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Investigating the factors affecting cooperating: a collaborative view of game theory

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Abstract:

Human relationships are very essential in the real world since humans interact with each other every day. However, the study of human relationships in the field of behavioral economics lacks a game theory approach. This paper presents an insider's view of how the closeness of people's relationships to their investment partners would influence their willingness to collaborate in an investor's game we self-designed. The results show that people who know their partner collaborate more than people who are close to or don't know their partner because they are not worried about future interactions. Further implications of this finding could involve seeking out individuals who are familiar with each other to avoid reaching Nash equilibrium and achieve the optimal outcome.

Keywords: Lab Experiments, Nash Equilibrium, Collaboration, Relationship

1. Introduction

In the past few decades, game theory has been extensively developed due to the works of John von Neumann and many other economists. Since then, researchers have gained numerous insights from studying mixed-strategy equilibria and two-player zero-sum games. Scientists in the field of game theory have foreseen the selfish side of human nature and investigated the predictions of how humans act when they can't communicate with their collaborative partner. Many theoretical analyses in standard economics have proven that a *Nash equilibrium* exists under the consequence that each and every one of the participants is totally rational (Lo, 1999). However, in real life, this is not always the case, as each individuals' optimal choice may not always align with the Nash equilibrium (Nash, 1950), granted that humans are not totally rational in real life, as believed by behavioral economics. This is especially the case when they cannot communicate with their partners (Kalai & Lehrer, 1993). Therefore, empirical research on strategic behavior in game theory is necessary to achieve an ultimate beneficial outcome, as opposed to individuals acting on their selfish instincts and achieving the worst possible outcome. So, when behavioral economists first started working, they found that different factors can affect people's decisions that lead to the most rational outcome. They did this by combining different field and lab experiments. For instance, gender and sex distinguish a person's choices. Females do behave significantly more like others in their group, selecting significantly more

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symmetric strategies than males (Cadsby & Maynes, 2005). Moreover, belief elicitation also affects what a person will choose. The results indicate that asking subjects to express their beliefs about the other party's actions in a game significantly increases their likelihood of playing the equilibrium outcome, compared to not asking (Croson, 2000). Furthermore, the number of trials in the experiment also influences the participants' decisions. People tend to cooperate until the last trial for finite Prisoner's Dilemma games (Normann & Wallace, 2012). Lastly, other factors such as personality also influence the results of games such as The Prisoner's Dilemma (Haesevoets, Van Hiel, Dierckx, & Reinders Folmer, 2020).

Based on existing literature, game theory is the study of how and why individuals and entities (called players) make decisions about their situations (Hayes, 2023). From industrial organizations (Bagwell & Wolinsky, 2002) to models of trading processes (Wilson, 1987) to input-output analysis (Tintner & Tiutner, 1957) to collaboration in firms (Shapira, 2002) to monetary and fiscal policies (Saulo, Rêgo, & Divino, 2013), this idea has come up in many areas of economics. John Von Neumann's "On the Theory of Games of Strategy" was the first book in the field of game theory. John Nash later found the difference between cooperative and non-cooperative games and Nash equilibrium. Later, Maynard Smith proposed differential games (Aart de Zeeuw, 2024), zero-sum games (Bacharach, 1989) (games where one person wins and the other person loses), repeated games (Mertens, 1990), evolutionary games (Friedman, 1991), and belief-based games (Serena, 2017). Then, game theory evolved into what it is now, an applied field of mathematics and economics that largely proposes ideas to understand people's behaviors. In 1950, a famous strategic interaction called the "Prisoner's Dilemma" was invented by the Rands Corporation (Kuhn, 2019). Since then, researchers have conducted extensive research to explore the game and develop effective conclusions (Axelrod, 1980; Rapoport, 1974; Rapoport, 1989). Despite the initial investigations, scientists have continued to explore the ways in which various factors can impact the outcome of this game. These factors include the involvement of multiple players (Hamburger, 1973), the number of trials (Embrey, Fréchette, & Yuksel, 2017), gender (Cadsby & Maynes, 2005), state beliefs (Croson, 2000), termination rules (Normann and Wallace, 2012), personality (Haesevoets, Reinders Folmer, Bostyn, & Van Hiel, 2018), etc. D espite the Prisoner's Dilemma, researchers have also examined the aforementioned factors in a variety of other game theory scenarios. For instance, researchers have investigated the factor of trials to determine whether multiple-trial games in the Prisoner's Dilemma, the Commons Dilemma, and the Public Goods Dilemma better reflect prosocial behavior than single-trial games (Haesevoets et al., 2020). Other studies also study how gender may influence the results (Carbone, 2023; Croson & Buchan, 1999; Schwartz-Shea, 2002).

Why human relations?

From all the studies we gathered, we discover that there aren't many investigations on human relations (or how close the person is with the other collaboration partner) in this field of game theory. As a result, we want to investigate game theory because it is essential in the real world. Studies about job satisfaction reveal that people who maintain good human relations with their colleagues tend to be more satisfied with their job (Verplanken, 2004). Various behavioral studies about "in-groups" and "out-groups" have proven that people will be more content when they are in an "in-group" and thus leads to positive actions (Brewer, 2007). We also know that it is a common fact that people tend to act differently when they are with strangers. During various trust games, the closeness of individuals also tends to influence their results by trusting their friends more than strangers (Jiménez *et al.*, 2022). As a result, we want to investigate whether this difference exists in game theory.

The fact that this field lacks studies on human relations and the fact that human relations are very important in society show the importance of our study. Therefore, our goal is to explore the impact of human relations on human decision-making within this context. This will allow us to contribute our observations and findings to this emerging field of research, involving participants of both sexes aged 13 to 55 from China.

We find out that participants who know their collaborative partner are more likely to choose to invest, compared to those who either do not know or are close to their partner. Therefore, when put into game theory terms, if people know their partner, they are least likely to result in Nash equilibrium.

The rest of the article proceeds as follows: Section 2 presents the summary statistics and methodology. Section 3 displays the results, while Section 4 interprets the results, draws conclusions, and discusses the limitations of this study.

2. Methodology

2.1 Subjects

We gather the naturally occurring data through online surveys. We contact everyone we know, either by WeChat or in person, by sending people surveys one by one and talking to them one by one. Thus, all of our participants are Chinese. We then cluster up the sex, age, and educational background of our participants and the time when they are free in a chart. Next, we analyze the times when our participants are free and randomly assign the above traits to the participants who signed up, ensuring our sample is representative of the people we know.

2.2 Variables

We set up two variables for each of the experiments. In experiment 1, "Close 1" is set up to deviate the partners who know each other (1) with the partners who do not know each other (0). In experiment 2, "Close 2" is set up to deviate the partners who know each other (1) with the partners who do not know or are close to each other (0). We define "not know" as the two have never seen and do not even know each other's names. We define "know" as the two know each other's names and faces but haven't gone out alone together or have known each other for less than three years. We define "close" as the two know each other's names, went out alone together, and have known each other for more than three years.

2.3 Hypotheses

We separate our experiment into two small studies. In the first study, we study the difference in collaboration between participants who know and do not know each other, while in the second study, we study the difference in collaboration between participants who know each other. Others do not know each other or are close.

We assume that there is a positive correlation between the degree of familiarity of the two participants and the rate of investment. To be more specific, we assume that people who have a close relationship with their partner will be more likely to collaborate than those who only know each other.

Experiment one:

H1: Partners who know each other will be more likely to collaborate than partners who do not know each other.

H0: Partners who know each other will be less likely to collaborate than partners who do not know each other.

Experiment two:

H1: Partners who know each other will be more likely to collaborate than partners who do not know each other or are close.

H0: Partners who know each other will be less likely to collaborate than partners who do not know each other or are close.

2.4 Procedure

We first distribute the survey, and then we begin conducting the experiment. We separate the enlisted subjects into groups of two (44 groups in total). We then set up three group chats entitled "Experimental Group1", "Experimental Group2", and "Experimental Group3". We then distribute a group announcement that explains to the participants that if they earn 0 — 500 of solely interest, they would have regular red packets distributed by us experimenters on the 26th of July; if they earn more than 500 of sole interest, they would gain a high-class red packet distributed by us experimenters on the 26th of July; if they gain a negative amount of interest, they would gain no extra money. We proposed this rule as a stimulus to compel our participants to act in a self-interested manner, thereby achieving a Nash equilibrium based on theoretical scenarios. Afterwards, we draw our participants two by two into our experimental chats. If both participants assure us that they understand the prize, they can start the game.

We first send them an invitation link to another survey which first asks the participants to fill out their age range, sex, and educational background. We then ask them to read the game's instructions. If they understand what the game is about, they are then instructed to choose "yes" and continue choosing an option to end the game. If they do not understand the game explanation and chose "no", they are then directed to us for further explanations. In our explanation section, we post a picture of a businessman making an investment to allow the participants to picture the scene. Then, we added a scenario to further help readers imagine the situation they are in. Furthermore, we explain to them the rules. Once the participants select their investment option, we express our gratitude and instruct them to exit the group chat. Subsequently, we reveal the experiment's results and the true purpose to each individual. Lastly, we combine all the data together and did regression analyses to come to a conclusion.

2.5 Game explanation

We call our experiment "an investor game" as a disguise to prevent our participants from immediately guessing the aim of our research to prevent participant biases. We self-designed the game based on many investor games and the main focuses of game theory and the Prisoner's Dilemma. We simply create a table that display our two participants, naming them as "Person A" and "Person B". Then, both of our participants, without communication, can choose either to invest \$0, \$500, or \$1000. Their investment, added together with their partner's investment, will be multiplied 1.5 times and distributed evenly to the two partners. According to theory (Axelrod), if both partners invest \$1000, it is the most desirable outcome for the collaborative group, meaning that both parties can gain a pure profit of \$500. However, as we have foreseen, people are rational (Axelrod) and they act towards gaining their

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individual maximum profit. Therefore, if both parties choose to invest $0, they will ultimately reach the worst possible outcome, which is the Nash equilibrium (Nash, 1950). This is especially the case under the precondition that the two individuals cannot communicate with each other to negotiate together for a profit-maximizing outcome. Therefore, our pre-condition effectively pushes our participants into choosing to invest $0 because they have no clue how much their partner will invest. Since $0 will not provide any negative profits for them whatsoever, it seems to be the best choice for them. As a result, our investigation on whether how well you know your partner will change people's choices will be successful under this assumption so that we can simply investigate how people's choices deviate from the Nash equilibrium in which everyone simply chooses to invest in $0.

2.6 Demographics

In this experiment, we want to investigate whether the relationship a person has with his/her collaboration partner would influence the results of their choice to either collaborate or not. By doing so, we then construct a variable (Close 1) that is equal to 1 if the two partners know each other and 0 if the two partners don't know each other. Furthermore, we aim to incorporate the impact of closing into the discussion. Therefore, we construct a separate indicator (Close 2), which is different from Close 1 because it equals 1 if the partners know each other and 0 if they do not or are close. As shown in Table 1, the average number of people who know each other is 30.9% compared to those who do not. The average of people who know each other compared to a sample of close, know, and do not know is 23.9%.

Table 1. Summary Statistics

Variable	Mean	St. Dev.	Min	Max	N
Demographics					
Age	21.420	7.958	13	55	88
Education Background	0.670	0.473	0	1	88
Experimental Outcome					
Gender (Female = 1)	0.636	0.484	0	1	88
Same sex (Yes = 1)	0.568	0.498	0	1	88
Same sex female only (Yes = 1)	0.409	0.494	0	1	88
Close 1 (Know = 1)	0.309	0.467	0	1	68
Close 2 (Know = 1)	0.239	0.429	0	1	88

Notes: Close 1 is a dummy in which "Know" equals 1 while "Not know" equals 0; Close 2 is a dummy in which "Know" equals 1 while "Not know" and "Close" equals 0. Education Background is a dummy variable in which participants have an education back ground in or under highschool = 1 while participants with a background higher than highschool = 0.

Table 2. T-test Results comparing the treatment and the control

	Experiment 1		Experiment 2	
	T-statistics	*P*-value	T-statistics	*P*-value
	（1）	（2）	（1）	（2）
Gender (Female = 1)	-0.016	0.988	-0.187	0.852
Age	0.302	0.763	1.096	0.276
Education Background	-1.250	0.216	0.964	0.338

Notes: Gender is a dummy variable where female equals 1 and male equals 0. Education background is set so that high school and middle school equal 1 while above high school equals 0.

Table 3. T-test Results for both Experiments

	T-statistics	*P*-value
	（1）	（2）
Gender	0.470	0.639
Age	0.396	0.693
Education Background	-0.266	0.790

Notes: Gender is a dummy variable where female equals 1 and male equals 0. Education background is set so that high school and middle school equal 1 while above high school equals 0.

To add on, according to Table 1, the total number of observations is 88, which means that we conducted a total of 44 experiments. Our participants' average age is about 21 years old, deviating from the mean by about 8 years, demonstrating their age diversity. Since we only asked the age range of the participants, we take the mean value when carrying this calculation out (we take 45 for the "40+" people's data we obtained). Our smallest participant is 13 years old, while our biggest participant is 55 years old. The T-statistics, according to Table 2, show that there is no significant difference statistically between the treatment (they know each other) and the control (they don't know each other) if we take the mean of each age range. Moreover, when we compare the ages of the two treatment groups (Close 1 and Close 2), as shown in Table 3, there is still no statistically significant difference. Therefore, the random allocation of our participants ensures that the treatments, rather than other variables, lead to any effect we find.

Furthermore, the education background of our participants ranged from middle school to high school, with 1 and the rest being 0. Our data display the fact that 67.0% of our participants are from middle school and high school, with a standard deviation of 47.3%. The T-statistics, according to Table 2, show that there is no significant difference statistically between the treatment (they know each other) and the control (they don't know each other) if we do the T-test by turning education background into 0s and 1s (where 0 equals above high school while 1 equal in or below high school). Moreover, when we compare the education backgrounds of the two treatment groups (Close 1 and Close 2), as shown in Table 3, there is still no statistically significant difference. Therefore, we can conclude that the random allocation of our participants ensures that the treatments, rather than other variables, lead to any observed effect.

The percentage of our participants who are all female is 63.6%, deviating by 48.4%. This means that females act as a larger population than our set. Furthermore, the percentage of trials in our experiment that are of the same sex is 56.8%, deviating by 49.8%, and the percentage that contain only two females is 40.9%, deviating by 49.4%. The T-statistics, according to Table 2, show that there is no significant difference statistically between the treatment (they know each other) and the control (they don't know each other) if we set gender as a dummy variable in which 1 equals female and 0 equals male. Moreover, when we compare the genders of the two treatment groups (Close 1 and Close 2), as shown in Table 3, there is still no statistically significant difference. Therefore, we can conclude that the random allocation of our participants ensures that the treatments, rather than other variables, lead to any observed effect.

3. Results

The results are presented in two groups. In the first group, we analyze the data gathered from the groups that either knew or did not know their collaboration partner. Then, we try to add a third possibility (the possibility that the two partners are close) to the discussion. The results are the following:

3.1 Experiment 1 (Know vs. Not know)

We gathered up all our data and transformed all the variables into dummy variables (except of age, in which we used numbers from 1 to 6). We call our main variable "Close 1", where 1 equal know and 0 equals do not know. Then, we place all the clustered data into regression analyses.

Table 4 displays the relationship between different independent variables and their influence on collaboration between investment partners. Column (1) shows that if a participant knows their partner, they are 26.1% ($p < 0.05$) more likely to collaborate. When we place other variables like gender, same sex, same sex solely female, age, and education background together with Close 1, the results remain broadly consistent. Column (2) shows when solely gender (female = 1 and male = 0) is taken into consideration with Close 1, the result does not change (26.1% ($p < 0.05$)). Column (3) displays when solely same sex (yes = 1 and no = 0) is taken into consideration with Close 1, it affects the regression output by lowering it down to 25.8% ($p < 0.05$). Column (4) depicts when solely same sex solely female (yes = 1 and no = 0) is added into the regression analysis, the result shows an increase of the "know effect" by 0.1%, making the result 26.2% ($p < 0.05$). Column (5) depicts when solely age (equal to 1 if between 10 and 15; equal to 2 if between 15 and 20; equal to 3 if between 20 and 25; equal to 4 if between 25 and 30; equal to 5 if between 30 and 40; equal to 6 if above 40) is taken into account, the results increase to 27.5% ($p < 0.05$). Column (6) demonstrates that when solely education background (high school and middle school = 1; undergrad, graduate and no education = 0) is being considered, the result increase to 28.4% ($p < 0.1$). Column (7) displays the result when all variables are taken into account, Close 1 also shows that there will be 25.5% ($p < 0.05$) more collaboration if the participants know their collaboration partner.

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Table 4. Regression Output for Close 1

Dependent Variable: Investment	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Close 1 (Know = 1)	0.261**	0.261**	0.258**	0.262**	0.275**	0.284*	0.255**
	(0.120)	(0.121)	(0.120)	(0.121)	(0.118)	(0.121)	(0.122)
Gender (Female = 1)		-0.026					-0.104
		(0.115)					(0.159)
Same sex (Yes = 1)			-0.11				-0.309
			(0.111)				(0.188)
Same sex female only (Yes = 1)				-0.025			0.284
				(0.117)			(0.237)
Age					0.101		0.109
					(-0.054)		(-0.085)
Education background						-0.148	-0.004
						-0.123	(-0.191)
R^2	0.067	0.067	0.080	0.067	0.113	0.087	0.152
N	68	68	68	68	68	68	68

Notes: robust standard errors at in parentheses, *** p<0.01, ** p<0.05, * p<0.1; we distribute age into 6 categories: equal to 1 if between 10 and 15; equal to 2 if between 15 and 20; equal to 3 if between 20 and 25; equal to 4 if between 25 and 30; equal to 5 if between 30 and 40; equal to 6 if above 40. Close 1 is a dummy in which "Know" equals 1 while "Not know" equals 0; Close 2 is a dummy in which "Know" equals 1 while "Not know" and "Close" equals 0. Education Background is a dummy variable in which participants have an education background in or under highschool = 1 while participants with a background higher than highschool = 0.

3.2 Experiment 2 (Know vs. Not know & Close)

Simply distinguishing human relations into know and not know is too simple, despite the complex architecture that exists in the real world. Hence, we decide to add another condition into our experiment in which our dummy variable "Close 2" is introduced. In "Close 2", 1 equal know and 0 equals not know and close. We decided to set this variable in this way due to our hypothesis that humans tend to act differently towards someone they know compared to someone they either do not know or are close to. We then do several other regression tests with Close 2 alone and Close 2 combined with other variables such as gender, same sex, same sex solely female, age, and education background.

Table 5 also displays the relationship between different independent variables and their influence on collaboration between investment partners. Column (1) shows that if a participant knows their partner, they are 26.0% ($p < 0.05$) more likely to collaborate. When we place other variables like gender, same sex, same sex solely female, age, and education background together with Close 1, the results remain broadly consistent and robust. Column (2) shows when solely gender (female = 1 and male = 0) is taken into consideration with Close 1, the result does not change (26.0% ($p < 0.05$)). Column (3) displays when solely same sex (yes = 1 and no = 0) is taken into consideration with Close 1, it affects the regression output by increasing it up to 26.1% ($p < 0.05$). Column (4) depicts when solely same sex solely female (yes = 1 and no = 0) is added into the regression analysis, the result shows an increase of the "know effect" by 0.1%, making the result 26.2% ($p < 0.05$). Column (5) depicts when solely age (equal to 1 if between 10 and 15; equal to 2 if between 15 and 20; equal to 3 if between 20 and 25; equal to 4 if between 25 and 30; equal to 5 if between 30 and 40; equal to 6 if above 40) is taken into account, the results increase to 27.6% ($p < 0.05$). Column (6) demonstrates that when solely education background (high school and middle school = 1; undergrad, graduate and no education = 0) is being considered, the result display 27.6% ($p < 0.1$). Column (7) shows the result when all variables are taken into account, Close 1 also shows that there will be 25.9% ($p < 0.05$) more collaboration if the participants know their collaboration partner.

Table 5. Regression Output for Close 2

Dependent Variable: Investment							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Close 2 (Know = 1)	0.260**	0.260**	0.252**	0.261**	0.276**	0.276*	0.259**
	(0.028)	(0.117)	(0.118)	(0.117)	(0.118)	(0.118)	(0.121)
Gender (Female = 1)		0.009					-0.107
		(0.104)					(0.155)
Same sex (Yes = 1)			-0.068				-0.248
			(0.101)				(0.171)
Same sex female only (Yes = 1)				0.020			0.278
				(0.102)			(0.217)
Age					0.039		0.027
					(0.040)		(0.068)
Education background						-0.087	-0.052
						-0.107	(0.182)
R Square	0.055	0.055	0.060	0.055	0.065	0.062	0.089
N	88	88	88	88	88	88	88

Notes: Robust standard errors at in parentheses, *** p<0.01, ** p<0.05, * p<0.1; we distribute age into 6 categories: equal to 1 if between 10 and 15; equal to 2 if between 15 and 20; equal to 3 if between 20 and 25; equal to 4 if between 25 and 30; equal to 5 if between 30 and 40; equal to 6 if above 40. Close 1 is a dummy in which "Know" equals 1 while "Not know" equals 0; Close 2 is a dummy in which "Know" equals 1 while "Not know" and "Close" equals 0. Education Background is a dummy variable in which participants have an education background in or under highschool = 1 while participants with a background higher than highschool = 0.

3.3 Comparing the results to the control

Since our control is a theoretical case in which everyone is rational and their choices result in the Nash equilibrium, the percentage that people who know each other deviates from either the case that they do not know (Experiment 1) or the case that they do not know or are close (Experiment 2) is all 0.0%. Hence, we can use the formula for the difference in differences to calculate how each case deviates from the control. The results show that Experiment 1 deviates from the control by 26.1% and Experiment 2 deviates from the control by 26.0%. Therefore, if we compare the two sets of data, we can tell that the difference is only 0.1%.

4. Discussion and conclusion

4.1 Experiment 1 (Know vs. Not know)

Based on the data we gathered, we can conclude that if people know their collaboration partner, they are 26.0% more likely to collaborate than if they don't know their partner. This is a robust conclusion since when we add factors like gender, same sex, same sex solely female, age, and education background into the discussion, the results don't change very much (only deviating from 25.8% minimum to 28.4% maximum). The results are significant, as depicted in the two "**" after the coefficients in Table 4. We can explain the results by stating that if a person is familiar with their investment partner, they may worry about disliking them due to potential future interactions. Conversely, if they are unfamiliar with their partner, they don't worry about potential future interactions, allowing them to select the option that best suits their needs.

4.2 Experiment 2 (Know vs. Not know & Close)

Then, we add "Close 2" into the discussion. We can conclude that if people know their collaboration partner, they are 26.1% more likely to collaborate than if they do not know or are close to their partner. This is a robust conclusion since when we add factors like gender, same sex, same sex solely female, age, and education background into the discussion, the results don't change very much (only deviating from 25.2% minimum to 27.6% maximum). The results are significant, as depicted in the two "**" after the coefficients in Table 5.

When we compare the results of Close 1 and Close 2, we do not see a large fluctuation in the regression outputs. Thus, we can then conclude that being close to one's partner stimulates the same results as when they do not know their partner. However, simply knowing the person's collaborative partner increases the person's chances to collaborate by 26%. One possible explanation could be that if they are familiar with their collaborative partner, they will be more mindful of future interactions and strive to avoid damaging their relationship by creating a negative impression if they decide not to collaborate. However, this issue does not exist if they either do not know or are close to their counterpart. This is because if they do not know

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their partner, they won't be worried of the future since they won't interact anymore. And if they are close to their partner, they wouldn't care about displeasing their partner either, since they know each other too well to know that their partner won't be angry if they choose not to collaborate.

From the above findings, we can conclude that if we put our results into the world of game theory, those who only know each other will be more likely to collaborate. Thus, this solves the ultimate bewilderment of the worst-case Nash-equilibrium scenario. If we put people who know each other but are not close together, they are very likely to collaborate, which will not lead to the worst outcome.

4.3 Evaluation

This paper presents the results of a computerized lab experiment based on online surveys. Mimicking the situations participants face in real life is important, as it would increase the external validity of our experiment. Hence, we try to use red packets handed out by WeChat on the 26th of July to motivate our participants to act toward self-interest-driven goals. We set the scenario at the beginning of our survey, along with an imaginary picture, to help our participants imagine themselves in a real-life setting, where they must make a real-life choice that could significantly alter their financial status. But this isn't a field experiment, and the results won't really change the participants' finances in real life. Also, the participants' finances change in real life, so there is still a problem that makes our internal validity lower.

Furthermore, there may still be issues with the experimental design that could influence people's decisions. For instance, the scenario we set may not be good enough for our participants to imagine themselves in such a situation. Moreover, although we tried our best to disclose the aim of the experiment, some of our participants may have already guessed from the chart we provided the real aim of our experiment. Additionally, we also cannot control how seriously the participants read our information, and some may not even care about the real money we give them as a prize. Thus, all the characteristics discussed above may influence and lower the internal validity of our experiment.

Moreover, our sample size is not very large (only containing 88 samples), with females being the majority (63.6%). In addition, our participants range in age from 13 to 55 years old, with the majority being in high school and residing solely in China.

We also found our sample by contacting people we knew either online or in person (convenient sampling). Therefore, we may suffer some internal validity since our sample may not be representative of the population we are studying (which is in fact everyone). When we are allocating our participants, we also may have created human error since we pick participants who are free at a certain time to conduct the experiment instead of totally randomly allocating them. In addition, in our analysis, we used Excel as a tool. However, this is not the most precise way of calculating the regression output, which shows that the real outcomes may deviate from our results. Additionally, many of our outputs from regression analyses are not statistically significant, and that may influence the real essence of what we derived from our data.

This study's findings have two implications. To begin with, the above conclusion of human relations (if they know each other then they are more likely to collaborate) comes into play when solving the "Nash Equilibrium dilemma" to result in the most desirable outcome. This article adds a human relations aspect into the game theory discussion and found out that due to relationships between people, their actions may diverge from the totally rational outcome. Interactions and collaborations push the outcome to derive from the Nash Equilibrium and towards the most optimum outcome. Secondly, we also found out that people who know their partner, compared to people that do not know their partner, would be more likely to collaborate and reach the outcome that benefits both parties. This finding not only prove the theory between collaboration and reciprocal actions, but also provide a reference for game theory in between people and oligopoly collaborations. Future studies need to be done in this field to gain more evidence into this approach.

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