Three Essays on Online Economic Experiments and Experimental Data Analysis

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Abstract

Three Essays on Online Economic Experiments and Experimental Data Analysis

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This dissertation consists of three chapters on economic experiments and experimental data analysis. The first two chapters are online experiments and surveys, which explore the two topics of the health state valuation and the voluntary provision of public goods, respectively. The third chapter is a strategy analysis of trust behavior.

In the first chapter, to explore how people value the state of health and what socio-economic factors they might consider, I conducted a survey experiment to elicit individuals' decisions under hypothetical health states. The main task for the subjects was a valuation task (standard gamble) under given health states, in which the subjects were required to make decisions on whether to take a risky medical treatment when facing various success probabilities. After this procedure, the subjects filled a survey about what factors they might have considered when making the previous decisions. The subjects were from two separate online pools of the United States (Amazon MTurk) and Canada (AskingCanadians).

My results show that in those who choose the risky medical treatment under the same health states, the Canadian participants are willing to accept a lower success probability. Among the socio-economic factors that are significant to this health valuation, several factors are considered by both samples such as "employer-purchased insurance plans", "personal financial situations", and "waiting times for treatment". Some factors are only significant in one country's participants. For the American sample, it is "access to health insurance", while for the Canadian sample, it is "disturbances in everyday family life".

The second chapter is an online experiment of a public goods game, which has a particular feature of polarized preference. From the 2020 U.S. election to the oil pipeline development in Canada, these types of situations may be modeled by a public goods game in which two groups of individuals have polarized preferences. The outcome of the election or debate will affect the utility of individuals in both groups but in an opposite direction. Meanwhile, individuals from each group can make costly efforts (in their favor) trying to affect the outcome.

We study a public goods game with polarized preferences by using a generalized voluntary contribution mechanism (GVCM). The strategy method was applied to the design of an online experiment. There are two groups of players, a majority group and a minority group, who have polarized preferences for a public good. Each player decides whether to contribute to their group's public account or keep the token in their private account. The experiment consists of a 2×2 design, which allows us to examine the effect of different MPCRs and frameworks in the

conditional contribution. The subjects were recruited from Amazon MTurk and the experiment was implemented using o-Tree.

The main results that we found are that the MPCR effect and framework effect are mixed and only significant in some treatments. The results vary depending on the role of the participants (the majority and the minority). Overall, the individual contribution frequency in the majority group is significantly larger than in the minority group. Furthermore, players' contribution significantly increases with the contribution of others in their own group but is not dependent on the contribution from the other group.

The third chapter is an experimental data analysis, which seeks to reveal the strategy behind trust behavior among the encountering of strangers. The data set is from a trust game experiment reported by Duffy, Xie, and Lee (2013). If people never met again and people would not be punished for dishonesty (at least not directly from the person they cheated), the actions would be different. This scenario could be simulated in a trust game where there are two roles (Investor and Trustee) and the subjects are randomly and anonymously matched.

The method of finite automata is applied to infer the strategies subjects used in the experiment. In the strategy fitting procedure, I define for Investor 16 strategies and 6 strategy sets, and for the second player (Player B: Trustee) 24 strategies and 11 strategy sets. Then I match the data through a fitting procedure with these defined strategies. I report that the top three strategies in order are “grim trigger”, “systematically Send”, and “forgiving”; for Trustee, the most used strategies are “systematically Return”, “grim trigger”, and “tit-for-tat”. By taking the probability of the participant’s error into account, more observations are classified into the strategy, and the strategy pattern and proportions are still maintained.

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Last but most importantly, I dedicate this Ph.D. thesis to my beloved children, Linda (Keyue) Yao and Benjamin Yao for their unconditional love. At their current age, they may not understand what Experimental Economics is, or why their mother put so much effort and enthusiasm into computers -- but nothing is about playing video games. But I think that someday they will sense the fun of simulating the real world and discovering human behavior through academic tools just as their mom does.

Contribution of Authors

Chapter 2 of the thesis is joint work with my supervisor, Dr. Huan Xie, and Dr. Jipeng Zhang.

Chapters 1 and 3 are not co-authored.

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1.1 Introduction

Background

The fundamental purpose of a health service is to enhance the quality of life by maintaining or improving one's health status. "Quality of care is the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge" (Institute of Medicine, 1991)[32]. These services are centered around making health care accessible, high quality, and patient-centered.

Medical treatments can achieve great improvements in people's health but may also cause negative consequences. For patients who need to make decisions on whether to have a specific treatment, it is important to know not only the benefits the treatment can bring but also the possible risks related to the treatment. When valuing health and ill-health, it might be helpful to make accurate measurements of the health state in different dimensions.

Given the state of ill-health, some medical treatments may improve health conditions. When patients choose between remaining in ill-health and taking a risky treatment, they may consider different key factors. These factors may but not exclusively include the benefits, risks, costs, or other social and economic elements that may vary between patients. It is also unclear whether these components are related to the state of specific health. For example, a cancer patient may face a decision as to whether to pursue aggressive treatment to prolong life versus more palliative therapy and less risky treatment to increase the quality of life.

In reality, patients may face the risk of failure of treatment and/or the financial cost of receiving the treatment. Even under publicly funded health care for which patients will not need to make the payment out of their pockets, they still have to consider other factors such as the income deduction, the disturbance of daily life, and the support of the family.

This paper aims to explore the socio-economic elements that people may consider when valuing the state of ill-health. The key method used consists of a health state valuation and a survey.

Health state valuation

This paper applies a variant of a standard gamble (SG). The axiomatic basis of SG is regarded as the "gold standard" amongst valuation techniques in health care (Mehrez & Gafni, 1991)[44]. It has been shown to incorporate a person's relative attitude to risk (Dyer & Sarin, 1979)[20]. This is regarded as important given that health care decisions are made under conditions of uncertainty.

The SG values are obtained from a single gamble. In this health state gamble, the worst reference state is defined as death. Given the probabilities of success in this gamble, one values a non-fatal and non-referenced health state. One of the attractions of SG is that it mirrors elements of medical decisions. The SG offers a credible choice scenario. It is presumed that a standard gamble can be presented in terms of a decision about whether or not to have surgery:

"Choice A is to stay in the health state as shown and Choice B is a surgical procedure. Choice A is certain, but choice B (the surgery) is risky. It (the surgery) does not always work. If it does work, you will be in a perfect health state. But if the treatment does not work, you will die immediately, as shown in Choice B." (Thomas & Thomson, 1992)[58]

The SG method is directly derived from the expected utility theory. By setting death to zero and full health to one, the SG value, "P", is a cardinal index measuring an individual's preferences under uncertainty (Von Neumann & Morgenstern, 1944)[61]. In the survey, to make the notion of probability easier for respondents to understand, a table of probabilities ranging from 0 to 100 is presented to the respondents. They are asked to indicate whether or not they would accept the gamble. The respondents then work their way down until they are sure.

When considering the best outcome for health, individuals' value what state to live in as well as how long to live. In this methodology, the valuation is based on the concept that the quality and the quantity of life （QALY） are both valuable to the individual. This concept follows the quality-adjusted life-year definition proposed by the National Institute for Health and Care Excellence (2013)[46]. The quality-adjusted life-year assumes that individuals take on the disease burden, including both the quality and the quantity of life lived. The QALY can thereby capture benefits in terms of longer life and/or better quality of health-related quality of life.

In this valuation, subjects were given several hypotheticals (health states) that are defined in the six-digit dimension as physical functioning, role limitation, social functioning, bodily pain, mental health, and vitality. This six-digit dimension was introduced by Brazier et al. (1998)[9], and further developed in Brazier et al. (2002)[8].

The health state index includes more than simply the absence of disease and the associated clinical symptoms associated with the disease. These measures include those concepts which laypeople themselves regard as part of their health-related quality of life (Bergner, Bobbitt, Ruth A., Carter, & Gilson, 1981)[7]. In Brazier et al. (1998)[9], fifty-nine states are selected for valuation, and they focus on estimating and predicting single index scores for all health states by using statistical models. Based on a different research objective, this paper follows their concept of the health state; however, this paper filters out three health states (mild, moderate, and severe) for valuation. This valuation is a procedure for preference study, but it also offers a view of health behavior.

Health behavior and socio-economic factors

This paper belongs to the study of health behavior and socioeconomic factors. Unlike the study of individual health preference, in which the economic and financial factors are not considered in the utility score, this paper tries to explore these socio-economic factors during the decision-making process.

Health behavior is determined by multiple factors; studies (Culyer, 1989)[15] (Culyer & Simpson, 1980)[16] show that the consequences for health policy of the externalities arising from the health status of others are an estimation of health production functions and a determination of efficient spending patterns.

This paper tries to analyze the economic and social factors in the background when individuals value the state of ill-health. It is unclear whether individuals perceive factors such as payment methods, hospital service, and family member support that may relate to health decisions. In the literature, studies that address health state factors are seldom found. Exploring this possible relationship may lead us to a better understanding of individual health decisions and healthcare services.

Comparison between the U.S. and Canada

Similar to this paper, some studies in the literature focus on the topic of health and the economies of both America and Canada. To the author's knowledge, most comparisons are between these policies and the general population. For instance, International Health Policy Survey is such a study that was conducted by the Canadian Institutes of Health Research (2019).[1] Unlike most policy surveys, the comparisons in this paper are based on individual perspectives. This paper applies a method of health state standard gamble combined with specific social and economic backgrounds in each of the countries.

Among the aforementioned factors, the source of medical payments is one of the key factors. Although many specific details vary between the two countries, such as the proportion of the category and specific coverage, from the patients' expense perspective, the healthcare system in America and Canada has similarities in payment methods. The category of medical payments in this project is similar to Miller et al. (2004)[45]. [2] There are three categories in the source of medical payment (individual, government, and employer). The detailed discussion can be seen in section 2.2.

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[1] https://www.commonwealthfund.org/series/international-health-policy-surveys

[2] In Miller et al. (2004), the categories of payments between the two countries are divided into public, private, and uninsured groups.

Contribution

Describing health-related behavior and which components most affect these decisions is the focus of the paper. The survey is carried out in two separate online pools in the United States and Canada.

The standard gamble in health valuation is applied to record health-related decisions. Before and after the valuation, a survey is carried out regarding medical expenses and various factors that were considered during the valuation. Based on this feedback, two categories of components are created through the principal component analysis. By combining these components with values that were reported in the health state valuation, the paper identifies some outstanding factors concerning the two countries.

In the findings, this paper shows that (1) Subjects are sensitive to different levels of health states. When the health state worsens, the participants are willing to accept a risky medical treatment with a lower probability of success. This finding holds for both samples. (2) Between the two countries' participants, more Canadians choose not to take the risky treatment; furthermore, in those who choose the risky medical treatment under the same health states, the Canadian participants are willing to accept a lower success probability. (3) Among the socio-economic factors that are significant to this health-related decision, several factors are considered by the participants in two countries: "employer-purchased insurance plans", "personal financial situations", "waiting times for treatment", "hospital services", and "support from family or friends". (4) Some factors are only significant in one country's participants. For the American sample, it is "access to health insurance", while for the Canadian sample, it is "disturbances in everyday family life".

1.2 Experimental design and procedure

1.2.1 Health state valuation

The goal of the experimental design is to explore an individual's health decisions and the possible factors that are considered during the decision procedure. In the experiment, three hypothetical health conditions were presented to the participants one by one and they made decisions given each state. Since different people may have different conceptions of health status, to make health conditions measurable and comparable, the experiment needs to present general health states to the subjects before they make decisions.

The term "health state" used in this project is originally rooted in the concept of the quality-adjusted life-year (QALY) in Health Economics, which defines the desirability of a health state based on how an individual would value being in that health state herself or himself. Individual decisions are governed by individual ex-ante preferences (Weinstein, Torrance, & McGuire , 2009)[62].[3] This perspective is based on the notion that each individual is an ex-ante decision-maker. The relevant utilities are those of the individual, as viewed at the time of the decision. Hence, if the possible outcomes of the decision include a health state that the individual has never experienced, the relevant preferences are those of the individual ex-ante the decision and ex-ante any experience with the health (e.g., the decision to change or maintain the health state).

The dimensions of health state used in this paper are based on the SF-6D, which was a six-dimensional health state classification (Brazier, Usherwood, Harper, & Thomas, 1998)[9].[4] The six dimensions that are in order are physical functioning, role limitations, social functioning, pain, mental health, and vitality. Each of the six digits of the health state indicates the level on each dimension of the SF-6D (see Table 1.1). For example, the dimension of physical functioning varies from level 1 to level 6: Level 1 is "Your health does not limit you to vigorous activities (e.g. running, lifting heavy objects, participating in strenuous sports)", which represents the best state of physical functioning; Level 6 is the worst state of health, which limits you from bathing and dressing yourself. Between level 1 through level 6, there are gradually worse states, from limits in vigorous activities (level 2), limits in climbing several stairs (level 3), to limits in walking 100 yards (level 5). Similar measurements apply to other dimensions but with different levels: Dimension Role limitation (2 levels), Dimension Social functioning (5 levels), Dimension Bodily pain (6 levels), Dimension Mental health (5 levels), and Dimension Vitality (5 levels).

Table 1.1: Six dimensions of the health state SF-6D

	Dimension 1: Physical functioning
1	Your health does not limit you in vigorous activities (e.g. running, lifting heavy objects, participating in strenuous sports).
2	Your health limits you in vigorous activities (e.g. running, lifting heavy objects, participating in strenuous sports).
3	Your health limits you in climbing several flights of stairs or in walking half a mile.
4	Your health limits you in climbing one flight of stairs or in walking half a mile.
5	Your health limits you in walking 100 yards.
6	Your health limits you in bathing and dressing yourself.
	Dimension 2: Role limitation
1	You have no problems with your work or other regular daily activities as a result of your physical health or any emotional problems.
2	You have problems with your work or other regular daily activities as a result of your physical health or any emotional problems.
	Dimension 3: Social functioning
1	Your physical health or emotional problems do not interfere at all with your normal social

[3] Weinsten et al. (2009)[62]: The core concept of the conventional QALY is grounded in decision science and expected utility theory. The basic construct is that individuals move through health states over time and that each health state has a value attached to it.

[4] The SF-36 health survey is a standardized questionnaire used to assess patient health across eight dimensions (Ware et al., 1993). The SF-36 was revised into a six-dimensional health state classification called the SF-6D (Brazier et al, 2002). The SF-6D is a preference-based measure designed to calculate the Quality Adjusted Life Year.

	activities.
2	Your physical health or emotional problems interfere slightly with your normal social activities.
3	Your physical health or emotional problems interfere moderately with your normal social activities.
4	Your physical health or emotional problems quite a bit interfere with your normal social activities.
5	Your physical health or emotional problems interfere extremely with your normal social activities.
	Dimension 4: Bodily pain
1	You have no bodily pain.
2	You have very mild bodily pain.
3	You have mild bodily pain.
4	You have moderate bodily pain.
5	You have severe bodily pain.
6	You have very severe bodily pain.
	Dimension 5: Mental health
1	You feel tense or downhearted and low a little or none of the time.
2	You feel tense or downhearted and low some of the time.
3	You feel tense or downhearted and low a good bit of the time.
4	You feel tense or downhearted and low most of the time.
5	You feel tense or downhearted and low all of the time.
	Dimension 6: Vitality
1	You feel worn out or tired a little or none of the time.
2	You feel worn out or tired some of the time.
3	You feel worn out or tired a good bit of the time.
4	You feel worn out or tired most of the time.
5	You feel worn out or tired all of the time.

Source: Brazier et al. 1998

The six-dimension heath state offers a total of 9000 (i.e., 6*2*5*6*5*5) possible health state combinations. This project follows the selection in Brazier et al. (1998)[9]. Among the reported 24 health states, I filter three health states which are considered as mild, moderate, and severe (Health State A 111212, Health State B 422413, and Health State C 625655). [5] The contents of all three health states are shown in the following (Figure 1.1). [6]

Figure 1.1: The three health states used in the experiment

Health Sate A	**Health Sate B**	**Health Sate C**
no limit in **vigorous activities** (e.g. running)	**limit** in climbing one stair	**limit** in bathing and dressing yourself
(★ ★ ★ ★ ★)	(★ ★ ☆ ☆ ☆)	(☆ ☆ ☆ ☆ ☆)
never do less that you'd have liked in daily activities	**sometimes doing less** than you want in daily activities	**sometimes doing less** than you want in daily activities
(★)	(☆)	(☆)
do not interfere with social activities	**slightly** interfere with social activities	**extremely** interfere with social activities
(★ ★ ★ ★)	(★ ★ ★ ☆)	(☆ ☆ ☆ ☆)
very mild bodily pain	**moderate** bodily pain	**very severe** bodily pain
(★ ★ ★ ★ ☆)	(★ ★ ☆ ☆ ☆)	(☆ ☆ ☆ ☆ ☆)
never very nervous or downhearted	**never** very nervous or downhearted	**all of the time** very nervous or downhearted
(★ ★ ★ ★)	(★ ★ ★ ★)	(☆ ☆ ☆ ☆)
sometimes exhausted and empty	**a good bit of the time** exhausted and empty	**all of the time** exhausted and empty
(★ ★ ★ ☆)	(★ ★ ☆ ☆)	(☆ ☆ ☆ ☆)

Notes: Each state has six dimensions, including physical functioning, role limitations, social functioning, pain, mental health, and vitality. Each item describes a level in that dimension. The stars in brackets beneath each item are designed to match that level. The transparent star number represents a health state-level minus one. From the participants' point of view, the more stars that are solid, the better the health.

All three health states were presented to the participants one after the other on the computer screen, each in a pre-determined order designed for randomness. After being notified of one health state, the subjects valued this health state in a modified Health States Standard Gamble (SG) (Brazier et al., 1998)[9]. Since all three health states are somewhat ill-health states, participants could improve their health by accepting risky medical treatment. The success of a treatment is measured by its probability. Generally, the subject is offered two alternatives. Alternative A has a certain outcome of the chronic state for life (10 years). Alternative B is a treatment with two possible outcomes: either the patient is returned to perfect health (by definition) and lives for an additional 10 years (with probability P), or the patient dies

[5] The selection procedure was performed according to two criteria: the variability between different health states and the consistency of individuals' choices given different states. Brazier et al. show that the consistency is positively related to the distance between the health states and when the distance score is 8 or 13, the SG consistency is 100%.

[6]Thomas G. Poder (Université de Montréal) has offered great help with health state content and card format improvements.

immediately (with probability 1-P). In this valuation, the success probability P which is accepted by the subject is called the standard gamble value (SG value hereafter). In the experiment, the question presents respondents with a range of chances of success ascending from 0% to 100% (details in Figure 1.2). After acknowledging a certain health state, as discussed above, the participants decide whether or not they would take this risky treatment to improve their health. Furthermore, they need to decide what probability of success they will accept in the outcome of the treatment table. In the experiment, the choose button does not allow for multiple switches, i.e., if a participant chooses to accept the treatment given success probability p, then the program will automatically choose to accept the treatment for any success probability higher than p. Participants select the Option A button ascending all the probabilities until they want to switch to Option B (Treatment) at a certain probability. But they can always revise the switching point before they submit the choices.

Figure 1.2: A standard gamble question used in the valuation survey

IF TREATMENT SUCCEEDS ---- vs	-----IF TREATMENT FAILS
no limit in **vigorous** activities (e.g. running) (★ ★ ★ ★ ★) **never do less** that you'd have liked in daily activities (★) do **not** interfere with social activities. (★ ★ ★ ★) **no bodily pain.** **(★ ★ ★ ★ ★)** **never very nervous or downhearted** **(★ ★ ★ ★)** **never exhausted and empty.** **(★ ★ ★ ★)**	Unconsciousness followed shortly by death.

OUTCOME OF TREATMENT

Option A			Option B
No-Treatment			Treatment
Hypothetical health states			Chances of success
Remain in this condition for TEN years	o	o	0/100 (Immediate death)
Remain in this condition for TEN years	o	o	10/100
Remain in this condition for TEN years	o	o	20/100
Remain in this condition for TEN years	o	o	30/100
Remain in this condition for TEN years	o	o	40/100

Remain in this condition for TEN years	o	o	50/100
Remain in this condition for TEN years	o	o	60/100
Remain in this condition for TEN years	o	o	70/100
Remain in this condition for TEN years	o	o	75/100
Remain in this condition for TEN years	o	o	80/100
Remain in this condition for TEN years	o	o	85/100
Remain in this condition for TEN years	o	o	90/100
Remain in this condition for TEN years	o	o	95/100
Remain in this condition for TEN years	o	o	96/100
Remain in this condition for TEN years	o	o	97/100
Remain in this condition for TEN years	o	o	98/100
Remain in this condition for TEN years	o	o	99/100
Remain in this condition for TEN years	o	o	100/100

1.2.2 Socio-economic questionnaire

The second main part of the experiment is the questionnaire, which examines participants' healthcare background, payment methods, and other socio-economic factors (Details in Appendix: Experimental instructions and survey questions).

(1) Healthcare background

The healthcare and medical payment method are important backgrounds for a health-related decision. Therefore, this information is collected by the survey first. It includes two questions: one is the general question about health insurance and the other is about their experience related to the medical payment.

Based on the fact that participants are from the United States and Canada, this paper categorizes the medical payment into three groups which are similar to the categories used in Miller et al. (2004)[45]. They are the public group, the private group, and the uninsured group. The public group includes persons with coverage or eligibility for government programs; the private group includes people with private group coverage or offer; and the uninsured are those with no coverage in any of the above, no private group offer, and no public eligibility. In the survey, I specify the categories in the private group as employer-purchase and personal-purchase. It is based on the following summary of the two countries' healthcare.

Healthcare in Canada is delivered through the provincial and territorial systems of publicly funded health care, called Medicare (Canada's health care system, Government of Canada).[7]

[7] https://www.canada.ca/en/health-canada/services/health-care-system/reports-publications/health-care-system/canada.html

Under this system, all Canadian residents have reasonable access to medically necessary hospital and physician services. The Canadian Institute for Health Information (2007)[12]shows about 30% of Canadian health expenditures come from private sources, including both insurance and out-of-pocket payments. This mostly goes towards services not covered or partially covered by Medicare, such as prescription drugs, dentistry, and optometry. According to Kroll (2012)[39], approximately 65 to 75 percent of Canadians have some form of supplementary health insurance related to the aforementioned reasons.

In the United States, with its mixed public-private system, direct government funding of health care is limited to Medicare, Medicaid, and the State Children's Health Insurance Program (SCHIP), which cover eligible senior citizens, the very poor, disabled persons, and children. The federal government also runs the Veterans Administration, which provides care directly to retired or disabled veterans, their families, and survivors through medical centers and clinics.[8]

According to Health Insurance Coverage in the United States: "In 2018, 8.5 percent of people, or 27.5 million, did not have health insurance at any point during the year. The percentage of people with health insurance coverage for all or part of 2018 was 91.5 percent. In 2018, private health insurance coverage continued to be more prevalent than public coverage, covering 67.3 percent of the population and 34.4 percent of the population, respectively. Of the subtypes of health insurance coverage, employer-based insurance remained the most common, covering 55.1 percent of the population for all or part of the calendar year." (Berchick, Barnett, & Upton, 2019)[5]

Table 1.2 Comparison of medical payment systems between America and Canada

	Public	Private	Uninsured
USA	government-provided health-insurance including Medicare, Medicaid, the State Children's Health Insurance Program (SCHIP), and Veterans Administration	private health insurance plans including employer purchase and self-purchase	out-of-pocket payments
Canada	Medicare (including provincial and territorial governments and the federal government)	private health insurance plans through employers or secondary social service programs	out-of-pocket payments

In the survey, the participants were specifically asked two questions related to their medical payments and healthcare. The first question is designed to explore the medical payment methods used by the participants in the two countries. The question is, "How often have you used the following for your medical payments?" The payment categories include four methods, based on the information discussed above, that a resident can access when making a medical payment. These payments can be filled in at least one of the four: Government-provided health-insurance

[8] https://www.usa.gov/health-insurance

(state, national, local), Employer (current, former)-purchased insurance plans, Self-purchased insurance plans, or Out-of-pocket payments. Although there are many differences between the two countries in the medical and healthcare systems, from the residents' point of view there is something in common. The medical payments are addressed in this way: items are assessed using an a-point scale, with response options ranging from None = 1, Sometimes = 2, Usually = 3, to Always = 4.

The second question concerns their medical treatment experience relative to their actual financial situation. That is "In the last 12 months, has a lack of money kept you from going to the doctor, or not?" Considering that subjects may have a different level of privacy sensitivity, this project adds a choice of "Prefer not to answer the question" to the questionnaire. The other items are answered using a 2-point (yes=1, no=2) response format.

(2) Socio-economic factors

The factor questions are the second part of the questionnaire, which is also called "the follow-up". Participants were asked whether they had considered several factors when making decisions in the valuation. This section explores the influence of economic factors and social norms on health-related decisions. The factors displayed in the questionnaire include access to health insurance, personal financial situation, waiting times for treatment, services in hospitals, disturbances in everyday family life, and support from family or friends. The participants were asked how often they considered these factors when making the previous medical-related decision—Health States Standard Gamble. The response options range from None = 1, Sometimes = 2, Usually = 3, to Always = 4. At the end of the socio-economic factor part, the demographic information of participants such as the income range, age group, and gender are involved.[9]

1.2.3 Research questions

As discussed above, the overall procedure is summarized in Table 1.3. There are three steps in the whole experiment.

Table 1.3: Experimental Design and procedure

Step	Data generation process	Purpose and contents
1	Preface	Background in health insurance, finance-related medical experiences
2	Standard Gamble (SG)	Health state valuation given three health states
3	Follow-up	Considered socio-economic factors, demographic info

[9] These experiments were carried out during the COVID-19 pandemic period. To record this specific period, the last question is whether they are in such a state.

The “Preface” questions are purposely placed before the SG during step 1, serving as a “refreshment” for the participants” memory of their medical experiences. The participants would become familiar with the topic and recall their experiences with the reality of health decisions. Next, the participants were given a standard gamble for each of the three health states. As discussed in Section 2.1, the three health states represent the different health levels that will be presented to the participants in random order. Step 2 is the key part of the whole experiment: It records the participants’ choice and valuation of a particular health state, and the SG value is the focus of the data analysis. The “Follow-up” questionnaire is done right after step 2 and explores the socio-economic factors.

I aim to answer the following questions in this project:

Question 1: Will participants in both countries distinguish between the three health states and make corresponding decisions in each state?

Question 2: Will decisions on the health state standard gamble vary between the two countries? Is this difference consistent across all health states?

Question 3: Are there any common components of the payment system and socio-economic factors involved in a healthy state’s valuation? Are these components consistent across the three health states in each nation?

Question 4: How will these common components affect health-related decisions, and to what extent will the two countries vary in their respective features?

1.2.4 Experimental procedure

I designed the experiment for the two countries and coded the United States version with oTree (Chen, Schonger, & Wickens, 2016)[13]. The samples from the two countries were collected from two separate platforms. The U.S. part of the experiment was conducted on the online labor force platform Amazon Mechanical Turk (MTurk).[10] For the Canadian version, the researcher has cooperated with the third party AskCanadians.[11] AskCanadians’ posting period is 2020 March 24-March 30 and MTurk’s posting period is 2020 March 27 - April 02. The entire survey is completed in around 10 minutes. During the online postings, the participants were first notified of the procedures through a consent form and then asked to submit their consent form before taking the survey.

Participants completed the survey voluntarily and were guaranteed the confidentiality of their responses. Since the subjects were obliged to answer the questions to continue to the next page,

[10] http://www.mturk.com/mturk/

[11] https://www.askingcanadians.com/communities/default.aspx?p=p430686807&dlvl=9

they were required to complete all of the choices they had made, so no imputation was performed for missing data. The participants were paid $2.5 for completely finish the whole survey. But considering participants' sensitivity in nature, the survey puts a warning on each page and notifies the participants they have the option "Prefer not to answer" to move on to the next question.

This project was approved by the University Human Research Ethics Committee (Certification Number: 30012708). The subject's consent form was obtained by clicking on the start button right after the basic introduction page. All questionnaires were anonymous, and the data were stored on a protected network to ensure the confidentiality and protection of the respondents.

1.3. Results

In this section, I report the results both from the questionnaire and from the SG valuation of three health states. Section 2 is the experimental design and procedure. Sections 3.1 and 3.2 provide an overview of descriptive statistics for participants' demographic, financial background, and medical payments within each country. Sections 3.3 and 3.4 present the results from t-tests between the three health states and between the two countries. Sections 3.5 and 3.6 conduct a principal component analysis of the factors that are considered by the participants and then report a regression of the SG value based on the above factors.

1.3.1 Summary of demographic information

(1) Residence

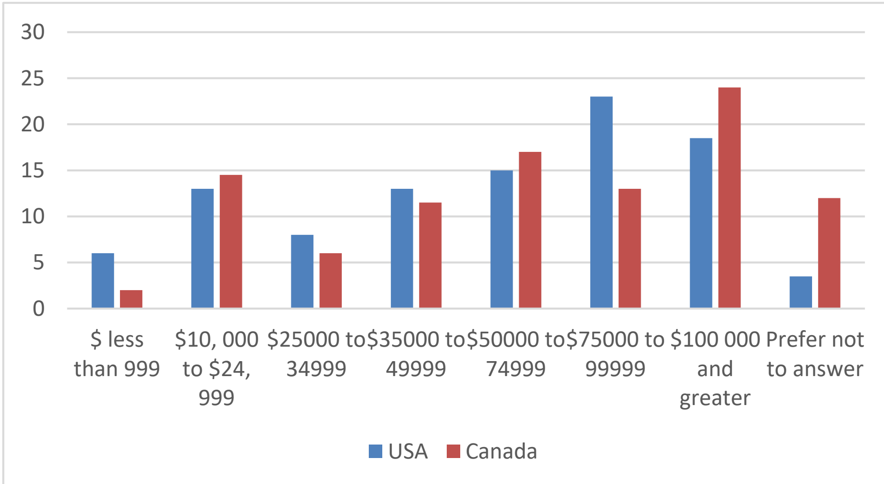
There are 200 participants from each country. The Canadian sample covers all ten provinces, and the four largest proportions of participants are from Ontario, Quebec, British Columbia, and Alberta. The American participants come from 38 states.

(2) Income

Generally speaking, the income distribution between the two samples is similar but not identical (see Figure 1.3). Participants from both countries cover all income levels listed in the category. The highest percentage in the American sample is 23%, for the category of $75,000 to $99,999; while the highest proportion in the Canadian sample is 24%, for the category of $100,000 or greater. The Kolmogorov-Smirnov test shows that there is no significant difference in the income distribution between the two countries (one tail p=0.299).[12]

[12] Participants who chose "Prefer not to answer" are not included in the income K-S test: the observation number for US is 193, CA is 176.

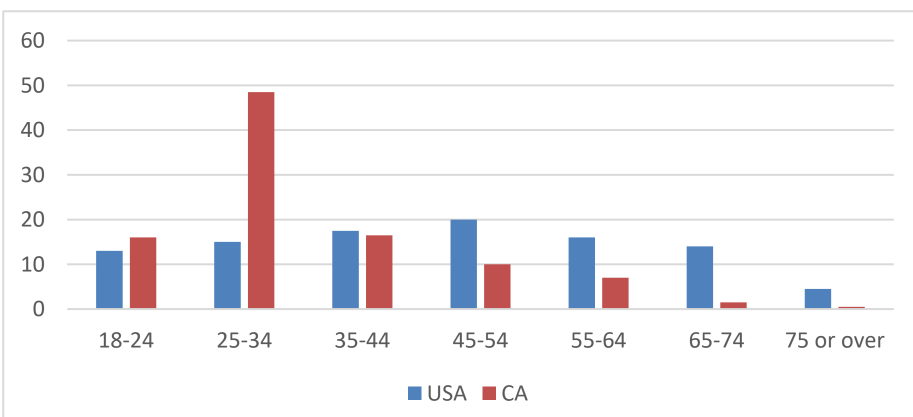
Figure 1.3: Income distribution of the two samples



(3) Age

The age distribution (see Figure 1.4) between the two countries shows that these 200 observations in each country are from various age groups. Normally, the online labor pool tends to be younger than the general population, and this project is no exception. One point that needs to be mentioned: the highest percentage in the Canadian sample is 48.5%, which is the age group of 25-34. This is also much higher than the American sample. According to the census from the two countries, this age shows no such a difference[13]. Kolmogorov-Smirnov test shows that in these two groups of participants the Canadian participants are significantly younger than the American participants (one tail p=0.000). This difference may come from this data collection and could have some influence in the results.

Figure 1.4: Age distribution of the two samples



[13] Statistics Canada (2020) DOI: https://doi.org/10.25318/1710000501-eng; US Census Bureau (June 2020) census.gov.

(4) Gender

One Canadian participant selected “Other” in gender; besides that, there are 52% female in the Canadian sample and 43.5% female in the American sample.

The summaries of the two samples are: both cover some provinces (states); the income distribution is not significantly different; they come from both genders and all age groups, while Canadian participants are slightly younger.

1.3.2 Background on financial and medical payments

(1) The medical payments

The medical payment system in the two countries has been discussed in Section 2.2. The following are the reports from the participants (see Table 1.4). The two countries present different patterns of payment methods.

America does not have a universal health insurance system; only some residents have access to a public-funded payment. In my sample, the highest percentage for “government-provided health-insurance” is "None". For “employer-purchased insurance plans”, the highest proportion is "Usually". “Self-purchased insurance plans” have a similar distribution to “government-provided health insurance”. For “out-of-pocket”, the most frequent answer is "Sometimes," and more than half the participants note this method as their sometimes-used payment method, which is also the highest among all four payment methods.

Canada provides universal health insurance, but it does not cover all medical expenses such as adult dental and prescription medications. Some employer insurance or self-purchased insurance will cover this part. In the survey, the most frequent answer for both “government-provided health-insurance” and “employer-purchased insurance plans” is noted as "Always." In contrast to this, for “self-purchased insurance plans”, the most frequent answer is "Never"; for “out-of-pocket payment”, the most frequent choice is "sometimes."

Table 1.4: Availability to each payment methods in the American and Canadian sample (%)

USA: availability to each payment methods	**None**	**Sometimes**	**Usually**	**Always**	**Prefer not to answer**	**Total**
Government-provided health-insurance	**35.5**	20.0	26.0	18.5	0.0	100
Employer (current, former)-purchased insurance plans	18.0	21.0	**32.5**	28.5	0.0	100
Self-purchased insurance plans	**40.5**	26.5	17.0	15.5	0.5	100
Out-of-pocket payments	15.5	**54.0**	19.0	11.5	0.0	100
Canada: availability to each payment methods	**None**	**Sometimes**	**Usually**	**Always**	**Prefer not to answer**	**Total**
Government-provided health-insurance	26.5	12.0	23.5	**37.0**	1.0	100
Employer (current, former)-purchased insurance plans	24.5	17.0	21.5	**36.0**	1.0	100
Self-purchased insurance plans	**76.0**	10.0	5.0	7.5	1.5	100
Out-of-pocket payments	24.0	**54.0**	9.0	12.0	1.0	100

In answering the question of "whether you were kept from going to the doctor due to a lack of money during the last 12 months?", more than half of the participants (52%) from America reported "yes", while for the Canadian participants this number is 7%.

Comparing the data from the two samples, over one-third of Canadian participants “Always” use “government-provided health-insurance” and “employer-purchased insurance plans”, more than half of Canadian participants “Sometimes” use “out-of-pocket payments”, and most of the Canadian participants “Never” use “self-purchased insurance plans”. While over one-third of American participants "Never" use “government-provided health-insurance” and "Usually" use “employer-purchased insurance plans”, more than half of American participants "Sometimes" use “out-of-pocket payments”. These results are consistent with the background research of current healthcare in section 2.2.

1.3.3 Choices on the health state valuation

In this subsection, I will discuss the results that are reported from the standard gamble in both countries and compare the results among the three health states.

There are three hypothetical health states (Health State 1: mild; Health State 2: moderate; and Heath State 3: severe) in the standard gamble (SG). At the beginning of the experiment, the participants were notified of the randomness of the order of the three states and were asked to make their decisions given their hypothetical health state. Before making decisions, participants were told the detailed contents of the six dimensions of the health states; however, the label of the health states which indicates the severity of the hypothetical health problem was unknown to the participants.

Based on the randomly presented health states, the majority of the participants chose to take the risky treatment (Option B) in all three health states, and this holds for both samples. Among the 200 participants from the USA, there are 171 records of Option B in health state 1, which is a mild disease. As the health state gets to moderate (health state 2) and severe (health state 3), this number increases to 180 and 189 separately. The same trend can be found in the Canadian participants (details in Table 1.5).

Table 1.5: Summary of Option A and Option B

USA	Option A: Remain in this condition	Option B: Taking the risky treatment	Total
Health Sate 1	29 (15%)	171 (85%)	200
Health Sate 2	20 (10%)	180 (90%)	200
Health Sate 3	11 (6%)	189 (94%)	200
Canada	**Option A: Remain in this condition**	**Option B: Taking the risky treatment**	**Total**
Health Sate 1	45 (23%)	155 (77%)	200
Health Sate 2	25 (13%)	175 (87%)	200
Health Sate 3	18 (9%)	182(91%)	200

Recall that in the survey participants need to choose between Option A and Option B, with various success probabilities that are arranged by ascending order in a table as in Figure 2. I have programmed the survey in a way that it requires consistency in participants' choices. Specifically, if a participant chooses to take the risky treatment Option B given a success probability p, then he needs to choose Option B for any success probability p'>p. That is, the real decision that participants make is on the lowest success probability that he will switch from Option A to Option B (although they are always allowed to choose Option A). Following the literature, I denote this cutoff probability as the SG value. The SG value shows how much risk the participants are willing to take to improve this healthy state. The lower the SG value is, the higher the risk taken.

The average SG value (see Table 1.6) shows that the subjects are sensitive to the different levels of health states (mild, moderate, and severe). They tend to accept medical treatment with lower success probabilities when facing worse health states, i.e., they are more likely to accept risky medical treatment when their health conditions are worse. For example, health state 3 is the worst and health state 2 is better than health state 1, therefore the expected results would be SG3<SG2<SG1.[14] This holds at all three levels and for both countries. This result is also consistent with the findings of the relationship between the SG value and health states in Brazier et al. (1998)[9].[15]

[14] SGi: the average standard gamble value under health state i, i=1,2,3.

[15] Brazier et al. (1998) reports that the coefficient between the dimension level and SG value is significantly negative.

Table 1.6: SG value between the three states

(Conditional on choosing Option B)

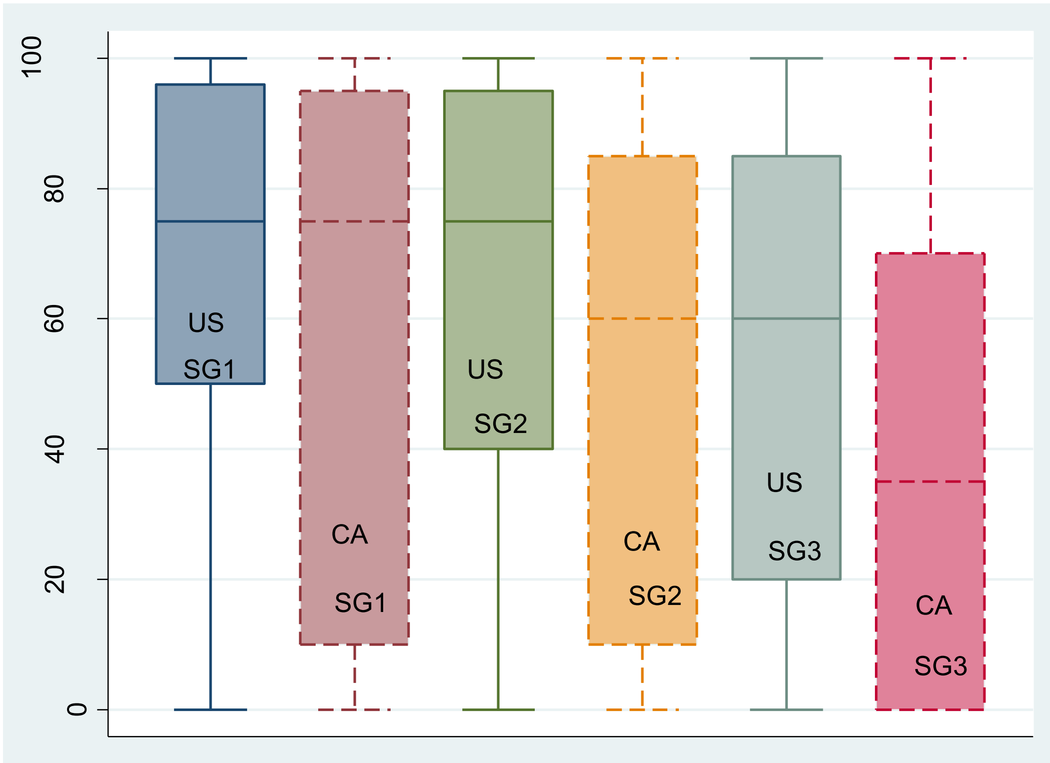
SG value [0,100]	Mild	Moderate	Severe
	Health State 1	**Health State 2**	**Health State 3**
USA	67/100	64/100	56/100
Canada	59/100	52/100	39/100

The box plot (see Figure 1.5) shows the SG value distribution of the two-group participants. First off, SG1 is similar to SG 2 in the percentage distribution. In the US sample (the solid line), the two health states have almost the same value at the 50^{th} (the median) and 75^{th} level. For both mild and moderate health, 50% of participants chose the SG value between 70/100 and 75/100; 75% of participants chose 90/100 to 95/100. For the Canadian sample (the dashed line), the 75th in SG1 and SG2 are not close, but the 25th is similar. Second, SG3 is far lower than SG1 and SG2, and the results are the same in both countries. Within each country, the SG3 is the lowest among the three health states. For example, the 50^{th} and 75^{th} SG values in health state 3 are lower than the other two health states. These results hold for both countries.

The box plot also shows that a few participants choose zero as the SG value in all three health states. There are several possible explanations: one approach is that these participants do not correctly understand the task. For example, 7 (US) and 19 (CA) participants put zero in all three SG values; or when they are making decisions, they just choose Option B (all from 0 to 100); the other approach is that some participants hold extreme views. For example, health state 3 is a severe condition such as a limit in bathing and dressing yourself, extreme interference with social activities, and very severe bodily pain; for some people they would value this health state as an immediate death (SG=0). For robustness check, considering the case of the special case of SG=0, tests have been done on the data that excludes the data that all three SG values are zero and that violate monotonicity (See Appendix A). The rests are the same result and with better significant levels.

Additionally, comparing the box by countries, the boxes of Canadian samples are lower than those of American samples in moderate and severe health states. It is an interesting topic that will be discussed in section 3.4.

Figure 1.5: Box plot for health state standard gamble (SG) value (Conditional on choosing Option B)



Notes: US: United States sample. CA: Canadian sample.

The paired t-tests (see Table 1.7) generally support the results found in the statistical summary. All comparisons between the three health states are significant for the Canadian participants. The SG value decreases as the health state deteriorates. For American participants, however, this difference between SG1 and SG2 does not appear to be significant. As a robust check, the tests are also done with the data excluding the SG=0 and violate monotonicity (see Appendix A). Compared to the original data, the excluding data shows SG1 >SG2 is significant in the USA.

At the 95% confidence interval level, for the American participants, SG1 is greater than SG3 by 4% to 15%. In the Canadian participants, the SG1 is significantly higher 14% to 27% than the SG3, and the differences between the SGs are larger than in the American participants (Table 1.7). The next step is to discuss the differences between the two countries.

Table 1.7: t-test on the SG values between the three states

(Conditional on choosing Option B)

The paired two-tailed t-test of the American sample			
Hypothesis (H_0)	SG1= SG2	SG2= SG3	SG1= SG3
Pr (|T| >| t|)	0.1237	0.0012***	0.0007***
[95% Conf. Interval of diff]	[-0.86, 7.07]	[3.00, 12.00]	[4.32, 15.71]
Paired obs.	161	173	163
Result (H_1)	SG1> SG2	SG2> SG3	SG1> SG3
The paired two-tailed t-test of the Canadian sample			
Hypothesis (H_0)	SG1= SG2	SG2= SG3	SG1= SG3
Pr (|T| >| t|)	0.0010***	0.0000***	0.0000***
[95% Conf. Interval of diff]	[2.99, 11.52]	[11.77, 20.84]	[14.85, 27.13]
Paired obs.	151	168	151
Result (H_1)	SG1> SG2	SG2> SG3	SG1> SG3

*** p<0.01, ** p<0.05, * p<0.1

Finding 1: (*Comparison across health states*) When the health state worsens, the participants are willing to accept a risky medical treatment with a lower probability of success. This finding holds for both samples.

1.3.4 Choice comparison across samples

More Canadians choose Option A than Americans in all three health states. Recall that choosing Option A means maintaining a given health state for ten years. Each individual makes decisions in each of the three health states. Measured in this way, some individuals put Option A in all three health states. Specifically, there are 2 in the American participants, and 10 in the Canadian participants.

Furthermore, in each of the health states, compared to the American participants, Canadian participants have a higher proportion of choosing Option A. Table 5 shows the percentage of participants who chose Option A in their respective samples. In moderate and severe health states, the Canadian rate is 3% higher than the American rate; and, in the mild health states, this rate is 8% higher.

According to the medical system comparison, Canadians have a universal medical system while Americans do not. Generally speaking, the Canadian participants have less concern about health care payments, and under the same conditions, there would be fewer people who choose to stay in the current health state. But the data shows that compared to Americans, more Canadians choose Option A.

It would be interesting to combine this with the response to the questions related to real-world payment experience – whether a lack of money kept you from going to the doctor. 9% of Canadian participants reported that they had this experience while 55% of American participants reported the same answer. This report shows that fewer Canadian participants have a payment problem compared to American participants. Combined with their options in medical treatment, I find that on one hand, Canadians are more like to maintain their given health status rather than take risk treatment; while on the other hand, they have less burden in payment. It could be the side proof that the payment may not be the key factor that influences Canadian participants' decisions in health.

Another finding is that the American participants generally have higher SG values than Canadian participants, regardless of the health state they were given. In other words, under the same health state, compared to the American participants, the Canadian participants tend to accept a treatment that has a lower success probability.

This conclusion is supported by the results shown in Table 1.8. The t-test shows that for all health states, the SG value in American samples is higher than Canadian's, which is all statistically significant at the 95% confidence level. While health state 1 is a mild disease condition, the confidence interval (CI) shows that zero is in between, and the two-tail test is significant at 0.05, meaning that the two countries' participants are statistically different in their SG values. Furthermore, both health state 2 and health state 3 have a positive confidence interval for the difference between the two countries. The difference is statistically significant. Americans are 4%-19%, 10%-24% higher than Canadian participants under health states 2 and 3, respectively.

Table 1.8: Paired two-tailed t-test of SG value between the two samples

(Conditional on choosing Option B)

	Health State 1	**Health State 2**	**Health State 3**
Hypothesis (H_0)	USA=CA	USA=CA	USA=CA
Pr (|T| > |t|)	0.0371**	0.0013***	0.00000***
[95% Conf. Interval of diff]	[-0.70, 15.03]	[4.06, 19.09]	[10.50, 24.58]
Combined obs.	326	355	371
Result (H_1)	USA>CA	USA>CA	USA>CA

*** p<0.01, ** p<0.05, * p<0.1

One possible explanation for the difference could be characteristics rooted in the two populations. For example, Chestnut et al. (2012)[14] study the risky preferences over health between the US and Canada.[16] Alternatively, it could also be due to socio-economic aspects that may influence decision-making. The purpose of this paper is to explore these factors that may have an impact on health-related decisions. As designed in the experiment, the Part 3 follow-up survey collects

[16] They conducted two internet-based surveys in the United States and Canada to estimate willingness to pay for reducing mortality risks through out-of-pock costs for health-care programs. They report that U.S. and Canadian results were similar.

socio-economic factors, which are reported by the participants during this standard gambling process.

As a robust check, the tests are also done with the data excluding the SG=0 and violate monotonicity (see Appendix A). Compared to the original data, the excluding data shows USA>CA is not significant in health state 1. The rest are the same result and with better significant levels.

Finding 2: (*Comparison across samples*) More Canadian participants choose Option A than American participants in all three health states. However, conditional on choosing Option B, the American participants significantly have higher SG values than Canadian participants, regardless of the health state they were given.

This finding seems contrary and unexpected. One possible explanation might be the samples' distribution. Canadian's participants are younger than American's. On the other hand, this decision may link to their socio-economic factors.

1.3.5 Socio-economic characteristics

(1) Socio-economic factors

This section explores socio-economic factors across two different categories. One category is the source of medical payments – which includes the individual, government, and employer (purchased insurance). The other category is the personal factor, which includes "Personal financial situation", "Waiting time for the treatment", "Disturbances in everyday family life", and so on (details see Appendix B). The two categories specified in the survey are separated into two separate questions. This paper presents a summary of the personal factors as follows.

Of all the American participants (details in Table 1.9), these factors are reported as "Sometimes considered" to be the highest rate: "Access to health insurance", "Personal Financial", "Services at hospitals", and "Support from family or friends". The "Disturbances in everyday life" are selected by most participants as a "usually" considered factor. Contrary to other factors, when it comes to "Waiting for treatment", most participants choose "Never" as their considered factor.

Table 1.9: Considered factors—American sample

	USA: consider factors percentage (%)	Never	Sometimes	Usually	Always
1	Access to health insurance	23.5	**33.0**	26.0	17.5
2	Personal financial situation	19.5	**30.5**	27.5	22.5
3	Waiting time for the treatment	**31.0**	30.0	25.0	14.0
4	Service of hospitals	25.0	**29.5**	24.0	21.5
5	Disturbances in everyday family life	12.5	29.0	**33.0**	25.5
6	Support from the family or friends	11.5	**37.0**	25.5	26.0

In the Canadian participants (details in Table 1.10), as opposed to the American participants, the rates are not so clear on several factors. For example, “Access to health insurance” is reported by most participants as both "Never" and "Always"; “Personal financial situations” are both "Sometimes" and "Always"; and “Waiting for treatment” is both "Sometimes" and "Usually". However, two factors hold "Always" as the highest proportion and both are related to the family.

Table 1.10: Considered factors—Canadian sample

	Canada: consider factors percentage (%)	Never	Sometimes	Usually	Always
1	Access to health insurance	**32.5**	20.0	15.5	**32.0**
2	Personal financial situation	26.5	**29.0**	15.0	**29.5**
3	Waiting time for the treatment	24.5	**27.0**	**26.5**	22.0
4	Service of hospitals	24.5	**28.0**	25.5	22.0
5	Disturbances in everyday family life	15.5	24.0	28.5	**32.0**
6	Support from the family or friends	18.0	25.5	26.0	**30.5**

(2) Component scores

Among all the factors reported in this survey, some factors are correlated, and many factors can be combined with others. This paper applies the principal component analysis (PCA) to payment sources and personal factors separately. The PCA measures the variation between the factors and builds the PCA components. Each component creates a score that is built on the variety and connections between all the variables, providing a better interpretation than the original variables that are directly derived from the survey. Unlike the original separate factors, the scores of the components are not correlated. Each component becomes a meaningful variable.

According to the survey, there are two categories known as category A (source of medical payments) and category B (personal factor). Based on the PCA, the paper reports three components in each category (see Table 1.11 and Table 1.12).

Table 1.11: PCA components —American sample

Category A	**Source of medical payment**
Payment Factor-Individual	Self-purchased insurance plans Out-of-pocket payments
Payment Factor-Government	Government-provided health-insurance
Payment Factor-Employment	Employer (current, former)-purchased insurance plans
Cumulative	0.8477
Kaiser-Meyer-Olkin	0.5446
Category B	**Personal factor**
Personal Factor-Financial	Access to health insurance Personal financial situation
Personal Factor-Service	Waiting time for the treatment

&Support	Service of hospitals Support from the family or friends
Personal Factor-Daily Life	Disturbances in everyday family life
Cumulative	0.7415
Kaiser-Meyer-Olkin	0.7227

Table 1.12: PCA components —Canadian sample

Category A	Source of medical payment
Payment Factor-Individual	Self-purchased insurance plans Out-of-pocket payments
Payment Factor-Government	Government-provided health-insurance
Payment Factor-Employment	Employer (current, former)-purchased insurance plans
Cumulative	0.8266
Kaiser-Meyer-Olkin	0.5231
Category B	**Personal factor**
Personal Factor-Service &Financial	Waiting time for the treatment Service of hospitals Personal financial situation
Personal Factor-family	Disturbances in everyday family life Support from the family or friends
Personal Factor-insurance	Access to health insurance
Cumulative	0.8802
Kaiser-Meyer-Olkin	0.7781

For American participants, in category A (Source of medical payment), the three components in order are “Payment Factor-Individual”, “Payment Factor-Government”, and “Payment Factor-Employment”; in category B (Personal factor), the three components are “Personal Factor-Financial”, “Personal Factor-Service & Support”, and “Personal Factor-Daily Life”. The PCA reports that after rotation, these components explain 84.77% of the variation in category A and 74.15% in category B.

For the Canadian participants, after rotation, the components can explain 82.66% and 88.02% of the variation in the two data sets, respectively. In category A, the components are composed of the three payment methods: “Payment Factor-Individual”, “Payment Factor-Government”, and “Payment Factor-Employment”. This is the same as in the American participants. However, in category B, the three components are “Personal Factor-Service & Financial”, “Personal Factor-Family”, and “Personal Factor-Insurance”. These “Personal factors” are different from Canadian participants.

Finding 3: (*Comparison in PCA*) The principal component analysis shows PCA components in the "Source of medical payment" are the same to the two countries’ participants, but the PCA components in the "Personal factor" category are not identical between the two countries' samples.

1.3.6 Decision and socio-economic factors

(1) SG value and factors

The SG value, the accepted probability of success in medical treatment, ranges from 0 to 100.[17]This range is followed by Brazier et al. (1998)[9], which takes the people's sensitivity to the probability into account. By regressing the SG value with PCA factor scores, this paper shows which factors may be associated with health state valuation (see Table 1.13 and Table 1.14). As each individual has three SG values for each health state, the panel data is compiled by comparing the three SG values for each observation. The independent variables are the PCA components of the payment source, the PCA components of the personal factor, and the exogenous variables. Based on the features of the dataset, which are two choices and right-censoring, a censored variable was created for this Tobit regression.

In the regression (Option B model), the record from Option A is defined as missing a record from Option B. As a robust analysis, Option A is defined as SG=100 in the second regression (Option AB model). The results of the two regressions are generally similar. This holds in both countries' samples.

Table 1.13: Tobit regression of SG value and factors in the American sample (Conditional on choosing Option B)

SG value	Option B	Option AB
Health State	-0.195	-0.247
	(-0.165)	(-0.155)
Gender	-8.563***	-9.138***
	(-1.152)	(-1.053)
Age	-1.241***	-1.483***
	(-0.344)	(-0.309)
Income	-0.432	-0.707**
	(-0.287)	(-0.291)
Lack	-7.104***	-7.877***
	(-0.942)	(-0.861)
Payment Factor-Individual	0.273	0.433
	(-0.629)	(-0.608)
Payment Factor-Government	0.637	0.586
	(-0.501)	(-0.498)

[17] From 0 to 70, it is the 10-points distance interval; from 70 to 95, it is the 5-points distance interval; from 95 to 100 it is the 1-point distance interval, i.e., all the possible numbers for option B, taking the treatment, are 0, 10, 20, 30, 40, 50, 60, 70, 75, 80, 85, 90, 95, 96, 97, 98, 99, 100.

Payment Factor-Employment	1.047*	1.361**
	(-0.634)	(-0.599)
Personal Factor-Financial	-1.246***	-1.214***
	(-0.453)	(-0.434)
Personal Factor-Service &Support	0.915*	1.062**
	(-0.543)	(-0.502)
Personal Factor-Daily Life	-0.0171	0.122
	(-0.529)	(-0.502)
Constant	55.27***	58.94***
	(-1.738)	(-1.649)
Log likelihood	-295.739	-302.182
Prob > chi2	0.000	0.000
Observations	537	597
Number of individuals	197	199

Notes: 1) Option B: SG value is in Option B only, while Option A is missing; Option AB: SG value is in Option B with defining Option A as 100. 2) 1 participant in the American sample prefers not to answer in medical payment methods; 2 participants in the American sample choose Option A in all three health states. 3) Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 1.14: Tobit regression of SG value and factors in the Canadian sample (Conditional on choosing Option B)

SG value	Option B	Option AB
Health State	-0.340***	-0.338***
	(-0.0825)	(-0.0754)
Gender	-9.525***	-8.227***
	(-0.756)	(-0.792)
Age	-2.205***	-2.316***
	(-0.196)	(-0.184)
Income	-1.685***	-1.755***
	(-0.163)	(-0.179)
Lack	-3.486***	-4.302***
	(-0.46)	(-0.408)
Payment Factor-Individual	-1.598***	-1.334***
	(-0.225)	(-0.224)
Payment Factor-Government	1.952***	1.855***
	(-0.222)	(-0.251)
Payment Factor-Employment	0.696***	0.683**
	(-0.269)	(-0.292)
Personal Factor-Service &Financial	-1.917***	-1.610***
	(-0.142)	(-0.125)
Personal Factor-Family	1.090***	0.238
	(-0.332)	(-0.321)
Personal Factor-Insurance	0.359	0.183

	(-0.435)	(-0.408)
Constant	53.86***	49.80***
	(-0.834)	(-0.902)
Log likelihood	-402.221	-411.831
Prob > chi2	0.000	0.000
Observations	503	591
Number of individuals	187	197

Notes: 1) Option B: SG value is in Option B only, while Option A is missing; Option AB: SG value is in Option B with defining Option A as 100. 2) 3 participants in Canada preferred not to answer in medical payment methods; 10 participants in Canada chose Option A in all three health states. 3) Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Among all the correlations between the SG values and factors, there are some commonalities between the two countries. The exogenous variables, gender, age, and "lack (of money)" are all significant, and they are negative. In the samples, males are more likely to accept the low success probability (smaller SG values); the older the participants are, the more likely they accept the low success probability; those who didn't experience lack of money for medical treatment are more likely to accept the low success probability.

There is one common "Payment source" in the two countries sampled; employer payment is positively significant in both groups of participants. Those who "Never" consider this payment method are more likely to accept the low success probability.

There is one common "Personal factor" that is significant for SG values in the two countries' sample: the "Service factor". The Service factor mainly considers "waiting time for the treatment" and "service of the hospital". Both are significant, but the sign is different. It is positive in the American sample but negative in the Canadian sample. Note that unlike the payment factor, the Service factor is not identical between the American and the Canadian samples, and the PCA rank is not the same. It is "Service & Support" (Ranked in 2nd) in the American sample, and it is "Service & Financial" (Ranked in 1st) in the Canadian sample.

(2) Decision-factors between the two countries

Despite the common factors discussed above, the findings show that various factors may be related to the decisions of the two countries' participants. After tracing the PCA factors back to the original factors in the survey, I summarize the factors in Table 1.15.

Among the socio-economic factors that are significant to this health-related decision, several factors are considered by the participants in two countries: "employer-purchased insurance plans", "personal financial situations", "waiting times for treatment", "hospital services", and "support from family or friends".

The difference in payment is that the Canadian participants reported all the payment methods are considered, while based on the American participants' report, only "employer-purchased insurance plans” are significant. As for the personally considered factors, each country has one special factor. For Americans' samples, it is “access to health insurance”, while for Canadians' samples, it is “disturbances in everyday family life”.

Table 1.15: Summary of the significant factors

	America	Canada
Source of medical payments	♦ **employer-purchased insurance plans**	♦ **employer-purchased insurance plans** ♦ self-purchased insurance plans ♦ out-of-pocket payments ♦ government-provided health-insurance
Personally considered factors	♦ **waiting time for the treatment** ♦ **service of hospitals** ♦ **personal financial situation** ♦ **support from the family or friends** ♦ access to health insurance	♦ **waiting time for the treatment** ♦ **service of hospitals** ♦ **personal financial situation** ♦ **support from the family or friends** ♦ disturbances in everyday family life
Exogenous variables	♦ **gender** ♦ **age** ♦ **lack**	♦ **gender** ♦ **age** ♦ **lack** ♦ health state ♦ income

Notes: The factors in bold are significant in both American and Canadian samples.

Finding 4: (*Significant factors in the American sample*) Among the socio-economic factors explored in the survey, the American participants are significant in “employer-purchased insurance plans”, “access to health insurance”, “personal financial situation”, “waiting time for the treatment”, “service of hospitals”, “support from the family or friends”.

Finding 5: (*Significant factors in the Canadian sample*) Among the socio-economic factors explored in the survey, the Canadian participants are significant in “self-purchased insurance plans”, “out-of-pocket payments”, “government-provided health-insurance”, “employer-purchased insurance plans”, “waiting time for the treatment”, “service of hospitals”, “personal financial situation”, “disturbances in everyday family life”, “support from the family or friends”.

Finding 6: (*Comparison across samples*) The two counties’ participants show different considered factors in the health state valuation. For the American sample, it is “access to health insurance”, while for the Canadian sample, it is “disturbances in everyday family life”.

1.4 Conclusion

From an individual’s view, health-related decisions may be associated with multiple socio-economic factors. This paper explores these decisions and factors through an experiment. By setting a scenario of health conditions and risky medical treatment, this paper applies a health state valuation to observe the subjects' choices. After this procedure, a questionnaire about the consideration of factors is filled in by the subjects.

When valuing health and ill-health, in the survey, subjects were given several hypotheticals (health states) that are defined as physical functioning, role limitation, social functioning, bodily pain, mental health, and vitality.

After acknowledging a certain health state, the participants make decisions in a health state valuation. They decide whether or not they would take a risky treatment to improve their state of health and choose the lowest success probability for this risky medical treatment.

The participants for this survey are recruited from two separate online pools in the United States and Canada, where they have a similar socio-economic background and different healthcare systems. In the experimental design, this paper adds the two countries' healthcare and insurance to the questionnaire. The other factors mentioned in the questionnaire are "personal financial condition", "service of hospitals", "family member support", etc.

Based on the feedback from the questionnaire, this paper follows the principal component analysis and categorizes these factors into several components. By combining these with values that were reported in the health state valuation, some outstanding factors concerning the two countries' participants are identified.

Both countries' participants take into account the following factors: "employer-purchased insurance plans", "personal financial situations", "waiting times for treatment", "hospital services", and "support from family or friends". Although some factors are only significant in one country's participants. For the American sample, it is "access to health insurance"; for the Canadian sample, it is "disturbances in everyday family life".

This paper also has some findings related to the health state decision. Subjects are sensitive to the levels of health states. When a person's health state worsens, they are willing to accept a risky medical treatment with a lower probability of success. This finding holds for both samples.

As the samples are from the two different countries. This paper shows some behavior differences between them. More American participants choose to take risky treatment; but in those who choose risky medical treatment under the same health states, the Canadian participants are willing to accept a lower success probability. This finding may link to the samples' distribution.

For future research, larger sample sizes may be considered for comparative studies in these two countries. This paper has a sample size of 200 participants for each country. Most of the results could have wider implications with larger sample sizes. In the survey, subjects make decisions based on a hypothetical health state that is designed to be comparable and measurable between different people. However, a person's actual health status could be an interesting variable that could be added to the experiment.

1.5 Appendices

Appendix A: Two-tailed t-test in the data excluding the SG=0 and violate monotonicity

For robustness check, considering the special case of SG=0, tests have been done on the data that excludes the data that is noise and that violate monotonicity. Specifically, noise data is that SG values are zero for all three health states. There are 7 in the American sample and 19 in the Canadian sample. Violate monotonicity about the SG=0 case, it includes the three cased: (SG1=0, SG2>0, SG3>0) (SG2=0, SG3>0) (SG1=0, SG2>0, SG3=0). Altogether, there are 14 in the American samples and 8 in the Canadian sample. Finally, 179 (USA), 173(CA) observations are tested between the health state levels (the summary details are in Tble A1.)

Compared to the original data, the excluding data shows two differences: 1. SG1 >SG2 is significant in the USA. 2. USA>CA is not significant in health state 1. The rests are the same result and with better significant levels.

Table 1.16.A1: SG value t-test between the three states (Excluding SG=0)

(Conditional on choosing Option B)

Paired two-tailed t-test American sample			
Pr (|T| >| t|)	0.0588*	0.0000***	0.0000***
[95% Conf. Interval of diff]	[-.7114021, 6.282831]	[7.130837, 15.92179]	[7.906793, 19.95236]
Paired obs	140	152	142
Health Sates	sg1>sg2	sg2>sg3	sg1>sg3

Paired two-tailed t-test Canadian sample			
Pr (|T| >| t|)	0.0001***	0.0000***	0.0000***
[95% Conf. Interval of diff]	[4.197839, 12.72152]	[15.64895, 25.25885]	[19.3695, 33.34017]
Paired obs	124	141	124
Health Sates	sg1>sg2	sg2>sg3	sg1>sg3

Between the two countries	**Health State 1**	**Health State 2**	**Health State 3**
Two sample t-test	USA>CA	USA>CA	USA>CA
Pr (|T| >| t|)	0.1715	0.0024***	0.00000***
combined obs	278	307	323
[95% Conf. Interval of diff]	[-3.646828, 10.4487]	[3.134863, 17.2306]	[8.399293, 23.19287]

*** p<0.01, ** p<0.05, * p<0.1

Appendix B: Experimental instructions and survey questions

Warning: The next few questions address topics that some may find to be personal and sensitive in nature. As a reminder, your participation in this survey is voluntary and you may exit the survey at any time. Please select the option "Prefer not to answer" to move on to the next question

---

You will be asked to make choices under some **hypothetical** health states.

Suppose you were in a state of ***ill-health****.*
The doctor tells you that you will remain in this condition for TEN years unless you have a treatment.
However, this treatment does not have a certain outcome.
If it succeeds, it will result in a better state of health.
If it fails, you will shortly die.

The choice is therefore between taking the treatment or not.
Please make your decisions after reading each hypothetical ill-health shown immediately after this page.
There are three hypothetical health states (1,2,3) in total.
They will be presented to you in a random order.

Next

Option A: Health state as the following for TEN years

---

limit in bathing and dressing yourself
(☆ ☆ ☆ ☆ ☆)

sometimes doing less than you want in daily activities
(☆)

extremely interfere with social activities
(☆ ☆ ☆ ☆)

very severe bodily pain
(☆ ☆ ☆ ☆ ☆)

all of the time very nervous or downhearted

(☆ ☆ ☆ ☆) **all of the time** exhausted and empty (☆ ☆ ☆ ☆)

Option B: Uncertain outcome with treatment

IF TREATMENT SUCCEEDS ----- vs-----IF TREATMENT FAILS
(Perfect health state) **(Death)**

no limit in **vigorous** activities (e.g. running) (★ ★ ★ ★ ★) **never do less** that you'd have liked in daily activities (★) do **not** interfere with social activities. (★ ★ ★ ★) **no bodily pain.** **(★ ★ ★ ★ ★)** **never very nervous or downhearted** **(★ ★ ★ ★)** **never exhausted and empty.** **(★ ★ ★ ★)**	Unconsciousness followed shortly by death.

In each row below, there is a different chance of success for taking the treatment. The chance of success in Option B increases as you move downwards.

Please make a choice between Option A (remain in the current health state) and Option B (take the treatment).

Option A (No-Treatment)			Option B (Treatment)
Hypothetical health state			**Chances of success**
Remain in this condition for TEN years	◌	◌	**0 in 100 (Immediate death)**

Remain in this condition for TEN years	○	○	**10** in 100
Remain in this condition for TEN years	○	○	**20** in 100
Remain in this condition for TEN years	○	○	**30** in 100
Remain in this condition for TEN years	○	○	**40** in 100
Remain in this condition for TEN years	○	○	**50** in 100
Remain in this condition for TEN years	○	○	**60** in 100
Remain in this condition for TEN years	○	○	**70** in 100
Remain in this condition for TEN years	○	○	**75** in 100
Remain in this condition for TEN years	○	○	**80** in 100
Remain in this condition for TEN years	○	○	**85** in 100
Remain in this condition for TEN years	○	○	**90** in 100
Remain in this condition for TEN years	○	○	**95** in 100
Remain in this condition for TEN years	○	○	**96** in 100
Remain in this condition for TEN years	○	○	**97** in 100
Remain in this condition for TEN years	○	○	**98** in 100
Remain in this condition for TEN years	○	○	**99** in 100
Remain in this condition for TEN years	○	○	**100** in 100

Next

In health state 3, your switching point of taking the treatment was at 97/100 chance of success.

Next

Survey

Preface Survey

Please answer the following questions:
(All your choice will be used and only be used for the academic research purpose of this project.)

1.1 In which province do you live?

1.2 How often have you used the following for your medical payments?

	None	Sometimes	Usually	Always	Prefer not to answer
Government-provided health-insurance (state, national, local):	○	○	○	○	○
Employer (current, former)-purchased insurance plans:	○	○	○	○	○
Self-purchased insurance plans:	○	○	○	○	○
Out-of-pocket payments:	○	○	○	○	○

1.3 In the last 12 months, has a lack of money kept you from going to the doctor, or not?

Follow-up Survey

Please answer the following questions:
(All your choice will be used and only be used for the academic research purpose of this project.)

3.1 When making the **previous** decisions, have you **considered** the following?

	Never	Sometimes	Usually	Always
Access to health insurance:	○	○	○	○
Personal financial situation:	○	○	○	○
Waiting time for the treatment:	○	○	○	○

	Never	Sometimes	Usually	Always
Service of hospitals:	○	○	○	○
Disturbances in everyday family life:	○	○	○	○
Support from the family or friends:	○	○	○	○

3.2 Which of these describes your income before tax during the last 12 months?

3.3 Which age group describes you?

3.4 Which gender describes you?

3.5 As far as you know, given the current situation with the **COVID-19**, were there any cancellations of gatherings in your city (such as conferences, classes, or sporting events), restricted mass transit and travel, and the recommendation to work from home?

2 Polarized preferences and voluntary provision of public goods: an online experiment

2.1 Introduction

Polarized preferences are drawing more and more attention in politics and economics. Recently, from the 2020 U.S. election to the oil pipeline development in Canada, people can observe that the tension and debate mainly come from two opposite directions. In a general sense, these types of situations may be modeled by a public goods game in which two groups of individuals have polarized preferences. The outcome of the election or debate will affect the utility of individuals in both groups but in an opposite direction. Meanwhile, individuals from each group can make costly efforts (in their favor) trying to affect the final outcome.

In most of the literature on public goods game, nevertheless, the public good is assumed to be "good" for everyone. Most previous studies have focused on the linear voluntary contribution mechanism (VCM), where players have the same preference over the public good (see the review of Ledyard (1995)[41]). More recently, Vesterlund (2012)[59] has reviewed the research on motives for giving to charities or public goods beyond the VCM mechanism. Some studies in the literature examine the public goods game with heterogeneous preferences such as Bagnoli and McKee (1991)[3], Brookshire et al. (1989)[10], Fisher et al. (1995)[30], Marwell and Ames (1979,1980)[42][43], and Rapoport and Suleiman (1993)[49]. None of these papers have investigated polarized preferences specifically.

In this paper, we study a public goods game with polarized preferences by using a generalized voluntary contribution mechanism (GVCM) proposed by Isaac et al (2019)[36]. In such a mechanism, the public good can be provided in a positive or negative amount. Some players benefit from a positive provision of the public good while others think the public good is bad (or equivalently, they only benefit from a negative provision of the public good). There are two groups of individuals: the majority and the minority. Each individual can choose whether to keep the tokens in their private account or contribute to the group account of their group. The final provision of the public good is decided by the difference in the number of tokens between the two group accounts. Theoretically, the Nash equilibrium is for each individual in both groups to keep the tokens in the private account. Therefore, the general free-riding problem continues to exist in this public goods game. The socially optimal outcome, however, is different from the traditional VCM game. It is not efficient anymore for all players to contribute to the group account. In a symmetric case, where the two groups have the same marginal per capita return (MPCR), the social optimum is for the majority to contribute to the group account. But in an asymmetric case, the social optimum will depend on the ratio of the group sizes and the ratio of the two MPCRs. Intuitively, the different socially optimal outcome comes from the polarized preferences of the two groups, since the contribution to the group account can increase the payoffs of the players in one's own group but will decrease the payoffs of the players in the other group, which results in efficiency loss.

Following the experimental design of Isaac et al. (2019)[36], one of our main treatment variables is the MPCRs of the two groups, under which different predictions of social optimum are provided. Different from the focus in Isaac et al. (2019)[36], our experiment also aims to study the provision of the public good under polarized preferences from a perspective of revealed preference and strategy method (Selton, 1967)[52]. Subjects are asked to complete two public goods games: an unconditional contribution task and a conditional contribution task. We use a similar procedure to Fischbacher & Gächter (2010)[28] and Fischbacher et al. (2001)[29]. The unconditional contribution task is a single decision about token allocation. After subjects make their unconditional contribution decision, they will fill out a conditional contribution task, in which subjects indicate, given each possible contribution level of his own group and the other group, whether they are willing to contribute to his own group. To reduce the length of the contribution table, each player is only endowed with one token in our public goods game. The contribution table elicits a contribution schedule (i.e. a vector of contributions). Each individual faces two vectors of contributions, one from his own group, the other from the other group. The order of others' contribution to one's own group and in the other group creates two different frameworks, so our second treatment variable investigates this framework effect particularly. In Fischbacher & Gächter (2010)[28]and Fischbacher et al. (2001)[29], it is found that about 50% of subjects are conditional cooperators. In our public goods game, however, given there are two groups, a question worth investigating is whether players choose their contribution conditional on others' contribution and, if this is the case, on which group they are conditional on, and whether it is also dependent on the framework effect.

In summary, we propose a 2×2 design to examine the effect of MPCR and the framework and focus on conditional contributions. By this design, we try to examine how individuals with polarized preferences behave given the two MPCRs of the two groups, and how their behavior is affected by the presentation of their own group contribution and the contribution of the opposite group.

The experiments we report were conducted over the World Wide Web using the popular crowdsourcing platform, Amazon Mechanical Turk.[18] Among online economic experiments, there are two main approaches to studying interactive games like the public goods game. One method is the "hot game", in which participants take actions simultaneously in the experiments (Suri & Watts, 2011). This approach requires participants to wait in one virtual waiting room until the necessary number of participants are in a position to complete the task. This method is used by Egas & Riedl (2008)[21] in their research on the public good game with or without punishment. The other is through the strategy method, in which participants report what they would do in various hypothetical situations. Horton, Rand & Zeckhauser (2011)[31] use this method in their prisoner's dilemma game. Our paper explores the second method on the public goods game with polarized preferences.

[18] http://www.mturk.com

The main results that we found are that the MPCR effect and framework effect are mixed and only significant in some treatments. The results vary depending on the role of the participants (the majority and the minority). Overall, the individual contribution frequency in the majority group is significantly larger than in the minority group. Furthermore, players' contribution significantly increases with the contribution of others in their own group but is not dependent on the contribution from the other group.

In the remainder of the paper, Section 2 introduces the model. Section 3 presents the experimental design. Section 4 reports the main result. Section 5 is the conclusion. Some additional results are also reported in Appendix A and B. The experiment content can be found in Appendix C.

2.2 The Model

Our model is a simplified version based on the generalized voluntary contribution mechanism (GVCM) from Isaac et al. (2019)[36]. [19] There are two groups of individuals, Majority Group A and Minority Group B. The two groups have opposing preferences over the public good and need to make decisions on whether or not to contribute to the public good. The contribution mechanism works as follows:

Each individual is endowed with one token and can allocate the token among two options:[20]

1) Keep this token in an individual account.

2) Allocate this token to a group account of their own.

The final provision of the public good is decided by the difference in the number of tokens between the two group accounts. The group exchange G_k, k=A or B, which is always equal to the number of tokens in group k's account minus the number of tokens in the other group's group account, represents the level of the public good for group k.

Each individual can benefit from the (positive) group exchange. The marginal per capita return (MPCR) is the marginal change in an individual's payoffs due to a one-unit increase in the level

[19] Our models are different in decision options and initial tokens. In Isaac et al. (2019)[36], subjects are given 500 tokens and are allowed to allocate these tokens in both public accounts of the two groups; in our experiment, there is only one token and it can only be allocated to its own group. The experimental conditions are also not the same. They are the lab experiment, and we are the online experiment.

[20] As we discuss later in the experimental design, our experiment involves a conditional contribution table, so we have to restrict subjects' decision to a binary choice {1, 0} in order to limit the length of the table.

of the public good. In the payoff function, the MPCR is α_i for role A and is β_i for role B. Both α_i and β_i are assumed to be positive.

Role A (Majority Group)

$$\pi_i^A = 1 - x_i + \alpha_i \mathrm{G}_A,$$

where $\mathrm{G}_A = \sum_{i \in A} x_i - \sum_{i \in B} y_i$, and $x_i = 0 \; or \; 1$.

Role B (Minority Group)

$$\pi_i^B = 1 - y_i + \beta_i \mathrm{G}_B,$$

where $\mathrm{G}_B = \sum_{i \in B} y_i - \sum_{i \in A} x_i$, and $y_i = 0 \; or \; 1$.

G_k is the provision of the public good for group k, $\sum_{i \in A} x_i$ is the total number of tokens contributed in the majority group account, and $\sum_{i \in B} y_i$ is the total number of tokens contributed to the minority group account. Notice that if one group has a positive provision of the public good, then the other group will have a negative provision at the same absolute level, which represents the polarized/opposite preferences between the two groups.

Each individual can choose whether to keep the token in their private account or contribute to the group account of their group. But individuals are not allowed to contribute to the group account of the other group. The unique Nash equilibrium of the public good game is for each individual to keep the token in the private account, which results in a zero contribution of the public good.

Based on the literature, MPCR is a key factor in the public goods game. We will examine the game in the cases of homogenous (α=β) and heterogeneous (2α=β) MPCRs. We further inspect what environmental modifications will trigger non-cooperation in the presence of intra-group and between-group conflicts. Theoretical predictions depend on the MPCRs of both groups and are presented in the next section.

2.3 Experimental Design

2.3.1 Treatment Variables

(1) Group MPCRs

The first treatment variable is group MPCRs. We use two different types of polarized preferences, symmetric and asymmetric. In one setting ("symmetric"), the absolute values of MPCRs are the same for all subjects. In the second setting ("asymmetric") the absolute values of MPCRs of the minority group are twice those of the majority group (see Table 1).

Each group consists of nine subjects, N = 9, who are divided into two subgroups of six and three persons. For each group, there are always 6 subjects in role A and 3 in role B. The subjects in the same role are assigned the same MPCR.

Table 2.1: Theoretical predictions (6A vs 3B)

Group	MPCRs {maj, min}	Individual optimum (Nash)	Social optimum
symmetric	{0.4, 0.4}	$x_i = 0, y_i = 0$	$x_i = 1, y_i = 0$
asymmetric	{0.4, 0.8}	$x_i = 0, y_i = 0$	$x_i = 0, y_i = 0$

The social optimum and individual optimal contributions (Nash Equilibrium) are represented in Table 2.1. There are two things to notice about these incentive structures. First, at the individual level, the standard free riding conditions hold. With a token kept in the individual account being paid on a one-to-one basis, and MPCR < 1 creates the typical free-riding incentives for individuals.

Second, in the asymmetric cases, not just the individual Nash Equilibrium but also the social optimum is for each player to keep the token in his/her individual account. The ratio of the group size between group A and B is designed to match the ratio of the MPCR of group B and A, such that the social optimum of the game is for neither group to contribute to the public good.

In the symmetric cases, the majority and minority have the same MPCR, but the majority group has more members. Therefore, the social optimum outcome is reached when the majority group contributes to the public account and the minority group does not contribute.

The matrix of theoretical benchmarks tells us that although the standard theory predicts that the nature of the groups should make no difference in outcomes, the divergence in incentives at the sub-group and group level suggests that if individuals have preferences that are sensitive to a subgroup or group optima, then our treatment variables could systematically affect players' behavior-observed decisions.

(2) Framework

In our experiment, subjects are asked to complete three tasks: first, an unconditional contribution task in the public goods game, i.e., subjects simply play the public goods game as the model describes; second, a conditional contribution task, that is, subjects need to make decisions on whether to contribute in each possible situation of others' contribution in their group and the other group; finally, subjects are asked to complete a survey. Our method of using both unconditional contribution task and conditional contribution task follows the strategy method design by Fischbacher et al. (2010)[28], which generates more choice data and helps us better understand subjects' motivations in their behavior.

In the second task of conditional contribution, each subject was shown a "contribution table". Each row of the table presents the combination of the contributions from other members in his/her own group (named as own-group contribution) and from members in the other group (named as other-group contribution). The subject needs to make a contribution decision for each row.

For better understanding, we present the conditional contribution table by ordering others' contributions from the lowest to the highest. However, different from Fischbacher et al. (2010)[28], since we have two groups of players, there may be an order effect in terms of whether we list the first column as the contribution from one's own group or from the other group. Therefore, our second treatment variable examines this potential framework effect and conducts sessions for both orders. A specific example of the two frameworks is given in Table 2.2.

Table 2.2: Two frameworks (for Role A and Role B)

Role A—Framework 1		
In Group A, the number of players invest in the group account	In Group B, the number of players invest in the group account	You invest in your group account(A): Yes/No
0	0	
0	1	
0	2	
0	3	
1	0	
1	1	
1	2	
1	3	
2	0	
2	1	
2	2	
2	3	
3	0	
3	1	
3	2	
3	3	
4	0	
4	1	
4	2	
4	3	
5	0	
5	1	
5	2	
5	3	

Role A—Framework 2		
In Group B, the number of players invest in the group account	In Group A, the number of players invest in the group account	You invest in your group account(A): Yes/No
0	0	
0	1	
0	2	
0	3	
0	4	
0	5	
1	0	
1	1	
1	2	
1	3	
1	4	
1	5	
2	0	
2	1	
2	2	
2	3	
2	4	
2	5	
3	0	
3	1	
3	2	
3	3	
3	4	
3	5	

Role B-- Framework 1		
In Group B, the number of players invest in the group account	In Group A, the number of players invest in the group account	You invest in your group account(B): Yes/No
0	0	
0	1	
0	2	
0	3	
0	4	
0	5	
0	6	
1	0	
1	1	
1	2	
1	3	
1	4	
1	5	
1	6	
2	0	
2	1	
2	2	
2	3	
2	4	
2	5	
2	6	

Role B-- Framework 2		
In Group A, the number of players invest in the group account	In Group B, the number of players invest in the group account	You invest in your group account(B): Yes/No
0	0	
0	1	
0	2	
1	0	
1	1	
1	2	
2	0	
2	1	
2	2	
3	0	
3	1	
3	2	
4	0	
4	1	
4	2	
5	0	
5	1	
5	2	
6	0	
6	1	
6	2	

2.3.2 Treatment

Based on the above two treatment variables, our research is built on a 2×2 design. Table 2.3 summarizes the four treatments. Based on the design, comparing T1 vs. T2 and T3 vs. T4 allows us to examine the effect of MPCR. Comparisons between T1 and T3, as well as T2 and T4, allow us to examine the effect caused by the framework of the conditional contribution table.

Table 2.3: The four treatments

Treatment	MPCRs	Framework order
T1	Symmetric (0.4, 0.4)	Framework 1
T2	Asymmetric (0.4, 0.8)	Framework 1
T3	Symmetric (0.4, 0.4)	Framework 2
T4	Asymmetric (0.4, 0.8)	Framework 2

Notes: Framework 1 refers to the case in which the first column in the conditional contribution table is the contribution from the player's own group and the second column is the contribution from the opposite group; Framework 2 refers to the case in which the first column in the conditional contribution table is the contribution from the player's opposite group and the second column is the contribution from his own group.

All four treatments have the following common features. 1) It is a one-shot game; all subjects are only played once. 2) Each participant is assigned to one of the two roles, A or B, and their role remains the same in the entire experiment. 3) The decisions were made under a strategy-method. After subjects submitted their decisions, we group the players randomly according to the instructions and generate the outcomes of the public goods game.

2.3.3 Hypotheses

Based on the experimental design, the comparison between treatments T1 and T2 and between treatments T3 and T4 identifies the effect of MPCRs. On the other hand, the comparison between treatments T1 and T3 and between treatments T2 and T4 captures the effect of different frameworks. We derive the following null hypotheses.

MPCR effect

Null Hypothesis 1 (H_0): Facing the same framework, the player's conditional contribution has no difference between different group MPCRs.

Alternative Hypothesis 1 (H_1): Player's conditional contribution increases as the MPCR for his own group increases and the contribution decreases as the MPCR for the opposite group increases.

1) $x_A(T_1) > x_A(T_2), x_B(T_1) < x_B(T_2)$.
2) $x_A(T_3) > x_A(T_4), x_B(T_3) < x_B(T_4)$.

As shown in the literature (Isaac & Walker, 1988) [1], in a standard public goods game where all players have the same payoff function, contribution to the public goods increases as the MPCR increases. In our setting, when the framework is fixed, i.e., when moving from T1 to T2 and from T3 to T4, the MPCR changes from 0.4 to 0.8 for player B. Therefore, it is natural to conjecture that players in group B will increase their contribution in treatment T2 and T4, compared to the contribution in T1 and T3, respectively. For players in group A, however, we conjecture the opposite direction, i.e., the contribution will decrease as we move from T1 to T2 and from T3 to T4. As shown in the Table for theoretical prediction, although in all treatments the Nash equilibrium prediction is always no contribution, the social optimum outcome in T1 and T3 is for players in group A to contribute. Therefore, if players in group A care about the social optimum, the comparative statistics predict that their contribution will decrease as the MPCR increases for players in group B.

Framework effect

Null Hypothesis 2 (H_0): Facing the same MPCRs, the player's conditional contribution has no significant difference between the two frameworks.

Alternative Hypothesis 2 (H_1): Player's conditional contribution is higher when facing framework 2, in which the first column in the conditional contribution table is the contribution from the player's opposite group.

3) $x_A(T_1) < x_A(T_3), x_B(T_1) < x_B(T_3)$.
4) $x_A(T_2) < x_A(T_4), x_B(T_2) < x_B(T_4)$.

For a higher benefit from the group exchange, they need the opponent to contribute less. The payoff model could have some subjects conjecturing that more from the opposite group may be bad for their own group. When the opposite group's contribution is presented in the first column, this framework may inspire a sense of competition. As a result, the contribution is higher in T3 compared to T1, and higher inT4 compared to T2.

Role effect

Null Hypothesis 3 (H_0): Facing the same MPCRs and framework, the two roles' contribution frequency has no significant difference.

Alternative Hypothesis 3 (H_1): Role A's contribution frequency is higher than role B's contribution frequency.

5) $x_A(T_i) > x_B(T_i),\ i \in \{1,2,3,4\}$.

In our experiment, there are consistently two groups, role A being the majority and role B being the minority. This was common knowledge to every player. The size of group A is twice that of group B, which may give a group-size advantage to role A.

Conditional contribution

Null Hypothesis 4 (H_0): Subjects' contribution is not conditional on others' contribution in their own group or the opposite group.

Alternative Hypothesis 4 (H_1): Subjects' contribution is conditional on others' contribution in their own group, or conditional on others' contribution in the opposite group, or both.

2.3.4 Experimental Procedure

The experiment was conducted over the World Wide Web using the popular crowdsourcing platform Amazon Mechanical Turk (MTurk) (http://www.mturk.com). The past demographic surveys found that 70–80% of workers on MTurk were from the United States and were relatively representative of the population of U.S. Internet users (Ipeirotis, 2009)[34] (Ross, Irani, Silberman, Zaldivar, & Tomlinson, 2010)[50]. Paolacci et al. (2010)[48] presented the results of classic experiments in judgment and decision-making; they found no differences in the magnitude of effects obtained using Mechanical Turk and using traditional subject pools.

On MTurk, researchers as requesters can post their designed surveys or games, which are called HITs (an acronym for Human Intelligence Tasks), and subjects as workers receive their compensations after successfully submitting HITs. Each HIT is equivalent to a session in traditional lab experiments.[21]

[21] In this paper, we may use session and HIT interchangeably. Same for subject and worker.

Since we need to have a fixed ratio between player A and player B, we conducted the session (HIT) for player A and player B separately for each treatment.[22] In each session, the same set of players participated in public goods games with polarized preferences programmed in oTree (Chen, Schonger, & Wickens, 2016)[13]. Each subject needed to finish three tasks before he or she could successfully submit the HIT. All sessions began with a consent form approved by Concordia University, followed by the instruction for Task 1, the unconditional public goods game, and a quiz. Then after each subject submitted his/her decision in Task 1, he/she read the instruction for Task 2, i.e., the conditional public goods contribution. Finally, after each subject completed Task 2, he/she needed to finish a survey. Detailed instructions can be found in Appendix A.

Task 1:

The "unconditional contribution" was just a single decision about whether or not to invest the token into the public good. In the instruction, the subject was given the payoff function which represents the public goods model with polarized preferences, as well as examples of how to calculate the payoffs. They were also told that there were two types of players, role A and role B, and the role would not change for the entire session.

Task 2:

The "conditional contribution" task was a variant of the "strategy method" (Selten R. , 1967)[52]. The procedure followed a similar procedure (Fischbacher & Gächter, 2010)[28] (Fischbacher, Gächter, & Fehr, 2001)[29] except that we incorporated the polarized preferences of the participants in the study. Specifically, subjects were shown a "contribution table" which contains all the possible combinations of the tokens in the two group accounts. For a subject in group A, there were 24 (6*4) rows (decisions) in the Table. Each row represented a possible contribution from other members in group A (0 to 5), combined with a possible contribution from members in group B (0 to 3). Similarly, for a subject in group B, there were 21 (3*7) rows in the Table, with the possible contribution from other members in group B ranging from 0 to 2 and in group A ranging from 0 to 6.

Task 3:

The survey task included 3 demographic questions, 3 CRT questions, and 1 comment. Subjects were asked to self-report their age, gender, and ethnicity. Then they would complete the cognitive reflection test (CRT). We modified some numbers in the standard CRT questions since otherwise subjects could easily find the solution from the Internet. Finally, they could leave a general comment about the experiment.

[22] We did a pilot session which put player A and player B in the same HIT. However, since we cannot control which subject would drop from the session, we cannot guarantee the ratio between the two types of players who complete the session.

All tasks were performed only once, which was made clear to subjects at the beginning of the session. Subjects did not receive feedback on other participants' decisions. Each subject made decisions individually and independently. To our knowledge, there was no communication or feedback during or after the experiment.

Subjects were told that, after all the participants submitted their HIT, the groups would be randomly formed according to the designed group size (6A vs. 3B). In practice, for each treatment, we waited for both HITs (one for role A and the other for role B) to complete before we randomly assigned subjects to groups and calculated their bonus payoffs. To reduce the variance between the bonus payoffs of Task 1 and Task 2, the groups were randomly matched independently between Task 1 and Task 2.

Payoff:

Subjects were paid a bonus payoff for each of the three tasks, as well as a base rate for the completion of the tasks. After collecting all the data from the 72 subjects in a given treatment, we randomly grouped subjects with 6 members in Group A and 3 members in Group B.

The way to determine subjects' payoffs is a modification from Fischbacher et al. (2001, 2010)[29][28]. In their design, subjects also made decisions on both the unconditional task and the conditional task. Then subjects were randomly assigned to groups of 4 members. Each group threw a 4-sided die to determine one group member whose contribution table would be used to determine the actual payment. For the other three group members, the unconditional decision was used to pin down the row in the conditional table of the chosen subject.

Our design differs from Fischbacher et al. (2001, 2010)[29][28] in two ways. First, we assign the groups for the unconditional task and conditional task independently, and pay for each task, to avoid extremely negative payoffs to some extent.[23] The payment for the unconditional task only depends on the unconditional contribution. Second, for the payment of the conditional task, unlike Fischbacher et al. (2001, 2010)[29][28], each subject's conditional contribution table was used to calculate his/her conditional task payoff, by using the unconditional contribution decisions of the other eight subjects in the group. However, our design has maintained the same incentives as in Fischbacher et al. (2001, 2010) [29][28]for the conditional task. This procedure ensures that for both roles all entries in the contribution table, as well as the unconditional contributions, are potentially payoff relevant.

Different from many other lab experiments on public goods games, subjects in our experiment only made the decisions for the three tasks once, i.e. there were no repetitions, and this was known to the subjects. The reason for this is similar to Fischbacher et al. (2001)[29]. Since our

[23] Another benefit of grouping the subjects twice is to have more observations at the group level.

main interest lies in eliciting preferences, we did not want to complicate matters by, for example, introducing reputation formation or any kind of repeated game consideration.

In each session, subjects went through the contents in the following order: Consent form, Instructions for Task 1, Quiz, Task 1, Instructions for Task 2, Task 2, and Task 3. They were notified that the expected duration of the session is around 23 minutes.

The nature of the public goods game with polarized preferences, theoretically, is that subjects may earn a negative bonus payoff from the game. We compensated subjects with a constant amount across role A and role B players in Task 3 to guarantee the total bonus payoff from the three tasks is positive. Specifically, the bonus payoff for Task 3 is 4.4 tokens for treatment T1 and T3 (MPCR= {0.4, 0.4}) and 8.4 tokens for treatment T2 and T4 (MPCR={0.4, 0.8}). But subjects only got to know the bonus payoff for Task 3 when they reached the page of Task 3, which is after they finished making decisions for Tasks 1 and 2.

The experimental money (token) used in the experiment was converted to USA dollars with an exchange rate of 1 token = $0.25. The base rate is USD$0.5 for T1 and T2, USD$1.0 for T3 and T4.[24] The average earnings per subject are USD$2.58 including the base rate. All HITs were conducted between 2019/1/18 and 2019/3/18. All subjects participated in only one HIT.

2.4. Experimental Results

In total, 288 subjects participated in our experiment, with 72 in each treatment (48 in Role A and 24 in Role B). Each subject finished the HIT independently.

Table 2.4: Session summary

	Treatment	Obs.	Age	Female	Ethnicity 2	CRT	Quiz	Bonus ($)
Role A	1	48	41	42%	69%	2.25	2.38	1.56
	2	48	38	38%	73%	2.27	2.54	2.47
	3	48	33	44%	80%	1.13	2.04	1.75
	4	48	31	33%	58%	1.15	2.10	2.64
	Total	192	36	39%	70%	1.70	2.27	2.64
Role B	1	24	36	25%	58%	1.92	2.54	1.21
	2	24	36	29%	58%	1.67	2.29	1.93
	3	24	30	54%	83%	1.21	2.33	0.75

[24] We increase the base rate in T3 and T4 by $0.50, in order to attract more participants.

	4	24	31	21%	75%	1.46	2.67	1.26
	Total	96	33	33%	69%	1.56	2.46	1.29

Notes: Ethnicity 2=Caucasian (of European ancestry)

As shown in the appendix for web content, we asked four quiz questions to help subjects understand the payoff function and team structure, with two questions from a perspective of role A and the other two from a perspective of role B. (Notice again subjects were only informed of their role in the official tasks but not in the stage of reading the instructions and quizzes.) The quiz outcome and correct answers were given after the subjects finished all the questions. It was made clear that the bonus is not determined by the quiz outcomes. In Task 3 we also included three CRT questions. The worker population distribution is mainly the ethnicity 2 Caucasian (70% in role A and 69% in role B).

Wilcoxon rank-sum two-tailed tests on the quiz outcomes and CRT questions show that there exists a significant difference in the CRT results: for the role A between T1 and T3 ($p<0.01$, 96 obs.), between T2 and T4 ($p<0.01$, 96 obs.), and for the role B between T1 and T3 ($p<0.05$, 48 obs.). However, no significant differences were found in any of the tests on the quiz outcomes.

2.4.1 Aggregate Analysis

We present the aggregate results of unconditional and conditional contributions in both roles in the four treatments (see Table 2.5). Based on the research goal, we further performed the Wilcoxon-Mann-Whitney test (WMW) on the individuals' contribution frequency in Task 2 across treatments, specifically related to the MPCR effect and Framework effect. These results are presented in Table 2.6.

Table 2.5: Mean contribution in each treatment

Treatment	Role A			Role B		
	Unconditional (Task 1)	Conditional (Task 2)	No. of Obs.	Unconditional (Task 1)	Conditional (Task 2)	No. of Obs.
1	69%	54%	48	63%	32%	24
2	54%	42%	48	88%	49%	24
3	79%	57%	48	71%	50%	24
4	81%	57%	48	83%	41%	24
Avg.	71%	53%	192	76%	43%	96

Notes: The values in the Unconditional column is the mean contribution in Task 1 in each treatment. The values in the Conditional column is the mean of individual contribution frequency across all decision rows in Task 2 in each treatment.

Table 2.6: P-value of WMW tests on the conditional contribution (Task 2)

		Role A	Role B
MPCR Effect	T1 vs. T2	0.047	0.038
	T3 vs. T4	0.959	0.207
Framework Effect	T1 vs. T3	0.700	0.018
	T2 vs. T4	0.036	0.457

Notes: The tests are conducted using each individual's contribution frequency in Task 2.

(1) MPCR-effect

We find parts of the MPCR-effect in certain treatments where own-group contributions were presented in the first. When moving from T1 to T2 and from T3 to T4, the MPCR for player B increases from 0.4 to 0.8 while the MPCR for player A remains as 0.4. As Hypothesis 1 predicts, player A's contribution may decrease, and player B's contribution may increase. In Task 2, this effect is significant in both roles A and B when comparing T1 and T2. However, no significant difference is found comparing T3 and T4 for either role.

(2) Framework-effect

We find mixed results regarding the framework effect, which varies depending on the role of the participant. Comparing T1 and T3, player B's contribution is higher in T3 than T1 (two-tailed WMW test, $p<0.05$, obs. 48) but no significant difference is found for player A. Comparing T2 and T4, player A's contribution is higher in T4 than T2 (two-tailed WMW test, $p<0.05$, obs. 96), but no significant difference is found for player B.

Finding 1: There are mixed MPCR-effect and framework effect across treatments.

(3) Role effect

We find a significant role effect when combining the four treatments. In Task 2, overall the role A (majority) players' individual contribution frequency is significantly larger than the role B (minority) players' individual contribution frequency (two-tailed WMW test, $p<0.01$, obs. 192 vs. 96). Specifically, the same pattern holds in T1 and T4 ($p<0.01$ and $p<0.05$, respectively), but no significant difference is found in T2 and T3 ($p>0.3$).

Table 2.7: Role effect WMW test on the conditional contribution (Task 2)

Task 2	Role A		Role B		Role A vs. Role B
	Mean	Obs.	Mean	Obs.	p-value of WMW
T1	54%	48	32%	24	0.0085
T2	42%	48	49%	24	0.3850
T3	57%	48	50%	24	0.3064
T4	57%	48	41%	24	0.0168
All	53%	192	43%	96	0.0060

Finding 2: Overall, the contribution frequency of the majority group members is significantly higher than that of the minority group members.

2.4.2 Individual Analysis

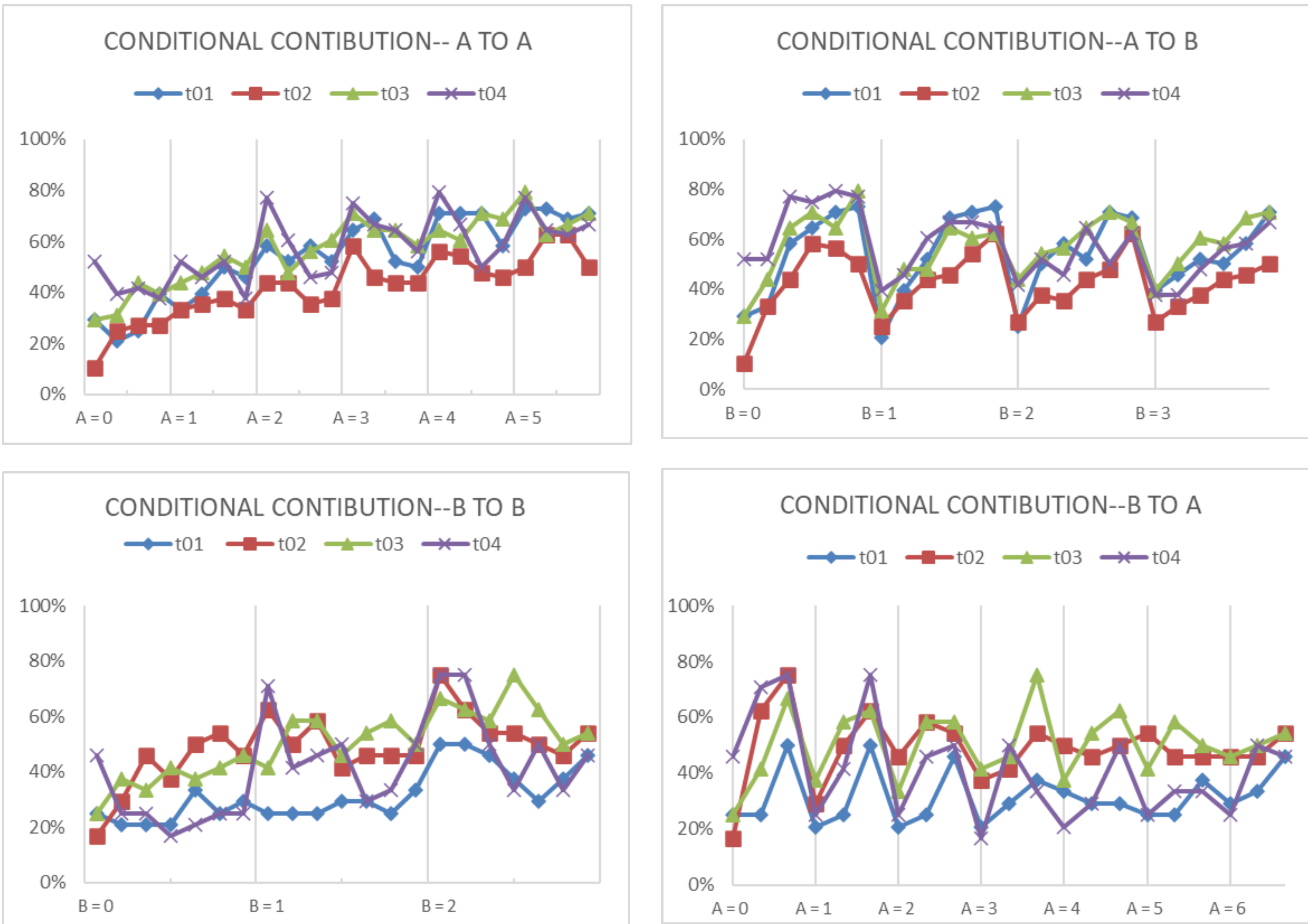
(1) Conditional contribution trend

We show that the MPCR effect and framework effect may combine to influence the contribution; in this sub-section, we will explore the conditional behavior, specifically by fixing the measure of the same group's contributions and the other group conditions.

In the charts (see Figure 1), each point in the horizontal axis represents a single unit of data, which includes all possible contribution numbers. For example, in the conditional contribution, A to A, the points within each group 'A=i' correspond to the case of B=0, B=1, B=2, B=3. In the conditional contribution A to B, the points within each group 'B=i' correspond to the cases of A=0, A=1, …, A=6.

The conditional contribution lines demonstrate two basic trends in player behavior: One is that players have an increased linear trend towards their own contributions; for example, in the A to A scenario, contributions increase as group A contribution increases from 0 to 5. Similarly, an upward but slightly flatter trend can be found in the B to B chart. The other finding is that contrary to this own-group trend, no such upward trend is shown for group contribution, for example in the A to B chart, where there exists an up and down pattern rather than an upward trend. Furthermore, these findings hold for both roles and in all treatments.

Figure 2.1: **Conditional contribution to own-group and the other group**



(2) Probit regression on the conditional contribution

To understand the conditional behavior of own-group and/or other-group contribution, we analyze the binary contribution panel data with the Probit regression and marginal effect of the conditional on own-group and other-group contributions (see Table 2.8).

The variables are the following: Own-group contribution is the total number of contributors from the same group. In group A, the contributions are from {0,1,2,3,4,5}; in role B, the contributions are from {0,1,2}. Other-group contribution is the total number of contributors from the other group. In group A, the contributions are from {0,1,2,3}; in role B, the contributions are from {0,1,2,3,4,5,6}.

At the same time, the treatment effect may combine with the conditional behavior of the interactive variables considered in model 2. For example, Own-group contribution ×T4: the interactive variable of treatment 4 and own-group contribution numbers. Other-group contribution×T2: the interactive variable of treatment 2 and the other-group contribution numbers.

Model 3 and model 6 include the exogenous variables in the contribution regression, which include Gender: dummy variable, in role A: 1= female; 2=male, 3=other; in role B: 1= female; 0=male. CRT: the rate of correct answers of 3 CRT questions, and Quiz: the rate of correct answers of all 4 quiz questions.

Table 2.8: Random effect Probit regression on the conditional contribution

(Task 2, Role A)

	All data			Data excluding pure free riders and pure altruists		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Treatment 2	-0.192*	-0. 109	-0. 074	-0. 051	0. 021	0.022
	(0.021)	(0.235)	(0.378)	(0.351)	(0.769)	(0.744)
Treatment 3	0.458	0.136	0. 085	-0. 001	0. 093	0. 059
	(0.586)	(0.144)	(0.355)	(0.983)	(0.168)	(0.399)
Treatment 4	0.0628	0. 289***	0. 242***	-0. 036	0. 200***	0. 171**
	(0.454)	(0.001)	(0.006)	(0.493)	(0.002)	(0.011)
Own-group contribution		0.122***	0. 114***		0. 126***	0.123***
		(0.000)	(0.000)		(0.000)	(0.000)
Own-group contribution ×T2		-0. 028*	-0. 026*		-0. 028*	-0. 027*
		(0.052)	(0.050)		(0.059)	(0.062)
Own-group contribution ×T3		-0. 047***	-0. 044***		-0. 051***	-0. 050***
		(0.000)	(0.000)		(0.000)	(0.000)
Own-group contribution ×T4		-0. 063***	-0. 058***		-0. 066***	-0. 064***
		(0.000)	(0.000)		(0.000)	(0.000)
Other-group contribution		-0. 006	-0. 006		-0. 007	-0.007
		(0.674)	(0.681)		(0.643)	(0.651)
Other-group contribution× T2		-0. 007	-0. 006		-0. 006	-0. 006

		(0.751)	(0.747)		(0.786)	(0.783)
Other-group contribution×T3		0. 013	0. 012		0. 013	-0. 013
		(0.496)	(0.500)		(0.493)	(0.500)
Other-group contribution ×T4		-0. 060***	-0. 057***		-0. 060***	-0. 060***
		(0.002)	(0.002)		(0.002)	(0.002)
Observations	4,608	4,608	4,608	3,864	3,864	3,864

Table 2.8: Continuous (Task 2, Role B)

	All data			Data excluding pure free riders and pure altruists		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Treatment 2	0.230**	0.260**	0.199**	0. 189**	0. 225**	0.180*
	(0.013)	(0.017)	(0.026)	(0.038)	(0.039)	(0.052)
Treatment 3	0.250***	0.203*	0.101	0. 144	0. 105	0.044
	(0.007)	(0.062)	(0.299)	(0.113)	(0.336)	(0.657)
Treatment 4	0.134	0.241**	0.215**	0. 0625	0. 176	0.171*
	(0.139)	(0.027)	(0.028)	(0.479)	(0.105)	(0.087)
Own-group contribution		0.129***	0.116***		0. 134***	0.124***
		(0.000)	(0.000)		(0.000)	(0.000)
Own-group contribution ×T2		-0.025	-0.023		-0. 027	-0.026
		(0.549)	(0.528)		(0.525)	(0.505)
Own-group contribution ×T3		0.013	0.011		0. 012	0.010
		(0.748)	(0.773)		(0.770)	(0.801)

Own-group contribution ×T4		0.030	0.029		0. 027	0.026
		(0.466)	(0.445)		(0.527)	(0.511)
Other-group contribution		-0.001	-0.001		-0.001	-0.001
		(0.939)	(0.921)		(0.965)	(0.948)
Other-group contribution× T2		-0.003	-0.003		-0.003	-0.003
		(0.864)	(0.862)		(0.848)	(0.846)
Other-group contribution×T3		0.008	0.007		0.007	0.007
		(0.637)	(0.640)		(0.660)	(0.663)
Other-group contribution ×T4		-0.049***	-0.44***		-0.050***	-0.046***
		(0.003)	(0.003)		(0.003)	(0.003)
Observations	2,016	2,016	2,016	1,911	1,911	1,911

Notes: Marginal effects reported.

The exogenous variables Gender, Age, Ethnicity, CRT, and Quiz are considered by the regression in Model 3 and Model 6, but they have no significant difference in both roles and treatments. As a dummy variable, treatment 1 is the compared variable.

Level of significance: *** 0.01, ** 0.05, * 0.1.

Finding 3:

(1) In all treatments, for both role A and role B, the probability of contributions to the public good increases significantly with the contributions of the other members in the same group.

(2) In all treatments, for both role A and role B, the probability of contributions either decreases or is not responsive to the contribution of the other group.

(3) The responsiveness to one's own-group contributions is larger than to other-group contributions in absolute value.

For role A

In the treatment and conditional contribution regression, there is a positive relationship between the role A contribution level and its own-group contribution (0.122), while it has a negative relation with the other-group contribution (-0.006). Adding the exogenous variables does not change the sign.

The positive to conditional effect is consistent across all treatments. The four treatments are all significant in the A to A relationship. When considering the treatment effect, only T2 is significant (model 1). After adding the conditional effect to the treatment (model 2), the positive to the other-group conditional effect holds and is strongly significant. This result holds well in model 3, where exogenous variables do not change either the pattern or its significance.

For role B

Similar to the above, the three findings hold up in role B. In the treatment and conditional contribution regression (see model Role B 3), there is a positive relationship between the role B contribution level and its own-group contribution (0.124), while this contribution has a negative relation with the other-group contribution (-0.001). Adding exogenous variables does not change the result.

2.5 Conclusion

Some public good is not assumed to be "good" for everyone. One group may benefit from a positive provision of the public good while the other only benefits from a negative provision of the public good. Individuals from each group can make costly efforts (in their favor) trying to affect the final outcome. In this paper, we study a public goods game with polarized preferences by using a generalized voluntary contribution mechanism.

In the game, there are two groups of individuals: the majority and the minority. Each individual can choose whether to keep the tokens in their private account or contribute to the group account of their group. The final provision of the public good is decided by the difference in the number of tokens between the two group accounts. One of our main treatment variables is the MPCRs of the two groups, under which different predictions of social optimum are provided.

Subjects were asked to complete two public goods games: an unconditional contribution task and a conditional contribution task. After they made their unconditional contribution decision, they will fill out a conditional contribution task, in which each individual faces two vectors of contributions, one from his own group, the other from the other group. Our second treatment variable is the framework.

The main results were based on the online experiment that was conducted on the crowdsourcing platform, MTurk. We report that the MPCR effect and framework effect are mixed and only significant in some treatments. The results vary depending on the role of the participants (the majority and the minority). Overall, the majority group individual contribution frequency is significantly larger than the minority players'. Additionally, players' contribution significantly increases with the contribution of others in their own group but is not dependent on the contribution from the other group.

This paper is the study of the public goods game with polarized preference combined with the strategy method. The experiment was conducted online. For future research, a lab experiment with a similar procedure would be an extension study. Comparing the two forms of the experiment would have a better implication on the result. Also, in the experiment design, a more simple or vivid screen with two teams would be helpful for participants' understanding.

2.6 Appendices

Appendix A: Removing pure free riders and pure altruists

The above analysis shows us that there is a consistent relation between the conditional contribution and other members either in the same group or in the other group. To carry on a further understanding of this conditional behavior, the conditional contribution will be targeted. In this case, those subjects who are proved to be pure free riders and pure altruists should be removed from the dataset, i.e., we want to look at this subset of data by removing the 0% or 100% contributors. It is called a conditional dataset.

Individual conditional contribution distribution

Firstly, we need to have a clear view of the distribution. In both roles and treatments, how many choices are beyond conditional behavior can be found in the following Table. The category is based on value ascending from 0, 0.25th quarter, 0.5th quarter, 0.75 quarter, to 1. 'always 0' stands for pure free riders, who put zero on all conditional contribution task; 'always 1' stands for pure altruists, who contribute on all the schedule.

In role A, all treatments have 'always 0' and 'always 1'. T2 and T1 are comparatively higher in 'always 0'. Other sections are similar for 4 treatments. In total, there are 20 'always 0' and 11 'always 1. The left 83.9% of the contribution can be considered as conditional contributors. For role A, the biggest contribution sections are in (0.5,0.75].

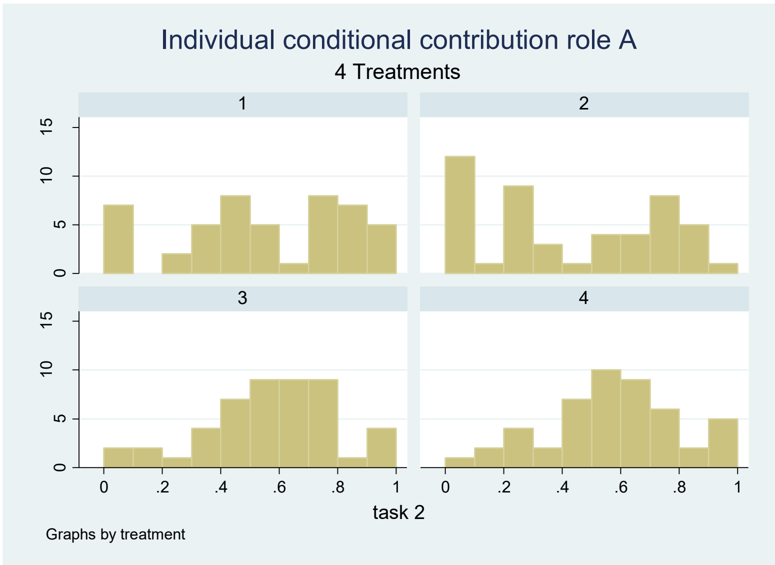
Different from role A, role B has fewer players who choose free rider and pure altruist. In T3 and T4, none goes for 'always 0'; while in T1, T2 and T4, none choose 'always 1'. From the general point of view, the two sections (0, 0.25] and (0.5,0.75] are the highest. But the conditional behavior players take 94.8% of the contributors, which is higher than role A. More conditional behaviors show up in role B (the minority).

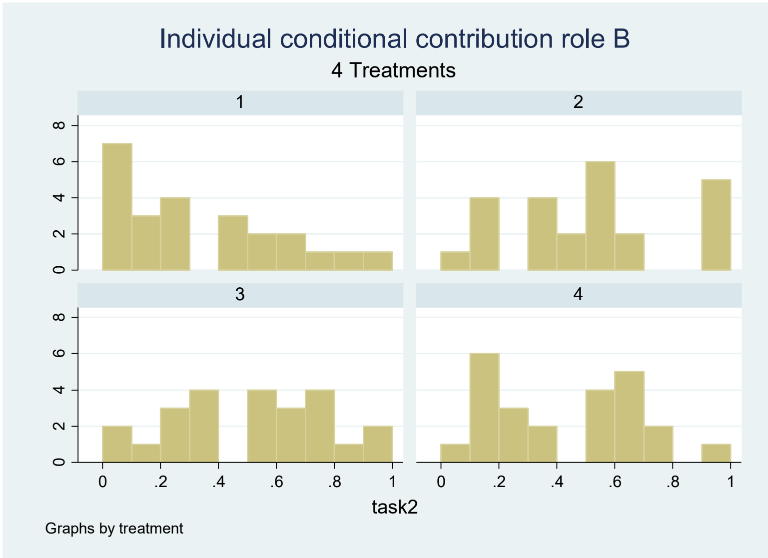
Table 2.9.A1: Individual conditional contribution distribution

role A	always 0	(0, 0.25]	(0.25,0.5]	(0.5,0.75]	(0.75,1)	always 1	Total
T1	6	3	16	8	11	4	48
T2	11	7	8	14	7	1	48
T3	2	3	13	19	9	2	48
T4	1	4	14	20	5	4	48
Total	20	17	51	61	32	11	192
role B	always 0	(0, 0.25]	(0.25,0.5]	(0.5,0.75]	(0.75,1)	always 1	Total

T1	3	11	3	5	2	0	24
T2	1	4	8	6	5	0	24
T3	0	5	6	8	4	1	24
T4	0	9	4	10	1	0	24
Total	4	29	21	29	12	1	96

Figure 2.2.A1: Individual conditional contribution distribution





Notes: the histogram charts have a different scale from the distribution table.

Aggregate Analysis

After moving pure free riders and pure altruists, we test the MPCR and framework effect again. The details can be seen in Table A2. It is an astonishing result. No matter what effect is found in the whole dataset, some contributions may be significant in one role or one treatment, others may not. These mixed results are no longer significant in the conditional dataset.

Table 2.10.A2: Mean Contribution in Each Treatment

(Excluding Pure Free Riders and Altruists)

Treatment	Role A			Role B		
	Unconditional (Task 1)	Conditional (Task 2)	No. of Obs.	Unconditional (Task 1)	Conditional (Task 2)	No. of Obs.
1	74%	58%	38	71%	38%	21
2	67%	53%	36	91%	53%	23
3	80%	58%	44	70%	49%	23
4	81%	55%	43	83%	43%	24
Avg.	75%	56%	40	79%	46%	23

Table 2.11.A3: p-value of WMW Tests on Conditional Contribution (Task 2 moving always)

		Role A	Role B
MPCR Effect	T1 vs. T2	0.293	0.072
	T3 vs. T4	0.518	0.321
Framework Effect	T1 vs. T3	0.952	0.141
	T2 vs. T4	0.957	0.310

Notes: The tests are conducted using each individual's contribution frequency in Task 2.

Table A3 presents the Wilcoxon-Mann-Whitney test results on the individuals' contribution frequency in Task 2 across treatments, specifically related to the MPCR effect and Framework effect.

The main results in the individual analysis continue to hold after removing the pure free riders and altruists.

Appendix B: Additional results

B.1 Comparison between Unconditional and Conditional Contribution

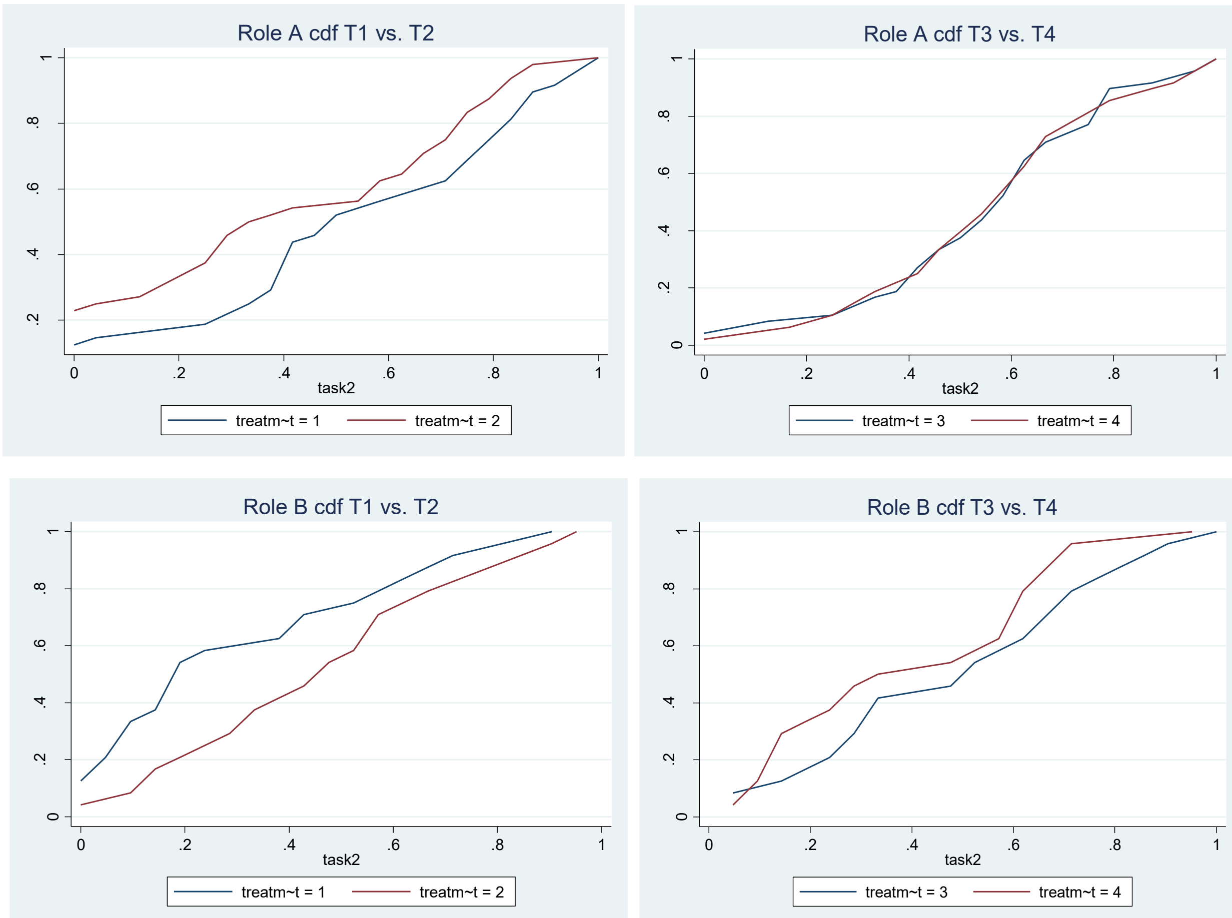
We report a test comparing the unconditional contribution and conditional contribution. Specifically, for each individual, we compare their contribution decision in the unconditional task with the row in the conditional table that is pinned down by their group members' unconditional contribution, which is similar to the way that the bonus payoff in Task 2 is calculated. In all the treatments, the contribution in Task 1 is significantly larger than that in the related rows in Task 2 (two-tailed Wilcoxon signed-rank test, $p<0.01$ or $p<0.05$, obs. 144 for each treatment).

Table 2.12.B.1: Comparison between Unconditional and Conditional Contribution

Role AB	Task 1		Task 2i		Task 1 vs. Task 2i
	Mean	Obs.	Mean	Obs.	p-value of Wilcoxon signed ranks test
T1	67%	72	51%	72	0.022
T2	65%	72	49%	72	0.014
T3	76%	72	61%	72	0.016
T4	82%	72	56%	72	0.000
All	73%	288	54%	288	0.000

B.2 CDF of conditional contribution

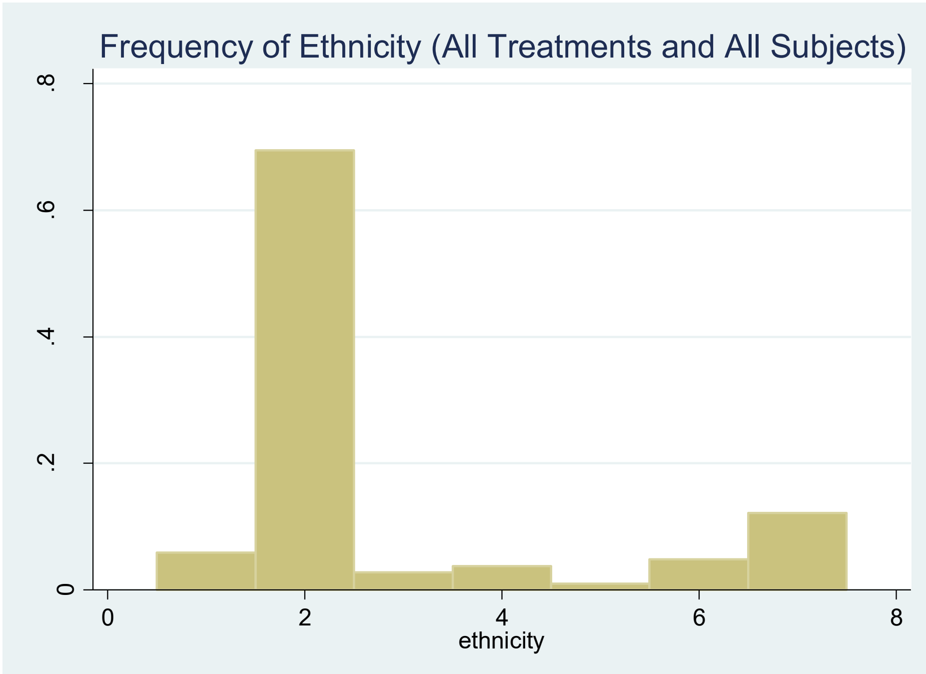
Figure 2.3.B.2: CDF of conditional contribution



Notes: The x-axis is the individual's contribution frequency in Task 2.

B.3: **Frequency of Ethnicity**

Figure 2.4.B.3: Frequency of Ethnicity



Notes: Ethnicity: 1=Black (of African ancestry), 2=Caucasian (of European ancestry), 3=East Asian (e.g., Chinese, Thai, Japanese, Malaysian, Vietnamese, Indonesian), 4=Hispanic, 5=Middle Eastern, 6=Mixed/Other, 7=South Asian Subcontinent (e.g., Indian, Pakistani)

Appendix C: Experiment Content

Attention !

Attention!

At the next page we will ask you to read and confirm your agreement with the Consent Form.

You will have **3 minutes** to do this.

Next

This study is conducted by the researchers from Concordia University (Canada).

If you have any issues regarding the study, please contact us immediately via

lia_wa@live.concordia.ca.

huan.xie@concordia.ca.

Page 1

Consent Form

Attention!

You have **3** minutes to read and accept this Consent Form.

If you are not going to proceed with this HIT **immediately**, please return it right now!

You must read the following carefully before checking the box next to the red informed consent statement below the text area to proceed with your participation.

You are being invited to participate in the research study mentioned above. This form provides information about what participating would mean. Please read it carefully before deciding if you want to participate or not. If you have any questions at any time, please contact: Dr. Huan Xie or Ph.D. candidate Liang Wang at 1455 Boulevard de Maisonneuve Ouest, Department of Economics, Concordia University, Montreal, QC H3G1M8, or by email at Dr. Huan Xie huan.xie@concordia.ca or Ph.D. candidate Liang Wang lia_wa@live.concordia.ca. By clicking the ‘‘I Agree’’ button below you affirm that you have read and understood the following consent form.

A. PURPOSE

The purpose of the research is to study economic decision making.

B. PROCEDURES

The Project is offered to individuals registered as ‘‘workers’’ with Amazon, Inc.’s ‘‘Mechanical Turk’’ service (http://www.mturk.com/mturk/welcome). Your participation in the Project as a worker is governed by Amazon, Inc.’s Mechanical Turk’s conditions of use (http://www.mturk.com/mturk/conditionsofuse). If you participate, you will be asked to make decisions that will earn you monetary payoffs as will be carefully explained in the instructions.

C. RISKS AND BENEFITS

You might face certain risks by participating in this research. These risks include a breach of confidentiality, but everything possible is done to protect your privacy. To reduce the likelihood of a breach of confidentiality, all researchers have been thoroughly trained to maintain your privacy.

Potential benefits include the monetary payment you gain from participating in the study. All payments will be made to you through the Mechanical Turk service as detailed in the Mechanical Turk conditions of use. There are no costs to you from participating in this experimental session other than your time.

D. CONFIDENTIALITY

We will gather the following information as part of this research: the decisions you make during the experiment and your consent form.

We will not allow anyone to access the information, except people directly involved in conducting the research. We will only use the information for the purposes of the research described in this form.

All data collected in the experiment could be associated only with participants' Amazon Turker ID, not with any personally-identifiable information; thus all players remained anonymous.

The data obtained from this experiment will be only accessible to the principle investigator, co-investigators and collaborators. Both the consent forms and receipts will be stored in locked files apart from any data gathered from this study. During the experiments, subjects will be identified by code numbers for the purpose of data collection. We will not have any means of identifying players by their code numbers either during the experiment or after.

We intend to publish the results of the research. However, it will not be possible to identify you in the published results.

F. CONDITIONS OF PARTICIPATION

You do not have to participate in this research. It is purely your decision. If you do participate, you can stop at any time. You can also ask that the information you provided not be used, and your choice will be respected. If you decide that you don’t want us to use your information, you must tell the researcher before you stop your participation in the study.

To make sure that research money is being spent properly, auditors from Concordia or outside will have access to the consent forms, receipts, and the electronic data files containing Amazon Turker ID and your decisions made during the experiment. But it will not be possible to link your real name with Amazon Turker ID and your decisions in the electronic files.

There are no negative consequences for not participating, stopping in the middle, or asking us not to use your information.

If you have questions about the scientific or scholarly aspects of this research, please contact the researcher. Their contact information is on the following. You may also contact their faculty supervisor.

If you have concerns about ethical issues in this research, please contact the Manager, Research Ethics, Concordia University, 514.848.2424 ex. 7481 or oor.ethics@concordia.ca.

Procedures:

You will be asked to make a series of decisions involving different payoffs.

The entire session consists of 3 tasks and will last about 23 minutes.

Your average payoff including base rate and bonus will be between $0.6 and $3.1 depending on your decisions and decisions of other MTurkers with whom you are matched.

Every participant is guaranteed a base rate of **$0.50** for completing a session.

In order not to make other participants wait for too long please make your decisions on time. If you fail to make the decision on time you may not be eligible for the full bonus payment.

You will be given detailed information on how to make choices and how payments will depend on decisions made by you and other participants.

Privacy:

The only personal information that will be available to the researchers is what is publicly available on your MTurk profile and any information that you choose to provide during the course of the study. This information will not be shared with any individuals who are not part of the research team.

Contact:

If you have questions or concerns, please contact the researchers at lia_wa@live.concordia.ca. or huan.xie@concordia.ca.

Consent:

By checking the box below next to the red informed consent statement, you acknowledge that you have read the rules and privacy policy, you certify you are 18 years of age or older, and you agree that your participation is voluntary.

G. PARTICIPANT'S DECLARATION

I have read and understood this form. I have had the chance to ask questions and any questions have been answered. I agree to participate in this research under the conditions described.

☐ *I acknowledge that I have read the rules and privacy policy, I certify I am 18 years of age or older, and I agree that my registration in the subject pool is voluntary.*

Time left to complete this page: **2:49**

Next

This study is conducted by the researchers from Concordia University (Canada).

If you have any issues regarding the study, please contact us immediately via

lia_wa@live.concordia.ca.

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Page 2

Participant Instructions

Welcome to the experiment! This is an experiment in economics decision making. Because the amount of money you can earn depends on your decisions in the game, it is important that you read these instructions with care. At the end of the instructions there is a quiz to ensure that you understand the instructions.

Overview

In the experiment, all participants will be randomly assigned to cohorts of 9 players. In each cohort, there are two groups: 6 players in group A and 3 players in group B. Each participant makes decisions on his own. The experiment (HIT) consists of **THREE** tasks. Each task will be only conducted ONCE.

We describe the exact experiment procedure below. During the game we will not report your earnings in terms of dollars and cents but rather in terms of tokens. At the end of the game the total number of tokens you have earned will be converted to dollars at the rate of 1 token = 0.25 US dollar.

The total payoff you earn from the experiment will be the base rate plus the bonus for this HIT.

You will earn **the base rate of $0.5** after submitting the HIT.

And after the HIT being submitted and accepted by the researcher, you will be paid **the extra bonus**.

Depending on decisions made by you and other participants, the bonus in some tasks may be negative, but the total bonus of the tree tasks is always positive.

Total payoff=base rate + bonus

Total payoff: min $0.6, max$3.1.

It will be explained later in each task how the bonus will be determined.

Next

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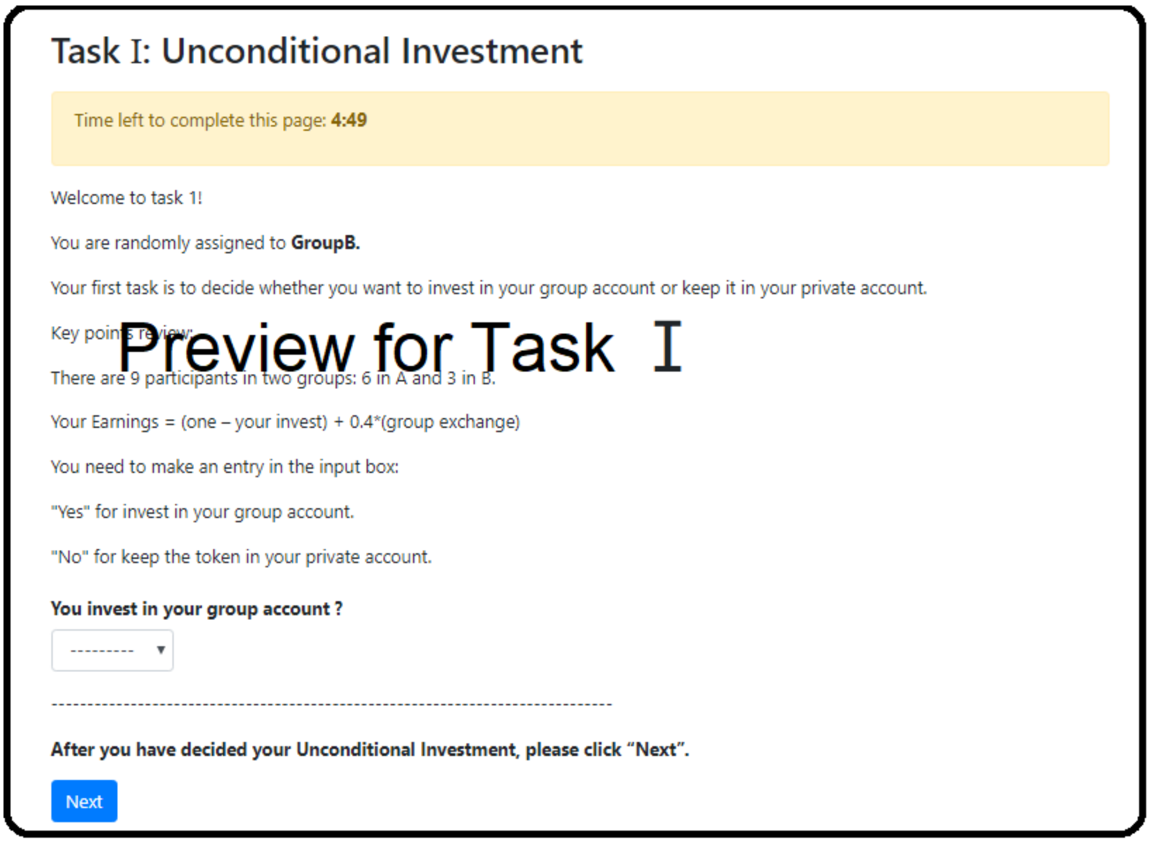
Task Ⅰ: Unconditional Investment

How the task works

1. All participants will be randomly assigned to cohorts of 9 players. In each cohort, each player will be randomly assigned to two groups (group A or group B), with 6 players in group A and 3 players in group B. Your income will be affected by the decisions made by members of both groups' in your cohort.

2. You will be given one token. The decision that you must make is whether to invest this token to your group account or keep it in your individual account. If you invest, please choose "yes", if you decide not to invest, please choose "No". Each group member decides independently and only invests in his own group count.

You can have a **preview in the following screenshot**:



3. Your income from this task consists of two parts: (a) the token kept in your individual account. (b) income from the investment. (Which is 0.4 x the group exchange).

The group exchange= total tokens in your group account – total tokens in the other group account

Your income is therefore: Income from the individual account + Income from the group account exchange = (1 – yours invest) + 0.4*(your group exchange)

The income of each person in the same group is calculated in the same way.

4. You have 5 minutes to make you decision. If you do not make a choice before the end of this session, you will not be paid.

5. After you have determined your unconditional investment, please click “next”.

Earnings for Task Ⅰ

As described, Your Earnings from this task is related to your investment decision and the result of group exchange.

After all participants submitted their decisions, you will be randomly matched with other participants to form a group of 9 participants, 6 in group A and 3 in group B. Then your earnings will be decided by the following.

Your Earnings

= income from individual account + Income from the group account exchange

= (1 – your invest) + 0.4*(group exchange)

Your earnings from this task range from -2.0 to 3.0 tokens.

Note: The total payoffs from three tasks are always positive.

Example one:

There are 9 participants in two groups: 6 in A and 3 in B. Assume you are in group A. All the other 5 players in your group choose NOT to invest in the group account, and all the 3 players in group B choose to invest in their group account.

(a) Now suppose you choose to invest in your group.

The total number of tokens in your group (group A) account is 1, and the total number of tokens in the group B account is 3.

Therefore, the group exchange would equal 1-3=-2, and your earnings would be 0+0.4*(-2)=-0.8.

(b) Now suppose you choose not to invest in your group account.

The total number of tokens in your group (group A) account is 0, and the total number of tokens in the group B account is 3,

The group exchange would equal 0-3=-3, and your earnings would be 1+0.4*(-3) =-0.2.

Example two:

Assume you are in group B. In your group, there are 2 other players who choose to invest in the group account, and in group A nobody invests in their group account.

(a) Now suppose you choose to invest in your group account.

The total number of tokens in your group (group B) account is 3, and the total number of tokens in the group A account is 0.

The group exchange would equal 3-0=3, and your earnings would be 0+0.4*3=1.2.

(b) Now suppose you choose not to invest in your group.

The total number of your group (group B) account is 2, and the total number of tokens in the group A account is 0.

The group exchange would equal 2-0=2, and your earnings would be 1+0.4*2=1.8.

When you are ready, you can proceed to the Quiz!

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Participant Quiz for Task Ⅰ

Question 1 of 4

Quiz. To make sure you have read and understood the instructions, please answer the following questions. The answers to all of the questions below are in terms of tokens.

Key points:

• There are 9 players in your cohort: 6 in group A and 3 in group B.

• You choose whether or not to invest in your group account.

Group exchange=total number of tokens in your group account - total number of tokens in the other group's group account

• Your Earnings = (one – your invest) + 0.4*(group exchange)

Assume you are in group A and one player in group B invest in their group. If in your group only one player invests. But you do NOT invest what would be your total income?

- 1
- 0
- -0.4
- 0.4

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Participant Quiz for Task I

Question 2 of 4

Quiz. To make sure you have read and understood the instructions, please answer the following questions. The answers to all of the questions below are in terms of tokens.

Key points:

• There are 9 players in your cohort: 6 in group A and 3 in group B.

• You choose whether or not to invest in your group account.

Group exchange=total number of tokens in your group account - total number of tokens in the other group's group account

• Your Earnings = (one – your invest) + 0.4*(group exchange)

Assume you are in group A and none players in group B invest in their group. If none of the other members in your group invest but you invest in your group account. What would be your income?

- **0.4**
- **0**

- ○ **-0.4**
- ○ **1**

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Participant Quiz for Task I

Question 3 of 4

Quiz. To make sure you have read and understood the instructions, please answer the following questions. The answers to all of the questions below are in terms of tokens.

Key points:

• There are 9 players in your cohort: 6 in group A and 3 in group B.

• You choose whether or not to invest in your group account.

Group exchange=total number of tokens in your group account - total number of tokens in the other group's group account

• Your Earnings = (one – your invest) + 0.4*(group exchange)

Assume you are in group B and none of the players in group A invests in their group. If only one member in your group invests and you do NOT invest. What would be your total income?

- ○ **1.4**
- ○ **-1.4**
- ○ **0.4**

- ○ **-0.4**

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Participant Quiz for Task Ⅰ

Question 4 of 4

Quiz. To make sure you have read and understood the instructions, please answer the following questions. The answers to all of the questions below are in terms of tokens.

Key points:

• There are 9 players in your cohort: 6 in group A and 3 in group B.

• You choose whether or not to invest in your group account.

Group exchange=total number of tokens in your group account - total number of tokens in the other group's group account

• Your Earnings = (one – your invest) + 0.4*(group exchange)

Assume you are in group B and none of the players in group A invests in their group. If only one member in your group invests and you invest too. What would be your total income?

- ○ **-0.8**
- ○ **0.8**
- ○ **0.2**
- ○ **1.8**

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Results

Time left to complete this page: **2:56**

You answered 4 out of 4 questions correctly.

Question	Your answer	Correct answer	Answered correctly?
Assume you are in group A and one player in group B invest in their group. If in your group only one player invests. But you do NOT invest what would be your total income?	1	1	True
Assume you are in group A and none players in group B invest in their group. If none of the other members in your group invest but you invest in your group account. What would be your income?	0.4	0.4	True
Assume you are in group B and none of the players in group A invests in their group. If only one member in your group invests and you do NOT invest. What would be your total income?	1.4	1.4	True
Assume you are in group B and none of the players in group A invests in their group. If only one member in your group invests and you invest too. What would be your total income?	0.8	0.8	True

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Task Ⅰ: Unconditional Investment

Time left to complete this page: **4:56**

Welcome to Task 1!

You are randomly assigned to **group A.**

Your first task is to decide whether you want to invest in your group account or keep it in your private account.

Key points review:

There are 9 participants in two groups in your cohort: 6 in A and 3 in B.

Your Earnings = (one – your invest) + 0.4*(group exchange)

You need to make an entry in the input box:

"Yes" for invest in your group account.

"No" for keep the token in your private account.

You invest in your group account ?

After you have decided your Unconditional Investment, please click "Next".

Next

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Instruction for task Ⅱ: Conditional Investment

How the task works

Key points review:

There are 9 participants in your cohort: 6 in A and 3 in B.

Your Earnings = (one – your invest) + 0.4*(group exchange)

Your second task is to fill in an “investment Table” where you indicate whether you want to invest under each possible investment condition, which depends on how many other players in your group invest and how many players in the other group invest. You may choose different options under different conditions.

You can have **a preview** in the following screen shot on the Table that will be presented to you in task II.

Preview for Task Ⅱ

In Group B, the number of players invest in the group account	In Group A, the number of players invest in the group account	You invest in your group account(B): Yes/No
0	0	You invest in your group account(B)? --------- ▾
0	1	You invest in your group account(B)? --------- ▾
0	2	You invest in your group account(B)? --------- ▾
0	3	You invest in your group account(B)? --------- ▾
0	4	You invest in your group account(B)? --------- ▾
0	5	You invest in your group account(B)? --------- ▾
0	6	You invest in your group account(B)? --------- ▾
		You invest in your group

Earning for Task Ⅱ

As described, your earnings from this task is related to yours investment decision and groups exchange result.

After all participants submitted their decisions, you will be randomly assigned again to a cohort of 9 participants, 6 in group A and 3 in group B. Your income in task II will depend on your input in the conditional table and the choices of your group members made in task I, i.e., the unconditional investment.

Example:

There are two groups in your cohort: 6 in group A and 3 in group B.

Assume that you are in group A, and assume your group members' choices in the unconditional invest (task I) are as follows:

in group A, 3 other players invest (3A),

in group B, 3 players invest (3B),

If you indicate in your **investment Table** that you will invest given 3 tokens from other players in the group A account and 3 tokens in the group B account, then the total investment is 4 in the group A account and 3 in the group B account. The group exchange for group A is 4-3=1. Therefore, you earn 0.4×1=0.4 tokens from the group account and 0 from your individual account.

If, instead, you indicate in your investment Table that you will NOT invest under the condition of the above case (3A vs. 3B), then the total investment of your group (group A) will be 3; As the group B has 3 tokens invested, the group exchange for your group is 3-3=0.

Therefore, you earn 0.4×0=0 tokens from the group account and 1 from your individual account, which results in 1 token in total earnings.

Your payoffs from this task range from -2.0 to 3.0 tokens.

Note: The total payoffs from three tasks are always positive.

When you finish reading the instructions, please proceed to the investment Table in Task II!

Next

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Task Ⅱ: Conditional Investment

Time left to complete this page: **9:53**

Welcome to Task Ⅱ!

You are randomly assigned in **group A.**

Now you have to decide to invest or not in each input box, conditional on each possible investment in your group and in the other group. You have to make an entry in each input box.

Once you have made an entry in each input box, click "next".

Key points review:

Two groups with 9 participants in your cohort: 6 in group A and 3 in group B

Your Earnings = (one – your invest) + 0.4*(group exchange)

In Group A, the number of players invest in the group account	In Group B, the number of players invest in the group account	You invest in your group account(A): Yes/No
0	**0**	You invest in your group

		account(A)? ---------
0	**1**	You invest in your group account(A)? ---------
0	**2**	You invest in your group account(A)? ---------
0	**3**	You invest in your group account(A)? ---------
1	**0**	You invest in your group account(A)? ---------
1	**1**	You invest in your group account(A)? ---------
1	**2**	You invest in your group account(A)? ---------

1	**3**	You invest in your group account(A)? [---------▼]
2	**0**	You invest in your group account(A)? [---------▼]
2	**1**	You invest in your group account(A)? [---------▼]
2	**2**	You invest in your group account(A)? [---------▼]
2	**3**	You invest in your group account(A)? [---------▼]
3	**0**	You invest in your group account(A)? [---------▼]
3	**1**	You invest in your group account(A)? [---------▼]

3	**2**	You invest in your group account(A)? ---------
3	**3**	You invest in your group account(A)? ---------
4	**0**	You invest in your group account(A)? ---------
4	**1**	You invest in your group account(A)? ---------
4	**2**	You invest in your group account(A)? ---------
4	**3**	You invest in your group account(A)? ---------
5	**0**	You invest in your group account(A)? ---------

5	**1**	You invest in your group account(A)? ---------
5	**2**	You invest in your group account(A)? ---------
5	**3**	You invest in your group account(A)? ---------

After you have decided your Conditional Investment, you can proceed to Task III.

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Task III: Survey

Please answer the following questions. The earning from this task is 4.4 tokens.

1. What is your age?

2. What is your gender?

- ○ Male
- ○ Female
- ○ Other

3. How would you describe your ethnicity (please pick the most applicable)?

- ○ Caucasian (of European ancestry)
- ○ East Asian (e.g., Chinese, Thai, Japanese, Malaysian, Vietnamese, Indonesian)
- ○ South Asian Subcontinent (e.g., Indian, Pakistani)
- ○ Middle Eastern
- ○ Black (of African ancestry)
- ○ Hispanic
- ○ Mixed/Other

4. A bat and a ball cost $1.20 in total. The bat costs $1.00 more than the ball. How much does the ball cost?______ cents :

5. If it takes 10 machines 10 minutes to make 10 widgets, how long would it take 100 machines to make 100 widgets?____ minutes :

6. There is a patch of lily pads in a lake. The patch doubles in size every day. If it takes 50 days for the patch to cover the entire lake. How long would it take for the patch to cover half of the lake? ____ days:

7. Do you have any comments about the experiment?

[ ]

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Final Outcome

Your final income is the sum of your base rate and the bonus from the three tasks.

Your base rate is $ 0.5, which will be transferred to you after you finish the experiment.

Your bonus from each task will be only calculated after we collect decisions of all participants, which will be done in a few days. After that we will notify you and transfer the bonus.

We thank you for your participation in our study.

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3 Strategy analysis on an experimental data of indefinitely-repeated trust game

3.1 Introduction

Background

From product design of financial investment to partnership agreements for international enterprise, trusting and reciprocating that trust with trustworthy actions is part of everyday economic behavior. Often, a mixture of trust and distrust exists in our economic behavior. Especially when facing a stranger with no record of a direct encounter with that same person being accessible, people may become more cautious in taking action. After encountering an untrusted stranger, people may vary their trusting behavior in the next new encounter. Some may still place their trust in strangers and expect society to return to a social norm of trust and reciprocity. Others may choose to punish untrusted behavior by showing no trust anymore. To understand the possible patterns behind trusting strangers, researchers use experimental approaches to study trust games that can be used to identify and predict trusting behavior in the context of monetary incentives.

Whether people trust strangers in modern society is an issue of economic importance as well as in the social and cultural domain. People interact with strangers anonymously and repetitively. If people never met again and people would not be punished for dishonesty (at least not directly from the person they cheated), the actions would be different. This scenario could be simulated in a trust game by running an economic experiment. In the trust game, there are two roles (Investor and Trustee). To simulate encountering strangers, subjects are randomly and anonymously matched in pairs after every encounter. The payments for both roles during this encounter are dependent on the result in the current encounter.

Although all actions observed in the experiments may show records of behavior related to trust, researchers are trying to identify potential patterns that may be linked to the individual strategy. This observation focuses mostly on trust behavior, where the logic and strategy behind trustworthy behavior rarely presents itself on the surface of the data. How the subjects react to each other or whether they are in certain behavioral patterns, which are not presented directly in the data set, is a matter of the unknown. This paper explores the implications of this behavior through a strategy analysis.

Contribution

The strategy analysis used in this paper is an application of the finite automata fitting. The findings of the specific strategies enrich the results in the literature of trust games. The dataset used in this paper is from an experiment paper (Duffy, Xie, & Lee , 2013)[19].

To the author's knowledge, most studies on strategy analysis focus on the repeated Prison's Dilemma game rather than the trust game. Among those papers on the Prisoner's Dilemma game, my methodology is mostly related to (Camera, Casari, & Bigoni, 2012)[11]. However, given the different game structure, this paper creates strategies for the trust game.

The other related paper is Engle-Warnick and Slonim (2006)[25], which also focuses on repeated trust games. However, their paper differs from this paper from several perspectives. First, the data used in this paper involves random rematching between the players in each period, which shows the implications of the social norm of trust and reciprocity at the stranger level. While their data involves a fixed matching protocol, which shows the implications of a fixed long-term relationship. Both papers apply the finite automata method, but this paper uses a different procedure of estimation.

In the strategy fitting procedure, I firstly code the initial-state automata for the strategies. In the trust game, there are two initial states for the first player (Player A: Investor): "Send" or "Don't send". Based on these actions, this project defines for Investor 16 strategies and 6 strategy sets; and for the second player (Player B: Trustee) there are three initial states: "Return", "Keep", or "Blank". Based on these states, this paper defines 24 strategies and 11 strategy sets. Then I match the data through a fitting procedure with these defined strategies. Furthermore, to allow the participants to make a certain level of error, an error probability is added to the strategy fitting. Finally, this paper identifies and characterizes some patterns employed at the individual level.

This paper shows that (i) When facing strangers in the trust game, for Investor, the top three strategies in order are "grim trigger", "systematically Send" and "forgiving"; for Trustee, the most used strategies are "systematically Return", "grim trigger" and "tit-for-tat". (ii) By taking the participant's error probability into account, the strategy pattern and proportions are still maintained. (iii) Compared to the results from the related study, this paper identifies several different strategies that are specific to the behaviors among strangers.

3.2 Literature review on methods of strategy analysis

The strategy analyses of trust games are mostly rooted in the Prison's Dilemma (PD) due to the similarities between these two games. To the author's knowledge, for these repeated game strategies, the most commonly used analysis is classified into four branches: regression inferring, strategy elicitation, maximum likelihood estimation, and finite automata fitting.

Regression

This paper reviews three main methods for regression inference: probit regression, direct inference, and indirect inferring regression.

The most popular method is probit regression, which explains an individual's choice to cooperate or not cooperate using various groups of regressors. The regressors are defined according to the research purpose; for example, Camera, Casari, and Bigoni (2012)[11] introduce several dummy variables that control for fixed effects (cycles, periods within the cycle, individuals), as well as for the duration of the previous cycle ("lag regressors"). Engle-Warnick and Slonim (2006)[25] estimate the effect of history on the probability of taking actions using fixed effects logit models in the preliminary results. Camera, Casari, and Bigoni (2012)[11] identify the grim trigger resulting from the aggregate level of the effect.

The second method for regression inference is direct inference, which allows strategies to be inferred directly from actions as they are called. There are two main approaches to information tracking: one is to validate inferred strategies by tracking how subjects collect and process information, i.e., to collect intentional data as in Johnson et al. (2002)[37]. The other path is to estimate a probabilistic choice model as in El-Gamal and Grether (1995)[22], Engle-Warnick (2003)[23], Seltenand Stoeker (1986)[53], and Stahl and Wilson (1995)[55].

The third is the indirect inferring regression. In this regression, the Bayesian method (Engle-Warnick, McCausland, & Miller, 2004)[24] has been used to estimate repeated game strategies when measuring the regression. They look at certain personality characteristics (such as extraversion, agreeableness, conscientiousness, self-esteem, etc.) and their effect on cooperation levels (e.g., see Kurzbanand and Houser (2001)[40] and the references therein.

The above methodology is primarily based on data regression. They can achieve a general action rate or present one or two related action parameters. However, they do not say exactly what players' strategies are or what the exact levels of cooperation would be. The following strategy analysis methods are capable of doing that.

Strategy elicitation

Researchers want to get specific strategy answers from the subjects themselves. Eliciting strategies have a long and well-known history, starting with the work of Robert Axelrod. Axelrod (1980)[2] reports results from an experiment in which 14 participants (game theorists) submitted strategies for a finitely repeated PD. This is a modified strategy method from Reinhard Selten and later used by Selten, Mitzkewitz, and Ulrich (1997)[54]. Recently, Dal Bó and Fréchette (2019)[17] study the strategy elicitation in their infinitely repeated PD experiment. Strategy choices are made observable through direct elicitation. The elicitation of strategies consists of asking subjects to submit a strategy: a plan of behavior for each possible contingency. Subjects are required to explicitly consider every contingency. Researchers analyze the subject's report and the actual choice.

Maximum likelihood estimation

Researchers have tried to measure the strategies with maximum probability. Engle-Warnick, and Slonim (2006)[25] add a stochastic element to the machines to do likelihood-based inference on machines using data from experiments. They interpret random actions as deviations from deterministic actions and realizations of low probability actions as errors. Their paper is the introduction of the first formal statistical procedure inferring finite state machines as repeated game strategies.

Dal Bó and Fréchette (2019)[17] also study an indefinitely repeated Prisoner's Dilemma with an expected duration. They estimate subjects' strategies by fitting the data, via the maximum likelihood approach, to a set of six possible strategies, which they then use to determine their outcomes. After looking at the behavior of experienced subjects, they find support for "tit for tat" and "always defect". However, their results are only based on the specific six strategies. An infinite number of strategies is still a problem until finite automata are created.

Strategy-oriented finite automata

Engle-Warnick and Slonim (2006)[25] apply the finite automata and estimate the strategies used in an indefinitely repeated trust game. They formalize strategies using the notion of finite automata (Rubinstein, 1986)[51]. They empirically identify the strategies employed by subjects and also use the randomness to describe transitions in Engle-Warnick et al. (2004)[24]. In their strategy set analysis, they model repeated game strategies using Moore Machines to an empirically manageable size and measure the fitting by the unique goodness of fit. They find that the grim-trigger strategy explains most first movers' behavior and a small number of strategies seem to explain second-movers' behavior.

Compared to the finite automata method that used Engle-Warnick et al. (2004)[24], Camera, Casari, and Bigoni (2012)[11] have different features. Subjects interacted as strangers for 20 periods in expectation. Bednar, Chen, Liu, and Page (2012)[4] present a multiple-game experiment (one of which is PD) demonstrating that significant ensemble effects on game-playing behavior are not observed in the control group. They introduce the finite automata method to strategy level analysis. Including the 2-state strategy, they take into consideration the use of 3-4-5-states. Ioannou and Romero (2014)[33] propose their belief-learning models with repeated-game strategies using the Moore Machine. Based on datasets from Prisoner's Dilemma, Stag-Hunt, Chicken Games, and the Battle of the Sexes, they find that the strategy-learning models approximate subjects' behavior substantially better than their respective models for action learning.

Summary

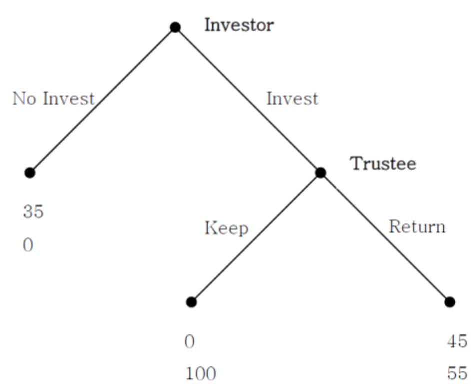
Generally, these strategy analyses can be classified into aggregates and individuals based on identifying specific and appropriate strategies. Probit and logic models typically use direct and indirect regression methods. Others are those methods that measure the distance with probability logic: Bayesian and maximum likelihood. These methods can present one or two general and common feature choices, but they cannot specify individual action strategies. This requires an action originating from method elicitation or a strategy-originating method from finite automata.

3.3 Experimental design and data

The trust game and dataset presented in this paper are all from Duffy, Xie and Lee (2013)[19].[25] They use a version of a repeated two-player sequential "trust" (or "investment") game (Berg, Dickhaut, & McCabe, 1995)[6]. In this version of the game, Player A or "Investor" decides whether to invest his endowment with the second mover (the latter is known in strategy as "Send" or "Don't send"), Player B or "Trustee", resulting in an uncertain payoff. Alternatively, the investor can simply keep his endowment. If the investor invests (or "Send"), the endowment is multiplied by a fixed factor that is greater than one and it falls to the trustee to decide on actions (the strategy is defined by "Keep" or "Return"): whether to keep the whole amount or to return some fraction of it to the investor (i.e. to "reciprocate"), keeping the remainder for himself. In the experiment, the return fraction is set by the researchers. Subjects are asked to play repeated versions of this game where, in each period, subjects were randomly and anonymously paired with one another.

The parameterization of the stage game used in all experimental sessions is given in Figure 3.1. In this figure, the terminal nodes of the tree give the number of points each type of subject earned under the three possible outcomes for each stage game played. This parameterization of the game was chosen to be consistent with the theoretical assumption (Duffy, Xie, & Lee , 2013)[19]. The experiment was programmed and conducted using z-Tree software (Fischbacher, z-Tree: Zurich toolbox for ready-made economic experiments, 2007).

Figure 3.1: Stage Game Parameterization Used in the Experiment



Source: Duffy et al. (2013)

The experiment is a non-information treatment where reputation formation is impossible. An

[25] Duffy, Xie, and Lee, (2013)[19], it is called “the experiment” in this whole section.

economy comprises six persons (3 investors and 3 trustees) who interact privately and anonymously. Each of these experimental sessions involves a single group of size 2n = 6. The interaction is private because subjects observe only outcomes in their pair but not in the rest of the economy. Subjects are randomly assigned to be an Investor or Trustee. Subjects are not in a stable partnership but are randomly matched in pairs after every encounter. Each period each Investor is paired with a Trustee by a uniform random matching rule to play the trust game. All session participants observed the same random draw, which means that rounds for all economies terminated simultaneously. All the sessions are independent of each other.

The experiment is a supergame (or round, as it was called in the experiment), which consists of an indefinite interaction among subjects achieved by a random continuation rule. The interaction is of finite but uncertain duration because in each period a round continues with a constant probability $\delta = 0.8$. Each supergame may have different periods. The length of the periods (also the number of actions) may be different for each individual. For the strategy analysis in this paper, an observation is a supergame of an individual, i.e. the sequence of all the actions of a subject in a supergame. There are 318 observations with a total of 1590 periods (Duffy, Xie, & Lee , 2013)[19].

Generally speaking, the trust game may have some resemblance to the Prison's Dilemma in roles, payoff, and iteration, but it has some interesting differences. Firstly the roles of the two players are not symmetrical in the trust game. Player A always makes the move before Player B. Player A is the trustor who is supposed to be in the role of giving trust. Player B is the trustee who decides whether or not to return this trust. Secondly, the sequence between the two players does make sense and may affect the results. Asymmetry and sequence are two key features of the trust game that will be key considerations in the identification of this strategy. Furthermore, these two roles differ in their strategy path, and connecting the two may have implications for trust-related procedures.

In this study, I want to study what strategies people use when facing strangers. Studying strategy adoption within an anonymous random matching experiment offers several advantages. In economies with more than two-paired participants' coordination on strategies is more interesting and challenging. Anonymity implies that strategies based on reputation cannot be employed. It also more closely resembles real-life stranger social norm function.

3.4 Methodology

3.4.1 States

As mentioned in the strategy analysis method literature review (section 2), strategy-oriented finite automata (FA) is a comparatively recent methodology to apply for the prisoner's dilemmas and trust game.

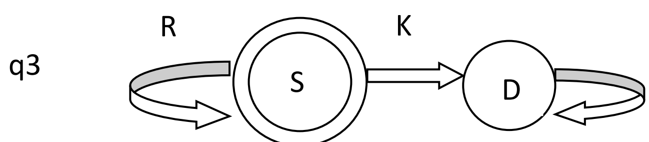
The idea that finite automata theory can be useful for modeling bounded rationality in economic contexts is formally introduced by Rubinstein (1986)[51]. He examines models where players select finite automata as their strategies. His Moore Machine and state constrain are widely acknowledged and most FA methods can be traced to his notations.[26]

By limiting recall to finite states, this paper tries to represent players' strategies by finite automata. Finite automata offer a way to delimit and determine the strategies among the infinite and uncertain action records. Automata with sufficiently many states can describe any type of behavior observed in the experiment. Intuitively, a finite automaton can be thought of as a set of mental states. Each state represents a different mood (for example good and bad) and therefore may lead to a different behavior (trust and distrust). Based on the actions of the other player, the mood might change, in which case the automaton moves (transitions) to a different state. A more sophisticated player may have many states which represent a complex strategy, while a simple player may have only a handful of states. Automata choose actions deterministically and can transition from state to state stochastically.

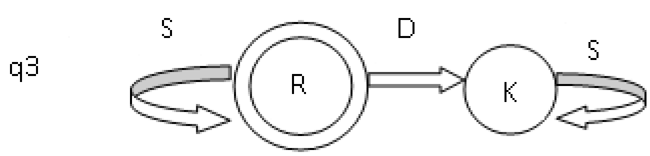
This paper considers the initial state automata. As an example, Fig. 3.2 illustrates “grim trigger” for Player A and Player B. Actions are either S=send or D=don’t send for Player A, R=return or K=keep for Player B; a circle corresponds to a state for the player, where the initial state is a double circle; the outcome function is the identity function. i.e. the unique action prescribed is written inside each circle; the arrows represent transitions between states, which depend on the opponent’s action reported next to each arrow. Take Player A, for example: her initial action is Send, she chooses to trust Player B and expects to be reciprocated in the next period. And as long as Player B reciprocates her (chose Return), she will choose to “Send” in the next period. But if she saw Player B “keep” all the money, she will choose “Don’t send” for all the following periods.

Figure 3.2: Trust game strategy: grim trigger, two-states

For Player A



For Player B



By identifying the initial state and combining each period of action, this paper tries to identify

[26] In such model, each agent’s pure strategy space is the space of modified FA called Moore machines. A Moore machine is a FA that labels each state with an output. This output corresponds to the action that that agent plays at his/her next choice node.

and classify the possible strategies used for both Players within the initial states. To identify different strategies and classify similar strategies, the next step is to have a strategy definition based on the initial states.

3.4.2 Classification

The trust game strategy definition in Table 3.1 and Table 3.2 are separate for Player A and Player B strategies. Those are similar to the strategies used by Camera, Casari, and Bigoni (2012)[11], but they designed it for Prison's Dilemma, and they have 32 strategies. This paper focuses on the trust game and builds in 16 strategies for Player A and 24 strategies for Player B. For a detailed explanation see Appendix A: FA definition of strategy and strategy set.

For Player A, there are 2 initial states identified by the action prescribed in that state, S or D, which are reached depending on the 3 possible outcomes of the match (SR, SK, D). This class of automata is small—there are only $2^4 = 16$ two-state automata—yet it allows representing the most common strategies in the literature. This paper names each a strategy code ($q_i, i \in [1,16]$).

In Table 1, Player A starts with one of the two initial states (S or D). Each of the 16 strategies is coded as a four-element vector. Each element corresponds to a state, i.e. an action to be taken, with S=1 and D=0 (for Player A). The first element is the initial state. The remaining three elements identify the state reached following current play (equivalently, the action to be implemented in the next period). The remaining elements identify the states reached given the last period play (S, R), (S, K), and (D), respectively.

Table 3.1: Classification of strategies for Player A

strategies starting with S=send			strategies starting with D= don't send		
	strategy	strategy set		strategy	strategy set
q1	1111	systematically Send	q9	0000	systematically Don't send
q2	1110		q10	0100	
q3	1100	grim trigger	q11	0010	
q4	1101	forgiving	q12	0110	
q5	1011	unconventional	q13	0001	unconventional
q6	1010		q14	0101	
q7	1001		q15	0011	
q8	1000		q16	0111	

For Player B, there are 3 initial states: K=0, R=1, B=2. Besides Return and Keep, Player B may face Blank as the first mover Player A doesn't send at the beginning. They are defined as in Table 2. There are 3 initial states (R, K, B) which are reached depending on the 3 possible outcomes of the match (SR, SK, D). This class of automata is 24. Each strategy is named as strategy code ($q_i, i \in [1,24]$). Player B starts with one of the three initial states (R, K, or B). Each element corresponds to a state, i.e. an action to be taken is R=1, K=0 (for Player B's choice). The remaining elements are similar to Player A strategy definition.

Table 3.2: Classification of strategies for Player B

strategies starting with R=return			strategies starting with K=keep		
	strategy	strategy set		strategy	strategy set
q1	1111	systematically Return	q9	0000	systematically Keep
q4	1101		q10	0100	
q3	1100	grim trigger	q11	0010	unconventional
q2	1110	tit-for-tat	q12	0110	
q5	1011	unconventional	q13	0001	
q7	1001		q14	0101	
q6	1010		q15	0011	
q8	1000		q16	0111	

Table 3.2 (continuous)

strategies starting with Blank		
	strategy	strategy set
q17	2111	always Return
q18	2100	grim trigger
q19	2110	tit-for-tat
q20	2000	always Keep
q21	2101	unconventional
q22	2001	
q23	2011	
q24	2010	

These four-element instructions are interpreted to define certain strategies and strategy sets. For Player A, the initial action is S for four strategy sets and D for two sets. For example, the automaton (strategy code q_1) 1111 is "always trust" and does not allow for errors or experimentation. No matter what outcome in the previous (SR, SK, D), this player will always "Send" (initial state:1, SR:1, SK:1, D:1).[27] The same holds for 0000; it is always distrust. The automaton (strategy code q_2) 1110 is Player A starts with "Send", and she always chooses "Send" when the last period outcome is SR or SK; she is only allowed to "Don't send" if in the last period her action is "Don't send"; this q_2 with q_1 comprise a strategy set called "systematically send". The strategy code q_3 (1100) matches the case called "grim trigger" where Player A starts with "Send". As long as the outcome is SR, she will "Send". Until she sees "SK" in the last period, she will choose "Don't send" as a punishment for the trust-broken outcome. The unconventional strategies may prescribe those unusual, irregular actions.

[27] SR: Player A "Send" with Player B "Return"; SK: Player A "Send" with Player B "Keep"; D: Player A "Don't send".

3.4.3 Fitting procedure

The strategy-fitting procedure is a mapping from the experimental data into the strategies and strategy sets in Table 1 and Table 2. The observation is the sequence of all actions of a subject in a supergame. Observation is a sequence. For every individual, I first select the strategy that best describes ("fits") her sequence of actions among the sixteen strategies available. Then I check whether the description of behavior provided by this best-fitting strategy is sufficiently accurate. If it satisfies the critical value, I classify the individual by that strategy.

Every non-initial period, one subject's action will be traced and limited within one of the three states (SK, SR, D). These states are linked to three automata ($Z_i, i \in [1,2,3]$). Each time, subjects make a decision with knowledge of their outcome in the previous period. One observation could be classified by more than one strategy as long as her action consists of those automata.

Observations of the strategy

In the fitting procedure, one observation is the choices of a subject in a super game. N is the number of observations classified by a strategy. Note that this observation is a sequence of actions. The total fit N(q) of a strategy q is the number of observations that strategy q fits. One sequence of actions could sometimes be classified by more than one strategy. Therefore, the summation of observations that all the strategies fit, i.e., the summation of N(q) overall strategy q, does not necessarily equal the total number of the supergames.

I also group similar strategies into a strategy set and count the number of observations that fit with the strategy set. Most importantly, if the same observation can fit multiple strategies in the same strategy set, it will be only counted once. For example, an individual in player A sends in the first period. After seeing the last period result is SR (player B returned), she chooses to send. This sequence fits both strategy q1 (1111) and strategy q2 (1110), which are in the strategy set named "Systematically Send" The strategy set in this case is to count either q1 or q2 happens, i.e. those observations that double-counted in both q1 and q2 will be only counted once.

The number of observations classified by the strategy set is the total number of observations classified by any strategy in the strategy set without duplication. The total fit N(Q) of a strategy set Q is the number of observations that can be explained by at least one strategy $q \in Q$.

Consistency score

Each strategy code is a four-element automaton, so this paper fits a strategy code when the initial state is correct, and the consistency score is one. Suppose all the subjects know their strategy and they accurately follow each code when any one of the three spaces occur, there will be a consistent record between their action and strategy state. This paper modifies the consistency score (Camera, Casari, & Bigoni, 2012)[11] to the trust game strategy. It is the average of all the actions during that period: $X_q(T) = \sum_{\tau=1}^{T} x_{q,\tau} / T$ in a supergame of duration T, if a subject's action in period t of around corresponds to the outcome generated by correct implementation of strategy q, the average consistency should be the full score, which is one.

For instance, q3 (1100) is a grim trigger. Player A starts with Send, and when she sees last period Player B Return, she will keep Send; otherwise, either she sees Player B Keep, and she moves by Don't send as punishment. Or, when she sees last period Don't send, this means that she is still in the act of punishing. If these separated actions are consistent with this definition, the consistency score will be one.

3.4.4 Random transition

In some cases, certain random transitions are allowed during the strategy fitting. Subjects may make mistakes or implement experiments, so the actions probably don't match all the strategy automata. In this case, I use the Binomial distribution as a statistical test.[28]

This research sets the participant's error probability, denoted as p, equal to 5%, and tests the data with the 0.1 significant level. For example, if a sequence lasts less than four periods, not even one inconsistent action is admissible; the largest period is 28 in this data; the above statistic significant level allows at most 2 incorrect transitions in this sequence.[29]

To be precise, one observation can be classified to strategy q if firstly it correctly predicts the initial action, $x_{q,1} = 1$ (This is because errors in transition can occur only across periods); Then, if q has the largest consistency score among all strategies considered, $X_q(T) \geq X_{q'}(T)$ for all $q' \neq q$. Finally, Strategy q does not fit the observation if the observations lay in the 10% right rail of the distribution of errors. The observation is counted by strategy q if the Binomial value is small and equal to 0.9. Table 3 and Table 4 are the output summary of the strategy fitting with a 5% error probability.

[28] The number k of a subject's actions that are inconsistent with a strategy q in a sequence of duration T is distributed according to a binomial with parameters p and T-1. P is the possibility of inconsistent. T is the period that players make moves. Specially mentioned, T for Player B is not the same as Player A since it is the periods that the trustee can have actions. It is smaller than Player A's. In some cases, Player B has no action record at all because Player A never sends during the whole sequence. The expected number of inconsistent actions increases with T and p.

[29] Technique part: As a statistical test, strategy q does not fit the observation if the observation lays in the 10% right tail of the distribution of errors. The strategy does not fit the observation if the probability of observing k or more inconsistent actions is smaller than 0.1.

3.5 Results

3.5.1 Results on strategy and strategy set

The fitting results of strategy and strategy set are presented in Table 3.3 and Table 3.4. When no error is allowed, the results are in the p=0 column. An observation's consistency score for that strategy needs to be equal to one. When allowing subjects to make mistakes, the results are in the p=0.05 column. Observations need to pass the statistical test.

On one hand, 138 observations fit the grim trigger, and this is the topmost strategy among all the strategies starting with Send. Allowing a 5% probability of error, this number increases to 151 and it is still the most commonly used strategy in this classification.

On the other hand, strategy q1 (1111) and strategy q2 (1110) are both ranked as the second strategies. Their difference in coding is the last dimension: when facing the last period of "Don't send", q1 action is "Send" but q2 action is "Don't send". The result from the data set shows that they both fit 122 observations. The strategy set for these two strategies (counting either of them) is 122 observations. It is called systematically Send. One possible interpretation is that these 122 observations are the same. They are counted in both strategies q1 and q2. Then they also present in the strategy set.

At p=0.05, both q1 and q2 strategies fit more observations of 128; however, the strategy set for these two increases to 133. Each strategy increases by 6 fittings (128-122), while the strategy set increases by 11 fittings (133-122) not 12 fittings (6+6). It means that 6 fittings in both q1 and q2 are not identical. Only 1 fitting is overcounted between q1 and q2.

Although some sequences are overcounted in the fitting procedure, finite automata can still show us a distribution of trusting behaviors among all the strategy and strategy set. In the following section, I will deal with the overcounting in the strategy set and specifically pin down the percentage for the individual level.

Table 3.3: Player A strategies p=0 and p=0.05

strategies starting with S=send						
			p=0		p=0.05	
	strategy	strategy set	strategy	strategy set	strategy	strategy set
q1	1111	systematically Send	122	122	128	133
q2	1110		122		128	
q3	1100	grim trigger	138	138	151	151
q4	1101	forgiving	115	115	119	119
q5	1011	unconventional	52	83	52	90
q6	1010		50		52	
q7	1001		56		57	
q8	1000		69		76	

Table 3.3 Continuous

strategies starting with D=don't send						
			p=0		p=0.05	
	strategy	strategy set	strategy	strategy set	strategy	strategy set
q9	0000	systematically Don't send	75	75	79	84
q10	0100		75		82	
q11	0010		75		78	
q12	0110		75		81	
q13	0001	unconventional	17	28	18	31
q14	0101		24		26	
q15	0011		19		19	
q16	0111		24		26	

*Note*s: The observation is a supergame of an individual.

Table 3.4: Player B strategies p=0 and p=0.05

strategies starting with R=return						
	strategy	strategy set	p=0		p=0.05	
			strategy	strategy set	strategy	strategy set
q1	1111	systematically Return	106	106	119	121
q4	1101		106		115	
q3	1100	grim trigger	87	87	94	94
q2	1110	tit-for-tat	87	87	98	98
q5	1011	unconventional	47	53	55	64
q7	1001		47		55	
q6	1010		48		55	
q8	1000		42		47	

Table 3.4 Continuous

strategies starting with K=keep						
	strategy	strategy set	p=0		p=0.05	
			strategy	strategy set	strategy	strategy set
q9	0000	systematically Keep	61	61	63	63
q10	0100		61		61	
q11	0010	unconventional	37	59	42	64
q12	0110		39		39	
q13	0001		48		50	
q14	0101		46		46	
q15	0011		35		40	
q16	0111		34		36	

Table 3.4 Continuous

strategies starting with Blank						
	strategy	strategy set	p=0		p=0.05	
			strategy	strategy set	strategy	strategy set
q17	2111	always Return	28	28	34	34
q18	2100	grim trigger	20	20	22	22
q19	2110	tit-for-tat	16	16	20	20
q20	2000	always Keep	20	20	23	23
q21	2101	unconventional	28	43	33	50
q22	2001		14		17	
q23	2011		14		17	
q24	2010		15		18	

Notes: The observation is a supergame of an individual.

3.5.2 Results on the classification

The number of observations for strategy sets in Table 5 and Table 6 are the same as shown in Table 3.3 and Table3.4, respectively. To count the observations for the initial states, I remove the duplicated counting among these strategy sets and count the classified and unclassified observations for each role.

Player A output

Among the total 318 observations, 273 can be classified, i.e. 85.8% of observations have been classified into this FA strategy. Among the 215 observations with the initial state of "Send", 184 can be classified, i.e. 85.6%. Among the 103 observations with the initial state of "Don't send", 89 can be classified, i.e. 86.4%. When taking into account the participant's error probability as 0.05, the classification increases to 95.2%. Table 3.5 displays a summary of the results from the empirical identification of strategies.

For Player A, the most common behavior is consistent with the "grim trigger". The other two largest clusters of classifieds are "systematically Send", and "forgiving", which present some similar results to Engle-Warnick and Slonim (2006)[25]. When subjects distrust at the beginning (the initial state is "Don't send"), two strategies are identified: "systematically Don't send" and "unconventional". Most people will consist of the distrust strategy as they chose distrust initially. When allowing the participant's error probability of 0.05, the distrust strategy distribution keeps the same shape as well as increases in the fitting numbers.

Table 3.5: Player A strategy classification

All observations			318	
	S in period 1		215	
	D in period 1		103	
			p=0	**p=0.05**
Classified			273	303
	S in period 1		**184**	**205**
		systematically Send	122	133
		grim trigger	138	151
		forgiving	115	119
		unconventional	83	90
	D in period 1		**89**	**98**
		systematically Don't send	75	84
		unconventional	28	31
Unclassified			45	15
	S in period 1		31	10
	D in period 1		14	5

Notes: The observation is a supergame of an individual.

Player B output

For Player B, those who begin with Return (from Table 3.6) would reciprocate to Player A for her trust. “Systematically Return”, “grim trigger” and “tit-for-tat” appear the equal influence under the deterministic actions. When allowing them to test opponent reaction, do and learn, or even make mistakes, the “systematically Return” tops the other two strategies. That means most people chose to return the trust and no matter what. The second and the third most used strategies are “grim trigger” and “tit-for-tat”, which suggests the rule that as long as you trust me, I will return. But they still observe how the trust was broken. If the opponent stops following the trust and return, they may react by punishing (grim trigger) or forgiving (tit-for-tat).

For Player B, the FA strategy classifies most of the subjects' behaviors, just as it does for Player A. Under the deterministic case, the majority of observations have been classified into this FA strategy. As Player B is the second mover, they have the chance to take an action only when the first player chooses “Send”. If Player A always chooses “Don’t send” in the supergame, Player B does not have any action in this supergame. Among the total 318 observations, 45 observations are those that they have no action in the entire sequence, so we only analyze the remaining 273 observations.

Among the 273 observations for Player B, 240 (87.9%) can be classified according to our method. Among the 140 observations with the initial state of “Return”, 121 can be classified, i.e. 86.4%. Among the 75 observations with the initial state of “Keep”, 70 can be classified, i.e. 93.3%. Among the 58 observations with the initial state of “Blank”, 49 can be classified, i.e. 84.5%. When taking into account the participant’s error probability as 0.05, all observations can be classified by the FA strategy.

Table 3.6: Player B strategy classification

All observations		318		
	R in period 1	140		
	K in period 1	75		
	B in period 1	58		
	no actions	45		
			p=0	**p=0.05**
classified			240	273
	R in period 1		**121**	**140**
	systematically Return		106	121
	grim trigger		87	94
	tit-for-tat		87	98
	unconventional		53	64
	K in period 1		**70**	**75**
	systematically Keep		61	63
	unconventional		59	64
	B in period 1		**49**	**58**
	always Return		28	34
	grim trigger		20	22
	tit-for-tat		16	20
	always Keep		20	23
	unconventional		43	50
unclassified			33	0
	R in period 1		19	0
	K in period 1		5	0
	B in period 1		9	0

Finding 1: This paper classifies 85.8% of Investors and 87.9% of Trustees into these FA strategy sets. Furthermore, allowing participants to have a 5% error rate, for Investors, the fittings increase to 95.2% and for Trustees, all observations are classified.

Finding 2: Considering the initial states, the majority of participants start by trusting strangers. In the classified strategy sets, the highest rates are "Send" and "Return" for the Investors and Trustees, which is 67.3% and 50.4% respectively.

Finding 3: For the Investors, if they start with “Send”, the top strategy is “grim trigger”. For the Trustees, if they “Return” the trust at the initial, the top strategy is “systematically return”.

Finding 4: For the Investors, if they “Don’t send” in the initial state, the top strategy is “systematically Don't send”. For the Trustees, if they “Keep” in the initial state, the top strategy is “systematically keep”.

Finding 5: Various strategies are identified in different roles. “Forgiving” is observed in the Investor with an initial state of “Send”. “Tit-for-tat” is observed in the Trustee with an initial state of “Return”.

3.6 Comparison with Engle-Warnick and Slonim (2006)

As mentioned in part 2, to the author's knowledge, one paper also analyzes strategies in repeated trust games. Engle-Warnick and Slonim (2006)[25] estimate the strategies used in an indefinitely repeated trust game. They find that the grim-trigger strategy explains most first movers' behavior and a small number of strategies seem to explain second-movers' behavior. Both papers focus on the repeated trust game, but the data used in this paper is random opponent settings. And further analysis in this paper allows for participant's errors. Hence, the strategies (strategy sets) found in the paper have a fundamental difference from theirs. Their data set is from a fixed relationship, while the data set for this paper is from a random stranger. The detailed research target and experimental parameters are shown in Table 3.7.

Table 3.7: Comparison of the experiments

	indefinite supergame	random opponent	obs per role	average rounds	continuation probability
Engle-Warnick and Slonim (2006)	√	×	553	5.1	0.8
Duffy, Xie, and Lee (2013)	√	√	318	5.0	0.8

Table 3.8: Comparison of the results

	Strategy result	Investor	Trustee
(1)	measure a few strategies fitting percentage	grime trigger	1. unconventional 2. systematically return 3. systematically keep
(2)	code all the strategies distribution	1.grim trigger 2. systematically send 3.forgiving	1. systematically return 2. grim trigger 3. tit-for-tat

Notes: (1): Engle-Warnick and Slonim (2006); (2): this paper

These two papers use different finite automata to identify their own trust game. But there is still a significant similar strategy result (see Table 3.8). Engle-Warnick and Slonim (2006)[25] find the most fitting four inferred strategies in an indefinite super game. For Player A the most fitting strategy is the grim trigger strategy, which is also the strategies, q3, found in this paper. Besides this, the other two strategies: "systematically send" and "forgiving" are also identified in this paper. For Player B, Engle-Warnick and Slonim (2006)[25] find that the most fitting strategies are Mb6, Mb11, Mb25, and they are corresponding to this q5, q4, and q10 respectively; by this definition, they are "unconventional", "systematically return" and "systematically keep". As shown in section 5, this paper separates Player roles and their initial state to present specific strategies. This paper discovers more strategies like the "grim trigger" and "tit-for-tat" from the data.

Finding 6: Compared to the results in Engle-Warnick and Slonim (2006), this paper identifies more strategies in Investors and several different strategies in Trustees.

3.7 Conclusion

This paper applies the state finite automata for the trust game and identifies the player's strategies in an indefinitely repeated trust-game experiment. It forms three demission strategies that include all the possible actions of inefficient states. It turns the indefinite action history into definite strategies by constructing strategy codes. As this paper has shown, the method performs well if the relevant strategies are included in the set of possibilities. Furthermore, this paper presents and discusses the player's random actions under the statistic test. The introduction of participant's error probability allows for learning, testing, or error actions in trust game strategy analysis, so it enhances the strategy fitting score and categories identification.

The main result from this paper is that if the Investor starts with "Send", the top strategy is "grim trigger". If the Trustee chooses to "Return" this trust initially, the top strategy is "systematically Return". The implications are for trust between strangers: while some people choose to trust strangers first then turn to distrust forever if they are deceived, others reciprocate that trust as long as they are on the road of being trusted.

3.8 Appendix A: FA definition of strategy and strategy set

Player A

- ✧ 4 vectors: (initial, SR, SK, D),
- ✧ Four states, one initial state, and a three-dimension state
- ✧ Z0==initial: 1: Send, 0: Don't send
- ✧ Z1==SR (last period player A Send and player B Return)
- ✧ Z2== SK (last period player A Send and player B Keep)
- ✧ Z3==D (last period player A Don't send)
- ✧ Z0 to Z3: Each vector has two choices (1: Send, 0: Don't send)
- ✧ $2^4 = 16$ Number of strategies

Table 3.9.A1: Classification of strategies for Player A

strategies starting with S=send			strategies starting with D=don't send		
	strategy	strategy set		strategy	strategy set
q1	1111	systematically Send	q9	0000	systematically Don't send
q2	1110		q10	0100	
q3	1100	grim trigger	q11	0010	
q4	1101	forgiving	q12	0110	
q5	1011	unconventional	q13	0001	unconventional
q6	1010		q14	0101	

q7	1001		q15	0011	
q8	1000		q16	0111	

q1 1111: **always send.** The people who use this strategy will always send regardless of what the end results are.
q2 1110: **systematically send**. People start with Send, seeing SR, SK will send, only Don't send when seeing D. When no allowing for transition errors, q2 doesn't happen, q2 will consist of q1.
q3 1100: **grim trigger**. People start with Send, only seeing SR player A choose to send; Otherwise, when the result is SK, I start punishing you; when the result is D, I am still in the punish mood.
q4 1101: **forgiving.** People start with Send, as long as SR I will send, but when I see your keep (SK), I will punish you with D, then I come back to send.
q5 1011-q8 1000: **unconventional strategy.** People start with Send, seeing SR choose don't send, it should be on the high payoff road if persist on send. However, she chooses to Keep all the way. So it is contradicted to the bounded rationality (to maximize the expected payoff). Those who have SR-K are classified into this and named as unconventional.
q9 0000: **always Don't send**.
q10 –q12: **systematically Don't send**. People start with Don't send, allowing for random-transit action on either of SR, and SK happens; or both happen (q12). While persist on Don't send seeing last period Don't send.
q13-q16: **unconventional.** People start with Don't send. It is supposed that she will on the path of don't send; However, when she saw that the last period result is Don't send, she chooses to Send all the way. It is a contradiction. They are classified as unconventional.

Player B

- ✧ 4 vectors: (initial, SR, SK, D),
- ✧ Four states, one initial state, and a three-dimension state
- ✧ Z0==initial: 1: Return, 0: Keep, 2: Blank
- ✧ Z1==SR (last period player A Send and player B Return)
- ✧ Z2== SK (last period player A Send and player B Keep)
- ✧ Z3==D (last period player A Don't send)
- ✧ Z1 to Z3: Each vector has two choices (1: return, 0: keep)
- ✧ $2^4 = 16$ Number of strategies under the initial state of R and K
- ✧ $2^3 = 8$ Number of strategies under the initial state of B

Table 3.10.A2: Classification of strategies for Player B

strategies starting with R=return			strategies starting with K=keep		
	strategy	strategy set		strategy	strategy set
q1	1111	systematically Return	q9	0000	systematically Keep
q4	1101		q10	0100	
q3	1100	grim trigger	q11	0010	unconventional
q2	1110	tit-for-tat	q12	0110	
q5	1011	unconventional	q13	0001	

q7	1001		q14	0101	
q6	1010		q15	0011	
q8	1000		q16	0111	

q1 1111: **always Return.** People who use this strategy will always return regardless of what the last period results are.
q4 1101: **systematically Return.** People start with Return, Return, when the last period is SR; Keep, when the last period is SK. If this person is a systematically Return, the SK will never show up. Only when allowing for errors does q4 show up as a different number to q1. When not allowing for transition errors, q4 will consist of q1.
q3 1100: **grim trigger.** People start with Return, if the last period is SR, she will Return. But, if the last period is SK, she is in a punishing mood. The last period D is the trigger for this punishment.
q2 1110: **tit-for-tat.** People start with Return. Seeing the last period is SR, they Return; Seeing that the last period is SK, they Return; Seeing that the last period is Don't send, they Keep. It is always the same as the opponent's last period of action.
q5-q8: **unconventional.** People start with Return. Seeing that the last period is SR, they react with K. It is contrary to the bounded rationality.
q9 0000: **always Keep**.
q10 0100: **systematically keep**. If that person is a systematically Keep strategy, the vector SR won't matter and shouldn't show up for determination.
q11-q12 **unconventional.** People start with Keep. Seeing that the last period is D, they always K; However, seeing SK they jump to Return.
q13-q16 **unconventional.** People start with Keep. When she is trusted, seeing that the last period is D they contrarily jump to Return.

Table 3.10.A2: (continues)

strategies starting with Blank		
	strategy	strategy set
q17	2111	always Return
q18	2100	grim trigger
q19	2110	tit-for-tat
q20	2000	always Keep
q21	2101	unconventional
q22	2001	
q23	2011	
q24	2010	

q17 2111: **always Return**.
q18 2100: **grim trigger.** Seeing SR, they stay at return; Seeing D, they go to punish. When seeing the last period is SK, they Keep. It means they are in a punishing mood.
q19 2110: **tit-for-tat**. Seeing you send, I will return; Seeing you don't send, I will keep. Exactly, I copy your strategy.
q20 2000: **always Keep**.

q21-q24 **unconventional**. The return or keep has no rules to follow and changes without clearly defining the result.

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