." The paper contributes to the literature of motivated beliefs and can be easily replicated using different parameters and controlling for different factors.

The assumption of an individual's neutral estimation about his teammates is worth more discussion. Under this assumption, an individual's overly high estimated group talent comes from his own talent. If this assumption is alternatively released, the increased belief of high type group may be a result of the belief of a better self, a set of better teammates, or both. I would call this the "decomposition" of groupthink. In this paper, I choose one way to decompose it by holding team members' type neutral. One can choose another way to decompose. However, the observed results do not depend on which decomposition is chosen. Therefore, although by this experimental design one is not sure where the overconfidence comes from, it is clear that it is there, and it must be from the individual himself, the teammates, or both.

There are several paths to consider in future work. First is the decomposition just mentioned. It would be interesting to alter the design of the experiment and to hold one's estimation of self or the team members' type constant, thus to enable identification of the decomposition. It would be of interest for anyone who is concerned about the effect of group dynamics, e.g., in the areas of management, group learning in education, or other social groups. The second potential extension is to consider incorporating competition or a tournament. The best hypothesis of the effect of competition is that it would enlarge the effect of group dynamics. However, experimental evidence is still required. Lastly, an analysis of the chat records would be worth exploring. What kinds of language are potentially pushing the groups to overinvest? What sort of language is helpful for facing reality? Can we find a predictor of groupthink by observing how people interact? How do we prevent unwarranted illusions of groups?

The findings in this paper suggest that a significant portion of "investments," including financial investments, commitments to new projects, political movements, as well as time and energy devoted to social groups such as amateur sports teams, non-profit organizations, and religious institutions, may simply be the result of the nature of the a group setting. The group is one of the most common units of decision making. Each group is a living organism. A better understanding of the systematic patterns in group decision making is crucial to analysts and decision makers, and of course economists.

Appendix A. Instructions

A. Introduction

This is an experiment about group decision making. In this experiment, you will make a number of decisions as part of a group. Funding for this experiment has been provided by the Center for Economic Behavior, Institutions and Design (CEBID) and the Department of Economics at Rutgers University. You will be paid $5 for your participation plus an additional amount which depends upon the decisions that you and your group members make and upon random luck. Please read these instructions carefully so that you understand how your decisions help to determine your earnings.

This experiment consists of two parts. There are six rounds in each part. At the end of the experiment, your payoff in one randomly chosen round will determine your monetary payment for that round. In other words,

Your total earnings = $5 + payoff in one round in part 1 + payoff in one round in part 2.

The currency in this experiment is the Experimental Currency Unit, or ECU. At the end of the experiment, your payoffs in ECUs will be converted into U.S. Dollars at the rate of $1 per 8 ECUs, and you will be paid this amount in cash before you leave the experiment.

B. Individual introduction

In this part of the experiment, you will be making a series of decisions about whether to invest at a cost in a project. In each of the six decision-making rounds, you will independently decide whether to invest or not. The payoffs that you earn in each round will only depend upon your own cost, your own investment decision in that round, and your own score in the previous test. The specifics of how your payoff varies with the effort levels you choose will be explained below.

Your payoff of one randomly chosen round will determine your total monetary payoff in this part of the experiment.

Here we explain how your payoff is determined. Remember, payoff does not accumulate. The payoff in each round is independent of your payoff in another. At the end of this stage, one payoff of the six rounds will be randomly drawn to determine your monetary payment of this stage.

1. ENDOWMENT

In each of the following six rounds, you will decide whether or not to invest at your own cost. In each round, you will be given 50 ECU to begin with.

2. GROSS RETURN

The gross return of your investment is determined by your score in the previous test. If your score is in the top 50% amongst all the participants in this room right now in this experiment, the gross return of your investment will be 50 ECU. If your score is in the bottom 50% amongst all the participants in this room, the gross return of your investment will be 20 ECU. The gross return is always zero when you choose not to invest.

3. COST

In addition to the gross return, a cost will occur each time you invest. The cost is always zero when you choose not to invest. Unlike the gross return, the cost may vary in each round. Before you make the investment decision in each round, you will learn the value of the cost in that round.

4. PAYOFF and the formula

The net payoff in each round is the endowment (50) plus the gross return of your investment (which depends on your score for the pretest) minus the cost in that round. In short, it is described by this formula:

Net payoff = Endowment** + Gross return of investment – Cost of investment in that round.

**Where endowment is equal to 50.

5. EXAMPLE

Suppose the cost in a certain round is 33 ECU.

If your score is amongst the top half, your gross return of investment is 50 ECU. Therefore, your payoff from investing in this round is 50 + 50 – 33 = 67 ECU.

If your score is amongst the bottom half, your gross return of investment is 20 ECU. Therefore, your payoff from investing in this round is 50 + 20 – 33 = 37 ECU.

If you choose not to invest, your payoff is 50 + 0 – 0 = 50 ECU, since there is neither a cost nor return for not investing.

C. Group introduction

In this part of the experiment, you will be randomly organized into a group of three. You will be making a series of decisions about whether or not to contribute at a cost to this group endeavor. In each of six decision-making rounds, each member of your group will independently decide whether to invest or not. The payoffs that you earn in each round will depend upon the investment decisions made by all members of your group in that round, your cost, and the test scores of all your team members in the previous test. The specifics of how your payoff varies with you and your group's investment decisions and test scores will be explained below.

One payoff will randomly be selected to determine your total monetary payoff in this stage of the experiment.

Here we explain how your payoff is determined. Remember, payoff does not accumulate. The payoff in each round is independent of your payoff in another. At the end of this stage, one payoff of the six rounds will be randomly drawn to determine your monetary payment of this stage.

1. ENDOWMENT

   In each of the following six rounds, you will decide whether or not to invest at your own cost. In each round, you will be given 50 ECU to begin with.

2. GROSS RETURN

   The gross return to your investment is determined by the scores of all your teammates in the previous test AND the total investment of your team.

   If all three team members' scores are in the top 50% amongst all the participants in this room right now in this experiment AND if all three team members choose to invest, the gross return from your investment will be 30 ECU. If two of three team members' scores are in the top 50% AND if all three team members choose to invest, no matter what your own score is, the gross return from your investment will be 10 ECU. If one of three team members' scores is in the top 50% AND if all three team members choose to invest, no matter what your own score is, the gross return from your investment will be -10 ECU (a loss.) If none of your team members' scores are in the top 50% AND if all three team members choose to invest (including you,) the gross return from your investment will be -30 ECU (a loss.)

If two out of three team members choose to invest, no matter what your own score is and regardless of whether you are one of the investors or not, the above mentioned gross returns will be multiplied by a factor of 2/3.

If one out of three team members choose to invest, no matter what your own score is and regardless of whether you are the investor or not, the above mentioned gross returns will be multiplied by a factor of 1/3.

The gross return is always zero when no one chooses to invest.

Summary Table of Gross Return

This following table shows how the test scores and decisions of you and your teammates jointly determine the gross return to investing. This table will be provided later each time when you make your investment decision.

		Number of team members score in the top half			
		3	2	1	0
Number of team members who choose to invest	3	30	10	-10	-30
	2	20	6.67	-6.67	-20
	1	10	3.33	-3.33	-10
	0	0	0	0	0

Table 1. Gross returns in group investment

3. COST

However, a cost will occur each time you invest, which will be subtracted from your gross return. Unlike the gross return though, the cost may vary in each round. Before you make the investment decision in each round, you will learn the value of the cost in that round.

When the cost is a negative number, it is a subsidy. In other words, instead of spending money to invest, you are receiving money to make investment.

The cost or the subsidy is always zero when you choose not to invest.

4. PAYOFF and the formula

The net payoff in each round is the endowment (50) plus the gross return of your investment (which depends on your team's scores for the pretest) minus the cost in that round. In short, it is described by this formula:

Net payoff = Endowment** + Gross return of investment – Cost of investment in that round. **Where endowment is equal to 50.

5. EXAMPLES

Example 1.

Suppose your cost in a certain round is 10 ECU.

Suppose all of your team members choose to invest. Your payoff from investing is 50 + 30 – 10 = 70 if all of your scores are in the top half. Your payoff is 50 + (-30) – 10 = 10 if all of your scores are in the bottom half. Your payoff is 50 if ALL of you choose not to invest.

If all of your team members' scores are in the top half, and if you alone choose not to invest, your payoff is 50 + (30)*(2/3) – 0 = 70 ECU, since there is no cost or subsidy for not investing.

If two out of three in your team scored in the top half, and one person on your team chooses to invest, your gross return to investment is 10*(2/3) = 6.66 ECU if you also invest and 10*(1/3) = 3.33 ECU if you do not invest. Therefore, your payoff from investing in this round is now 50 + 6.66 – 10 = 46.66 ECU. If you choose not to invest, your payoff is 50 + 3.33 – 0 = 53.33 ECU, since there is no cost for not investing.

Example 2.

Suppose your cost in a certain round is -10 ECU. That is, you will be receiving 10 ECU if you choose to invest.

Suppose all of your team members choose to invest. Your payoff from investing is 50 + 30 – (-10) = 90 if all of your scores are in the top half. However, if all of your scores are in the bottom half, your payoff is 50 + (-30) – (-10) = 30. If ALL of you choose not to invest, your payoff is 50.

If all of your team members' scores are in the top half, and if only one another team member chooses to invest, your payoff is 50 + (30)*(1/3) – 0 = 60 ECU, since there is no cost or subsidy for not investing.

If one out of three in your team scored in the top half, and one person on your team chooses to invest, your gross return to investment is (-10)*(2/3) = -6.66 ECU if you also invest and (-10)*(1/3) = -3.33 ECU if you do not invest. Therefore, your payoff from investing in this round is now 50 + (-6.66) – (-10) = 53.34 ECU. If you choose not to invest, your payoff is 50 + (-3.33) – 0 = 46.67 ECU, since there is no cost (subsidy here) for not investing.

Example 3.

Suppose your cost in a certain round is 5 ECU.

If you and one of your teammates scored in the top half, and one person on your team chooses to invest, your gross return to investment is 10*(2/3) = 6.66 ECU if you invest and 10*(1/3) = 3.33 ECU if you do not invest. Therefore, your payoff from investing in this round is now 50 + 6.66 – 5 = 51.66 ECU. If you choose not to invest, your payoff is 50 + 3.33 – 5 = 48.33 ECU, since there is no cost for not investing.

D. Communication (in treatments with communication)

In each round, after you learn the cost and before you make your investment decision, you will have the opportunity to communicate with all members of your group. You are free to communicate about what investment decision you intend to choose, or anything else that you think would be useful to communicate prior to the start of play. The only restriction is that YOU MAY NOT REVEAL YOUR IDENTITY in your messages. We will record the messages to verify whether this restriction is violated.

E. Decision making screen

1. Individual decision making screen

In this round, you cost is ___.

If your score in the pretest is in the top 50%, your payoff will be 50 + 50 - ___ = ___.

If your score in the pretest is in the top 50%, your payoff will be 50 + 20 - ___ = ___.

If you choose not to invest, your payoff will be 50.

Your choice is: ___ Invest.

___ Not invest.

2. Group decision making screen

In this round, your cost is _____.

Your payoff will be the Endowment (50) + Gross Return (see table below) - _____.

This following table shows how the test scores and decisions of you and your teammates jointly determine the gross return to investing. This table will be provided later each time when you make your investment decision. Your cost is zero when you choose not to invest.

(Insert Table A1. Gross returns in group investment.)

Your choice is: ___ Invest.

___ Not invest.

Appendix B. Sample chat records

Table A1. Sample chat records

Treatment C1; Round 3; Session 2			
Group 1, cost = 2	Group 2, cost = -2	Group 3, cost = -7	Group 4, cost = 2
9: let's invest 4: 2? 12: this round is cheap 9: the cost is only 2 12: lets all invest 4: okay 12: BJ lol 4: LMAOOOO 9: childish lmfao 12: haha sorry 4: I feel like this is a trap 9: i wonder what they get from making us do this 4: I sorta dont wanna invest now 4: it sounds too good to be true 12: nahh werre all gonna make mad money 9: INVEST 9: i think we got it 12: they are only gaining data from us doing this 4: my heart says no 12: so lets invest	11: we should all invest right 3: so what's a low cost? anything less than 25? 11: yeah less than 20 3: and yes, I think so! 7: okay so if its above 20 noone invest 3: it's -2 for next round 3: so all of us 7: oh wow didnt see that haha okay so all invest 3: invest 7: yeah 11: yeah 3: lol I didn't either at first	1: so everyone invest? 1: lol its hard to tell bc if we all invest and we all got it wrong then we have the biggest loss lol 10: lol true 8: so if we don't it gets bigger or smaller? 1: what? 10: it depends 10: but i dont think everyone should invest 1: it depends on how many people invest and how many people got it right 1: alright so shoudl we do 1 or 2 people invest 8: I won't then I guess 1: ok so i will 10: i will too	2: i think we should invest in this round 6: I am planning to invest in this round 6: yeaa 5: me too

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Figure 1. Communication structures.

(a) No chat. (b) One-way leadership. (c) Full chat.

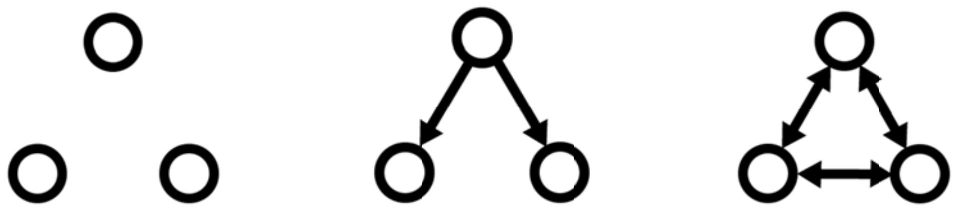


Figure 2. Distribution of the Scores

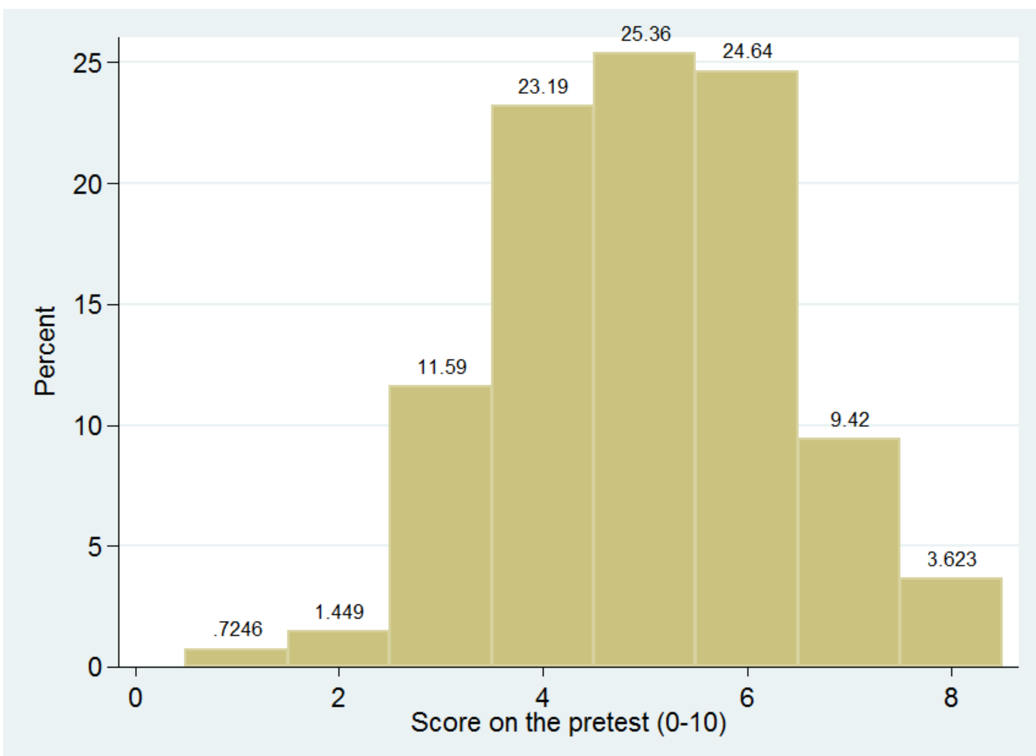
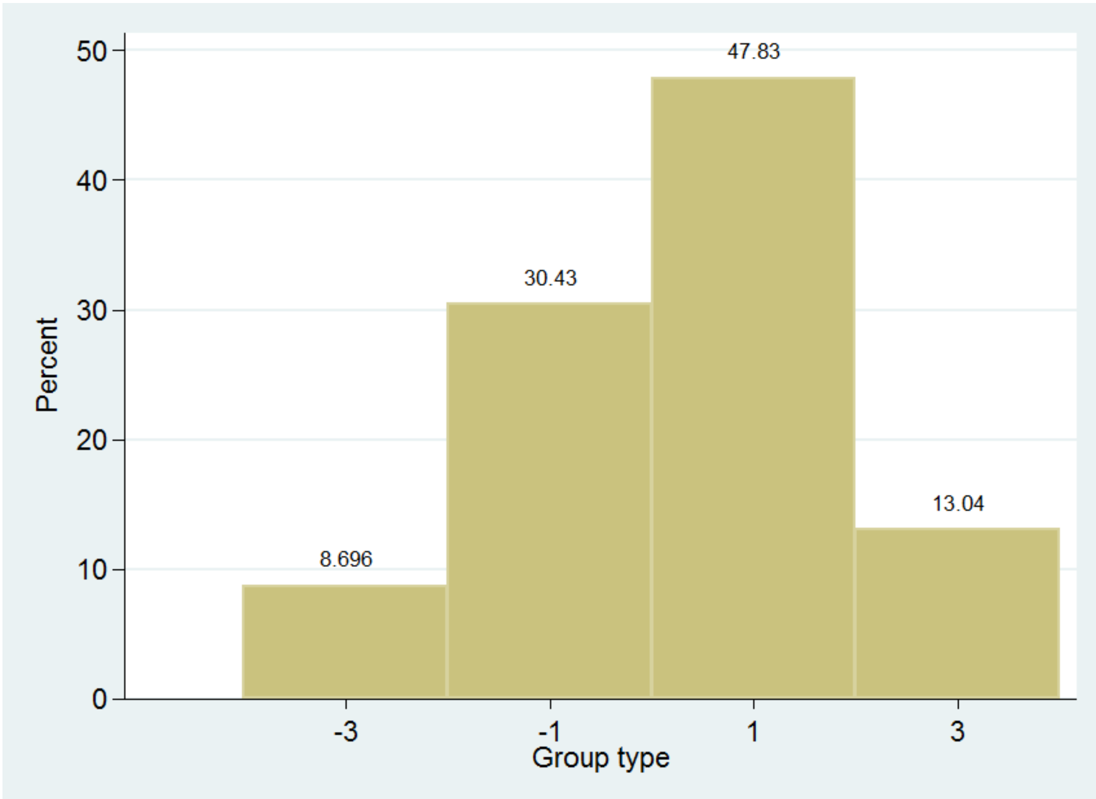


Figure 3. Distribution of the group types



Notes: 1. The total number of groups is 46.

Figure 4. Distribution of increase in belief because of group, Δp_i

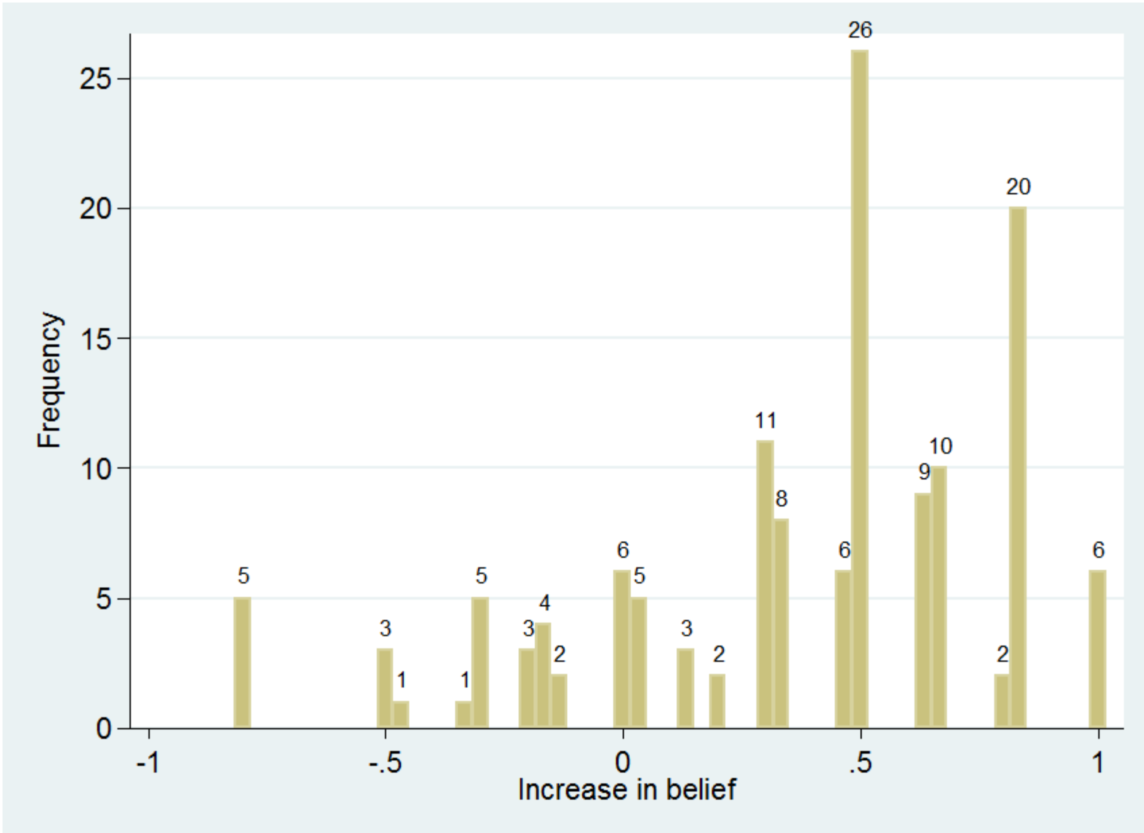


Table 1. Gross returns in the group part

		Number of team members score in the top half			
		3	2	1	0
Number of team members who choose to invest	3	30	10	-10	-30
	2	20	6.67	-6.67	-20
	1	10	3.33	-3.33	-10
	0	0	0	0	0

Table 2. The 2×3 experimental design.

Communication \ Order	1: Individual → Group	2: Group → Individual
A: No chat	Treatment A1	Treatment A2
B: One way leadership	Treatment B1	Treatment B2
C: Full chat	Treatment C1	Treatment C2

Table 3. Summary of the treatments.

Treatment	Sessions	Subjects	Groups
A1	2	15 + 9 = 24	8
A2	2	15 + 6 = 21	7
B1	2	9 + 15 = 24	8
B2	2	9 + 12 = 21	7
C1	2	12 + 12 = 24	8
C2	2	12 + 12 = 24	8
Total	12	138	46

Notes: 1. Treatment A: no chats; treatment B: one-way chat; treatment C: full chats. Treatment 1: individual part first; treatment 2: group part first.
2. Subjects number: number of subjects in session 1 + number of subjects in session 2.
3. The first session of each treatment was conducted in May, June 2016. The second session of each treatment was conducted in September 2016.

Table 4. Descriptive statistics.

Variable	Mean	Standard deviation	Min	Max	Number of observations
Score on the pretest	5.01	1.38	1	8	138
Self-eval (to be high type =1)	0.60	0.49	0	1	138
High type (=1)	0.55	0.50	0	1	138
Group type	0.30	1.63	-3	3	138
Earned bonus (=1)	0.44	0.50	0	1	138
Average contribution in individual part (invest=1)	0.48	0.50	0	1	828
Average contribution in group part (invest=1)	0.61	0.49	0	1	828
Profit per round of individual (ECU)	5.70	14.31	-40	40	828
Profit per round in group (ECU)	3.47	13.15	-37	43	828
Male (=1)	0.54	0.50	0	1	138
Taken Econ course (=1)	0.76	0.43	0	1	138
Taken Stats course (=1)	0.72	0.45	0	1	138

Notes: 1. The profits are gross profits without the endowment.

Table 5. Average contributions (exclude $c = 25$ in individual part)

Communication \ Order	Column (1) 1: Individual → Group		Column (2) 2: Group → Individual		Column (3)	
A: No chat	A1		A2		A	
	Individual: 0.47 (n=120) In group: 0.60 (n=144)	Difference: 0.13**	Individual: 0.38 (n=105) In group: 0.65 (n=126)	Difference: 0.27***	Individual: 0.42 (n=225) In group: 0.57 (n=180)	Difference: 0.15***
B: One way leadership	B1		B2		B	
	Individual: 0.43 (n=120) In group: 0.48 (n=144)	Difference: 0.05	Individual: 0.34 (n=105) In group: 0.64 (n=126)	Difference: 0.30***	Individual: 0.39 (n=225) In group: 0.56 (n=180)	Difference: 0.17***
C: Full chat	C1		C2		C	
	Individual: 0.52 (n=120) In group: 0.65 (n=144)	Difference: 0.13**	Individual: 0.47 (n=105) In group: 0.65 (n=126)	Difference: 0.18***	Individual: 0.49 (n=225) In group: 0.65 (n=180)	Difference: 0.16***
	Overall: Individual → Group		Overall: Group → Individual		Overall	
	Individual: 0.47 (n=360) In group: 0.58 (n=432)	Difference: 0.11***	Individual: 0.40 (n=330) In group: 0.65 (n=396)	Difference: 0.25***	Individual: 0.44 (n=690) In group: 0.61 (n=828)	Difference: 0.17***

Notes: 1. This table excludes the observations when c = 25 in the individual part. Therefore, the theoretical average in each cell is 0.5.
2. n is the number of observations. The number of subjects is $n/6$.
3. *: $p < 0.1$; **: $p < 0.05$; ***: $p < 0.01$. One-tail p-values.

Table 6. Average contributions with negative expected payoff

Communication \ Order	Column (1) 1: Individual → Group		Column (2) 2: Group → Individual		Column (3)	
	A1		A2		A	
A: No chat	Individual: 0.13 (n=48) In group: 0.35 (n=72)	Difference: 0.22**	Individual: 0.07 (n=42) In group: 0.51 (n=63)	Difference: 0.44***	Individual: 0.10 (n=90) In group: 0.42 (n=135)	Difference: 0.32***
	B1		B2		B	
B: One way leadership	Individual: 0.08 (n=48) In group: 0.35 (n=72)	Difference: 0.27***	Individual: 0.10 (n=42) In group: 0.60 (n=63)	Difference: 0.50***	Individual: 0.09 (n=90) In group: 0.47 (n=135)	Difference: 0.38***
	C1		C2		C	
C: Full chat	Individual: 0.19 (n=48) In group: 0.57 (n=72)	Difference: 0.38***	Individual: 0.27 (n=48) In group: 0.43 (n=72)	Difference: 0.16**	Individual: 0.23 (n=96) In group: 0.50 (n=144)	Difference: 0.27**
	Overall: Individual → Group		Overall: Group → Individual		Overall	
	Individual: 0.13 (n=144) In group: 0.42 (n=216)	Difference: 0.29***	Individual: 0.15 (n=132) In group: 0.51 (n=198)	Difference: 0.36***	Individual: 0.14 (n=276) In group: 0.46 (n=414)	Difference: 0.28***

Notes: 1. Only include the observations with the theoretical expected payoff is negative. Therefore, the theoretical average in each cell is 0.
2. The number of observations is denoted by n. The number of subjects is n/6.
3. *: $p < 0.1$; **: $p < 0.05$; ***: $p < 0.01$.

Table 7. Marginal effects of probit models

Dependent variable: $P(e^i = 1 \mid X = x)$	Model (1)	Model (2)	Model (3)	Model (4)
Group	.175*** (.023)	.123*** (.026)	.175*** (.022)	.123*** (.025)
Group first	-.003 (.025)	-.015 (.028)	-.012 (.024)	-.022 (.026)
Chat (No chat = 0)				
One-way leadership	-.045 (.030)	-.048 (.034)	-.047 (.031)	-.054 (.035)
Full chat	.044 (.031)	.047 (.034)	.036 (.030)	.040 (.033)
Group type (ref. -3)				
-1 (2 low 1 high)	.054 (.064)	.039 (.064)	.040 (.061)	.025 (.060)
1 (1 low 2 high)	.019 (.060)	-.012 (.059)	.015 (.058)	-.018 (.058)
3 (3 high)	.084 (.070)	.055 (.071)	.072 (.066)	.040 (.065)
Exclude costs near zero (cost = 2 & -2)	No	Yes	No	Yes
Self-eval (to be high type =1)	No	No	.057* (.029)	.045 (.031)
Male	No	No	.054* (.030)	.070** (.031)
Taken econ course	No	No	-.032 (.038)	-.022 (.040)
Taken stats course	No	No	.013 (.036)	.013 (.036)
Pseudo R-squared	0.0336	0.0236	0.0398	0.0307
Number of observations	1,518	1,242	1,518	1,242

Notes: 1. Standard errors (in the parentheses) are clustered at the individual level.
2. The reference group of group type dummy is -3 (three low types.)
3. The number of observations in model (1) and (3) is equal to 138 subjects times 11 rounds, by the exclusion of $c = 25$ in the individual part.
4. The number of observations in model (2) and (4) is equal to 138 subjects times 9 rounds, by the exclusion of $c = 25$ in the individual part and the exclusion of $c = 2$ and -2 in the group part.
5. *: $p < 0.1$; **: $p < 0.05$; ***: $p < 0.01$.

Table 8. Cutoff beliefs in the individual part and in the group part

Column (1)	Column (2)	Column (3)	Column (4)	Column (5)	Column (6)
Costs in the individual part	Cutoffs $\overline{p_i}$: $\frac{c-20}{50-20}$	Number of observations	Costs in the group part	Cutoffs $\underline{p}_i^g$: $\frac{3c-R_i(-1)}{R_i(1)-R_i(-1)}$	Number of observations
10	-0.333→0	10	-13	-1.45→0	3
25	0.167	38	-7	-0.55→0	5
30	0.333	19	-2	0.2	20
35	0.500	45	2	0.8	34
40	0.667	12	7	1.55→1	26
60	1.333→1	14	13	2.45→1	49

Table 9. OLS and probit estimation of the increase in belief, Δp_i

Independent Variables	Column (1) OLS Dependent variable: Δp_i	Column (2) OLS Dependent variable: Δp_i	Column (3) Probit (Marginal effects) Dependent variable: $P(\Delta p_i > 0)$
Group first (=1)	.238*** (.071)	.167 (.133)	.142** (.063)
Chat (ref.: No chat)			
One-way	.091 (.090)	.007 (.137)	.047 (.079)
Full chat	.059 (.090)	.056 (.144)	-.024 (.084)
Group first × One way	No	.368*** (.116)	-
Group first × Full chat	No	.238* (.135)	-
Group type (ref.: -3)			
-1 (2 lows 1 high)	-.191 (.134)	-.205 (.150)	-.048 (.134)
1 (1 low 2 highs)	-.109 (140)	-.114 (.145)	.019 (.133)
3 (3 highs)	-.051 (.166)	-.038 (.170)	.014 (.161)
Score evaluation (high = 1)	-.162** (.080)	-.164** (.081)	-.081 (.074)
Individual type (high = 1)	-.083 (.090)	-.083 (.090)	-.066 (.082)
Male (=1)	-.068 (.074)	-.071 (.076)	-.065 (.073)
Taken econ (=1)	-.289* (.153)	-.283* (.153)	-.037 (.097)
Taken stats (=1)	-.124 (.121)	-.129 (.121)	.079 (.099)
Taken econ × stats	.362** (.183)	.345* (.183)	-
Constant	.580*** (.136)	.627*** (.180)	-
R-squared	0.1827	0.1922	0.1032 (pseudo R^2)
Number of observations	138	138	138

Notes: 1. Standard errors in the OLS model are clustered at the individual level.
2. *: $p < 0.1$; **: $p < 0.05$; ***: $p < 0.01$.