FINITELY REPEATED PRISONERS' DILEMMA GAME: EXPERIMENTAL EVIDENCE FROM ARMENIA

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By: Yeva Lalayan

Supervisor: Dr. Aleksandr Grigoryan

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ABSTRACT

Game Theoretical approach was used in multiple spheres as a good determinant of human behavior. It was known to be a solid theory of games and rationality that are proven by mathematical equations and derivations until the time where the real-life interactions of humans within the experimental framework started to differ from the one told in theory. This paper tries to identify the behavioral patterns of Armenian students who took part in the Prisoners' dilemma experiment conducted during the Capstone Simulation program offered as a required course for AUA BAB senior students.

Keywords: *Prisoners' Dilemma, behavioral patterns, experiment*

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INTRODUCTION

What is game theory good for?

Is it a good predictor of human behavior? Or does it give good advice in the situations when a person needs to make a decision? For a theorist, game theory is an answer to mathematical questions for what should players with varying rationality do, and how they might act in the best of their self-interest. For economists, it's an appreciated mechanism of a payoff, or usually, profit maximization that directs to more rational thinking toward business-related problems.

But what is the game theory really about? During the past decades, many psychologists, economists, and sociologists started to perceive a Game Theoretical approach as a very good determinant of human behavior. By analyzing the inner structure of the games played within the framework of game theory, they have got to the conclusion that it is a human behavior that is eventually being analyzed throughout the history of game theoretical evidence. The analytical game theory not only predicts but also explains certain decisions that are being made every day by a person who tries to identify if it's a good decision to clean up the shared room in the dormitory or to leave that pity job for a fellow roommate.

It seems that games which are solved with mathematical derivations and equations exist in real life, and people make such decisions every day with a poor understanding of what analytical and psychological mechanisms they can use to get the payoff they are looking for. For this purpose, it is particularly important to be able to understand what behavioral trends that are existent in the surrounding society. In this paper, we will go through different sections starting from the theoretical background of a simple Prisoners' Dilemma game to experimental evidence collected by various scholars who experienced the nature and the power of game theory in the present reality.

Also, we will design and perform an experiment to understand and analyze the behavioral patterns of Armenian students studying in their senior years of a particular academic program. The paper will summarize the experiment results in a finitely repeated PD game with a comparison to an existing experiential result available in the literature.

LITERATURE REVIEW

As mentioned above, this paper aims to study the behavioral patterns of the players of the games played during the real-life experiments. Game theory has a lot of mathematical proofs involving complicated derivations and equations. However, when the theory suggests an obvious solution to a particular game, humans differ in their thinking and do not always follow the theoretical solution. The experimental evidence collected throughout the years shows that the behavioral patterns observed during the games differ in their nature because of the multiple approaches in game construction, experimental design, payoff structure, objective orientation, and other relevant factors that contribute to the game results but are not included in the theory itself.

There were several steps to be initiated for conducting an experiment and being able to analyze behavioral patterns of the experiment participants. First of all, it was crucial to develop a theoretical background that would be the base of game-theoretical research. Secondly, the aim was to conduct an experiment that would have reliable results, such that the respondent decisions would not be biased and can be analyzed thoroughly. And finally, it was essential to capture the behavioral trends of the people involved in the experiment.

One of the first and critical steps was to decide on the game type. In his book called "Behavioral Game Theory," Colin F. Camerer analyzed dozens of games from the perspective of experimental evidence, and their theoretical solutions. He mostly concentrated on the ultimatum

bargaining games, "continental divide" coordination games, "beauty contest" guessing games, and Dominance-Solvable games[1]. For the ultimatum-bargaining games, the concept was such that if the Responder rejects the offer, then there is something to conclude regarding his self-interested behavior (given the Nash Equilibrium of accepting any offer by Proposer). The experimental evidence has shown that only 20% of the observational group chooses to play in the Nash-Equilibrium, whereas other 80% starts accepting the offers only after the stakes get closer to an equal amount (see McCabe, and Smith, 1996). From this information, it is seen that ultimatum-bargaining games follow non-equilibrium experiment results such that the psychological and behavioral factors of this kind of performance are in large numbers. Hence, the control mechanisms are in limited foresight to be able to analyze behavior in ultimatum-bargaining games. For the coordination games, the objective of the game is to be able to coordinate while maximizing the payoffs, such that the highest payoff is achieved whenever the coordination can take place. For the "Beauty Contest" guessing games and Dominance-Solvable games, Camerer pointed out the importance of working memory[2]. The winners of the game are the ones who can remember, analyze, and calculate within multiple levels of their memory and perform several steps in iterated thinking. These types of games are poor determinants of human behavior also, and for that reason,

[1] Ultimatum bargaining games are the ones in which one player makes take-it-or-leave-it offer, and the other player either rejects the offer, or accepts it. In case of the rejection, players gain nothing. In Game Theory, ultimatum games are very popular, and players are named as Proposers and Responders, and the money offered is usually called a stake. Continental Divide coordination games are the games where players want to conform to what others do, although they may have different ideas about which conformist convention is the best. Battle of Sexes is one of the most popular coordination game, where a couple fails to coordinate where to go on a date.
Beauty Contest guessing game is a game where players try to guess something in accordance with their perception of what others will guess. The famous example of a beauty contest game is to tell the group to pick a number from [0,100] that will be two-thirds of the average number all the others have chosen.
Dominance-Solvable games are the games in which the process of iteratively deleting dominated strategies leads to a unique equilibrium.
[2] Working memory is a system for temporarily storing and managing the information required to carry out complex cognitive tasks such as learning, reasoning, and comprehension.

the decision was made to construct a Prisoners' Dilemma game, which was evaluated many times throughout the history of experimental evidence in Game Theory.

The experiments in Prisoners' dilemma are very well presented in David Sally's research called "Conversation and Cooperation in Social Dilemmas: A Meta-Analysis of Experiments from 1958 to 1992". In his research, Sally analyzed over 100 studies in the principal journals of political science, social psychology, economics, and sociology and developed a data set consisting of 130 distinct treatments from 37 different studies. Sally identified a set of variables that can influence the results of the game and pointed out the possible consequences of a certain set of actions done during the creation experimental design, game structure, and the procedure. As the study was based on the identification of the cooperative mechanism of the players, the dependent variable was said to be COOPRATE (the percentage of total choices in the experiment that benefits the overall group at the expense of the individual deciding). The independent variables included factors such as COOP (if the subjects are directed to cooperate in terms of instructions), MAX (if the instructions tell to maximize the payoffs or win as much as they can), KNOWN (if the game is repeated such that there are two or more trials and the subjects are fully informed), MONEY (if the incentive mechanism of the play is giving out cash), SIZE (size of the group representing an individual subject), COMMUNICATION (if the subjects had the chance to communicate), VISUAL (if the subjects could see their fellow players), etc. After the statistical analysis, Sally has come to the conclusion that if the subjects are instructed to cooperate, if they can look at their partners when deciding, if they can select an affectively named choice, and, most importantly, if they can engage their partners in conversation, they will show very high rates of cooperation, such that corresponding variables are significant and highly influence the results of the game.

Prisoners' Dilemma games cannot be analyzed without two major theories of observed cooperation: altruism[3] and reputation building. These two were profoundly investigated by Russel Cooper in his study called "Cooperation without Reputation: Experimental Evidence from Prisoners' Dilemma Games." In his experimental research, Cooper conducted two types of experiments, one for games with a repeated interaction, and the other one for one-shot games. The aim of the research was to explore and identify altruists or reputation builders and to distinguish between them. He claims that "a leading alternative to reputation theories of cooperation admits the possibility that some players are actually altruistic. In this way, cooperate is not a dominated strategy since true payoffs differ from those given in Prisoners' Dilemma game". He also states that real altruists have additional payoff δ from cooperation, as it is shown in the payoff matrix below.

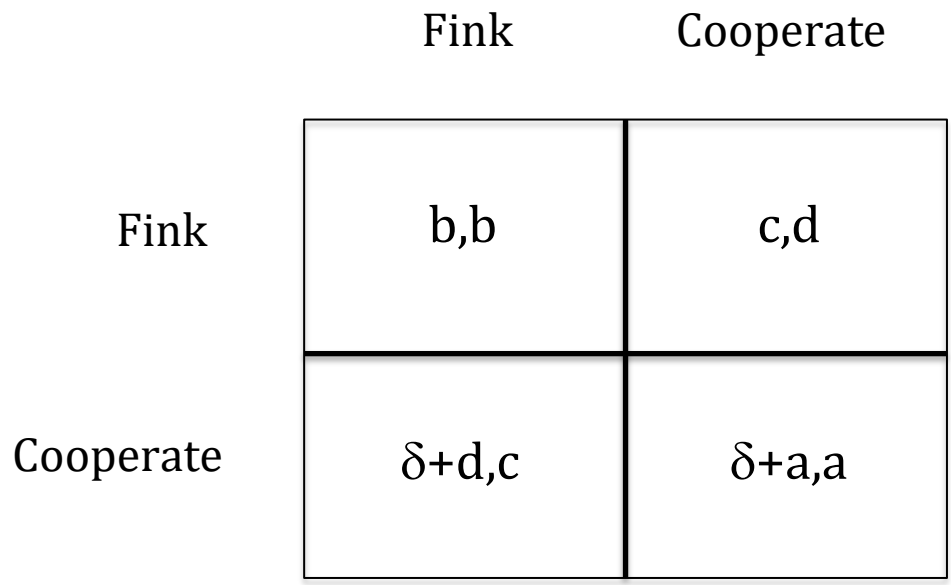

FIGURE 1: PAYOFF MATRIX OF ALTRUISTS

$c>a>b>d,\ d=0$

[3] Altruism is usually defined as a voluntary, costly behavior motivated by the desire to help another individual

The number of real altruists from Cooper's model is declared to be approximately 12%-13%, which is a significant fraction of players. He derived this number by selecting the subjects that played cooperatively in one-shot games during the several periods of play because by the theory, there is no incentive for a person to play cooperatively during the game that will not be repeated. In our case, the possibility of altruistic play is also possible, because "we seriously underestimate the frequency of altruism when, having designed our lives to make self-interest and altruism coincide, we interpret such coincidences as demonstrating the pervasiveness of self-interest rather than altruism. And because thinking that another has acted unselfishly often leads people to behave unselfishly themselves, underestimating the frequency of altruism can itself determine unselfish behavior" (Mansbridge, 1990).

METHODOLOGY

The experiment was conducted on the BAB senior students who were the participants of the Capstone Simulation course. The Capstone Simulation course was a program in which student groups were building a model for their company, competing with each other on the basis of the similar products, creating necessary financial statements following the transactions, contracts, sales, prices, and negotiations. The aim of the simulation process was to achieve the highest return on assets for a particular team that would be the determining factor of their academic grade.

There were 32 groups with five students in each group, with an overall of 160 people. All students were representatives of AUA's BAB program, majoring in economics, marketing, accounting, and general business. The groups were consisting of students with different majors and academic performance. The teams were formed by the students themselves, during their initial enrollment in the capstone simulation course. All students had specific roles for their simulation

program within groups, that includes people responsible for Finance, Operations Management/HR, Negotiations/International Trade, and Marketing. During their capstone simulation program, teams had multiple interactions between each other, including negotiation meetings, contract signing, experience sharing, and friendship.

During the experiment, students were supposed to play a simple Prisoners' Dilemma game, with a payoff matrix shown below.

	Red	Blue
Red	3, 3	-6, 6
Blue	6, -6	-3, -3

FIGURE 2: PAYOFF MATRIX OF THE EXPERIMENTAL PRISONERS' DILEMMA GAME

The groups were playing against each other in separate rooms such that there was no information available regarding the rival group identity. In each room, there were four groups, and two instructors, each responsible for two rival groups that are located in separate rooms. All students had the common knowledge that they were playing the game within the framework of the Capstone Simulation course and had no idea that they were experiment participants.

Initially, the game was constructed in a way that there was only one possible solution to get the highest cumulative payoff for five consecutive rounds. The participants knew that they would be

playing five rounds with the rival group without any communication. The number of rounds was chosen based on the timing limitations of the experiment and students' false expectations on the communication during the Capstone Simulation process. By the initial instructions, the obvious and theoretically driven solution was to play Nash Equilibrium for all five rounds (see Appendix 2 for the 2-round game), such that theoretically, there was no incentive to play Red on any round during the game.

There are several factors that create fewer incentives for the groups to cooperate. First of all, it is known that economics graduates cooperate far less frequently than other types of people (Marwell and Ames, 1981) and Frank (1988) has the same conclusion in his research conducted with business and economics students. It turns out that the probability of cooperation decreases when the experiment participants are economics or business students, and that is the case for our experiment. Secondly, after interviewing the two professors that lead the Capstone Simulation program, it was seen, that the non-cooperative behavior was captured within the groups during their day-to-day interactions and simulation activities. From this information, the experimental design had to play a huge role during the experiment preparation stage. For our research, the main objective of the game was changed to gain not only a maximum cumulative value throughout the five rounds but to gain a positive value which is merely impossible without cooperation.

In his meta-analytical research, Sally (1995) has shown that the wording and the language of the instructions can have a significant effect on the results of the experiment. It is seen that if the instructions include phrases such as "win as many points as you can" or "maximize your earnings," the cooperative outcome would be seen less frequently because of the instructions that intuitively direct to more self-interested behavior. Also, if the instructions include words such as "do better than the others" or "the objective of the game is to win the others" the experiment

participants would be directed on the competition and rivalry between each other rather than cooperation. In our experiment, the decision was made to include a more or less fair phrase, namely "the objective is for your group to finish with a highest(positive) score."

Regarding the incentive mechanism, Sally's research has shown that the most well-known incentive approach is money or cash, which would be negatively affecting cooperation because of the real stakes and the costs incurred from the cooperative play. In our experiment, there was no other incentive mechanism rather than grade increase that could be incentivizing enough the students to take part in the experiment and be enthusiastically involved in it. There were 2% bonus points (from overall 100%) added to students' Capstone Simulation course final grade if the experiment participants could reach the objective, directed in the instructions.

Theoretical Solution

It is seen above (and in Appendix 2) that the theoretical solution for the initially proposed game was to play Blue (not cooperate) in all rounds. However, after the change in the main objective from the Highest possible score to Highest (positive) score, the initial Nash Equilibrium of defection is not an equilibrium anymore. The game is solvable using the grim strategy from trigger strategies applied for the repeated games. That is, "A player using a trigger strategy plays cooperatively as long as her rival(s) do so, but any defection on their part "triggers" a period of punishment, of special length, in which she plays non-cooperatively in response. Two of the best-known trigger strategies are the grim strategy and tit-for-tat. The grim strategy entails that cooperating with your rival until she defects from cooperation; once a defection has occurred, you punish your rival (by choosing the Defect strategy) on every play for the rest of the game. Playing

TFT involves cooperating on the first play and then choosing in each future period, the action chosen by your rival in the preceding period". (Dixit, 2015)

Applying a grim strategy, it is seen that to gain at least a cumulative score of 0, the group that is using a grim strategy should cooperate at least four times during the whole game. See the calculations below.

-6 + -3(4) = -18 *(cooperated on the first round, defected on the rest)*

3 + -6 + -3(3) = -12 *(cooperated on the first 2 rounds, defected on the rest)*

3(2) + -6 + -3(2) = -6 *(cooperated on the first 3 rounds, defected on the rest)*

3(3) + -6 + -3 = 0 *(cooperated on the first 4 rounds, defected on the last)*

And, for the opponent group

6 + -3(4) = -6 *(defected on all rounds)*

3 + 6 + -3(3) = 0 *(cooperated on the first round, defected on the rest)*

3(2) + 6 + -3(2) = +6 *(cooperated on first 2 rounds, defected on the rest)*

Here, a group playing against grim-strategy player should cooperate two times and defect once, to get a positive score of 6 and eventually meet the objective of the instructions. However, it is seen that the theory explained behind the trigger strategies may apply only in the cases when the cooperative rounds are consecutive, such that the groups that haven't shown cooperative play during the initial rounds, namely the first two rounds, the probability of future cooperation is decreasing (Cooper et al., 1992). This phenomenon can be explained by the theory of reputation building and altruism discussed by Kreps et al. and Cooper et al. in their findings. It is becoming

evident, that the number of cooperative rounds suggested for winning the game is not sufficient to presume that the opponent will be motivated enough to cooperate if the decision was made to randomly defect in one or several rounds. So, as there is enough evidence in favor of the reputation model and theory (Andreoni and Miller, 1991) I will state that the winning strategy of any group is to cooperate on the initial stages of the game, rather than to come out with the optimal number of cooperative rounds and randomize during the play. Thus, explained by theory and observations, there is less incentive to defect on the first rounds, especially, on the very first one.

RESULTS

The results of the experiment were quite unexpected as the cooperative play was seen even less than anticipated taking into account logically, theoretically, and morally driven decisions that could arise in the minds of the experiment participants. Figure 3 summarizes the frequency of cooperation throughout the five rounds.

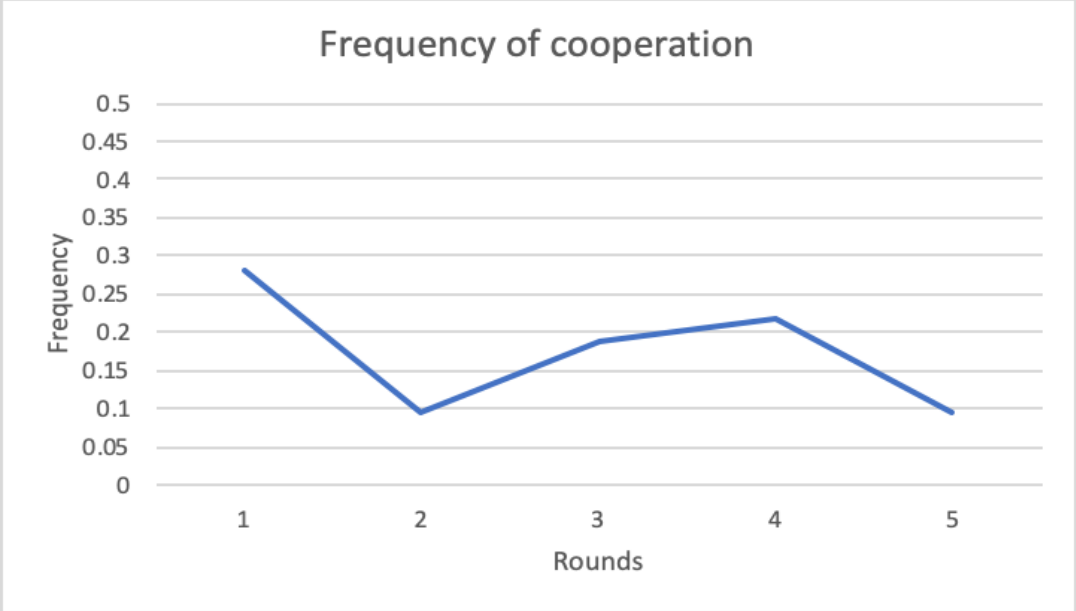

FIGURE 3: FREQUENCY OF COOPERATION GRAPH

The trend is the same as presented by Cooper *et* al. during his research for finitely repeated games. The only difference is that a dramatic decrease in cooperation arises during the second round of the game which is not the case for Cooper *et* al. (the cooperation has increased during the second round from overall of 10 rounds). As the figure shows, only 9 groups out of 32 started the game by playing cooperate with a frequency of 0.28, and only 3 groups out of 9 continued playing Red on the second round. From the observation of 32 groups, the number of Reds played during the game is the same for the second round and the last round, which is not a typical pattern for Prisoners' Dilemma game experiments. Usually, the initial rounds are played cooperatively with a peak during the second round, or during the third round (depending on the overall number of rounds), and the last round is said to be the most defective one, such that there is no relationship to build anymore and people decide that there is no incentive to play Cooperate on the last round. Even for the one-shot games analyzed by Cooper *et* al., the cooperation rate decreases sharply during the last periods of play. In our case, the last round results are consistent with round 2 results (exactly the same), which is not a typical result observed throughout the whole experimental evidence. Out of 32 observations, only 2 groups played the grim strategy mentioned above, and both groups defected on the third round and gained a cumulative payoff of *-3* for all five rounds. Other than that, Blue (defect) was played 132 times out of 160, which is a very high indicator even for the students majoring in business, taking into consideration the payoff mechanism shown above.

The cooperation rate defined in Sally's research, which is the percentage of total choices made in an experiment that benefit the overall group is a determinant variable that will be used to make comparisons across experimental evidence. The cooperation rate in our experiment is 0.175 or 17,5% which is a very low indicator across the existing data. As discussed in Sally's meta-

analysis from 37 different studies of Prisoners' Dilemma game, it is seen that on average, the cooperation rate varies from 30% to 40%, where the minimum observation is 5% in Brechner (1997) and maximum is 96.9% in Deutsch (1960).

The joint plays of opponent groups were also considered as another mechanism for capturing cooperative behavior. There were several joint strategies the groups could play, namely Red – Red, Blue – Blue, Red – Blue/ Blue – Red. The joint cooperation (Red – Red) was only seen 6 times during the whole experiment, whereas joint defection (Blue – Blue) was observed 58 times. Another 16 observations were accounted for the Red – Blue or Blue – Red strategies. Here, the joint cooperation is only seen in the 7.5% of the observations (see the figure below).

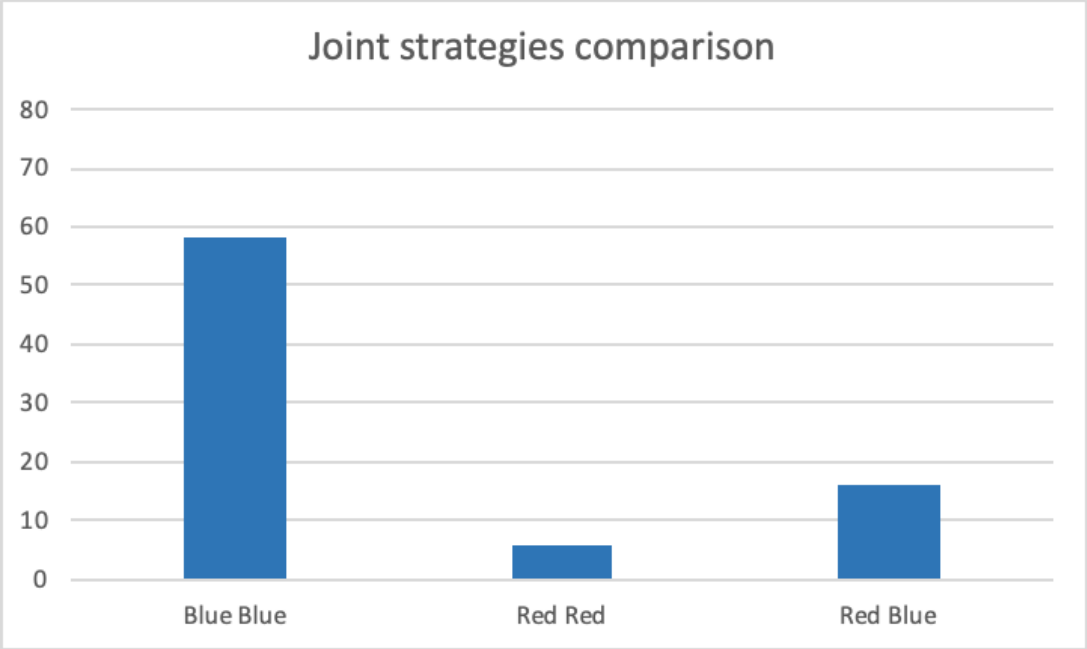

FIGURE 4: JOINT STRATEGIES COMPARISON GRAPH

Another interesting observation from the experiment results was that female dominated groups have shown more cooperative behavior than male-dominated groups. As there are 32

groups in the whole dataset, we identified 20 groups which are female-dominated (more than 50% of the group members are females) and 12 groups which are male-dominated (more than 50% of the group members are males). From the joint-cooperation statistic given in the previous paragraph, five of six joint cooperation observations belonged to the groups where the opponent teams are both female-dominated. Whereas for the male-dominated groups playing against each other (4 observations) only joint defection was seen. This is an indicator, that female-dominated groups are more eager to cooperate with each other than male groups.

DISCUSSION AND CONCLUSION

This experimental evidence from the finitely repeated PD games done in Armenia clearly shows that the behavioral patterns of Armenian society are more directed to defection rather than cooperation. There are multiple reasons this phenomenon could take place. First of all, it could be the fact that students are majoring in Business. As several researchers have shown, the influence of such a profession can be very much decisive in the game experiments like Prisoners' Dilemma. Then, Capstone Simulation course itself directs groups to some kind of competition where the students are aimed to *do everything better than somebody else*, so that the game played in the framework of the simulation has to have the same objective even if the true objective of the game was written in the instructions. The factors can vary from the very obvious ones to the ones that have never been discovered, but the results are very disappointing for the country like Armenia. By the way, it is always very important to know in which society you live in, so hopefully, this paper has given some basic understanding of the behavioral patterns of Armenian society.

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APPENDIX 1

RED-BLUE EXERCISE

This is a game played in five rounds. The objective of the game is for your team to finish with the **HIGHEST (positive)** score. On each round you can play either **RED** or **BLUE**. Points are then scored as follows:

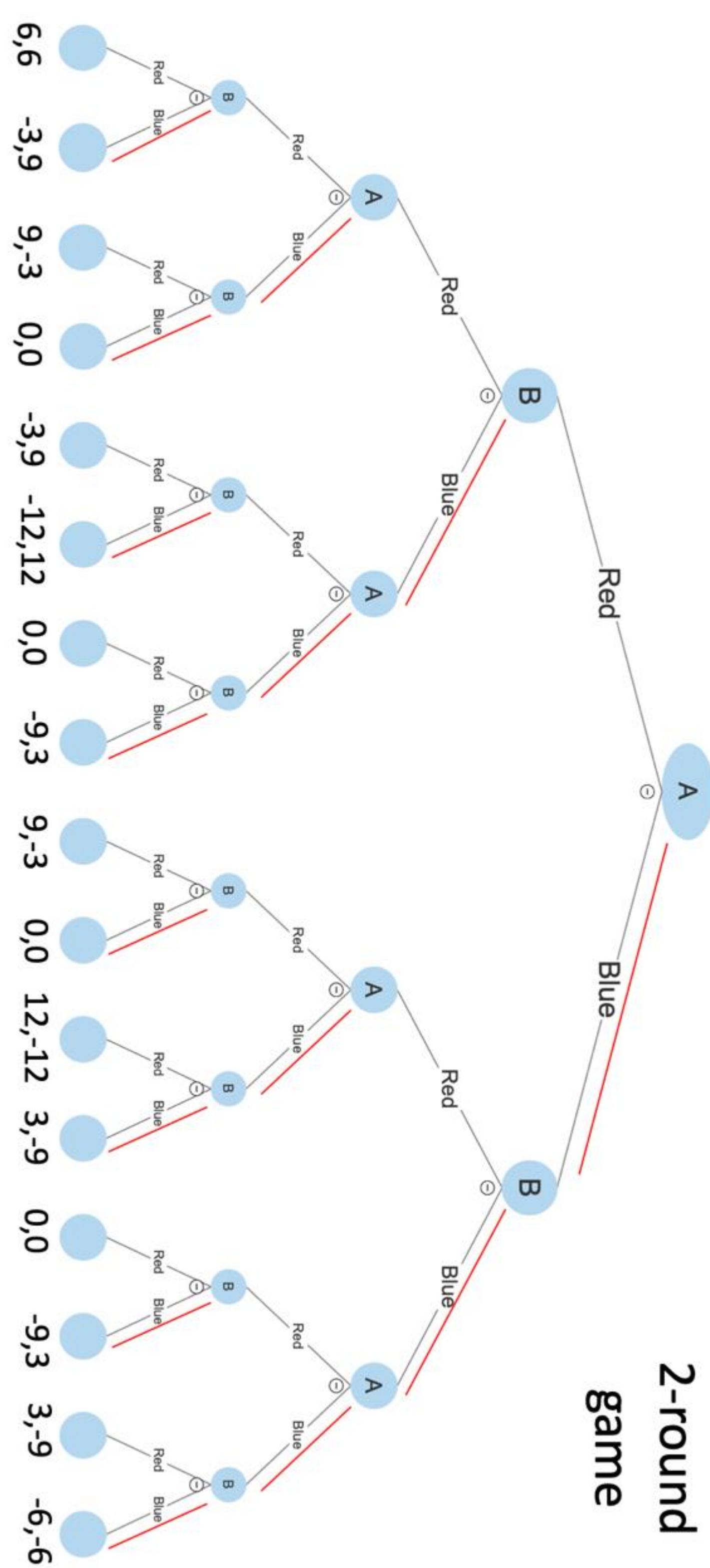
If team A play	If team B play	Team A scores	Team B scores
RED	RED	+3	+3
RED	BLUE	-6	+6
BLUE	RED	+6	-6
BLUE	BLUE	-3	-3

There will be **FIVE** rounds.

You will not know what the other team has played on each round until you have made your choice, nor will they know what you have played. After both teams have made their choice on each round the facilitator will tell each group what has been played and what the scores are.

REMEMEBER: THE OBJECTIVE IS FOR YOUR GROUP TO FINISH WITH A HIGHEST (positive) SCORE.

APPENDIX 2


2-round game
A
B
Red
Blue
6,6
-3,9
9,-3
0,0
-3,9
-12,12
0,0
-9,3
9,-3
0,0
12,-12
3,-9
0,0
-9,3
3,-9
-6,-6