The Effect of Emotion in an Ultimatum Game: The Bio-Feedback Evidence

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Abstract. In neoclassical economics, Rational Choice Theory states that individuals always make prudent and rational decisions provided with the greatest benefits. In Ultimatum Game, the proposer (Player I) proposes how to split a sum of money. The responder (Player II) decides to accept or reject the proposal. If the responder accepts, the sum is splitted as proposed; otherwise, neither player can receive money. One of the results shows that some "unfair" offers are often rejected, which implies the effect of emotion in an economic decision-making. In this research, a special Ultimatum Game has been designed to collect bio-feedback evidence for emotion in an economic decision-making using the Galvanic Skin Response (GSR) sensor. Also, an Ultimatum Game with computer simulation had been designed to collect bio-feedback results when the sum of money is in virtual points offered by a computer.

Keywords: Ultimatum Game · Emotion factor · Galvanic Skin Response · Economics

1 Introduction

Though economists have not denied the existence and significance of emotion in economical decision-makings, in the past, emotion were still left out of the analysis in an economical behavior modeling because of the unpredictability and complexity. However, recent research has shown the strong relation between emotion and economic decision-makings. The researchers reported that people's bargaining behavior, inter-temporal choices and decision-making under risk or uncertainty are strongly affected by the emotion [1].

Ultimatum Game, a famous economic experiment, has been widely used to prove the limitation on emotional factors of current standard economic models [2–5]. In Ultimatum Game, two players (one as a proposer; the other as a responder) are required to split a sum of money. The proposer will first give a proposal on how to split the sum and the responder will decide to accept or reject the proposal. If the proposal is accepted, the money will be split as proposed; otherwise, neither of the players can receive any money. Based on Rational Choice Theory, the expected result of Ultimatum Game is that the proposer splits most of the sum to leave it to himself/herself and the responder accepts the proposal. However, prior researchers reported two opposite results:

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1. The most frequent outcome of the proposal is a fair share.
2. Some unfair proposals are often rejected by the responder.

One of the explanations such conflicting results are that the "benefits" in Rational Choice Theory also includes emotional benefits [5]. In other words, the experiment results showed the existence of emotion in Ultimatum Game.

Sensor technology has been widely applied in the prior research of emotion. GSR sensor can measure the electrical conductance of the skin. Strong emotion can cause stimulus to the nervous system, resulting more sweat being secreted [6]. Therefore, applying GSR sensor is an effective method to monitor emotion. In this research, a special Ultimatum Game has been designed, applying GSR sensor technology, to find the bio-feedback evidence for emotion in the game. Another experiment has been designed to test the bio-feedback results when the sum to split is in virtual points rather than real money. To improve the experimental effects, during the whole experiment, the players have been required to make decisions in a limited time, and "fair" split is not allowed. Before we present our studies, earlier works will be discussed in the next section.

2 Related Work

2.1 Emotion and Ultimatum Game

The Role of Emotion in Economic Decision-Making. Economists have been focus on emotion in a decision-making. For decades, different from physiologists who mainly studied immediate emotion, they turned their attention to anticipated emotions which are not experienced at the time of the decision-making. However, in 2000, it is reported that a kind of immediate emotion, more specifically, visceral factors, should be considered as significant factor in decision-making as well [1]. The researcher pointed out that visceral factors can grab people's attention and motivate their special behaviors. These behaviors are applied in almost all-domains but when it comes to economic behaviors, three categories are of special relevance: bargaining behavior which is easily affected by anger, fear and embarrassment, inter-temporal choice which is strongly influenced by multiple factors, and decision-making under risk and uncertainty which is easily influenced by factors like fear. In the following years, researchers and scientists continued to pay attention on the immediate emotion as a factor of decision-makings, including the famous Ultimatum Game.

Emotion in Ultimatum Game. The "irrational" decisions, especially the "irrational" rejection for the unfair proposals in Ultimatum Game have been discussed for a long period. Recent years researchers have started to find bio-evidence of emotion which has been considered to be the cause of "irrational" decisions. Researchers have found neural basis evidence of the economic decision-making in the Ultimatum Game, using magnetic resonance imaging (fRMI) technology in 2003 [2]. They scanned the brains of responders after responding to fair and unfair proposals. The magnetic resonance

setting has detected the brain activity in the areas related to emotion (anterior insula) and cognition (dorsolateral prefrontal cortex) when responding unfair offers. They also reported the heightened activity in the anterior insula when a responder rejected an unfair offer. Besides the neural basis evidence, researchers also found electrodermal activity evidence. In 2006, researchers applied skin conductance amplifier in the Ultimatum Game [3]. The collected data revealed that skin conductance activity was higher for unfair offers and was associated with the rejection of unfair offers. However, this pattern only occurred for offers proposed by human.

2.2 GSR and Emotion Detection

To detect emotion, such technologies like speech recognition, face recognition and brain signal scanning are often applied [7, 8]. GSR value is another effective indicator for emotion activities. Also, GSR sensor is a more portable tool which can monitor the emotion of users compared to the skin conductance amplifier. Therefore, it is widely applied in the research on emotion and recognition. A research group built an emotion recognition system based on Electromyography (EMG) data and skin conductance signals which can be indicated by GSR data in 2005 [4]. They reported the model using Bayesian network and other methodologies to recognize user's emotion. In 2006, researchers developed a stress detection system based on physiological signals monitored by non-invasive and non-intrusive sensors [9]. The system performed supervised classification of affective states between "stress" and "relaxed" using a support vector machine based on the four kinds of data, GSR, Blood Volume Pulse (BVP), Pupil Diameter (PD) and Skin Temperature (ST).

3 Our Experiment

The entire experiment included an Ultimatum Game with a sum of real money and an Ultimatum Game with the sum of virtual points of simulated money. The first game was to collect the bio-feedback evidence in the Ultimatum Game. The second game was to probe whether the computer simulated game can reach the same goal.

3.1 Participants and Apparatus

10 participants (5 proposers and 5 responders) chosen from a local university were divided into two groups. Group I contained 6 participants (3 proposers and 3 responders) and Group II contained 4 participants (2 proposers and 2 responders). To collect the bio-feedback data, participants were required to wear a Seeed Grove - GSR sensor connecting to the Arduino (Fig. 1). The bio-feedback data would be shown as a line chart.

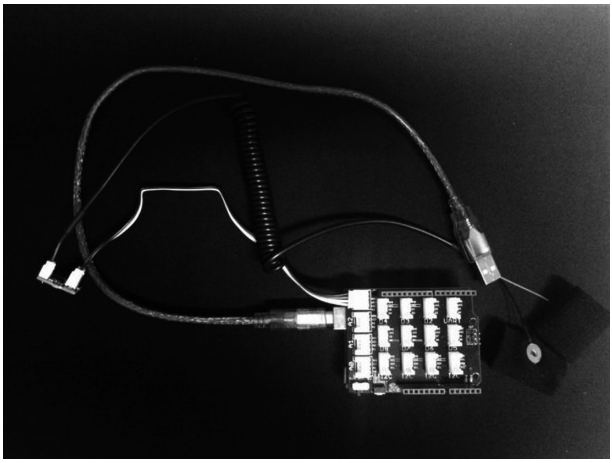

Fig. 1. Seeed Grove - GSR Sensor and Arduino used in the Ultimatum Game experiment.

3.2 Study Design

To improve the experimental effects, the experiment was designed based on these rules:

1. The participants need to make a decision in a limited time.
2. The proposers cannot propose a fair offer.
3. Every partition in a split should be integer multiples of 10%.

Ultimatum Game I. Two groups of participants were required to play Ultimatum Game with real money. Each pairs in Group I (3 proposers and 3 responders) were going to split the sums of 20 RMB (3 USD). Pairs in Group II (2 proposers and 2 responders) were instructed split the sums of 50 RMB (7.5 USD). Both proposers and responders were required to make decisions in 10 s.

Ultimatum Game II. All participants were required to play Ultimatum Game with virtual points. Each proposers were asked to propose an offer to split the sums of a random virtual points from 100 to 10, 000. Each responders were expected to make a decision among randomly generated proposals. Both proposers and responders were

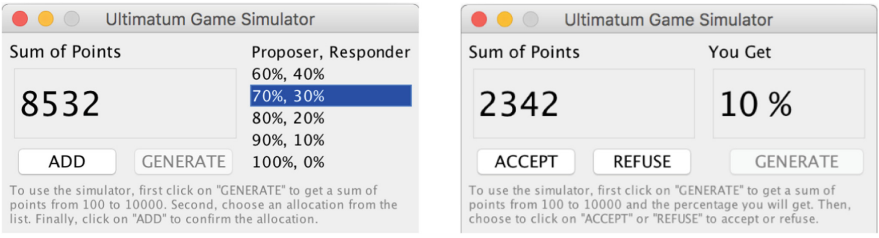

Fig. 2. Ultimatum Game simulators to generate random sums for proposers (left) and random proposals for responders (right).

required to make decisions in 10 s. The sums and proposals were generated by two separated programs (Fig. 2). The program for proposers would not generate a fair offer as well as an offer which the proposer receive less than half of the sum.

3.3 Experiment Procedure

Ultimatum Game I. Before the experiment, participants were allocated as proposers or responders randomly. Proposers in both groups were required to fill the form on how to split the sum of money in 10 s. After proposers filling the forms, the experimenter collected the form and allocated the forms to the responders randomly. The responders were also required to decide on accepting or not within 10 s. In this experiment, only the proposers were required to wear the GSR sensor when filling the form. The data collected by GSR sensor would be shown as line charts in Arduino Serial Plotter (Fig. 3).

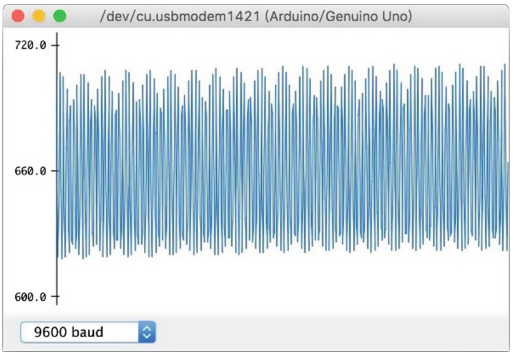

Fig. 3. A line chart of GSR sensor data of a participant who was taking a break shown in Arduino Serial Plotter.

Ultimatum Game II. Before the experiment, participants were randomly divided into groups of proposers and responders. Proposers were required to choose a proposal from among five proposals provided by the program in 10 s. And the sum of points to split was randomly generated. Responders were going to make decisions on whether to accept or reject the randomly generated proposals in 10 s. In this experiment, both proposers and responders were required to wear the GSR sensor when making decision.

4 Experiment Results and Analysis

In this research, the bio-feedback of emotion of each player was collected as quantitative data. The results of the first and the second Ultimatum Game are shown in the tables below.

4.1 Results of Two Ultimatum Games

The value variation of GSR sensor are shown in one or multiple "+" and "−". More "+" means a larger variation in GSR sensor value. "−" stands for no significant variation.

Table 1 shows the proposals of each proposers and corresponding GSR sensor value variations in the first Ultimatum Game experiment. Two of the proposers from Group I offered proposals that provided 60% of the sum to themselves and the rest 40% to their responders. Only one proposer (Proposer 3) in this group made a decision to provide 70% of the sum to himself and the rest 30% to his responder. In Group II, both two proposers decided to offer 60% of the sum to themselves and the rest 40% to their responders. Among the five proposers, the GSR value variations of Proposer 3 and Proposer 4 were largest (both of them reached "+ + +") during decision-making period. The variation of Proposer 2 ("+") was the least. The GSR value variations of rest two proposers were both "+ +".

Table 1. Proposals of proposers and corresponding GSR value variation in Ultimatum Game I.

Group number	Proposer	Proposal (proposer, responder)	GSR sensor value variation
I	1	60%, 40%	+ +
	2	60%, 40%	+
	3	70%, 30%	+ + +
II	4	60%, 40%	+ + +
	5	60%, 40%	+ +

Tables 2 and 3 show the experiment results of the second Ultimatum Game. Among the five proposers, Proposer 4 made a proposal on the largest sum of the points (8532). Proposer 3 made a decision on the minimum sum of the points (1009). Three proposers decided to split the sum as two partitions of 70% (for themselves) and 30% (for responders). One of the rest proposers proposed 60% for himself and the other proposed 90% for himself. The GSR sensor value variation of Proposer 1 is largest among the five proposers. Two of the proposers did not have significant variation in GSR value. Among the five responders, the largest percentage of the sum which a responder can receive if he/she accepted the proposal is 40% (Responder 3 and Responder 5). The largest amount of points which a responder can receive if he/she accepted the proposal is $6185 \times 40\% = 2474$ (Responder 3). The largest GSR value variation of five responders is "+" (Responder 2 and Responder 3). No significant variation of GSR value was found during the rest responders were making decisions.

Table 2. Proposals of proposers and corresponding GSR value variation in Ultimatum Game II.

Proposer	Sum of points	Proposal (proposer, responder)	GSR sensor value variation
1	4277	70%, 30%	+ +
2	1389	60%, 40%	+
3	1009	90%, 10%	+
4	8532	70%, 30%	−
5	4879	70%, 30%	−

Table 3. Proposals and GSR value variation of each responder in Ultimatum Game II.

Responder	Sum of points	Proposal (proposer, responder)	GSR sensor value variation
1	2342	90%, 10%	−
2	2082	90%, 10%	+
3	6185	60%, 40%	+
4	5027	70%, 30%	−
5	1722	60%, 40%	−

4.2 Discussion

In Ultimatum Game, when a proposer is required to propose an offer to split the sum of money, his/her emotion variation during the decision-making will be indicated by GSR data. On one hand, when a proposer makes decision on a large amount of money, he/she will have a larger variation of GSR value as well as emotion. On the other hand, the proposer will also have a larger variation of GSR value, when he/she is making decision to split more percentage of the money to him- or her- self. For example, in Ultimatum Game I, Proposers 1, 2, 4 and 5 offered a same splitting method (Proposer: Responder = 3: 2). Proposers 4 and Proposer 5 who were required to split 50 RMB, while Proposer 1 and Proposer 2 were required to split 20 RMB. The experiment result showed that the average GSR value variation of Proposer 4 and 5 is larger than Proposer 1 and 2. Proposer 3 was required to split 20 RMB and he offered a proposal that he would get 70% of the sum. Compared with Proposer 1 and 2, his GSR value variation was larger. However, in the second experiment, where players were required to making decisions on virtual points or proposals offered by computer, we failed to draw the same conclusion. Hence, we speculate that players will have a variation in emotion only when he/she is making decision on the real money. Further studies need to be conducted in order to explore such differences.

5 Future Study

In the current experiment design, the number of participants is limited. In Ultimatum Game I, only the data of proposers was recorded. Also, in both experiments, the acceptance statuses of each proposals were not recorded yet. Therefore, in the future, we are going to re-design a new experiment and test with more participants.

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