國立台灣大學社會科學院經濟學系

碩士論文

Department of Economics
College of Social Sciences
National Taiwan University

Master Thesis

用經濟學實驗研究:
為什麼有人願意跳出來為大眾服務
Other-regarding Preferences in Experimental Dynamic Volunteer's Dilemmas

林政澤

Cheng-Tse Lin

指導教授: 王道一 博士

Advisor: Joseph Tao-Yi Wang, Ph.D.

中華民國 102年8月

August, 2013

誌謝

2012 年初是我生命重要的時間點, 因爲我遇到多位非常好的老師。每位老師各有個性, 待我都是亦師亦友。我向他們學習的東西有的是知識性的學問、有的是佛法的內容, 表面上看來有很大的不同, 但對我來說更深刻的內涵實爲相同。

能完成這篇論文特別感謝我的指導老師: 王道一老師悉心的指導。老師總是給予學生機會和資源, 傾力支持一位學生的成長。老師並在與學生相處過程中, 體現對追求知識的熱情與態度。特別記得在今年初論文進度落後時, 老師以邊雲波先生的詩給我鼓勵:「是自己的手甘心放下世上的享受; 是自己的脚甘心到苦難的道路上來奔走! 」。因爲有老師, 我有非常愉快的台大經研時光。

也感謝在一年香光慧青中心課程中, 關照我的見日法師、見寂法師。還要感謝長時間在福智大專班關心我、照顧我的老師們。其中特別感謝蘇緯博老師, 幫助我更認識善知識的心和自己的心。

感謝經濟系教導過我的老師們。古慧雯老師的個體經濟學、劉錦添老師的計量經濟學、毛慶生老師的總體經濟學讓我對經濟學開始眞的有興趣。吳聰敏老師帶給我思考問題的角度, 並且教我使用 cwTeX 排版。對學問追求認眞且嚴謹的黃貞穎老師也是我景仰的老師之一。張素梅老師則是我的經濟學原理啓蒙老師。還有, 陳旭昇老師、林明仁老師、樊家忠老師、陳釗而老師, 在碩班時間皆不吝給予我不少建議及指導。黃貞穎老師、黃景沂老師, 以及陽明大學吳仕煒老師, 擔任口試委員。在此一併向他們致謝。

特別感謝我親愛的父母親。從小到大是您們無怨無悔養育我、栽培我。升大四那年我說想要念經濟所, 您們全力支持。甚至我達到任何目標, 您們都比我自己還要歡喜。

謝謝 TASSEL 的夥伴們: 特別是同屆的璽維、恩信和一路鼓勵並給予珍貴建議的易珊學姊, 以及曉芳、書彧、富文、孟謙協助執行多場實驗。謝謝同屆的同學們: 日青、玉琦、本剛、安正、奕賢、冠瑋、柏沅、智源, 一起共享台大經濟所難得的時光。

謝謝性航師, 大四上你給的祝福早已成眞。謝謝琬珮一路的陪伴、鼓勵。謝謝一路相伴成長的許多好朋友、老朋友。我不確定這篇論文能對於人類的福祉有多少幫助, 但至少是我的起點。衷心希望所有生命持續走向光明和希望。

林政澤

2013 年 8 月

用經濟學實驗研究:
為什麼有人願意跳出來為大衆服務

林政澤・王道一

民國 102 年 8 月 14 日

摘要

現實生活中, 許多公衆享受的好處來自於個人的志願行爲。例如, 在公車站等車, 至少需要一位乘客注意並即時舉手攔下公車; 一個系所需要一位教員擔任系主任爲全系服務; 嬰兒在深夜哭鬧時, 夫妻兩人至少有一位要犧牲睡眠安撫嬰兒, 否則兩人都不得安寧。在這些情境下, 愈早有人挺身而出, 所有人能享有的好處更多。例如: 在嬰兒深夜哭鬧的例子中, 愈早有人起身安撫嬰兒, 兩人都能得到更多睡眠時間。然而, 志願者必須付出額外的成本, 才能提供此「服務」, 如: 擔任系主任必須犧牲研究。因此, 所有人希望等待別人挺身而出, 自己坐享其成。過去的文獻僅在自利的假設下分析志願者的行爲, 並未加入「考量他人的偏好」(other-regarding preferences)。本文以經濟學實驗驗證「考量他人的偏好」是否影響人類的志願行爲。實驗中, 參與者兩兩分組, 並決定何時跳出來爲全組服務。選擇最早挺身而出的人爲志願者。由於挺身而出花費一定成本, 志願者的報酬將低於非志願者。受試者亦與電腦配對進行相同的實驗, 以資對照。本文發現: (一) 當挺身而出的成本較小, 受試者較願意挺身而出。(二) 相較於受試者兩兩配對, 當受試者與電腦配對時挺身而出的傾向較大。因此,「考量他人的偏好」的確在志願行爲中扮演重要角色, 但並非利他使得人們較願意挺身而出, 而是忌妒使得人們較不願意挺身而出。

關鍵詞: 志工服務、動態志工兩難賽局、社會困境、社會偏好、經濟學實驗

Other-regarding Preferences in Experimental Dynamic Volunteer's Dilemmas

Cheng-tse Lin Joseph Tao-yi Wang*

August 14, 2013

Abstract

Dynamic volunteer's dilemmas have been modeled as individuals deciding whether to volunteer or not based on cost-benefit analysis, as in the war of attrition game. However, this analysis is usually carried out assuming self-interest, without other-regarding preferences. In this paper, we investigate the role of other-regarding preferences in dynamic volunteer's dilemmas using lab experiments in which two players decide when to jump in and volunteer for the pair and contrast the results with a control treatment where subjects play against computers. We find that subjects are more likely to volunteer when dealing with the computer rather than with other participants. Our experimental data provide direct evidence that other-regarding preferences do play a critical factor in this problem, but through envy instead of altruism.

Keywords: Volunteerism; Dynamic Volunteer's Dilemma; Social Dilemmas; Social Preferences; Laboratory Experiment

JEL classification: C91

*Department of Economics, National Taiwan University, 21 Hsu-Chow Road, Taipei 100, Taiwan. Cheng-tse Lin: r00323035@ntu.edu.tw; Joseph Tao-yi Wang: josephw@ntu.edu.tw. En-Hsin Tang, Hsi-Wei Wang, Fu-Wen Hsieh, Meng-Chien Su, Yi-Shan Li, Shu-Yu Liu, and Ally Wu provided excellent research assistance. We thank comments from Chen-Ying Huang, Ching-I Huang, and Shih-Wei Wu and the financial support of the National Science Council of Taiwan. All remaining errors are our own.

Contents

List of Figures

List of Tables

1 Introduction

Among public affairs, many opportunities that benefit a group are affected by individually costly activities. For example, consider a group of people waiting for the bus. When they see the bus at 300 meters away from the bus stop, as long as at least one person raises his/her hand and calls for the bus to stop, the bus driver is likely to see it and not pass through without stopping. Moreover, the earlier one raise his/her hand the more certain the bus will stop. If "raising one's hand" endures an additional cost, it is not clear who will be that person to do so. Quieting a crying baby at night is another impressive example (Bilodeau and Slivinski, 1996). When a baby starts to cry at night, either the wife or husband has to get up and spend his/her sleeping time to quiet the baby while the other can have good sleep. The sooner the baby is calmed, the more good sleep can both wife and husband can have. In these situations where benefits are decreasing as time passes, at least one group member has to be the "volunteer" and bear the cost individually, to maximizes group benefit, while other members can free ride on him/her. This is what is known as the "dynamic volunteer's dilemma".

Other-regarding preferences are likely to play an important role in the dynamic volunteer's dilemma. Imagine a couple quieting a crying baby. The wife (or husband) is willing to sacrifice her (his) own sleep to get up to quiet the baby not only because she/he care about her/his own sleeping time but also that of her/his spouse. It is only if the couple do not love each other, can the one who gets up to quiet the baby be interpreted as a dull volunteer who did so only because he/she could not endure the noise anymore. Thus, assuming self-interest without other-regarding preferences in the dynamic volunteer's dilemma does not reflect the reality.

Nonetheless, nearly all theoretical and experimental studies in economics of "dynamic volunteer's dilemma" are based on self-interest assumption without other-regarding preferences (e.g., Bliss and Nalebuff, 1984; Bilodeau and Slivinski, 1996). Past experimental studies found that the theoretical prediction poorly explain the experimental data. For examples, Bilodeau et al. (2004) found that given subjects' initial endowment and waiting cost, the predictive power of the subgame perfect equlibrium (SPE) is very poor. Otsubo and Rapoport (2008) found that subjects fail to achieve the asymmetric equlibria in which only one group member volunteers immediately, but volunteer earlier than predicted by the symmetric subgame perfect equlibrium (SSPE).

In this paper, we investigate the role of other-regarding preferences in dynamic volunteer's dilemma by incorporating other-regarding preferences into the model, and provide direct experimental evidence to test the model. Using lab experiments in which two players decide when to jump in and volunteer for the group and contrast the results with a control treatment where subjects play against computers, we find that other-regarding preferences do play a critical factor in this problem, but through envy instead of altruism. In fact, subjects tend to volunteer more when facing computerized players, compared to facing other fellow subjects. This documents the exact difference other-regarding preferences make in the dynamic volunteer's dilemma, and demonstrates that other-regarding preferences per se cannot account for the discrepancy between theory and experimental data.

The rest of the paper is organized as follows. Section 2 introduces the dynamic volunteer's dilemma. Section 3 provides the experimental design and Section 4 shows the result. Section 5 contains a discussion of the results and Section 6 concludes.

2 Dynamic Volunteer's Dilemma Game

2.1 The Environment

The dynamic volunteer's dilemma game we investigate is a simplified version of that in Otsubo and Rapoport (2008). Players try to maximize their own utilities by volunteering or wait for other to volunteer and free ride on other's effort. We assume all players in the game are risk-neutral. They each have their own other-regarding preference but they have the same belief of the distribution of all players' other-regarding preferences. Time is discrete and finite, and there are T periods.

In the experiment, we employ the strategy method by asking players to decide when they want to stop the timer before the countdown starts. Whoever chooses the earliest stopping time in the group would be the volunteer of the group, and the timer would stop at that time. Players also can choose not to stop the timer.

Let H_t and L_t be the payoffs of free rider and volunteer for each period t, respectively. The two payoff functions H_t and L_t satisfy the following assumptions:

1. $H_t > L_t$ for all $t \in \{0, 1, ..., T\}$.
2. Both H_t and L_t are strictly decreasing with t.
3. If the timer ends with no volunteer, all players earn a fixed payoff $\varepsilon(\varepsilon > 0)$, which is strictly smaller than L_T.
4. If there are multiple volunteers at the same period t, every volunteer receives L_t.

2.2 Equilibrium with Other-regarding Preferences

Here we consider the case that two players, player 1 and 2, form a group. We use a simple other-regarding model to capture other-regarding preferences in this dynamic volunteer's dilemma game.

$$U_i(x_i, x_{-i}) = x_i + \lambda_i \cdot x_{-i} \tag{1}$$

x_i denotes the monetary payoff of player i, and λ_i indicates player i's other-regarding preferences. We assume $\lambda \in (-1, 1)$. If player i is altruistic, λ_i should be greater than 0. In contrast, if player i is spiteful, λ_i should be smaller than 0.

First, an asymmetric subgame perfect equilibrium in which only one group member volunteers at $t = 0$ exists if $U_i(L_0, H_0) > 0$, for some i.[1]

Secondly, the symmetric subgame perfect equilibrium (SSPE) consists of all players playing the same mixed strategy and volunteering with certain probability each period. We consider the SSPE when both players have the same other-regarding preferences, $\bar{\lambda}$. Let σ_t be the probability that each player volunteers at period t. Therefore, the payoff of both player in each period is

$$u_t = \begin{cases} H_t + \bar{\lambda} L_t & \text{, if free ride.} \\ L_t + \bar{\lambda} H_t \cdot (1 - \sigma_t) & \text{, if volunteer and other free ride.} \\ L_t + \bar{\lambda} L_t \cdot \sigma_t & \text{, if both volunteer.} \end{cases}$$

We derive the equilibrium strategy as follows players volunteer with σ_T at $t = T$ to satisfy:

$$L_T + \bar{\lambda}[H_T(1 - \sigma_T) + L_T \sigma_T] = (1 + \bar{\lambda})\varepsilon(1 - \sigma_T) + (H_T + \bar{\lambda} L_T)\sigma_T \tag{2}$$

where ε is the fixed payoff for every player when game ends with no volunteer. The above equality indicates that player would volunteer at $t = T$ only if the expected utility of volunteering (the left hand side) is equal to the expected utility if she free rides on the other one (the right hand side).

Thus, the equilibrium probability that a player volunteers at $t = T$, σ_T, is

[1] In which case $\lambda_i > -\frac{L_0}{H_0}$.

$$\sigma_T = \frac{L_T + \bar{\lambda} H_T - (1+\bar{\lambda})\varepsilon}{(1+\bar{\lambda})(H_T - \varepsilon)} \tag{3}$$

For an altruistic player whose $\bar{\lambda} > 0$, the probability to volunteer, σ_T will be larger than both a self-interest and spiteful player whose $\bar{\lambda} = 0$ and $\bar{\lambda} < 0$, respectively. Thus we have:[2]

Lemma 1 *Let H_t and L_t be payoff of free rider and volunteer, respectively. Assume $H_t > L_t$, $\forall t$. When $\bar{\lambda}$ increases, the equilibrium probability that player volunteer at period t, σ_t, increases.*

By backward inducting, we can calculate, for each period t,

$$\begin{aligned} & L_t + \bar{\lambda}[H_t(1-\sigma_t) + L_t\sigma_t] = \\ & \qquad \{L_{t+1} + \bar{\lambda}[H_{t+1}(1-\sigma_{t+1}) + L_{t+1}\sigma_{t+1}]\}(1-\sigma_t) + (H_t + \bar{\lambda}L_t)\sigma_t \end{aligned} \tag{4}$$

The equilibrium probability that player volunteer at period t, σ_t, where $0 \leq t < T$, is iterated determined by

$$\sigma_t = \frac{L_t + \bar{\lambda}H_t - L_{t+1} - \bar{\lambda}[H_{t+1}(1-\sigma_{t+1}) + L_{t+1}\sigma_{t+1}]}{(1+\bar{\lambda})H_t - L_{t+1} - \bar{\lambda}[H_{t+1}(1-\sigma_{t+1}) + L_{t+1}\sigma_{t+1}]} \tag{5}$$

Using the equilibrium strategy, σ_t, we obtain the equilibrium outcome such that the game will terminate at period t with probability

$$g_t(\bar{\lambda}) = [1-(1-\sigma_t)^2]\prod_{\eta=0}^{t-1}(1-\sigma_\eta) \text{ for } t \in \{1, 2, ..., T\} \tag{6}$$

where $\prod_{\eta=0}^{t-1}(1-\sigma_\eta)$ is the probability for the game not to terminate, and $g_0(\bar{\lambda}) = 1-(1-\sigma_0)^2$.

To transform this into a strategy method determining termination cutoffs, we

[2]See the complete proof in the appendix.

obtain the equilibrium CDF of cutoffs, $F_t(\bar{\lambda})$, by pitting one players' SSPE strategy against another players' strategy of never stop the timer (NS):

$$
\begin{aligned}
F_0(\bar{\lambda}) &= \sigma_0 \\
F_1(\bar{\lambda}) &= \sigma_0 + (1-\sigma_0)\sigma_1 \\
F_2(\bar{\lambda}) &= \sigma_0 + (1-\sigma_0)\sigma_1 + (1-\sigma_0)(1-\sigma_1)\sigma_2 \\
&\vdots \\
F_{30}(\bar{\lambda}) &= \sigma_0 + (1-\sigma_0)\sigma_1 + (1-\sigma_0)(1-\sigma_1)\sigma_2 + \dots \\
&\quad + (1-\sigma_0)(1-\sigma_1)\dots(1-\sigma_{28})\sigma_{29} \\
&\quad + (1-\sigma_0)(1-\sigma_1)\dots(1-\sigma_{29})\sigma_{30} \\
F_{NS}(\bar{\lambda}) &= \sigma_0 + (1-\sigma_0)\sigma_1 + (1-\sigma_0)(1-\sigma_1)\sigma_2 + \dots \\
&\quad + (1-\sigma_0)(1-\sigma_1)\dots(1-\sigma_{28})\sigma_{29} \\
&\quad + (1-\sigma_0)(1-\sigma_1)\dots(1-\sigma_{29})\sigma_{30} \\
&\quad + (1-\sigma_0)(1-\sigma_1)\dots(1-\sigma_{29})(1-\sigma_{30}) = 1
\end{aligned}
$$

3 Experimental Design

Various experimental studies investigate "static" volunteer's dilemma (e.g., Diekmann, 1993; Przepiorka and Diekmann, 2013). The few experimental studies on "dynamic" volunteer's dilemma are Bilodeau et al. (2004) and Otsubo and Rapoport (2008). Our experiment is closest to Otsubo and Rapoport (2008), but:

1. We use strategy method instead of the real-time decision method.

2. Our group size is two players.

3. We instruct subjects to stop the countdown timer (from 30 to 0), instead of

having the clock advance from 0 to 30.

4. We do not show the total profit to subjects in the end of each round.

3.1 Procedure

Table 1: Experiment Procedure

	Stage 1	Stage 2	Stage 3
Elicit Risk Attitude	Volunteer facing fellow subjects	Volunteer facing computerized player	Volunteer facing fellow subjects
10 questions	30 rounds	30 rounds	30 rounds

Table 1 shows the experiment procedure. We employ a with-in subject design and have subjects play against both the computer and fellow subjects. We first elicit subjects' risk preferences using lottery choices of Holt and Laury (2002). Thus, although we assume risk-neutral players, we still can control for individual risk preferences using their measured relative risk aversion (RRA) in our regression analysis. To reduce income effects from payoffs in the Holt-Larry task, the payoffs of lottery choices are realized only 50% of the time.[3]

The dynamic volunteer's dilemma game is conducted in Stage 1 to Stage 3. Each round 2 players were randomly matched to form a group. A timer would countdown from 30 to 0. Subjects were asked to decides when to stop the timer. After every group member made their decision, the game was played out, and the earliest stopping time chosen would determine the termination time of each group. Whoever chooses this time would be the volunteer, while the other the free rider.

In Stage 1, subjects were randomly re-matched with other participants in the same experiment. In Stage 2, subjects were matched with computerized players whose behaviors were randomly drawn from other subjects' prior decisions in Stage 1. To avoid possible learning effects at the beginning, we used subjects' decision

[3] However, theoretically, a "probabilistic" income effect could still exist.

in last 20 periods of stage 1. This design turns off subjects' other-regarding preferences; Hernandez et al. (2012) used the same method to study other-regarding preferences in relative performance schemes. In order to ensure subjects understand the random process we adopt in Stage 2, we show a random process sample table in the orientation. Finally, subjects performed another 30 periods of volunteer decision again facing randomly matched fellow subjects in Stage 3. See the experiment instructions in the appendix.

The payoff functions we used is adopt from Otsubo and Rapoport (2008):

$$
\begin{aligned}
H_s &= 20(e^{-0.1(30-s)} - e^{(-6)}) + \varepsilon \\
L_s &= 20\delta(e^{-0.1(30-s)} - e^{(-6)}) + \varepsilon
\end{aligned} \tag{7}
$$

where $\varepsilon = 1$ and δ stands for the volunteer's payoff ratio. Using this payoff setting, the equilibrium probability that player volunteer at period T is:

$$
\sigma_T = \frac{(\delta + \bar{\lambda})H_T - (1 + \bar{\lambda})\varepsilon}{(1 + \bar{\lambda})(H_T - \varepsilon)} \tag{8}
$$

and the equilibrium probability that player volunteer at period t, where $0 \leq t < T$ is:

$$
\sigma_t = \frac{(\delta + \bar{\lambda})H_t - \delta H_{t+1} - \bar{\lambda}[(1 - \sigma_{t+1} + \delta\sigma_{t+1})H_{t+1}]}{(1 + \bar{\lambda})H_t - \delta H_{t+1} - \bar{\lambda}[(1 - \sigma_{t+1} + \delta\sigma_{t+1})H_{t+1}]} \tag{9}
$$

A smaller δ indicates a larger cost of volunteering, and hence, a smaller probability for players to volunteer.

We conduct two volunteer's cost treatments, $\delta = 0.1$ and $\delta = 0.3$. Table 2 shows the payoff in both treatments. $\delta = 0.1$ means the volunteering cost is about 90% of the benefit (less $\varepsilon = 1$). $\delta = 0.3$ means it is 70%. This lets the two treatments fall exactly on the two sides of the cutoff ratio 8:2 in ultimatum game which is found to induce rejection in many experimental studies (Camerer, 2003, p.49). [4]

Table 2: Payoff Tables for the Experiment by Treatment

Time Period	Payoffs: Volunteer ($\delta = .1$)	Volunteer ($\delta = .3$)	Free rider	Time Period	Payoffs: Volunteer ($\delta = .1$)	Volunteer ($\delta = .3$)	Free rider
0	3.00	6.99	20.95	16	1.40	2.20	4.99
1	2.80	6.41	19.05	17	1.36	2.08	4.60
2	2.63	5.90	17.33	18	1.33	1.98	4.26
3	2.48	5.43	15.77	19	1.29	1.88	3.94
4	2.34	5.01	14.36	20	1.27	1.80	3.66
5	2.21	4.62	13.08	21	1.24	1.72	3.40
6	2.09	4.28	11.93	22	1.22	1.65	3.17
7	1.99	3.96	10.88	23	1.20	1.59	2.96
8	1.89	3.68	9.94	24	1.18	1.53	2.76
9	1.81	3.42	9.08	25	1.16	1.48	2.59
10	1.73	3.19	8.31	26	1.14	1.43	2.44
11	1.66	2.98	7.61	27	1.13	1.39	2.29
12	1.60	2.79	6.97	28	1.12	1.35	2.17
13	1.54	2.62	6.40	29	1.11	1.32	2.05
14	1.49	2.46	5.88	30	1.09	1.28	1.95
15	1.44	2.32	5.41	NV[a]	1	1	1

[a] NV means that the game ends with no volunteer.

We conduct 4 sessions for both treatments, $\delta = 0.1$ and $\delta = 0.3$. All sessions are conducted at the Taiwan Social Science Experimental Laboratory (TASSEL) in National Taiwan University (NTU). 56 subjects participated in each treatment. All 112 subjects were NTU undergraduate or graduate students. Total experiment time is about 2 hours, and subjects' payoff for treatment $\delta = 0.1$ and 0.3 were NTD\$471.3 and NTD\$770.1 (approximate US\$15.6 and US\$25.4), respectively.[5] The experiment is conducted in Chinese and programmed using z-Tree (Fischbacher, 2007).

[4] $\delta = 0.1$ and $\delta = 0.3$ can be understood as 10:1 and 10:3, respectively.

[5] At the time of the experiment, the exchange rate between NTD and USD is around $1 : 0.033$.

3.2 Experimental Hypotheses

We proposed three hypotheses. First, when subjects are matched with the computerized player, their own other-regarding preferences are turned off, while when they are facing fellow subjects, the other-regarding preferences are turned on. Thus, we arrive at our first hypothesis:

Hypothesis 1 *Due to other-regarding preferences, subjects' behavior when facing computerized player in Stage 2 is different from that when facing a real person in Stage 1 and Stage 3.*

Our second hypothesis is based on the statics predict that subjects' volunteer behavior will be different under different volunteer cost settings, δ:

Hypothesis 2 *Volunteer behavior observed in* $\delta = 0.1$ *differs from that in* $\delta = 0.3$.

Finally, we conjecture that prediction power of model under self-interest assumption with other-regarding preferences will be better than without other-regarding preferences.

Hypothesis 3 *Theoretical prediction will be more accurate with the other-regarding preferences than without other-regarding preferences.*

4 Result

Table 3 shows basic information of subjects by treatment. After checking each variables by treatments, we find no selection bias in our data. The results of two-sample proportion tests indicate that there is no statistically significant difference between two treatments for gender ("Female", $p = 0.742$) and consistence in the Holt-Laury tasks ("NoSwitch", $p = 0.449$). The result of nonparametric median test indicates that there is no statistically significant difference between two treatments for "Age" ($p = 0.571$).

Table 3: Descriptive Statistics by Treatment

	$\delta = .1$ ($n = 56$)	$\delta = .3$ ($n = 56$)
Female (%)	44.6	46.4
Age, *median (min.-max.)*	21 (18-26)	22 (19-29)
NoSwitch[a](%)	92.9	94.6

[a] NoSwitch denotes subjects who switch only once in the Holt-Laury (2002) task.

4.1 Effects of Other-regarding Preferences

Table 4 is the observed frequency percentage of Cutoff in each stage by treatment. We refer Stage 1 as "Human(Before)", Stage 2 as "Computer", and Stage 3 as "Human(After)" in the following discussion. To compare subject behavior in *Human(Before)* and *Human(After)*, we conduct the Kolmogorov–Smirnov test. In both δ treatments, we could not reject the null hypothesis that the behavior distributions in *Human(Before)* and *Human(After)* are the same ($\delta = 0.1$: $D = .250$, and $p = 0.270$; $\delta = 0.3$: $D = .125$, and $p = 0.964$). Thus, in the following analysis, we will merge data from *Human(Before)* and *Human(After)* and refer them as "facing fellow subjects", as opposed to data from *Computer* where subjects face computerized players.

It is obvious that in *Computer* when facing computerized players, subject behavior is very different to that when facing fellow subjects. In *Computer*, of both δ treatments, more subjects choose to volunteer at $t = 0$ and less subjects choose never to stop the timer. Overall, when facing fellow subjects, subjects tend to volunteer more in $\delta = 0.3$ treatment. Moreover, the difference of volunteer at $t = 0$ between "facing fellow subjects" and "facing computerized players" is more large in $\delta = 0.1$ treatment.

Figure 1 plots the observed cumulative probability of subjects' cutoff, $F_t\bar{\lambda}$ and theoretical prediction ($\bar{\lambda} = 0$) by δ. The most interesting feature is in *Computer* subjects tend to volunteer more earlier than *Human(Before)* and *Human(After)*.

Table 4: Observed Frequency Percentage of Cutoff by Stage for Treatments δ =.1 and .3

	30	29-28	27-26	25-21	20-11	10-1	0	NS*	Obs.
δ =**0.1**									
Human(Before)	4.4%	7.4%	1.9%	5.1%	6.7%	17.0%	10.0%	47.6%	1680
Computer	19.2%	7.0%	3.7%	9.3%	8.3%	8.9%	5.5%	38.1%	1680
Human(After)	5.5%	9.2%	1.0%	6.1%	8.7%	10.7%	4.5%	54.4%	1680
Overall	9.7%	7.9%	2.2%	6.8%	7.9%	12.2%	6.6%	46.7%	5040
δ =**0.3**									
Human(Before)	8.3%	7.9%	5.9%	6.4%	23.6%	13.7%	7.1%	27.0%	1680
Computer	14.8%	14.9%	7.8%	9.6%	18.9%	10.1%	5.2%	18.8%	1680
Human(After)	10.4%	8.3%	5.8%	6.1%	23.9%	9.5%	5.6%	30.0%	1680
Overall	11.2%	10.1%	6.5%	7.4%	22.1%	11.1%	6.4%	25.3%	5040

* NS means that subject choose never to stop the clock.

It seems that subject are more generous when dealing with computerized players, because computerized players would not earn more than themselves by free riding on their cost volunteering. Figure 2 plots observed cumulative probability of termination time, $G(\bar{\lambda})$, and theoretical prediction ($\bar{\lambda} = 0$) by δ.

4.2 Effects of the Costs of Volunteering

We find that when $\delta = .3$ subjects tend to volunteer earlier than when $\delta = .1$, although when facing computerized players, the proportion of volunteers at $t = 0, 1$ in $\delta = .1$ condition is larger than $\delta = .3$ treatment. This is consistent with Otsubo and Rapoport (2008), in which they found that subjects tend to volunteer earlier when $\delta = .6$ comparing to $\delta = .3$. The Kolmogorov–Smirnov test statistics for *Human(Before)*, *Computer*, and *Human(After)* between two cost treatments are $D = .500$ ($p < 0.001$), $D = .531$ ($p < 0.001$), and $D = .563$ ($p < 0.001$), respectively. Figure 3 plots observed cumulative probability of cutoff by opponent.

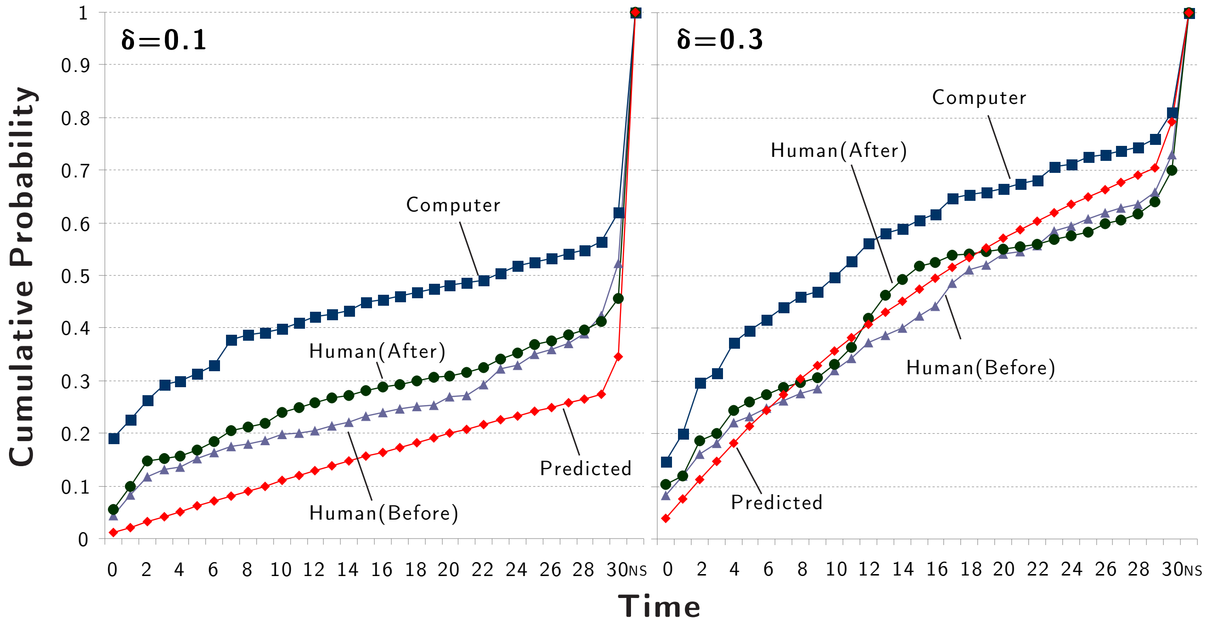

Figure 1: Cumulative Distribution Function of Cutoff by Treatment

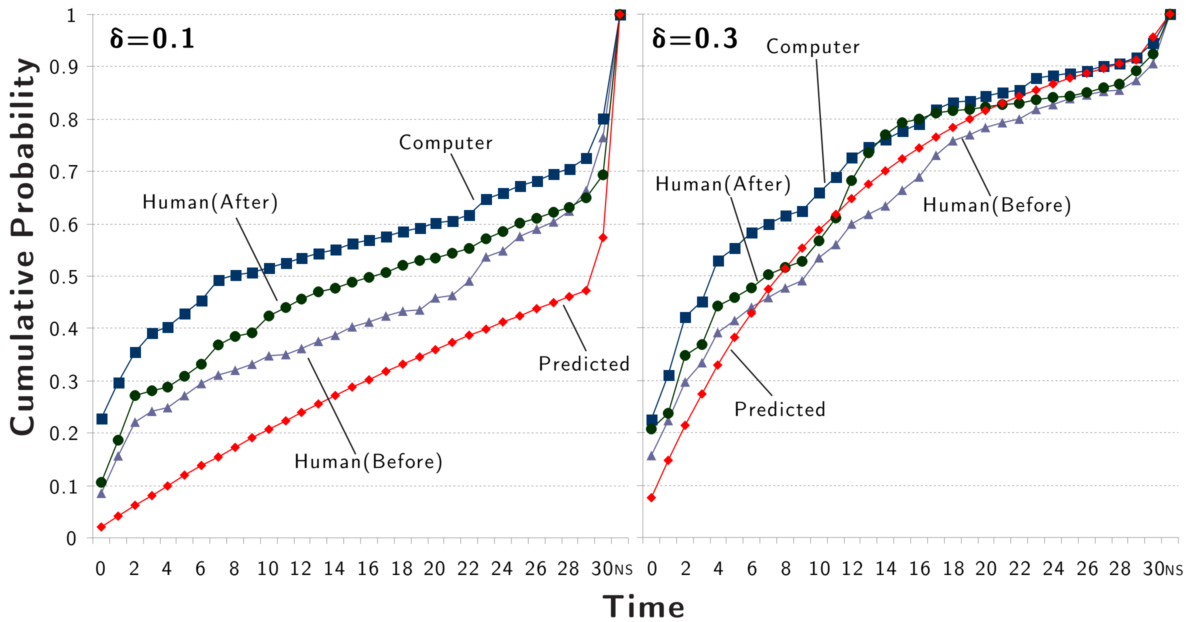

Figure 2: Cumulative Distribution Function of Termination Time by Treatment

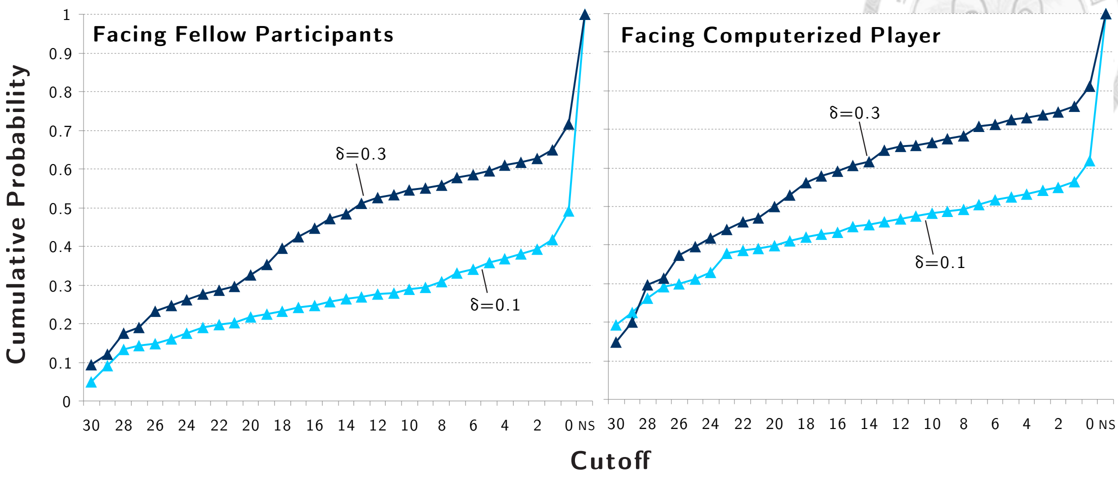

Figure 3: Cumulative Distribution Function of Cutoff by Opponent

4.3 Regression Analysis

In order to further investigate the relationship between other-regarding preferences and the tendency of volunteering/free-ride, we conduct the following panel logistic regressions[6]:

$$Pr(Volunteer_{it}=1)=\alpha_i+\beta_1 Gender_i+\beta_2 RRA_i+\beta_3 Age_i+\beta_4 Human_{it} +\beta_5 Treatment_{it}+\beta_6 Human_{it}\cdot Treatment_{it}+\beta_7 WhenOtherTerminates_{i,t-1}+\varepsilon_{it} \tag{10}$$

$$Pr(NeverStop_{it}=1)=\alpha_i+\beta_1 Gender_i+\beta_2 RRA_i+\beta_3 Age_i+\beta_4 Human_{it} +\beta_5 Treatment_{it}+\beta_6 Human_{it}\cdot Treatment_{it}+\beta_7 WhenOtherTerminates_{i,t-1}+\varepsilon_{it} \tag{11}$$

where the dependent variable is subjects' volunteer behavior.

We analyze both whether subject "volunteer immediately " (which means those decided to stop clock at $t = 0$) (Volunteer=1) and "never stop" (which means those

[6]We also conduct panel probit regression, the result is very similar to panel logistic regression.

decided never to stop clock in that period and chose number -1) (NeverStop $=$ 1).These two dependent variables present "volunteering" and "free riding", respectively.

In the specification, $Gender = 1$ if subject is male; RRA is subject's relative risk aversion measured by the Holt-Laury task[7]; $Human$ is the dummy variable for facing fellow subjects; $Treatment$ is the dummy for $\delta = 0.1$ treatment; $WhenOtherTerminates_{t-1}$ is the termination time in last period where the other player is volunteer, otherwise $WhenOtherTerminates_{t-1} = 0$; and α_i is the constant term.

The result of panel logistic regression is showed in Table 5. The coefficient of $Human$, β_4, can capture the differences between behavior with or without other-regarding preferences. We find that the differences are significant in both specifications. β_6 is the interaction effects of $Human$ and $Treatment$ which stands for the effect of other-regarding preferences under the more unfair treatment for the volunteer. We find that the interaction effect are also significant in both specifications. The coefficient interpretation of our 2 by 2 design is showed in Figure 4.

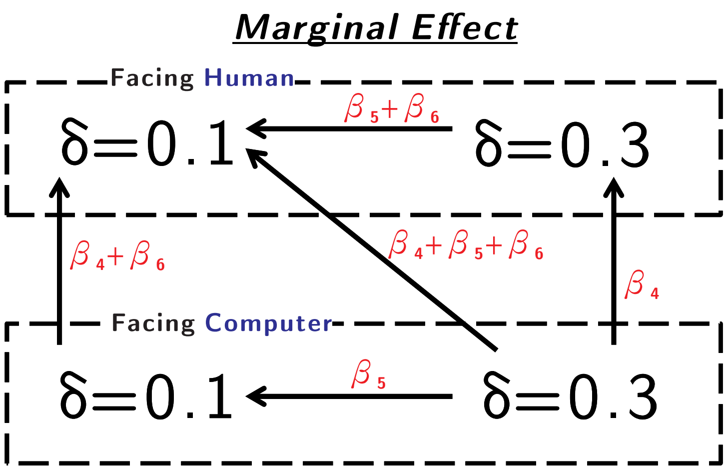

Figure 4: Coefficient Interpretation

Using the marginal effects of regression analysis, we can calculate the effect

[7]If in all 10 questions, subject choose less than 2 (greater than 8) safe choices, we only can obtain upper bound (lower bound) of their RRA. Hence, the mean RRA is not available for thos subjects. 104 subjects' RRA are available in our regression analysis. If we drop those switch more than once in Holt-Laury measurement, there are only 97 subjects.

Table 5: Marginal Effects from Panel Logistic Regression

	Volunteer Immediately			Never Stop		
	(1)	(2)	(3)	(4)	(5)	(6)
Gender (d)	-0.002 (0.012)	0.002 (0.012)	0.002 (0.012)	-0.020 (0.085)	0.021 (0.086)	0.019 (0.085)
RRA	0.038* (0.017)	0.039* (0.017)	0.038* (0.017)	0.058 (0.110)	0.109 (0.112)	0.106 (0.110)
Age	-0.007* (0.003)	-0.005 (0.003)	-0.005 (0.003)	0.021 (0.020)	0.029 (0.021)	0.028 (0.020)
Human (d)	-0.030*** (0.007)	-0.024*** (0.006)	-0.021*** (0.006)	0.158*** (0.023)	0.143*** (0.022)	0.141*** (0.022)
$\delta = 0.1$ (d)	0.011 (0.013)	0.012 (0.013)	0.012 (0.012)	0.279** (0.085)	0.225** (0.087)	0.225** (0.086)
Human$\cdot\delta = 0.1$ (d)	-0.027*** (0.007)	-0.035*** (0.008)	-0.036*** (0.008)	0.019 (0.026)	0.073** (0.028)	0.075** (0.029)
WhenOtherTerminates$_{t-1}$			-0.001*** (0.0004)			0.006*** (0.001)
NoSwitch[a]		✓	✓		✓	✓
N	9360	8730	8439	9360	8730	8439

[1] Standard errors in parentheses ;* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
[2] (d) for discrete change of dummy variable from 0 to 1.
[a] NoSwitch denotes that regression only included subjects who switch only once in Holt-Laury measurement.

of other-regarding preferences and cost of volunteering (Figure 5).[8] When facing fellow subjects, subjects tend to less volunteer and tend more to free-ride on others. This result indicates other-regarding preferences do matter in volunteer's dilemma. In $\delta = .1$ treatment, subjects tend less to volunteer and tend more to free-ride on others. Comparing facing computerized player in $\delta = .3$ treatment (*baseline*), the probability for subjects to volunteer immediately decrease almost 5% and that for subjects to free ride others increase 44% when facing a real person in $\delta = .1$

[8] We use the marginal effects from regression (2) and (5). *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

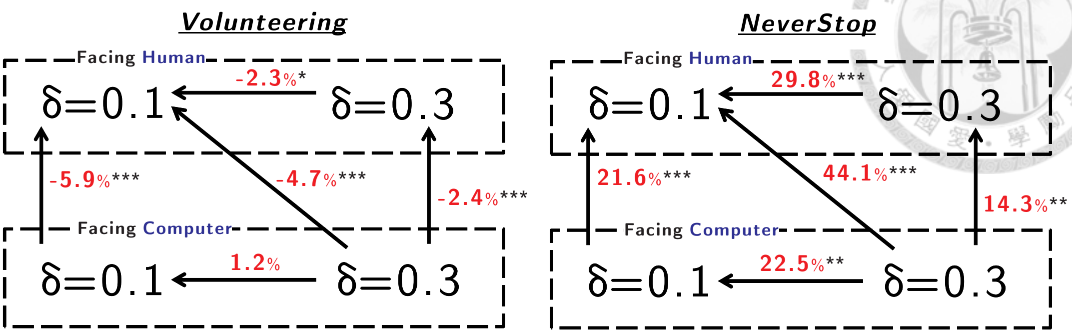

Figure 5: Marginal Effect Interpretation: Volunteering/NeverStop

treatment.

In regression (3) and (6), we find that $WhenOtherTerminate_{t-1}$ is significant. It shows that if the opponent stop the timer more later in period $t-1$, subjects tend to treat her opponent with same way in period t. For example, if the opponent stop the timer at $t = 30$ in period $t-1$, the probability that subject volunteer immediately will decrease 3%, while the probability that subject never stop the timer will increase 18% in period t.

5 Discussion

In Figure 1, we find that subjects volunteer at $t = 0$ more than the theoretical prediction. It makes empirical CDF more left than the theoretical CDF. An alternative interpretation we propose here to explain the experimental data is some subjects play asymmetric subgame perfect equilibrium (ASPE) and others play SSPE. Assuming there are θ proportion subjects play ASPE and $1-\theta$ proportion subjects play SSPE. We categorize subjects choose volunteer at $t = 0$ as the one who play ASPE. Figure 6 is the cumulative probability of cutoff for subjects playing SSPE.

Using the Kolmogorov-Smirnov test, we find that both treatments are significantly different to the theoretical predictions under 5% significant level. ($\delta = 0.1$: $D = .701$, and $p < 0.001$; $\delta = 0.3$: $D = .276$, and $p = 0.018$)

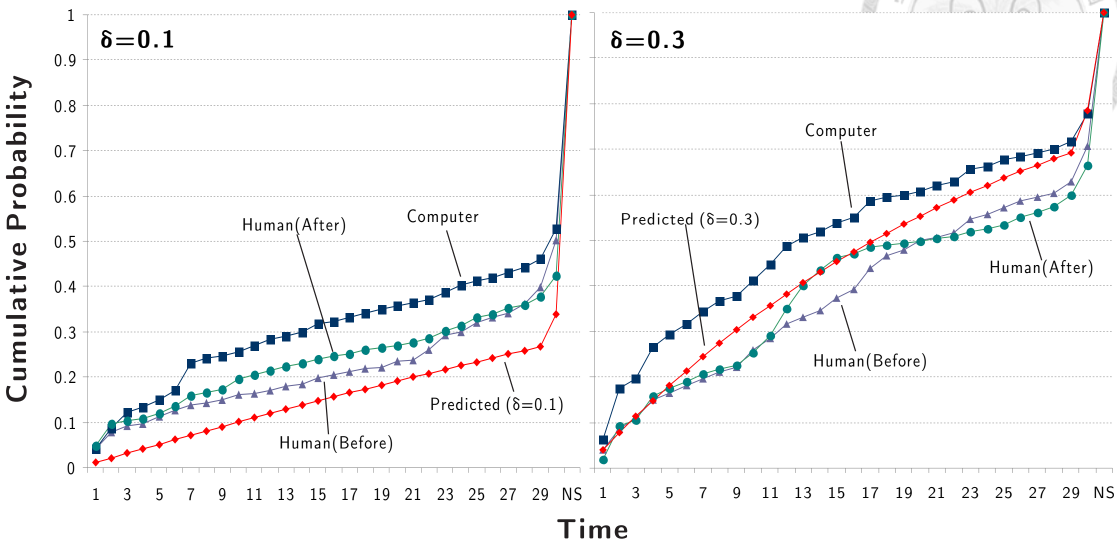

Figure 6: Cumulative Distribution Function of Termination Time by Treatment (SSPE)

6 Conclusion

Since subjects' other-regarding preferences are turned off under the design of matching with computerized players in Stage 2, the behavior difference between "facing fellow subjects" and "facing computerized player" should result from other-regarding preferences. It seems that subjects are not willing to benefit others by volunteering when they have to endure the extra individual cost. However, when they are dealing with computerized players, since the computer cannot benefit from their volunteering, they tend to volunteer to ensure a smaller but certain payoff. Thus, we argue that other-regarding preferences do play important role in volunteer's dilemma game, but through envy not altruism. Our result suggests that a good incentive design in reality should avoid creating a huge payoff gap between volunteer and free riders.

A potential limitation of this study is that subjects from a college students pool may be less pro-social because they participate the experiment only for monetary payoff. A recent study by Anderson et al. (2013) supports this perspective, finding self-selected college students subjects less pro-social than self-selected adults subjects.

References

Anderson, Jon, Burks, Stephen V., Carpenter, Jeffrey, Götte, Lorenz, Maurer, Karsten, Nosenzo, Daniele, Potter, Ruth, Rocha, Kim, and Rustichini, Aldo (2013), "Self-selection and variations in the laboratory measurement of other-regarding preferences across subject pools: Evidence from one college student and two adult samples", *Experimental Economics*, 16, 170–189.

Bilodeau, Marc, Childs, Jason, and Mestelman, Stuart (2004), "Volunteering a public service: an experimental investigation", *Journal of Public Economics*, 88, 2839–2855.

Bilodeau, Marc and Slivinski, Al (1996), "Toilet cleaning and department chairing: Volunteering a public service", *Journal of Public Economics*, 59, 299–308.

Bliss, Christopher and Nalebuff, Barry (1984), "Dragon-slaying and ballroom dancing: The private supply of a public good", *Journal of Public Economics*, 25, 1–12.

Camerer, Colin F. (2003), *Behavioral Game Theory : Experiments in Strategic Interaction*, The Roundtable Series in Behavioral Economics, Princeton: Princeton University Press.

Diekmann, Andreas (1993), "Cooperation in an asymmetric volunteer's dilemma game theory and experimental evidence", *International Journal of Game Theory*, 22(1), 75–85.

Fischbacher, Urs (2007), "z-tree: Zurich toolbox for ready-made economic experiments", *Experimental Economics*, 10(2), 171–178.

Hernandez, Pablo, Minor, Dylan B., and Sisak, Dana (2012), "Social preferences or collusion? Experimental evidence", *working paper*.

Holt, Charles A. and Laury, Susan K. (2002), "Risk aversion and incentive effects", *American Economic Review*, 92, 1644–1655.

Otsubo, Hironori and Rapoport, Amnon (2008), "Dynamic volunteer's dilemmas over a finite horizon: An experimental study", *Journal of Conflict Resolution*, 52, 961–984.

Przepiorka, Wojtek and Diekmann, Andreas (2013), "Individual heterogeneity and costly punishment: a volunteer's dilemma", 280.

Appendix A - Proof

Proof of Lemma 1 *First, considering the case that $0 \leq t < T$, i.e. case of σ_t.*

$$\sigma_t = \frac{L_t + \bar{\lambda} H_t - L_{t+1} - \bar{\lambda}[H_{t+1}(1-\sigma_{t+1}) + L_{t+1}\sigma_{t+1}]}{(1+\bar{\lambda})H_t - L_{t+1} - \bar{\lambda}[H_{t+1}(1-\sigma_{t+1}) + L_{t+1}\sigma_{t+1}]}$$

For simplification, let $A = H_{t+1}(1-\sigma_{t+1}) + L_{t+1}\sigma_{t+1}$, therefore

$$\sigma_t = \frac{L_t + \bar{\lambda} H_t - L_{t+1} - \bar{\lambda} A}{(1+\bar{\lambda})H_t - L_{t+1} - \bar{\lambda} A} = \frac{L_t - L_{t+1} + \bar{\lambda}(H_t - A)}{H_t - L_{t+1} + \bar{\lambda}(H_t - A)}$$

Secondly, considering the case that $t = T$, i.e. σ_T.

$$\sigma_T = \frac{L_T + \bar{\lambda} H_T - (1+\bar{\lambda})\varepsilon}{(1+\bar{\lambda})(H_T - \varepsilon)} = \frac{L_T - \varepsilon + \bar{\lambda}(H_T - \varepsilon)}{H_T - \varepsilon + \bar{\lambda}(H_T - \varepsilon)}$$

Since $H_t > L_t$, when $\bar{\lambda}$ becomes larger, both σ_t and σ_T will be larger.

□

Appendix B - Instruction for $\delta = 0.3$ Treatment

TASSEL **實驗說明** p.1

實驗報酬

感謝你參加本實驗。本實驗結束後, 你將得到定額車馬費新台幣100元, 以及你在實驗中獲得的「法幣」所兌換成之新台幣。(「法幣」爲本實驗的實驗貨幣單位。) 你在實驗中能獲得的「法幣」會根據你所做的決策、別人的決策, 以及隨機亂數決定, 每個人都不同。每個人都會個別獨自領取報酬, 你沒有義務告訴其他人你的報酬多寡。

請注意: 本實驗中的「法幣」與新台幣兌換匯率為1:1。(法幣1元=新台幣1元)

實驗說明-第一部份

本實驗第一部分的實驗共有10個決策問題, 你所要做的決策是選擇 A 福袋或 B 福袋。等到今天所有實驗結束後, 實驗者會請你擲一顆六面骰。**若六面骰為奇數**, 則會再請你擲兩顆十面骰。第一顆骰子的數字將決定採用的決策, 接下來根據你在該決策中的選擇(A 或 B 福袋) 及第二顆骰子的數字決定你此部份的報酬。 **若六面骰為偶數**, 則此部分的報酬爲新台幣0元。

如果你對本部份實驗有任何疑問, 請在此時舉手。實驗者會過來解答。

實驗正式開始

現在實驗正式開始, 你一共有120秒的時間做決定! 請注意, 每一題都**有可能**經由隨機過程、被選中來決定你參加本次實驗的報酬。因此, **每一題都請務必審慎決定**, **彷彿該題就會實現一般!**

TASSEL **實驗說明** p.2

實驗說明-第二部份

第二部分的實驗共有三個練習回合與三十回合的正式實驗。每一回合電腦會將所有參與者分組, 你將與另外一位參與者配對進行實驗。請注意, 每一回合電腦都會隨機重新配對, 因此與你配對的不一定是上一回合與你配對的同一位參與者。

每一回合中, 你以及跟你同組的參與者, 要做的決策是**在什麼時間停止計時器**(停止計時器的方法容後敍述)。實驗中的計時器將從30倒數至0, 也就是30、29、28直到0。本實驗中, 每一回合**第一個**停止計時器的爲「終止者」, 否則爲「非終止者」。若在同一數字停止計時器, 則都是「終止者」。

每回合你的報酬將取決於計時器停止時的數字, 報酬將隨著數字減少而遞減, 也就是說愈早停止計時器則報酬愈高, 但「終止者」的報酬無論在哪一個數字停止計時器, 都會低於「非終止者」的報酬。

實驗畫面如投影片上的畫面所示。螢幕上方分別顯示: 回合數(左上角); 計時器之倒數數字(中間上方); 計時器如果在此時停止,「終止者」與「非終止者」分別會得到的報酬(右上角)。螢幕正中間, 是「終止者」與「非終止者」的「計時器停止時間與報酬對應圖」。X 軸爲倒數時間,Y 軸爲報酬。報酬曲線由黑色方塊組成, 而此時的報酬則會以紅色方塊標示於圖表上。

在時間報酬對應圖下方**請你選擇**一個30至0的數字, 作爲你在本回合中「**你停止計時器的時間**」。如果你不要停止計時器, 則請你選擇 -1。選擇完畢請按右下角的「確認」, 請注意, 一但做決定後即不能更改。當同組所有參與者都做完選擇, 計時器就會開始倒數計時, 直到至少有一位參與者停止計時器。舉例來說, 你選擇在數字爲25停止計時器, 跟你配對的參與者選擇某一個比25還小的數字停止計時器, 則計時器會在25時停止。

請注意, 無論是否所有組別都已經停止計時器, 本部分實驗並不會提前進入下一回合, 而是會等到**所有組別**都計時結束, 才結束本回合。

TASSEL 實驗說明 p.3

以下爲範例, 請同時參考另一頁說明的表1。表1爲第二部分實驗之計時器停止數字與「終止者」、「非終止者」對應的報酬。

1. 例1: 所有參與者在數字歸零前皆沒有停止計時器。因此, 該回合所有人的報酬皆爲法幣1.00元。

2. 例2: 其中一位參與者先行在數字爲25的時候, 停止計時器。因此, 該回合「終止者」獲得4.62法幣的報酬,「非終止者」獲得13.08法幣的報酬。

3. 例3: 兩位參與者都在數字爲10的時候, 停止計時器。因此, 該回合兩位都是「終止者」都獲得1.80法幣的報酬。

每回合結束後, 螢幕上會顯示這回合的實驗結果, 包含本回合計時器停止的時間、由誰停止計時器、你所得到的報酬。你共有10秒的閱讀, 閱讀完畢請按「確認」進入下一回合。

練習階段

此階段共有三回合, 目的爲幫助你熟悉正式實驗的操作介面及計分方式。**請注意, 練習階段的得分僅供你熟悉本實驗的進行方式, 與你最後的現金報酬無關。**練習結束後, 實驗者會宣佈「實驗正式開始!」, 然後才進入正式實驗。

如果你對本實驗有任何疑問, 請在此時舉手。實驗者會過來解答。

實驗正式開始

現在實驗正式開始, 一共有三十回合! 在正式實驗中所獲得的「法幣」都會在實驗結束後, 按照1:1的匯率 (法幣1元=新台幣1元) 兌換成新台幣付給你。因此請愼重選擇、愼重決定。

TASSEL 實驗說明

表 1: 計時器停止數字與報酬對應表

	法幣			法幣	
	非終止者	終止者		非終止者	終止者
30	20.95	6.99	14	4.99	2.20
29	19.05	6.41	13	4.60	2.08
28	17.33	5.90	12	4.26	1.98
27	15.77	5.43	11	3.94	1.88
26	14.36	5.01	10	3.66	1.80
25	13.08	4.62	9	3.40	1.72
24	11.93	4.28	8	3.17	1.65
23	10.88	3.96	7	2.96	1.59
22	9.94	3.68	6	2.76	1.53
21	9.08	3.42	5	2.59	1.48
20	8.31	3.19	4	2.44	1.43
19	7.61	2.98	3	2.29	1.39
18	6.97	2.79	2	2.17	1.35
17	6.40	2.62	1	2.05	1.32
16	5.88	2.46	0	1.95	1.28
15	5.41	2.32	計時結束	1.00	1.00

TASSEL **實驗說明** p.4

實驗說明-第三部份

第三部分的實驗共有三十回合的正式實驗。每一回合電腦會將所有參與者分組, 你將與電腦配對進行實驗。

每一回合中, 你與電腦要做的決策是**在什麼時間停止計時器**(停止計時器的方法與第二部分相同)。每一回合, 實驗中的計時器將從30倒數至0, 也就是30、29、28到0。本實驗中, 每一回合第一個停止計時器的爲「終止者」, 否則爲「非終止者」。如果在同一數字停止計時器, 則都是「終止者」。

請注意, 每一回合電腦將隨機採取**除了你自己以外**的某一參與者**在第二部份**11 30**回合之中的一個決策**。舉例說明, 本部份第1回合跟你配對的電腦採取某位參與者第二部份第13回合的決策, 該參與者在第二部份第13回合選擇數字爲7時停止計時器, 則在第1回合跟你配對的電腦就會選擇在數字爲7時停止計時器 (前提是計時器在數字爲7之前, 尚未被停止。)。

每回合你的報酬將取決於計時器停止時的數字, 報酬將隨著數字減少而遞減, 也就是說愈早停止計時器則報酬愈高, 但「終止者」的報酬無論在哪一個數字停止計時器, 都會低於「非終止者」的報酬。計時器停止數字與「終止者」、「非終止者」對應的報酬, 同樣請參考表1。

請注意, 無論是否所有組別都已經停止計時器, 本部分實驗並不會提前進入下一回合, 而是會等到**所有組別**都計時結束, 才結束本回合。

每回合結束後, 螢幕上會顯示這回合的實驗結果, 包括本回合計時器停止的時間、由誰停止計時器, 以及你所獲得的報酬。你共有10秒的時間閱讀, 若已閱讀完畢請按「確認」進入下一回合。如果你對本實驗有任何疑問, 請在此時舉手。實驗者會過來解答。

實驗正式開始

現在實驗正式開始, 一共有三十回合! 在正式實驗中所獲得的「法幣」都會在實驗結束後, 按照1:1的匯率 (法幣1元=新台幣1元) 兌換成新台幣付給你。因此請慎重選擇、慎重決定。

TASSEL **實驗說明** p.5

實驗說明-第四部份

第四部分的實驗共有三十回合的正式實驗。每一回合電腦會將所有參與者分組, 你將與另外一位參與者配對進行實驗。請注意, 每一回合電腦都會隨機重新配對, 因此與你配對的不一定是上一回合與你配對的同一位參與者。

每一回合中, 你以及跟你同組的參與者, 要做的決策是**在什麼時間停止計時器**(停止計時器的方法與第二部分相同)。每一回合, 實驗中的計時器將從30倒數至0, 也就是30、29、28直到0。本實驗中, 每一回合**第一個**停止計時器的為「終止者」, 否則為「非終止者」。如果在同一數字停止計時器, 則都是「終止者」。

每回合你的報酬將取決於計時器停止時的數字, 報酬將隨著數字減少而遞減, 也就是說愈早停止計時器則報酬愈高, 但「終止者」的報酬無論在哪一個數字停止計時器, 都會低於「非終止者」的報酬。計時器停止數字與「終止者」、「非終止者」對應的報酬, 同樣請參考表1。

請注意, 無論是否所有組別都已經停止計時器, 本部分實驗並不會提前進入下一回合, 而是會等到**所有組別都計時結束**, 才結束本回合。

每回合結束後, 螢幕上會顯示這回合的實驗結果, 包括本回合計時器停止的時間、由誰停止計時器, 以及你所獲得的報酬。你共有10秒的時間閱讀, 若已閱讀完畢請按「確認」進入下一回合。

如果你對本實驗有任何疑問, 請在此時舉手。實驗者會過來解答。

實驗正式開始

現在實驗正式開始, 一共有三十回合!在正式實驗中所獲得的「法幣」都會在實驗結束後, 按照1:1的匯率 (法幣1元=新台幣1元) 兌換成新台幣付給你。因此請慎重選擇、慎重決定。

表2-1: 電腦決策依據參考表-自己以外的參與者編號

參與者編號	第1回合	第2回合	第3回合	第4回合	第5回合	第6回合	第7回合	第8回合	第9回合	第10回合
1	10	7	2	5	3	2	9	10	9	2
2	5	9	1	7	9	9	1	4	1	3
3	10	9	9	5	5	8	9	10	6	6
4	7	7	2	1	7	9	8	2	9	6
5	3	6	8	4	8	10	7	3	1	3
6	10	8	5	1	10	2	8	1	5	5
7	9	1	9	2	4	2	1	8	3	6
8	10	9	10	6	10	4	3	5	1	5
9	7	7	10	10	5	7	2	5	4	3
10	5	8	6	4	2	9	6	9	8	6

參與者編號	第11回合	第12回合	第13回合	第14回合	第15回合	第16回合	第17回合	第18回合	第19回合	第20回合
1	8	9	10	10	4	9	2	3	9	7
2	1	9	8	10	1	6	5	4	8	1
3	7	7	2	5	5	10	6	7	4	8
4	3	8	5	8	9	10	9	5	9	8
5	6	3	1	1	7	7	9	8	9	9
6	2	10	10	5	9	7	1	4	5	4
7	4	3	8	9	1	9	5	5	6	10
8	9	6	5	5	6	1	6	6	2	4
9	8	1	6	10	1	4	10	8	5	10
10	7	9	6	7	2	7	9	6	8	1

參與者編號	第21回合	第22回合	第23回合	第24回合	第25回合	第26回合	第27回合	第28回合	第29回合	第30回合
1	4	5	3	2	7	8	6	3	3	7
2	10	7	7	1	10	7	1	8	4	6
3	4	2	8	6	10	2	10	7	5	4
4	9	7	8	10	7	10	9	3	5	1
5	10	2	7	4	2	2	7	7	4	4
6	7	8	9	10	7	3	2	2	5	9
7	6	8	8	5	6	3	4	4	3	2
8	3	9	3	10	5	9	7	5	1	1
9	10	6	2	3	2	2	3	3	10	2
10	3	3	3	3	9	3	9	9	9	8

註:本表以參與者人數為10人舉例，不一定與實際實驗人數相同。

表2-2: 電腦決策依據參考表-所抽回合數

參與者編號	第1回合	第2回合	第3回合	第4回合	第5回合	第6回合	第7回合	第8回合	第9回合	第10回合
1	21	23	22	25	19	18	25	18	16	29
2	18	28	18	27	27	20	13	14	17	27
3	20	12	28	17	25	18	17	28	17	29
4	24	11	26	22	27	14	19	15	16	29
5	26	17	25	25	20	27	22	17	11	19
6	26	25	25	17	30	13	18	24	17	17
7	30	17	11	23	23	12	17	13	29	30
8	19	30	30	13	30	26	17	26	30	22
9	11	22	19	14	22	19	18	20	17	19
10	14	12	12	23	18	21	17	11	12	23
參與者編號	第11回合	第12回合	第13回合	第14回合	第15回合	第16回合	第17回合	第18回合	第19回合	第20回合
1	14	30	25	16	18	30	29	23	22	27
2	11	15	23	27	26	22	19	30	11	14
3	20	11	19	28	24	13	23	17	11	12
4	22	23	16	11	20	25	11	19	17	29
5	28	24	29	24	22	20	11	23	27	30
6	21	17	16	24	15	30	16	22	30	18
7	28	14	12	30	29	17	25	30	17	22
8	21	15	13	23	13	13	19	27	20	30
9	16	20	20	25	17	30	17	18	17	29
10	12	14	26	16	27	17	15	21	12	16
參與者編號	第21回合	第22回合	第23回合	第24回合	第25回合	第26回合	第27回合	第28回合	第29回合	第30回合
1	21	11	14	28	17	13	16	13	25	17
2	11	24	22	18	29	24	21	21	21	24
3	24	30	18	16	18	30	12	16	27	21
4	16	17	21	30	18	19	12	27	28	24
5	19	21	26	11	26	16	24	14	21	29
6	15	14	27	16	23	27	24	14	11	20
7	28	14	27	24	28	13	17	14	18	26
8	19	14	26	12	18	30	29	27	12	11
9	27	14	12	24	29	22	19	18	12	14
10	23	18	19	14	12	19	14	16	19	15

註:本表以參與者人數為10人舉例，不一定與實際實驗人數相同。