UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

Colegio de Posgrados

Matching Protocols based on payoffs: Evidence from experiments with incomplete information

Kevin Ricardo Rojas Satián

Pedro Romero, PhD.
Director de Trabajo de Titulación

Trabajo de titulación de posgrado presentado como requisito para la obtención del título de Magíster en Economía

Quito, 6 de julio de 2020

UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

Colegio de Posgrados

HOJA DE CALIFICACIÓN DE TRABAJO DE TITULACIÓN

Matching Protocols based on payoffs: Evidence from experiments with incomplete information

Kevin Ricardo Rojas Satián

Pedro Romero

PhD

Director de la Maestría en Economía

Santiago Gangotena

PhD

Decano del Colegio de Administración y Economía

Hugo Burgos

PhD

Decano del Colegio de Posgrados

Quito, Julio 2020

Derechos de Autor

Nombre del estudiante:	Kevin Ricardo Rojas Satián
Código:	00209992
C. I.:	1722658604

Quito, 6 de julio de 2020

ACKNOWLEDGEMENTS

It is my desire to mainly thank my tutor Pedro Romero for all the standards, time, dedication, and understanding he has had with me during the completion of this degree project.

This project was entirely supported by the School of Economics and the Experimental and Computational Economics Laboratory. I belong to both the school and the Laboratory, which is why I know that is a better environment for developing any research project. My eternal gratitude with both of them.

I want to thank my parents César and Mercedes, as well as my brother Konrad for being the pivot of my family life, filling each of my days with happiness and hope.

My heartfelt thanks to Santiago José, Diego, Julio, Sergio, Pablo, Sebastian, Carlos, Olga, and Victor for such excellent training.

I would also like to thank Santiago Sandoval for becoming the best Master's classmate that anyone could have asked for. Likewise, my colleagues Paul, Russian, Ale, Gabriel, Mishell, Daniela, and Miguel.

Thank you all.

ABSTRACT

In this document, we consider two payment-based matching protocols: mean matching and random into an incomplete-information scheme. We separated two groups, with similar characteristics in different sessions, facing matching protocols on games of conflict with similar and comparable theoretical characteristics. We find significant evidence that, on average, better final payments were obtained among the participants within the mean matching Protocol due to their performance in the experiment, showing consistency also at the level of session sizes. Likewise, there is evidence that in the mean matching protocol, aggressive strategies tend to be more recurrent. We conduct all the sessions using an online format, which explains the experimental procedure with which they were carried out; we consider that this proposed procedure is relevant for literature since this experiment was conducted during the emergency due to the pandemic lock-downs.

Keywords: Matching Protocols, incomplete information, experimental economics, Nash Equilibrium, Mean Matching, Random Pairwise.

TABLE OF CONTENTS

FIGURES

TABLES

Introductory Material

2.1 Introduction

Several research papers have been written based on experimental designs that use either the Random Pairwise matching protocol (from now RP) or the Mean Matching protocol (from now MM). However, bibliography using or comparing matching protocols is very limited, and the purpose for those is to define the treatment of an experiment instead of comparing the behavior of the subjects when they face this type of matching. On the other hand, experimental research is costly, so considering the scenario where the specific characteristics of one of these matching protocols that reach better or faster results might reduce several sessions, rounds, or amount of participants.

The traditional and well-known Random Pairwise matching protocol in the classical game theory is a two-player, one-shot game. To evaluate the evolution of behaviors, we repeat over several rounds in which every participant matches a distinct participant. Also, for the classical game theory, the Mean Matching protocol is an n-player game repeated over several rounds in which every participant receives his payoff based on every other participant's decision for every round.

Research related to matching protocols covers several branches of game theory, including the newest ones. Since the first experiments, researchers use the traditional RP matching protocol due to its simplicity; first implemented experiments like the Dictator or the Ultimatum games always assume this matching protocol. On the other hand, the MM protocol was first proposed by Daniel Friedman (Friedman, 1996) when he was defining and explaining the replicator dynamics concept applied to games with human participants in a two-players format. He also provides strong evidence (Cheung & Friedman, 1998) on how the "mean matching" protocol aids in the speed of adjustment relative to the RP.

The results explained above consider experimental frameworks with complete information as one of their assumptions. Complete information assumes that participants can know everything related to their payoff and the payoffs of other participants. Alternatively, if an incomplete information scenario, participants could either do not know someone else payoff or do not know her payoff (Jensen & Rigos, 2018). This concept of the information's completeness is fundamental for neuroscience due to the process of thinking and our capacity to affront risk situations.

We research to evaluate the behavior of the participants considering some of the concepts described above: (Baliga & Sjöström, 2012) considered an incomplete information scenario in a chat-allowed laboratory experiment to identify theoretical predictions involving manipulation of the decision-makers. (Oprea, Henwood, & Friedman, 2011) defines an experiment with matching protocols based on populations (one-population and two-populations) instead of payoffs. They found that changing this structure; participants change their behavior among treatments converging to asymmetric mixed Nash equilibrium in the first case and asymmetric equilibrium in the second case. Finally, (P. Grossman, Komai, & Jensen, 2015) conduct a laboratory experiment to study the role of gender on social welfare outcomes in a strategic commitment game of incomplete information founding exciting results in terms of convergences to the social welfare and gender differences. In this research, we want to consider both the incomplete information assumption and the matching protocol classification based on payoffs (RM and MM) to identify a difference in terms of equilibrium convergence and speed.

2.2 Conceptual Framework

2.2.1 Introducction

We aim to develop an experimental procedure divided into two stages that let us evaluate how experimental matching protocols could give us better approaches in terms of Nash Equilibrium. Following research from (Van Huyck, Viriyavipart, & Brown, 2018), (P. Grossman et al., 2015), we consider for the first stage of the experimental procedure the same methodology that the one proposed by the authors; after this, we slightly modify the payoff structure among subjects in order to emulate a process involving MM protocol.

For this setting, we also consider a scheme of incomplete and imperfect information. The concept of complete and perfect information is associated with the idea that a player can identify and thoroughly understand the other players' decisions and payoffs. Thus, to achieve this scheme, we consider that payoffs will be random when the player decides on an aggressive strategy; also, every player's decisions should depend on the random number in a way that we can quickly identify their intention. To achieve this, we create a random number, drawn from a uniform distribution of $F \in [0, k]$; also player decides on a number on the same interval $[0, k]$. We then compare the numbers to determine player decisions: if participants' number is larger than the random number, then she plays the aggressive strategy whereas if participants' number is shorter than the random number, then she plays the non-aggressive strategy. Since players can only take two decisions, we can define the payoff matrix for the game as a 2×2 matrix in which the first row will identify payments considering aggressive strategy, and the second row will identify payments considering non-aggressive strategies.

Consider for this stage the following payoff matrix:

$$\begin{pmatrix} x_i & \mu + x_i \\ k - d & k \end{pmatrix} \tag{2.1}$$

Where x_i is the random value generated for each participant in each round. Also, k = 100, μ = 10 and d = 95 are constants, the same values in (P. Grossman et al., 2015). [1]

2.2.2 First Stage: Incomplete information with Random Pairwise protocol

Several meaningful findings have come from Grossman in terms of gender differences. His results give us the necessary support to consider the same procedure as a base for the experimental design, that applying the description of the methodology described above, gives us the matrix 2.1:

$$\begin{pmatrix} x_i, NN_i & \mu + x_i, k - d \\ k - d, \mu + NN_i & k, k \end{pmatrix} \tag{2.2}$$

Where the value for NN is defined randomly for the second player.

2.2.3 Second Stage: Incomplete information with Mean Matching protocol

The same structure of the problem before, but considering that the payoffs for individuals will depend on the number of players that take some specific strategy. This payoffs, based on the matrix 2.1, will lead us to the following payments:

[1]By their own, (P. Grossman et al., 2015) takes the theoretical framework from (Baliga & Sjöström, 2004), used for conflict's analysis of arms. Then they define constants, empirically considering the most appropriate values that guarantee the conflictive condition

2.2.3.1 If I play H

$$x\frac{(N-1-z)}{(N-1)}+(x+\mu)\frac{z}{(N-1)} \tag{2.3}$$

2.2.3.2 If I play D

$$(k-d)\frac{(N-1-z)}{(N-1)}+k\frac{z}{(N-1)} \tag{2.4}$$

In both cases, z denotes players that plays opposite strategies in the same round.

2.3 Calculations and predictions

Once we have describe the design of the experiments, the next step is to go through the estimations for the results and clearly define the hypothesis we want to demonstrate and the formal design for players. As far, we should notice that equilibria for the first two stages are not the same given that players have to face the same decision on their payoff matrix but with the unique difference that every player is receiving their payoff. Therefore, the equilibrium for both incomplete information games came as follows:

2.3.1 Computing Equilibria

Given the structure of the payoff matrix and the incomplete information scheme considered for this research, we will consider cutoff strategies definition:

Definition 2.3.1. (Cutoff Strategy) Let A and B be the possible strategies for a player. We said that the player uses a cutoff strategy if there exists some type θ such that for each type t_1 of player:

1. if $t_1 \geq \theta$, then player chooses A for sure.
2. if $t_1 \leq \theta$, then player chooses B for sure.
3. if $t_1 = \theta$, then player is indifferent between the two choices

2.3.1.1 Equilibrium for the first stage

Consider the design of the experiment; players will have to consider that we are reaching a cutoff strategy, based on a Bayesian Nash Equilibrium x_{1s} in a point between the range of the option in such a way that one plays D when:

$$x_i \leq x_{1s}$$

Moreover, decide to choose h otherwise. When a player is indifferent between H and D, the cutoff is the (unique) fixed point satisfying:

$$x_{1s} := k - d + (d - \mu)F(x_{1s}) \tag{2.5}$$

Given that $F(.)$ follows a uniform distribution based on the assumptions, we can rewrite the cutoff point as:

$$x_{1s} = \frac{k \times (k-d)}{k - d + \mu} = 33 \tag{2.6}$$

2.3.1.2 Equilibrium for the second stage

The procedure for this new setting is quite different because of the weighted consideration explained in equations (2.3) and (2.4). The payoffs matrix we define stands as:

$$\begin{pmatrix} \frac{(N-1-z)}{(N-1)}x_i & \frac{z}{(N-1)}\mu + x_i \\ \frac{(N-1-z)}{(N-1)}k - d & \frac{z}{(N-1)}k \end{pmatrix} \tag{2.7}$$

Therefore, following same algebraic process than before, we can define the following:

Definition 2.1. (Equilibrium condition for the mean matching protocol) Let r_A and r_B be the proportion of players in a session with strategies A and B, respectively. Let F(.) be a uniform distribution between 0 and 101. Then the optimal equilibrium cutoff strategy occurs when:

$$x_i\left[r_A + F(\cdot)(r_B - r_A)\right] + F(\cdot)r_B\mu = F(\cdot)[k(r_B - r_A) + r_A d] + r_A(k - d)$$

Which is equivalent to say that the equilibrium can be characterized as:

$$x_i^2 + x_i\left[\frac{r_A(k-d)}{(r_B - r_A)} - k + \frac{r_B\mu}{(r_B - r_A)}\right] - \frac{r_A(k-d)}{(r_B - r_A)} = 0$$

For our particular case, considering the values used in the first stage to make the experiment consistent, the equilibria condition can be defined as a proportion-dependent cutoff strategy using the polynomial formula:

$$x_i^2 + x_i\left[\frac{1+5r_B}{(r_B-r_A)} - 100\right] - \frac{5r_A}{(r_B-r_A)} = 0$$

This gives us a proportion dependent solutions which are shown in figure 2.1.

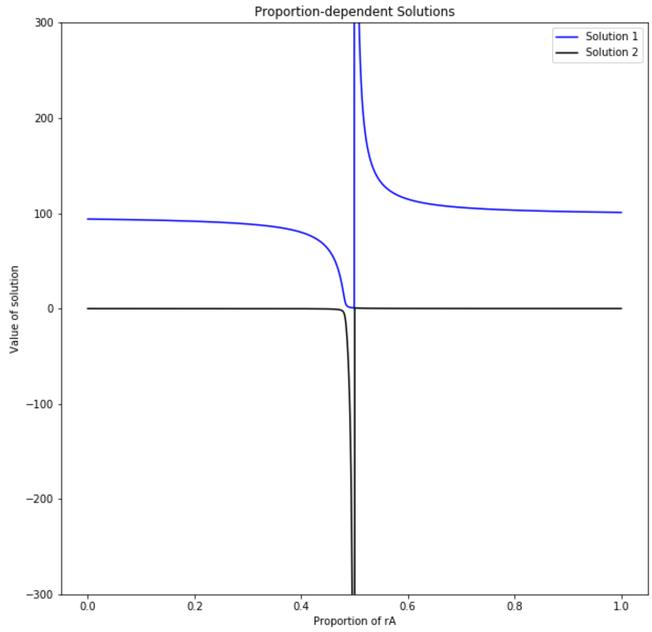


Figure 2.1: Proportion-Dependent Solutions

Thus, depending on the proportions, most solutions lie closer to 100 and 0 providing the conditions for a multiple Nash equilibrium. The strategies may depend only on the random number since the random number defines the final payoff. In this way, when the random payments are more significant, also the proportion of participants playing strategy A, and when the random payments are smaller, the same proportion is getting reduced as another strategy starts to represent better payoffs.

2.3.2 Consideration about payments similarity

Players in each round receive payment according to the decision and the random number provided. Every payment in the MM protocol has to be between the maximum and minimum payment in the RP matching protocol since each decision is the linear combination of the payoffs received in any strategy. Let us state this as follows:

Theorem 2.3.1. *Let p_A be the payoff that participants might receive, without loss of generality of self-decision, if another participant takes decision **A**. Also, let p_B be the payoff that participants might receive, without loss of generality of self-decision, if another participant takes decision **B**. Therefore, any weighted payoff that may result from the decision lies between payments for every α in [0,1]:*

$$p_A \leq \alpha p_A + (1-\alpha) p_B \leq p_B$$

2.4 Experimental Procedures

The ECEL team conduct sessions on an online basis. Using the student database for participants in Universidad San Francisco de Quito provided by Orsee, we invite almost 160 students using an invitation and a confirmation mail in the following way: students receive invitations, then they selected the preferred time responding the e-mail and then they receive a confirmation e-mail with the instructions for the connections and the correspondent data. Participants receive information about a Zoom meeting scheduled in the proposed times, and once they enter the meeting, they receive a link to connect with the server providing the application. They also receive a participation code using the private chat option, and finally, they take their decisions proposed for the experiment, answer the surveys, and finally proceed to the payment.

We reach incentive-compatibility by paying each of the participants American dollars, the official currency in Ecuador, using an application called BIMO provided by Ecuador's internal banking network. They were asked in the invitation e-mail to download the app and register using a basic account provided by the same app. This process is private, and every payment process is registered individually.

During the sessions, we take care of the following:

1. Each participant is connected to the Zoom session at the selected date and time.

2. Each participant in the session receives a unique identification code using the Zoom session's private chat option.

3. Each participant is muted during the experiment, and they can only activate their microphone during payments.

4. Each participant is removed to the waiting room in the Zoom session at the moment it ends the end-question of the survey.

5. Each participant, following a random order, re-enters the main Zoom session, activates their camera and microphone, and receives the final payment after confirmation of their participants' code.

This process allows us to connect with participants and to obtain remarkable similarities with the conventional protocol applied in the laboratory. Since we connect with participants using the Orsee-University database, we can control that person that we do not trust, enters session. Furthermore, at the end of the session, every participant has to show their face also to control fraudulent or double participation. The activity of the participants was monitored using the app to check if they are actively responding. Payments were registered digitally using the bank account associated with the BIMO account.

2.4.1 Application and Programming

We develop the application for this research using oTree software. There is one base treatment where participants receive their payoffs based on the mean-matching protocol and one alternative treatment based on the randomized matching protocol. We host the application in the oTree recommended server provider Heroku and displayed in every participant computer meanwhile one of the members of the Lab team handles the monitoring screen.[2]

2.4.2 Sessions and payments

We conducted nine sessions with a total of 118 students divided between both treatments. For the MM protocol, we conducted a total of 5 sessions of 14, 18, 6, 12, and 8 participants in each one; in the same way, we conducted a total of 4 sessions with 16, 12, 4, and 28 participants. Sessions took place between

[2] Application used for the experiment is available at: `https://github.com/Crillboy314/Matching_Protocols`

Friday, June 5, and Wednesday, June 17. Each participant receives a dollar as a participation fee, then additional money is perceived due to the decisions took on the rounds of the experiment. The average payoff received, including the participation fee, was 6.56 American dollars. Every single payment was in private using the Zoom videoconferencing, and we record these moments to justify payments and to avoid fraudulent participation beyond the students' registration.

Analysis and Results

3.1 Analysis and Results

3.1.1 Defining Hypothesis

Its theoretical design explains the similarity between experiments using the MM or the RP. The payoff matrix is pretty the same, and the main difference is the weighted consideration for the MM protocol. However, the constant values are the same. Participants taking their decisions uses a slider that they can manipulate to select a number between 0 and 101, and this is the same for both treatments. Of course, the most significant difference is related to the weights of the decisions that the other players took, and this implies, as discussed before, an equilibrium condition with two points.
Recall theorem 2.3.1, it should be the case that payments on average should behave in the same manner. However, some exciting results appear when checking the results, since we concluded that the average final payoff that each participant receives is significantly different and more significant using the MM protocol. Results are shown in figure 3.1

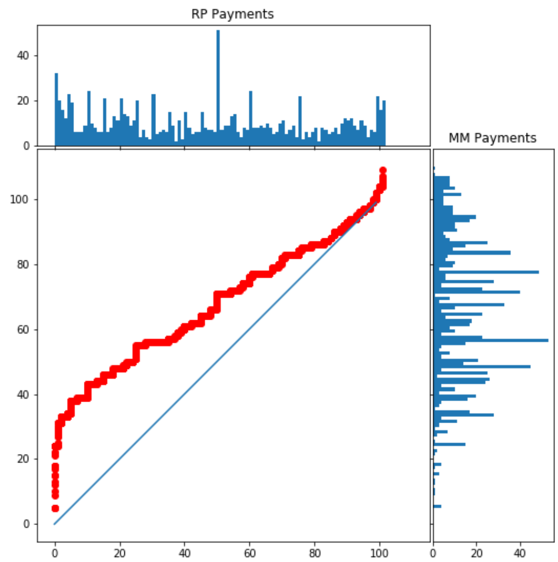
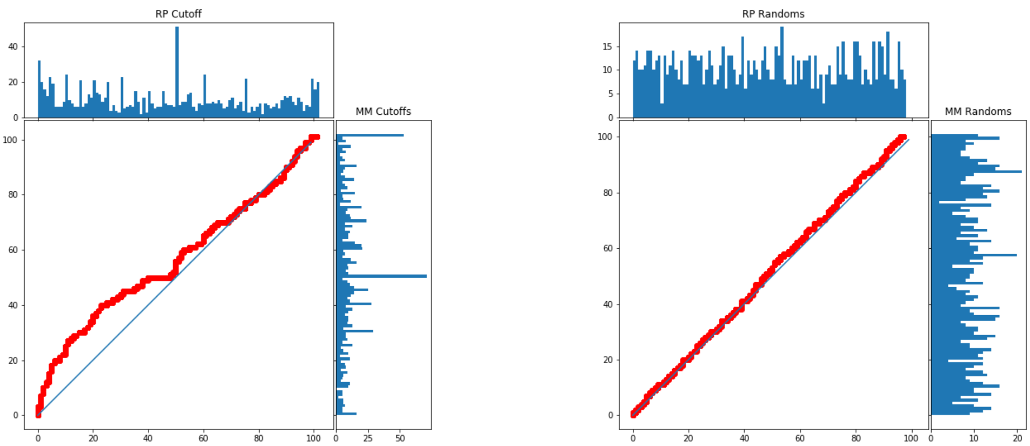


Figure 3.1: Scatter plot with histograms for payments

Payments were not the same. We also conduct a *t-test* to see if there is a significant difference between the group, finding results that the MM protocol payments are more significant than the ones for the RP. Applying a simple t-test for samples, over the entire population of data for payments (1080 observations for RM protocol and 1044 observation for MM protocol) we find an average in payments of 64.51 % for the MM protocol participants and an average in payments of 48.42 % for the RP matching protocol.

It is impressive that the payments on average changed that much, considering the first theorem of this section. What should we expect about the decisions played and the random numbers? We provide the same analysis for both of these variables in the figure 3.2



(a) Scatter plot with histograms for cutoffs (b) Scatter plot with histograms for random numbers

Figure 3.2: Other variable behaviors between treatments

Therefore, a random number is generated in the same way for both matching protocols, but participants differ in the cutoff decision significantly. With the same amount of observations, the average cutoff strategy for the MM protocol was 53.27; meanwhile, the average cutoff strategy for the RP matching protocol was 48.42.

Evidence shows us that there is some difference between treatments. This difference may provide from the direct response to the random number and the payoff background received by the player. We define the main hypothesis as follows:

Hypothesis 3.1.1. *In a similar-setting laboratory experiment where the only difference between control and treatment is the matching protocol (RM or MM), better responses are expected from participants in the MM protocol.*

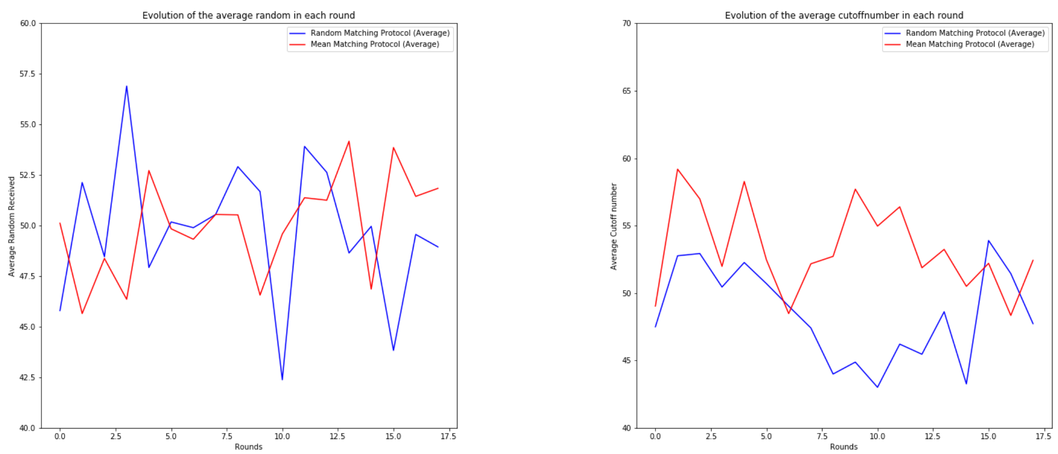
We will present some results providing evidence on the existence of this difference and its relation to some theoretical predictions.

3.2 Presenting Results

This research paper's main idea is to provide evidence or justify the difference stated in the formulation of the hypothesis. The next sub-sessions will cover the primary evidence we have found as follows:

3.2.1 How is the data looking like ?

First of all, we need to mention that from the output of our experiment there are four main variables that we need to consider: Cutoff strategy, an integer number from 0 to 101 that is selected by the participant using the slider; Random number, an integer number that each participant receives from a uniform distribution between 0 and 100; Payment, a rounded number that represents the final payoff of the participant in points; Strategy, a letter (could be A or B) that represents the decision after Cutoff and Random random numbers appear. We present data in the following figure 3.3



(a) Random numbers overall average (b) Scatter plot with histograms for random numbers

Figure 3.3: Cutoff values overall average

It is again pretty clear that we generate radon numbers in the same manner. However, some differences may appear in the cutoff values. On average, it looks like the MM protocol is over the RM protocol. Based on the theoretical results, people tend to choose more aggressive strategies depending on the social and cultural context when they feel that people are less collaborative. Participants from the MM protocol receives information about the number of participants in the group playing strategies A or B in the last round and also information about the random number generated. For the case of participants with the RP matching protocol, they receive information about the random number, but not about every participant's decision in the session, only about the participant that matched. Payoffs in average received differs mostly between treatments, as shown in figure 3.4

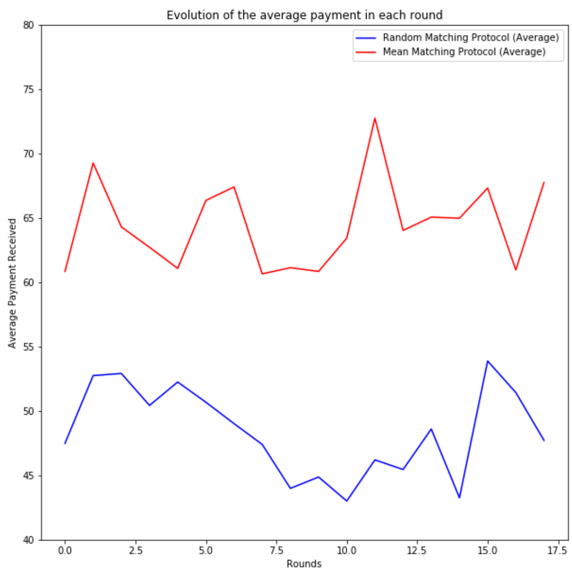


Figure 3.4: Average-Payment-All

3.2.2 Direct relations in the treatments

Thus, our first guess is that given that information related to the uncertainty is discarded, the information that might be relevant is the player's decision. To prove this, we present the following regressions considering payment as the dependent variable, explained by another three variables, obtaining the following results of table 3.1:

Table 3.1: Regression Analysis for RM

Dep. Variable:	RandomPago	R-squared:	1.000
Model:	OLS	Adj. R-squared:	1.000
Method:	Least Squares	F-statistic:	2.142e+28
Date:	Wed, 01 Jul 2020	Prob (F-statistic):	7.32e-194
Time:	17:41:08	Log-Likelihood:	525.73
No. Observations:	18	AIC:	-1043.
Df Residuals:	14	BIC:	-1040.
Df Model:	3		

	coef	std err	t	P> |t|	[0.025	0.975]
Intercept	-5.684e-14	4.72e-13	-0.120	0.906	-1.07e-12	9.56e-13
RandomCutoff	1.0000	6.87e-15	1.46e+14	0.000	1.000	1.000
RandomDecisions	-1.137e-13	5.15e-13	-0.221	0.828	-1.22e-12	9.9e-13
RandomAleatorio	1.332e-15	5.16e-15	0.258	0.800	-9.74e-15	1.24e-14

Omnibus:	3.485	Durbin-Watson:	0.017
Prob(Omnibus):	0.175	Jarque-Bera (JB):	1.080
Skew:	0.000	Prob(JB):	0.583
Kurtosis:	1.800	Cond. No.	3.45e+03

From these results, we can conclude that participants in the RP matching protocol payoffs depend entirely on the cutoff decision made. There is no evidence that it has something related to the number of participants taking a decision. The last is crucial since we do not find relation even in the last rounds, which means that participants completely ignores feedback about the other players' decision in each round. The random number does not show to be relevant as an explanatory variable, see table 3.2.

On the other hand, results for the MM protocol treatment show relations completely different. The relation between payments and the cutoff numbers is negative and with no significance. Relation with the groups' decisions is substantial; a negative relation (with is consistent with the learning process) explains how one could completely change the strategy in the group with significance in the final payoff. Finally, it is essential to notice that the random number has a significant-close to zero coefficient.

Table 3.2: Regression Analysis for MM

Dep. Variable:	MeanPago	R-squared:	0.761
Model:	OLS	Adj. R-squared:	0.709
Method:	Least Squares	F-statistic:	14.83
Date:	Wed, 01 Jul 2020	Prob (F-statistic):	0.000126
Time:	17:41:08	Log-Likelihood:	-34.508
No. Observations:	18	AIC:	77.02
Df Residuals:	14	BIC:	80.58
Df Model:	3		

	coef	std err	t	P> |t|	[0.025	0.975]
Intercept	72.5527	13.622	5.326	0.000	43.337	101.768
MeanCutoff	-0.1962	0.154	-1.276	0.223	-0.526	0.134
MeanDecisions	-62.8782	9.718	-6.470	0.000	-83.721	-42.036
MeanAleatorio	0.6491	0.202	3.212	0.006	0.216	1.083

Omnibus:	5.079	Durbin-Watson:	1.889
Prob(Omnibus):	0.079	Jarque-Bera (JB):	1.535
Skew:	-0.134	Prob(JB):	0.464
Kurtosis:	1.595	Cond. No.	2.35e+03

3.2.3 Evidence from analysis in sessions

One of the first objections that we can receive is that previous analysis is applied to the entire sample, only distinguished by the treatment used. Thus, in table 3.3, we provide the coefficients obtained in every single session regression analysis with the same consideration as before.

Table 3.3: Coefficients for regressions divided by sessions

SESSION	Intercept	Cutoff	Decisions	Random
MM - 6 part	71.73	-0.41	-54.04	0.65
MM - 8 part	55.00	-0.07	-38.98	0.58
MM - 12 part	61.64	0.13	-48.45	0.35
MM - 14 part	74.18	0.09	-46.58	0.14
MM - 18 part	69.56	-0.05	-66.06	0.60
RP - 4 part	30.98	0.41	41.61	-0.54
RP - 12 part	2.93	0.85	5.92	0.04
RP - 16 part	4.07	0.97	0.64	-0.09
RP - 28 part	-2.28	0.94	47.30	-0.32

One can see that the relations hold even for the small sessions. In every MM protocol session, the intercept, decisions, and random variables are significant in explaining the payment; meanwhile, for the RP matching protocol, the significant coefficient is, for most cases the associated with the cutoff strategy.

3.2.4 Socio-Demographic Considerations

One additional consideration might be related to the characteristics of the participants. We survey each participant to collect information about some social or demographic features that may explain the results in some manner. Participants provide data about their gender, age, race. Also, considering risk preferences for each participant, we additionally consider questions related to the perceptions of other participants (directly asking "how do you perceive the other's intentions") and the self-perception by asking, "how do you identify yourself as a person prepared to take a risk." As this experiment was holding in an online-basis, it was an outstanding idea also to consider a variable for the condition of students; we also include a binary for that. Finally, we were also interested in identifying relations with the participant's socio-economic conditions, so we also ask for the average ordinary income.

It might be interesting to first check for some personal features of the participants to see if the groups are comparable. We present some statistics in table 3.4:

Table 3.4: Description of participants by treatments

Element	Age Average (years)	% Male	% Mixed	%Students
MM	21.56	39.65	91.37	82.75
RP	21.61	38.33	88.33	91.66

At first sight, it is not significant differences between treatments. So then, we also add some regression analysis regarding these new features. First of all, let us consider for the regression the variables: Age(years - numerical), Gender(male or female - categorical), Ethnicity (mixed, native, black, white - categorical), Student (yes or no - categorical), Income (categorical), Intention (perception of the others - categorical), Risk (how much risk participant takes - numerical from 1 to 10) and Treatment (if RM or MM - categorical) in table 3.5.

Table 3.5: Regression Analysis of Payoff including Socio-Demographic data I

Dep. Variable:	Payment	R-squared:	0.321
Model:	OLS	Adj. R-squared:	0.189
Method:	Least Squares	F-statistic:	2.437
Date:	Thu, 02 Jul 2020	Prob (F-statistic):	0.00237
Time:	17:41:50	Log-Likelihood:	-108.99
No. Observations:	118	AIC:	258.0
Df Residuals:	98	BIC:	313.4
Df Model:	19		

	coef	std err	t	P> |t|	[0.025	0.975]
Intercept	7.5803	1.123	6.752	0.000	5.352	9.808
Sex[T.Masculino]	-0.0313	0.138	-0.227	0.821	-0.305	0.243
Race[T.Blanca]	0.2359	0.873	0.270	0.787	-1.496	1.967
Race[T.Indígena]	-0.6588	0.761	-0.866	0.389	-2.169	0.851
Race[T.Mestiza]	-0.0915	0.715	-0.128	0.898	-1.511	1.328
Race[T.Prefiero no decir]	-0.8676	1.070	-0.811	0.420	-2.992	1.257
Student[T.Sí]	0.0152	0.242	0.063	0.950	-0.464	0.494
Income[T.1601 a 2000]	-0.3181	0.250	-1.271	0.207	-0.815	0.179
Income[T.2001 o más]	-0.2351	0.181	-1.296	0.198	-0.595	0.125
Income[T.400 o menos]	-0.5475	0.319	-1.717	0.089	-1.180	0.085
Income[T.401 a 800]	0.2873	0.303	0.950	0.345	-0.313	0.888
Income[T.801 a 1200]	-0.1663	0.216	-0.771	0.442	-0.594	0.262
Intention[T.Generosos]	-0.3569	0.301	-1.187	0.238	-0.953	0.240
Intention[T.Hostiles]	-0.6393	0.268	-2.385	0.019	-1.171	-0.107
Intention[T.Interesados]	-0.1219	0.200	-0.610	0.543	-0.518	0.274
Intention[T.Irracionales]	-0.4924	0.243	-2.024	0.046	-0.975	-0.010
Intention[T.Racionales]	-0.3096	0.193	-1.600	0.113	-0.693	0.074
Treatment[T.Random]	-0.3996	0.138	-2.893	0.005	-0.674	-0.126
Risk	-0.1108	0.041	-2.697	0.008	-0.192	-0.029
Age	0.0264	0.029	0.899	0.371	-0.032	0.085

Omnibus:	1.588	Durbin-Watson:	2.036
Prob(Omnibus):	0.452	Jarque-Bera (JB):	1.095
Skew:	-0.183	Prob(JB):	0.578
Kurtosis:	3.298	Cond. No.	659.

As expected, the variable of treatment has a negative and significant coefficient when we try to explain the variable payment. Another interesting fact is that we found is with the intentions (hostile and irrational) that show negative and significant coefficients. The previous result may also relate to the selfish strategies that are typically used in this type of game. Finally, let notice that the Risk variable also has a significant and negative coefficient, which means that variations in people's attitude to risk also modifies in some way payments. To go further identifying these features, we remove the treatment variable from the regression in table 3.6.

Table 3.6: Regression Analysis of Payoff including Socio-Demographic data II

Dep. Variable:	Payment	R-squared:	0.263
Model:	OLS	Adj. R-squared:	0.129
Method:	Least Squares	F-statistic:	1.962
Date:	Thu, 02 Jul 2020	Prob (F-statistic):	0.0190
Time:	17:54:36	Log-Likelihood:	-113.83
No. Observations:	118	AIC:	265.7
Df Residuals:	99	BIC:	318.3
Df Model:	18		

	coef	std err	t	P> |t|	[0.025	0.975]
Intercept	7.5343	1.164	6.475	0.000	5.225	9.843
Sex[T.Masculino]	0.0033	0.143	0.023	0.981	-0.279	0.286
Race[T.Blanca]	0.3828	0.903	0.424	0.673	-1.409	2.174
Race[T.Indígena]	-0.4655	0.786	-0.593	0.555	-2.024	1.093
Race[T.Mestiza]	0.0609	0.740	0.082	0.934	-1.407	1.528
Race[T.Prefiero no decir]	-0.7551	1.109	-0.681	0.497	-2.955	1.445
Student[T.Sí]	-0.1028	0.247	-0.416	0.678	-0.592	0.387
Income[T.1601 a 2000]	-0.2458	0.258	-0.952	0.343	-0.758	0.266
Income[T.2001 o más]	-0.1179	0.183	-0.644	0.521	-0.482	0.246
Income[T.400 o menos]	-0.5120	0.330	-1.550	0.124	-1.167	0.143
Income[T.401 a 800]	0.3242	0.313	1.035	0.303	-0.297	0.946
Income[T.801 a 1200]	-0.0975	0.222	-0.439	0.662	-0.538	0.343
Intention[T.Generosos]	-0.3835	0.311	-1.232	0.221	-1.001	0.234
Intention[T.Hostiles]	-0.8072	0.271	-2.976	0.004	-1.345	-0.269
Intention[T.Interesados]	-0.1729	0.206	-0.838	0.404	-0.582	0.236
Intention[T.Irracionales]	-0.5219	0.252	-2.072	0.041	-1.022	-0.022
Intention[T.Racionales]	-0.3018	0.200	-1.505	0.135	-0.700	0.096
Risk	-0.1397	0.041	-3.382	0.001	-0.222	-0.058
Age	0.0244	0.030	0.802	0.425	-0.036	0.085

Omnibus:	4.295	Durbin-Watson:	1.898
Prob(Omnibus):	0.117	Jarque-Bera (JB):	3.691
Skew:	-0.393	Prob(JB):	0.158
Kurtosis:	3.364	Cond. No.	658.

We can see that both the intentions and the risk variables are the only sign in the regression. The previous result may be due to the natural dispersion of the data or the natural selfish attitude presented by humans in this type of game.

3.3 Conclusions

Experimental Economics is the branch that will always depend on the experimental support provided by the physical tools that the experimenter can consider and how he/she defines the experimental procedure in order to prove some hypothesis. In this context, several theoretical concepts become essential to be considered and to be tested to support the current bibliography related to all this topic. With this spirit, in this document, we start from an experimental procedure proposed by Grossman et al. in 2019 to prove conflict reactions and the role of gender in a continuous timing experiment. For this experiment, we used the traditional Random Pairwise matching protocol. We then propose an alternative treatment for which the payoff depends not only on the other participant's decision but also consider the payoff of every other participant by using a weighted rule of assignment payoffs based on the two possible payoffs that a participant could receive based on the decision that took. Also, for both treatment, we introduce an incomplete information scheme that was not yet studied when studying these treatments related to matching protocols based on payoffs.

We consider the same theoretical matrix construction for both the RP and the MM experiments to expect similar payments as described in calculations. Experiments have shown us that total payments received by participants are more significant when they face the MM protocol, and we found that this difference may be due to the reaction participants shows on the information. Participants in the RP matching protocol payments respond only to the decision that each one has taken in the round; meanwhile, participants in the MM protocol consider the decision and somehow the risk of the random values. Also, participants in the MM protocol tend to play aggressive strategies more frequently that the participants in the RP protocol, but we found no significant difference here. Finally, it is essential to mention that random information does not produce an essential difference between treatments.

We control our results by adding in the experiment socio-demographic conditions to prove that participants in each treatment have the same conditions in terms of age, gender, race, and academic status (to be students). We also use this as a new approach to experimental control procedures since we use an online basis. Participants (and their relatives) were only recruited using the University internal system, and so most of the participants for both treatments have the same characteristics. Essential results in this part show us that after the treatments, the most significant variable explaining the variation is the self-perception of risk, but the difference between two groups is not significant for the other features, so it might be a casual response to the time that participant spends in the computer.

We also consider the same analysis for each session, and we found that the behavior is the same and consistent among a different number of participants in the session. Participants in the MM protocol respond by considering the others' decisions and so on, receiving larger payments.

3.3.1 Further Research

We expect that this document could provide evidence that the reader expects from the modification of the payoff structure for the experiments. We consider that further research can be done in this same line to identify how, for example, the relation between the perceptions of the other participant decision could have some relation with the way we perceive the information. Also, we expect that the experimenter could consider the fact that participants respond better to the MM protocol but with this conflict game structure and therefore, even if an experiment satisfies the incomplete-information requirement, it might be the case that variables like cooperative or altruism between others provides another response from participants. Finally, we expect to conduct a pretty soon new session in a campus-basis in our laboratory also to check our results with this consideration.

REFERENCES

Baliga, S., & Sjöström, T. (2004, 04). Arms Races and Negotiations. *The Review of Economic Studies*, *71*(2), 351-369. Retrieved from `https://doi.org/10.1111/0034-6527.00287` doi: 10.1111/0034-6527.00287

Baliga, S., & Sjöström, T. (2012). The strategy of manipulating conflict. *The American Economic Review*, *102*(6), 2897–2922. Retrieved from `http://www.jstor.org/stable/41724675`

Carlsson, H., & van Damme, E. (1993). Global games and equilibrium selection. *Econometrica*, *61*(5), 989–1018. (Pagination: 30)

Cheung, Y.-W., & Friedman, D. (1998). A comparison of learning and replicator dynamics using experimental data. *Journal of Economic Behavior Organization*, *35*(3), 263 - 280. Retrieved from `http://www.sciencedirect.com/science/article/pii/S0167268198000523` doi: https://doi.org/10.1016/S0167-2681(98)00052-3

Friedman, D. (1996). Equilibrium in evolutionary games: Some experimental results. *The Economic Journal*, *106*(434), 1–25. Retrieved from `http://www.jstor.org/stable/2234928`

Grossman, P., Komai, M., & Jensen, J. (2015). Leadership and gender in groups: An experiment. *Canadian Journal of Economics*, *48*(1), 368 – 388. doi: 10.1111/caje.12123

Grossman, P. J., Park, Y., Rabanal, J. P., & Rud, O. A. (2019, February). *Gender differences in an endogenous timing conflict game* (Working Papers No. 141). Peruvian Economic Association. Retrieved from `https://ideas.repec.org/p/apc/wpaper/141.html`

Jensen, M. K., & Rigos, A. (2018, Sep 01). Evolutionary games and matching rules. *International Journal of Game Theory*, *47*(3), 707–735. Retrieved from `https://doi.org/10.1007/s00182-018-0630-1` doi: 10.1007/s00182-018-0630-1

Oprea, R., Henwood, K., & Friedman, D. (2011). Separating the hawks from the doves: Evidence from continuous time laboratory games. *Journal of Economic Theory*, *146*(6), 2206 - 2225. Retrieved from `http://www.sciencedirect.com/science/article/pii/S0022053111001475` doi: https://doi.org/10.1016/j.jet.2011.10.014

Van Huyck, J., Viriyavipart, A., & Brown, A. L. (2018, Sep 01). When less information is good enough: experiments with global stag hunt games. *Experimental Economics*, *21*(3), 527–548. Retrieved from `https://doi.org/10.1007/s10683-018-9577-0` doi: 10.1007/s10683-018-9577-0

ADDITIONAL FEAUTURES

Mathematical Details

Calculations of the equilibrium condition for RP matching protocol

Consider the payoff matrix described in (2.2), and let F(x) be the optimal decision for the other player. Then the equilibrium condition occurs when:

$$x(1 - F(\cdot)) + (\mu + x)F(\cdot) = (k - d)(1 - F(\cdot)) + kp$$

Thus, we just make the algebraic considerations

$$x + \mu F(\cdot) = (k - d) + dp$$

$$x = (k - d) + F(\cdot)(d - u)$$

Recall that $F(\cdot)$ depends of a uniform distribution and that defines the equilibrium strategy for other player. Then we can rewrite the expression as:

$$x = (k - d) + \frac{1}{k}(d - u)$$

$$\Longrightarrow x = \frac{(k - d)k}{k - d + \mu}$$

$$x = (k - d) + \frac{1}{k}(d - u)$$

Calculations of the equilibrium condition for MM protocol

For this protocol, we have to recall that it depends on the proportion of the participants playing the correspondent strategy. This give us the following condition of equilibrium:

$$r_A x_i + F(\cdot)r_B\mu + F(\cdot)x_i(r_B - r_A) = r_A(k - d) + F(\cdot)k(r_B - r_A) + F(\cdot)r_A d$$

That allows us to get:

$$x_i\left[r_A + F(\cdot)(r_B - r_A)\right] + F(\cdot)r_B\mu = F(\cdot)[k(r_B - r_A) + r_A d] + r_A(k - d)$$

Again, consider that $F(\cdot)$ depends of a uniform distribution and that defines the equilibrium strategy for other player. Then we can rewrite the expression as:

$$x_i\left[r_A + \frac{1}{k}(r_B - r_A)\right] + \frac{1}{k}r_B\mu = \frac{1}{k}[k(r_B - r_A) + r_A d] + r_A(k - d)$$

$$x_i^2 + x_i\left[\frac{r_A(k-d)}{(r_B - r_A)} - k + \frac{r_B\mu}{(r_B - r_A)}\right] - \frac{r_A(k-d)}{(r_B - r_A)} = 0$$

Considering values defined foe this experiment, we get:

$$x_i^2 + x_i\left[\frac{1 + 5r_B}{(r_B - r_A)} - 100\right] - \frac{5r_A}{(r_B - r_A)} = 0$$

Step-by-step visualization of the MM participant

Bienvenido

En este momento va a participar en una actividad remunerada. El pago que recibe por participar el día de hoy es de 1,00 $. Además puede incrementar sus ganancias en base a las decisiones que tome.

Por favor, tenga en cuenta que los dispositivos electrónicos deben estar apagados y que debe evitar cualquier otra actividad en su ordenador durante este momento. Ante cualquier duda que pueda surgir durante el desarrollo del experimento, por favor escribir la pregunta dentro del chat privado de la videoconferencia.

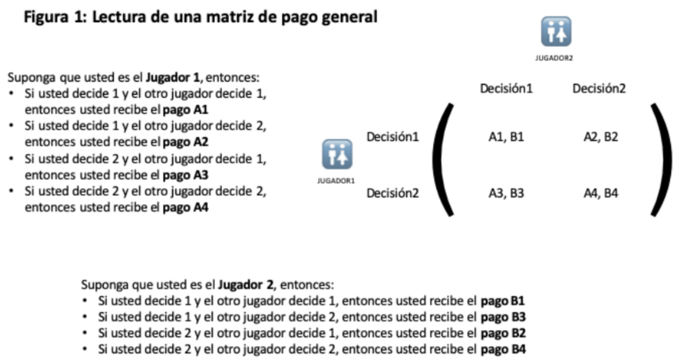
El experimento consta de 19 rondas en su totalidad: **Una ronda de prueba y 18 rondas pagadas**. En cada una de estas rondas, usted tomará una decisión que sera considerada para el pago que recibirá usted, así como otros participantes en esta sesión.

Siguiente

Instrucciones

Matrices de Pago

Para esta actividad, es importante entender una matriz de pago básica. Es por ello que se le solicita leer con atención la siguiente imagen que lo explica:



Instrucciones de pago en esta actividad

En cada ronda, usted recibirá puntos tomando en cuenta las decisiones que haga.

También se toman en cuentas las decisiones de todos los otros participantes en este sesión; estas decisiones se agrupan por medio de un ponderado W1,W2 (cantidad de participantes que toman decisión A o B respectivamente, sobre total de participantes en la sesión) que mide la proporción de otros participantes(menos usted),que tomaron las decisiones A o B, con las reglas de pago como siguen:

1. Si elige A, entonces usted recibe un ponderado de los pagos posibles para esta estrategia:

   W1 * (Pago si jugué A y oponente A) + W2 (Pago si jugué A y oponente B)

2. Si elige B, entonces usted recibe un ponderado de los pagos posibles para esta estrategia:

   W1 * (Pago si jugué B y oponente A) + W2 (Pago si jugué B y oponente B)

Donde los valores que multiplican los ponderados W1 y W2 son los que se visualizaran en la matriz de todas las rondas.

Toma de decisiones

En cada ronda, usted recibirá un número aleatorio X que se obtienen de un rango entre [0,100] donde todos los números tienen la misma probabilidad de ser escogidos. Al final de la ronda, usted sabrá que número X fue escogido aleatoriamente.

La decisión sobre las acciones A o B también están condicionadas y se toman antes de conocer el número aleatorio X. El juego funciona de la siguiente forma: Usted escoge el número más pequeño en el rango [0,100] por el cual escogería la acción A con la ayuda de un deslizador; la tabla a continuación (misma que podrá visualizar en cada página de decisión) especifica como se toma la acción A o B:

Tabla de Decisiones

Decisión	Comparación
Decidir A	Numero escogido ≤ X
Decidir B	Numero escogido > X

Recuerde que dado que usted escoge en el deslizador antes de conocer el número aleatorio, su elección final así como la de los otros participante estarán condicionadas al numero escogido. Cada participante se le asigna un número aleatorio distinto.

Ronda de Práctica

Antes de empezar con las rondas pagadas, usted enfrentará una ronda de prueba (no remunerada) para que pueda familiarizarse con lo que se despliega en la pantalla del computador.

Ganancias

Al final de cada ronda, recibirá información relacionada con los puntos que obtuvo en la ronda en cuestión, la elección que tomó, así como las ganancias promedio de los mismos. Al final del experimento, recibirá un pago en dólares en correspondencia con los puntos que ha obtenido tomando en cuenta la tasa de cambio de 0,005 $ por cada punto (100 puntos representarían 0.50 $), además del pago por participar.

Siguiente

El menor número por el cual seleccionaría A

Recuerde como se determinaban las decisiones

Decisión	Comparación
Decidir A	Numero escogido ≤ X
Decidir B	Numero escogido > X

Elija un número entre 0 y 101, recuerde que W1, W2 son las ponderaciones de la cantidad de jugadores en esta ronda que respondieron con la estrategia A o B respectivamente:

Su elección **0**

		El Otro Participante	
		A	**B**
Usted	**A**	**W1 * 0 puntos + W2 * 10 puntos**	
	B	**W1 * 5 puntos + W2 * 100 puntos**	

Siguiente

Resultados

Usted jugó B puesto que:

El número aleatorio 26 puntos fue menor que su elección de 85 puntos.

Tomando en cuenta su decisión. En esta ronda, **1 jugadores tomaron estrategia A** , mientras que **1 jugadores tomaron estrategia B**.

De esta forma, **usted ganó 5 puntos** . El pago promedio de la ronda anterior fue de **52 puntos**

Siguiente

Step-by-step visualization of the RP participant

Bienvenido

En este momento va a participar en una actividad remunerada. El pago que recibe por presentarte el día de hoy es de 1,00 $. Además puede incrementar sus ganancias en base a las decisiones que tome.

Por favor, tenga en cuenta que los dispositivos electrónicos deben estar apagados y que debe evitar cualquier otra actividad en su ordenador durante este momento. Ante cualquier duda que pueda surgir durante el desarrollo del experimento, por favor escribir la pregunta dentro del chat privado de la videoconferencia.

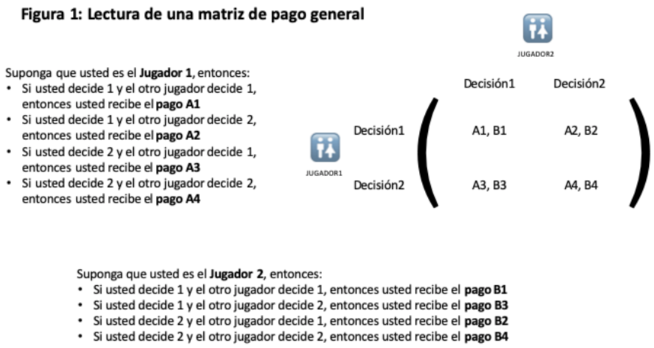
El experimento consta de 19 rondas en su totalidad: **Una ronda de prueba y 18 rondas pagadas**. En cada una de estas rondas, usted tomará una decisión que sera considerada para el pago que recibirá usted, así como otros participantes en esta sesión.

Siguiente

Instrucciones

Matrices de Pago

Para esta actividad, es importante entender una matriz de pago básica. Es por ello que se le solicita leer con atención la siguiente imagen que lo explica:



Instrucciones de pago en esta actividad

En cada ronda, usted y el otro participante con el que fue emparejado recibirán puntos tomando en cuenta la tabla:

Tabla de Pagos

Decisión	Otro Participante decide A	Otro Participante decide B
Decide A	X puntos, Y puntos	X + 10 puntos, 5 puntos
Decide B	5 puntos, Y + 10 puntos	100 puntos, 100 puntos

Donde las decisiones suyas y del jugador con el que fue emparejado condicionan los puntos recibidos tomando en cuenta las siguientes reglas:

1. **Si ambos eligen A**, Entonces usted recibes X puntos y el otro participante recibe Y puntos.
2. **Si usted decide A y el otro participante B**, Entonces usted recibe X + 10 puntos y el otro participante recibe 5 puntos.
3. **Si usted decide B y el otro participante A**, Entonces usted recibe 5 puntos y el otro participante recibe Y + 10 puntos.
4. **Si ambos eligen B**, Entonces usted y el otro participante reciben 100 puntos.

Los números aleatorios X y Y se obtienen de un rango entre [0,100] donde todos los números tienen la misma probabilidad de ser escogidos. Al final de la ronda, usted sabrá que número X fue escogido aleatoriamente, pero no conocerá el valor Y del otro participante.

La decisión sobre las acciones A o B también están condicionadas y se toman antes de conocer el número aleatorio X. El juego funciona de la siguiente forma: Usted escoge el número más pequeño en el rango [0,100] por el cual escogería la acción A con la ayuda de un deslizador. La tabla a continuación especifica como se toma la acción A o B:

Tabla de Decisiones

Decisión	Comparación
Decidir A	Numero escogido ≤ X
Decidir B	Numero escogido > X

Recuerde que dado que usted escoge en el deslizador antes de conocer el número aleatorio, su elección final así como la de los otros participantes, estarán condicionadas al numero escogido.

Ronda de Práctica

Antes de empezar con las rondas pagadas, usted enfrentará una ronda de prueba (no remunerada) para que pueda familiarizarse con lo que se despliega en la pantalla del computador.

Ganancias

Al final de cada ronda, recibirá información relacionada con los puntos que obtuvo en la ronda en cuestión, la elección que tomó, así como las ganancias promedio de los mismos. Al final del experimento, recibirá un pago en dólares en correspondencia con los puntos que ha obtenido tomando en cuenta la tasa de 0,005 $ por cada punto, además del pago por participar.

Siguiente

El menor número por el cual seleccionaría A

Recuerde como se determinaban las decisiones:

Decisión	Comparación
Decidir A	Numero escogido ≤ X
Decidir B	Numero escogido > X

Elige un número entre 0 y 101, recuerde que NN es el número aleatorio del otro:

Su elección **0**

		El Otro Participante	
		A	**B**
Usted	**A**	**0**, NN puntos	**10**, 5 puntos
	B	**5 puntos**, NN+10 puntos	**100 puntos**, 100 puntos

Siguiente

Resultados

Usted jugó B, puesto que:

El número aleatorio 28 puntos fue menor que su selección de 56 puntos.

El otro jugador **tomó decisión B**.

Con estas decisiones, **su pago fue de 100 puntos** , mientrás que el **otro jugador ganó 100 puntos**

Siguiente