PRINCIPLES OF BEHAVIORAL ECONOMICS

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Week 55

Lecture 55

Hello everyone. Welcome back to the course on Principles of Behavioral Economics. This is Lecture 55. We started discussing strategic interactions, under which we first discussed the classical or analytical game theory. And in the last module, we discussed problems with classical game theory.

In this module, we will continue discussing problems with classical game theory. So here, we would first talk about one type of game called centipede games. Centipede games were originally introduced by Rosenthal in 1981 as dynamic games of perfect information that have a finite number of players and strategies. in the typical game there are two players who make alternative moves. At each move a player can either play down D, that is one strategy and end the game or play across which is denoted by A and pass on the move to the other player.

Payoffs accrue at each terminal node. At each move, a player can take 80% of a growing pie, leaving the other 20% with the other player and ending the game, or they can pass and let the other player move with the pie doubling with each move. Assume that the initial size of the pie is 0.5 and there are four moves. So, there are a large number of variants of the centipede game.

We are just presenting one such type here. So as the characteristics are mentioned, In the beginning, the pie size is 0.5. So as you can see that 0.4 plus 0.1 makes it 0.5. We also see that with each move, the pie doubles in size.

So in the second move, the size of the pie is 1, which is double the initial amount. In the third move the size of the pie is 2 which is again double the previous one and so on. This is just a 4 move centipede game. Centipede games are experimented with a large number of moves including infinite moves. So in the beginning player 1 has the option to play D or down. In that case the game ends and she gets 80% of the pie so 80% of 0.5 is 0.4 so she gets 0.4 20% accrues to the other player if she chooses to play across then the next move would be by player 2 and here the player 2, if he puts down, then he gets 80% of the pie. Now, the pie size has doubled. It is 1. So, 80% of it, that is 0.8 goes to player 2 and 20% remains with player 1. If he plays across, it again goes to player 1 and player 1 then gets 80% of the pie size which is now 2 and 80% of 2 is 1.6.

The rest goes to player 2 and so on. So, this is the final move. if player 2 at the 4th move plays across then the distribution is like 6.4 which is 80% of 8 goes to player 1 and 1.6 goes to player 2. Now understandably if we apply backward induction you would see that player 1 would definitely be benefited here as compared to this position because he was getting only 0.8 here he will be getting 6.4 here but player 2

will be getting 3.2 and here 1.6 so why should he play across he has all the motivation to play down so he plays down here now when he plays down here then player 1 sees that he would be getting 0.1 and if he would have played down before that, then he would get 1.6. So player 1 in that case won't play across, rather he would also play down. So going in this fashion, the unique Nash equilibrium of this game is to put down in the very first move. So applying backward induction, the outcome is for player 1 to play D

at the very first move and end the game. This can be a disturbing outcome even for classical game theorists. This is a Pareto inefficient outcome as the Pareto efficient outcome is to choose A at the final node. Basically, as you can see that if you consider D outcomes and the outcomes here, the final node then of course both of them are better off and the total supply size is also much greater here it is

0.5 and here it is 8 so both of them will benefit here and as a result of which this is a pareto efficient outcome but still The Nash equilibrium is this, which is a Pareto-inefficient outcome. The rationality requirements for the backward induction equilibrium in the case of the centipede game are even more stringent compared to other games. For instance, in a 6-move centipede game, Player 1 has to solve 6 steps of iterated reasoning. In the backward induction, this number increases with the increase in moves.

Insofar as the evidence generated by simple games suggest that players fail to successfully iterate over lower number of steps that we also observed in the case of strategic thinking for example, p-beauty contest games and other examples that we discussed. We showed that actually players fail to move or iterate beyond, you know, a couple of steps. So, it should not come as a surprise that the prediction of backward induction often fails for the centipede games as well. Overall, from a large number of experiments, one can conclude that, first, there is very little evidence of the backward induction outcome.

Second, the probability of playing D increases as we move closer toward the last node. So, basically, players keep on playing from the beginning, and then, as we get closer to the last nodes, the possibility of someone putting down increases, but not much before that. If I consider 4-move games, then backward iteration requires going 4 steps back. As we say, people cannot go beyond a couple of steps. So, one can play the D move around the second or third move.

Similarly, if I expand the game, then again iterations might happen only at the last second, first, or second moves, right? So, that is why, as we go near the final node, only then can we observe that people play the D move, or they basically end the game. Overall, from a large number of experiments conducted with varied contexts, the evidence appears to be mixed, though it still does not largely support the outcome D at the very first node. Next, we talk about mixed-strategy Nash equilibrium and empirical failures in them.

Much of the work on testing MSE or mixed strategy equilibrium has relied on finite that is typically two player zero sum games in which players have finite strategies typically two to five strategies. Furthermore, the games considered have a unique MSE in order to abstract from the issues of coordination. The empirical validity of MSE has been questioned through a series of experimental studies. These studies reveal that players often deviate from the behavior predicted by MSE, challenging its applicability as a descriptive theory of human behavior in strategic settings.

For example, Shachat in 2002 showed that players do play mixed strategies, but the mixtures they use are significantly different from those predicted by MSE. Hence, players' randomization behavior does not align with classical theory, undermining the empirical validity of both the direct MSC prediction and its equilibrium in beliefs variant. This study strengthened the case for alternative models that incorporate bounded rationality and learning. Mookerjee and Sopher offered another critical perspective by rejecting MSE at both the individual and aggregate levels. Unlike earlier studies that found aggregate level support, they concluded that MSE cannot even be treated as an acceptable "as if" theory.

Their findings highlighted the persistent failure of players to converge to MSE over repeated rounds. Players' decisions were influenced by factors external to the classical model, reinforcing the need for more behaviorally grounded theories. Beyond abstract games, experiments have tested MSE in economically relevant settings. Collins and

Sherstyuk studied a three-firm Hotelling competition model, finding violation of MSE predictions at both individual and aggregate levels. Similarly, Rapoport and Amaldoss investigated an R&D investment game with a unique MSE.

While aggregate-level play showed some conformity, individual-level behavior significantly deviated from MSE predictions. These results underscore the broader challenge of applying MSE to real-world strategic interactions. The next thing we talk about is coordination failures, that is, failures in coordination games. Coordination failures provide an important explanation of human behavior in a wide range of areas in economics. Coordination problems underpin a range of macroeconomic models, particularly those that use imperfect competition.

Models of network externalities and standards also rely on solutions to coordination problems. For instance, a technology, process, or standard might become useful and commercially viable only when a certain critical number of users coordinate on adopting it. Now, early evidence in coordination failures is provided by a study by Cooper and others in 1989. They considered coordination in the battle of sexes game.

So this is the game that they had considered. This is Player 1, we all know, and here we are Player 2. Each one has two strategies 1-2, 1-2 and these are the payoffs. Two pure strategy Nash equilibria are 1-2, that is this one, and 2-1. These are the Nash equilibria.

And in the mixed strategy Nash equilibria, each player plays strategy 1 with a probability of 0.25. So this plays with 0.25, this is 0.75, again 0.25 and 0.75. This gives an expected payoff to each player from the mixed strategy of 150 points which is worse than coordinating on any of the two Nash equilibria, so if they go for Nash equilibria then their benefits would be more because mixed strategy is going to give each one of them a payoff of 150 And this is less than both 200 and 600.

The experimental evidence indicates that the actual observed frequency of play, when aggregated over all players, was close to the mixed strategy equilibrium. The two pure strategy equilibria were played less than 40 percent of the time. So these are, as you can understand, irrational decision-making, even though pure strategies are going to give you better payoff on the basis of coordination, and you are choosing the mixed strategy equilibrium. Hence, there are widespread coordination failures. Multiple equilibria are indicators in economic models, from macroeconomics to industrial organization. Classical game theory assumes that players will coordinate on an equilibrium but offers limited guidance on which equilibrium will actually emerge. For example, in the last game itself, we saw that there were two Nash equilibria, say, in pure strategy. But then there is no guidance about which one is going to be adopted or which one is going to be considered by the players as the final outcome. Empirical evidence indicates that coordination failures are widespread even in simple games, posing a serious challenge to the predictive power of classical game theory. Coordination games can be classified based on whether equilibria are payoff-symmetric or asymmetric and whether players are symmetric or not.

For example, Schelling's classic meeting game involves symmetric payoffs and relies on focal points for coordination. Games like the battle of sexes involve asymmetric payoffs where pre-play communication and timing can influence outcomes. So as you understand that battle of sexes is a asymmetric payoff game because the outcomes are like 200, 600, 0, 0, 0, 0, 600, 200.

So, basically, when one player is getting 200 in the other Nash equilibrium, the other player is getting 600. So, that is why the payoffs are asymmetric. If the payoffs are the same across all Nash equilibria, then we can call it a symmetric game. Researchers in 1991 studied median action games where players' payoffs depended on the chosen action and the group's median action.

Their experiments revealed widespread coordination failures, with players failing to converge on Pareto optimal equilibria. Neither payoff dominance nor risk dominance could consistently account for the observed behavior. Moreover, equilibria were strongly history-dependent, indicating that early-round outcomes had a persistent influence on subsequent play, a phenomenon not predicted by classical models. So, again, human behaviors are influenced by past and future events. So, this is also one observation that equilibria were strongly influenced by history-dependent previous round outcomes.

So, in the sense that the outcome of the previous rounds impacted the future decision-making by individual players. But classical game theory, of course, does not take into consideration or accommodate such possibilities. Schelling argued that players might use salient or focal points to achieve coordination in the absence of communication. In the presence of multiple equilibria, economic agents must form beliefs about which equilibrium is likely to be played. Coordinating on certain actions may give everyone a higher payoff, which makes them salient.

It is also possible that some actions are salient in other respects, also termed as focal points. Salient actions may serve as a coordinating device for players. A focal point can be defined as players tending to choose those strategies whose levels are salient. An equilibrium that results from such choices is a focal point. The definition is given by Mehta et al. in 1994.

They also distinguished between primary salience actions that are salient for a player and secondary salience that is coordinating on actions that are believed to have primary salience for other players so basically when you take into considerations what is important for other players then that becomes a case of secondary salience and otherwise primary salience is when the action is important for the primary player or for a particular player himself. In order to test for the significance of these concepts, they divided subjects in experiments into two groups.

Group C, those who are coordinating condition or basically the experiments would consider two different groups. One is under coordinating condition called group C and group P is picking condition. They are basically picking up actions that are best suitable for themselves. Group C's payoffs dependent on coordinating their actions with the actions of others while the actions of group P were independent of any coordination. Subjects are asked 20 questions, 10 of which are shown here in short.

So, for example, a coin was tossed, it came down. So, there were subjects who were supposed to coordinate and if their answers are close to each other, then that would be considered as sign of coordination. So, if both players say head, both players say tail, then these are indications of coordination. The doctor asked for the patient's records, the nurse gave them to then the individual's name. Or maybe not the name exactly.

Give it to the doctor, the patient. Write down any year, any flower, any car manufacturer, any day of the year, any British town or city, any positive number, any color, anybody's name. So these are the first 10 questions. The next 10 questions were somewhat more abstract. A total of 178 undergraduate students participated in the experiment.

Group C was relatively more successful at coordinating actions as compared to group B. A coordination index C is used to measure the probability that individuals who are chosen at random will coordinate on their actions or decisions. If individuals make completely distinct choices, that is, different choices or choices not taking into consideration the other individual's choices, then the coordination index C will take a value of 0. And if they make identical choices, then the coordination index C will take a value of 1.

Values of C between these two extremes denote partial coordination. The coordination index for Group C was higher relative to Group P for each of the 10 questions. So, of course, we can say that there was some level of coordination within the C group. The modal response was the same in 16 out of the 20 questions for both groups.

This seems consistent with secondary salience, that is, when one individual takes into consideration what is salient for the other players. Hence, labels do convey important information that can help coordinate activities. So basically, the moment we have two groups labeled as the coordinating group and the picking group, these labels help them coordinate. However, despite the high degree of salience in the questions, the coordination index is, on average, less than 60% for the first 10 questions for Group C.

this is suggestive of a degree of coordination but also of coordination failure Interestingly, even non-Nash strategy profiles could serve as focal points demonstrating that equilibrium selection often relies on labels and salience rather than strict adherence to Nash's prediction. So Nash equilibrium is of course supposed to be the best response to other players strategies right however If people are influenced by certain focal points, salience and labels, then of course their decisions might deviate from Nash equilibrium. Experimental studies have identified several factors that influence coordination outcomes, none of which are adequately captured by the classical game theory.

For instance, outside options and forward induction can alter predicted outcomes, even when classical theory suggests they should not matter. So options that are outside of the game but relevant to the game can also influence one's decision. But of course, they are not part of the formal game, so certainly not considered by the game theory. In a similar fashion, we have so far talked about backward induction, but it has been observed that people play forward induction,

beginning from the beginning, then what will be the final outcome? And accordingly, people may deviate from Nash equilibrium. Framing effects, timing of moves, and pre-play communication also play critical roles. In some cases, forward induction facilitates coordination, while in others, factors like loss aversion provide a better explanation for observed behavior. These complexities highlight the inadequacy of classical models in predicting coordinating outcomes.

Now, we talk about forward induction timing and coordination failure. Specifically, let us consider two players who play the battle of sexes game in a sequential game that can be represented in an extensive form. In the first stage, player 1 chooses an outside option which gives him a payoff X and end the game. So, if you remember we had a sequential game or extensive form game, where there is a possibility that player 1 plays one move, which ends the game and gives some payoff to the two individuals.

If player 1 decides to play some other move, then it goes to player 2, and then player 2 has further moves. Or, that is, player 1 can choose not to exercise the outside option. So, this is the outside option. He may decide not to exercise the outside option. The outside option, in which case the game proceeds to the second stage.

In the second stage, the two players play the Battle of the Sexes game. So, this is the battle of sexes game that they would play in the second stage. Suppose that the outside option X belongs to this interval, 200 and 600, both exclusive, and this is known to both players. then using forward induction player 2 can now reason that if player 1 has foregone his outside option then he must hope to get a higher payoff and must intend to play strategy 2 so we begin from here and then there is x what it says here is that what player 2 thinks is if player 1 does not play

the first strategy, strategy 1 and say this is strategy 2. so if he is not playing the outside option x then it must imply that the payoff from this outside option must be less than either 200 or 600 or actually both coordinating expectations in this manner player 2 would then play strategy 1. Now, understanding that if this belongs to, say, between 200 and 600, and so it is some number, but player 1 is not playing the outside option, which means that he is expecting a higher payoff from his strategy 2 that is the battle of sexes and what is the payoff which is higher than 200 in the battle of sexes? only strategy or profile 2-1 can give player 1 payoff of 600, which is the maximum possible.

So, in understanding that, this is the kind of coordination that player 2 decides to play strategy 1, so that it ensures 600 for player 1. Thus, the prediction is that the players will coordinate on the equilibrium, which is 2-1. This is the equilibrium. On the other hand, if x equals 100, rejecting the outside option is not informative about Player 1's intentions. So, if x takes a value of 100, and if the player is actually rejecting it, then it is not clear which strategy he wants to play between 1 and 2 because the payoffs are in any case greater than 100.

The outcome is predicted to be identical to the game of BoS, that is the usual battle of sexes game in which the outside option does not exist. Classical game theory predicts that the choices of players in extensive-form games and their equivalent strategic-form representations are identical. We have already discussed that. They do not believe in any kind of framing effect in any context.

However, empirical evidence does not support this prediction. Researchers have found systematic differences between choices made in strategically equivalent normal and extensive forms that cannot be ascribed to other factors. If we denote the game with outside option x equals to 300 by BoS 300, so BoS 300 is the game where the outside option for player 1 was strategy 1 and that gives x equals to 300 then 90% of the equilibrium outcomes in BOS 300 are 2-1, as predicted.

But following similar nomenclature, it was observed that BoS 100 did not have outcomes identical to BoS. So, BoS 100 is basically the same extensive form game with x equals to 100. For Player 1, the first strategy is as follows. The second strategy is to play BoS. BoS 300 did not have outcomes identical to BoS 300 normal form.

So, BoS 300 is basically the extensive form with one first option of X equals to 300. And when if we talk about BoS 300 normal form, then in that case player 1 will have one first strategy which is like 300 0 and 300 0. After that, for strategy 2 and 3, for player 2, these are 1 and 2, the payoffs would be the identical like 00, 200, 600, 600, 200 and 00. BoS did not have outcomes identical to BoS sequential.

Again, this implies that, as classical game theory suggests, there should not be an impact of framing. So, BoS normal form and BoS sequential should give us the identical outcome, but that we did not find. Researchers have found that for the BOS game, The non-coordinated outcome accounted for 60 percent of the cases, coordinated outcomes at 1, 2 for 26 percent of the cases, and coordinated outcomes at 2, 1 for 14 percent of the cases. So, as you can see, 26 plus 14 makes it 40.

So, in the case of 40, only in 40 percent of the cases were there coordinated outcomes. as predicted by or one of the BoS Nash equilibrium. In a nutshell, different outside options, timing issues, and framing effects—whether the game is presented in normal or sequential forms—have an important bearing on the level of coordination. So, with this, I conclude this module discussing classical game theory. We will continue with further problems in classical game theory in the next module.

Thank you.