Prisoner's Dilemma Study Guide

Prisoner's Dilemma by William Poundstone

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Plot Summary

In Prisoner's Dilemma, William Poundstone gives a history of game theory through the eyes of its principal founder, John von Neumann with the cold war and nuclear brinksmanship as the backdrop.

The book begins with a discussion of dilemmas in popular culture and in folklore. A dilemma is a situation with no good answer; something must be given up whichever side you choose. Many thinkers in the 1950s and 1960s saw the nuclear stalemate between the Soviet Union and the United States as a kind of dilemma. During this period, one mathematician, John von Neumann, would give intellectuals and theorists the mathematical tools to understand and to describe the strategic dilemma.

Von Neumann was a mathematician of uncommon ability. Born and raised to a prominent Jewish family in Budapest, from an early age von Neumann showed a keen intellect and interest in problem solving and mathematics. In his twenties, he was recognized as one of the greatest mathematicians in the world. Escaping from the increasingly unstable situation in Germany, von Neumann joined Einstein, Godel, Oppenheimer and others at Princeton's Institute for Advanced Studies. There he worked with his partner, Oskar Morgenstern, to develop a general mathematical theory of two-person, non-cooperative conflicts, or games. Economist, social scientists and policy makers as well as mathematicians would wildly use this game theory.

Von Neumann then went on to work on developing first the atomic bomb and then the hydrogen bomb, helping to create a dangerous situation between the Soviet Union and the United States; a situation where each side sought advantage for themselves at the cost of the other. At the RAND Corporation, a private think tank developed to study interesting questions of national importance, one of von Neumann's colleagues developed a game that seemed to model the situation that the US and the Soviet Union found themselves in, the prisoner's dilemma.

The prisoner's dilemma and several other games led to extensive research in psychology and social science. Many thinkers attempted to find a cooperative "solution" to the prisoner's dilemma, with no success. Some developed a version of game theory to model evolutionary changes in nature. At the University of Michigan, Robert Axelrod tested many different strategies in a prisoner's dilemma tournament. He found that one strategy, tit for tat, could win the tournament and was very stable. This led some to develop theories to explain human cooperation as a kind of tit for tat strategy. Over time, game theory became used in many different contexts, though primarily in social science and economics. Von Neumann never saw the end of the Soviet Union and the cold war that he had worked so hard to win, but his theories live on in the social sciences, biology and mathematics.

Chapter 1 Dilemmas

Chapter 1 Dilemmas Summary and Analysis

Chapter one begins with a discussion of various dilemma problems. These are hypothetical situations that afford no good solution to some kind of ethical problem. One example is a case where you and a loved one are put in rooms with a button. You are notified that if you push your button you will kill your loved one but save yourself, the same holds for your loved one in the other room. You might be willing to allow your loved one to push their button to kill you so that you might not have to kill them, but you are also told that if neither of you has pushed the button after an hour, you will both be killed. What do you do? You would prefer to wait and let your loved one push the button, but assume your loved one thinks the same thing, as the clock winds down you will be tempted to push the button yourself to prevent the death of both people.

After World War II, the United States and the Soviet Union were engaged in a prolonged nuclear arms race. Both the philosopher Bertrand Russell and the mathematician John von Neumann advocated preventative war, that is, a first strike on the Soviet Union. Both men believed that the logic of the situation led itself to preventative war. The deterrence doctrine of the time, "Mutually Assured Destruction" held that war could be prevented because both parties knew that if either party launched a first strike, the other would massively retaliate, and hence both countries would be destroyed. Russell and von Neumann realized, though, that once a country initiated a first strike, there is no longer any reason for retaliation and therefore the first striking country would have the advantage. Although, fortunately, the cold war ended without a nuclear exchange, the logic of this strategic thinking became the logic of mathematical "game theory" that von Neumann would develop and that would revolutionize mathematics, economics, philosophy, biology and a variety of other fields.

Game theory is a theory of competitive games between perfectly rational and opposed players. One such game, a prisoner's dilemma, involves two criminals who were both captured by the police and have been separated in different interrogation rooms. The police tell each person that if they confess that their partner committed the crime, they will receive a lighter sentence. If neither person says anything, they will both go free. If, however, one's partner implicates them and they remain silent, they will receive a harsher sentence. It looks like it is rational to implicate your partner. Unfortunately, it seems the same way to him as well and you both confess leading to harsher sentences for both people. A prisoner's dilemma is an example of a game where the rational action will be detrimental to both parties, but there is no way to resolve the problem. Game theory seeks to understand these types of situations.

Chapter 2 John Von Neumann

Chapter 2 John Von Neumann Summary and Analysis

John von Neumann descended from a family of Hungarian Jews in what was still a very anti-Semitic Hungary. John showed great intelligence even at an early age learning mathematics, Greek, and several other subjects very quickly. As a young man, von Neumann earned a Ph.D in mathematics in Hungary to them move to a teaching position in Germany with the great mathematician David Hilbert. Only in his mid-twenties, John was already respected as a great mathematician. At the age of twenty-six, von Neumann was invited to Princeton to teach a course on quantum theory. Before leaving, he married his girlfriend, Mariette Koevesi. Princeton was so impressed with him that they awarded him a teaching position, and later he accepted a position at the Institute for Advanced Studies. Von Neumann joined Einstein and Oppenheimer among other great thinkers at the Institute. Shortly after moving to the IAS, Mariette requested and was granted a divorce so that she could marry another man that she had fallen in love with in the meantime. Their daughter, Mariana, would stay with her mother until she was in her teens, whereupon she would move in with von Neumann.

Soon after his divorce, John took up with an old girlfriend, Klara Dan, who he later married. Their relationship was stormy, but their life in Princeton was content. The nightlife in Princeton at the time was lively. The geniuses would work all day at the IAS and then spend the nights at cocktail parties at each other's houses, drinking massive amounts of bourbon. John was a common participant at these regular parties and loved to tell dirty jokes and limericks to anyone who would listen. Despite the parties, John von Neumann would work from early in the morning to the late evening parties, leaving little time for other pursuits and for his wife. During this period though, von Neumann made important contributions to almost every subfield in mathematics. He was also extremely knowledgeable about history and was said to have the "best brain in the world", all before he had even made the contribution that he would be principally remembered for, the development of game theory.

Chapter 3 Game Theory

Chapter 3 Game Theory Summary and Analysis

The game Kriegsspiel was developed in the eighteenth century as a game to be used in military academies to train officers for war. The game became very popular among the Prussians during the nineteenth century, so popular, in fact, that the Prussian command issued a game to every regiment and officers were required to play the game. Unlike chess, Kriegsspiel is an imperfect information game. The players are unable to see their opponent's pieces and, hence, must infer where their opponent is. Von Neumann played Kriegsspiel as a boy and apparently the game was popular in the lunch rooms of the IAS.

Game theory is a theory of games like Kriegsspiel. Chess, like tic-tac-toe, is a game that has a certain determinate decision space based on the possible moves of the pieces and size of the board. There is a finite, though very large, number of possible games of chess that can ever be played. A very fast and large computer could potentially store every possible chess move and response in its database. Poker, however, or Kriegsspiel, relies on imperfect information and the indeterminacy of other players. Game theory is a mathematical model of competitive games between two relentlessly rational and self-interested parties. Game theory then, is a model of conflict. The gamest that von Neuman concerned himself with were what are called zero-sum games, that is, games where for one person to gain, another must lose. In such a game, von Neumann proved, the correct strategy was embodied in the "minimax theorem."

Imagine a situation that involved two people and one cake. On person cuts the cake however they like and the other person chooses what piece they want. The cutter, realizing that the chooser will determine which piece he gets will attempt to maximize the minimum piece that he gets realizing that the chooser will select the largest piece for himself. Chooser on the other hand, seeks to minimize the maximum of the cutter. With both parties being rational and self-interested, they will simultaneously choose an equal division, which is the "minmax solution" and hence the "saddle point", or the solution that both will pick. Minimax is the "pure strategy" of making a decision in the game as if your opponent were the one determining the outcome of the game. In this game of "divide the cake", there is a saddle point at equal division, but not all games have "saddle points." Games without saddle points require "mixed strategies", or strategies that are random or combine some set of conditional pure strategies. Mixed strategies can be quite complex depending on the particular game.

Poker and baseball both involve mixed strategies. There is no one strategy that will work in all cases, and so the player must assign probabilities to what their opponent will do and decide which move will be most beneficial, realizing that their opponent will do the same thing. A batter trying to decide what pitch to look for or a poker player deciding whether his opponent is bluffing are both examples of mixed strategies in action. The minimax theorem itself states that every two-person game that is completely defined where the players have completely opposed interests will have a solution in either a pure or mixed strategy. Von Neumann developed game theory, partially to provide an alternative foundation to economics, though the complexity of economic exchange delayed the direct application of the theory.

Chapter 4 The Bomb

Chapter 4 The Bomb Summary and Analysis

During World War II, in late 1943, J. Robert Oppenheimer invited von Neumann to join the Manhattan project, the secret US program to build an atomic bomb. The project was located in Los Alamos, New Mexico. Many of the of the greatest scientist of the day joined von Neumann on the project in a rush to create a bomb before Germany or Russia could. Von Neumann as instrumental to solving an important technical problem that allowed for the development of the "fat man" bomb that could be used as a basis for later nuclear devices.

During this time, von Neumann's friend, Merrill Flood, would use game theory to help the Allies improve bombing efficiency in Europe. Von Neumann also helped to develop the strategy of how to use the bomb to end the war in Japan. John thought that after the end of the war, a new war between the Soviet Union and the United States would begin. Another great thinker of this age, the Cambridge philosopher Bertrand Russell, also believed that a war between the Soviet Union and the United States was inevitable. Russell, a pacifist and left-wing, though anti-communist, critic of American foreign policy also, strangely, joined von Neumann in advocating preventative nuclear warfare. Russell believed that in the age of nuclear weapons, war would be so destructive that it must be avoided at all costs. To this end he advocated world government. Realizing that the Soviet Union stood in the way of the plan, he advocated the United States to issue an ultimatum to the Soviet Union: either disarm and join a world government or the United States will bomb Russia with nuclear weapons. However silly this idea may seem, many people at the time found it reasonable. Partly because the United States alone possessed nuclear weapons and partly because the total number of weapons available was small, many thought preemptive nuclear war would be an acceptable cost if it led to world government and peace.

During this time, von Neumann also worked with IBM to develop what would become the digital computer. Von Neumann helped IBM move its design into more reasonable territory towards digital, stored, binary computers rather than the large, slow analog, decimal computers that they had been using. One of von Neumann's last work was an attempt to design a computer based on the human brain.

The RAND Corporation

The RAND Corporation Summary and Analysis

The RAND corporation became a home to many distinguished scientists in the 1950s. Along with von Neumann, at one time, the institute had almost every great mathematician, physicist, and economist in America and the free world working there. The RAND corporation was originally suggested by Douglas Aircraft company as a research and development institute where the US government could fund important research on military technology and strategy. RAND was eventually created as a kind of hybrid business government institution, something similar to what became known as a "think tank." Eventually, RAND secured funding from the Air Force under Curtis LeMay and began to amass a collection of the world's top experts in a variety of topics. RAND became famous for "thinking about the unthinkable"; that is, applying their considerable intellectual talents to thinking about problems that would arise during or due to disasters such as nuclear warfare. One study looked at life after nuclear warfare, another famous study looked at the plausible public response to contact with aliens. Ultimately, the think tank was responsible for many important innovations in nuclear strategy. For instance, it was a RAND study that helped to develop modern "fail-safe" strategies for nuclear attacks and to also develop strong security mechanisms to make sure that rogue officer could not either intentionally or accidentally start a nuclear war. Eventually, scientists at the institute developed a "second strike" strategy that made sure the United States would have plenty of ICBMs available that could survive a Soviet first strike and be available for retaliation. The idea was that a good second-strike capability would act as a deterrents against a first strike.

While not a full-time member of the RAND Corporation, von Neumann would often spend summers there and would fly out when needed for a specific project. This absence put even more strain on his already rocky marriage. While at RAND, von Neumann had occasion to interact with an old Princeton colleague, John Nash. John Nash was a brilliant, though mentally unbalanced mathematician would developed a mathematical way of extending game theory beyond what von Neumann and Morgenstern had originally developed. The original minimax theorem showed that any two-person, zero-sum, non-cooperative game had an equilibrium solution. Nash extended this insight by showing a method to find an equilibrium solution to n-person, zero-sum and non-zero sum games. These "Nash equilibriums" are strategies for each player where there is no regret, that is a strategy that the player has no reason to unilaterally change. This is an important development because it allowed game theory to be extended into areas than the original minimax, two-person game model would allow.

Chapter 6 Prisoners Dilemma

Chapter 6 Prisoners Dilemma Summary and Analysis

One of von Neumann's colleagues at RAND during the 50s was Merrill Flood. At the time, many researchers would come to RAND during the summer and then leave when school started. Flood starting watching what would people would sell when they left California and noticed that they seemed to often behave irrationally. He noticed that in division games or bargaining situations where neither party has any bargaining power over the other, say where two people are deciding how to divide a bonus check, each party can veto the other and hence any point can be a potential Nash equilibrium. People did seem to, especially when they knew each other, settle on mostly fair divisions in problems like this. This is a case of the desire for cooperation overriding the game-theoretic notions of rationality. Another game that Flood would develop would show exactly the opposite, however.

The game that Flood developed is now known as a "prisoner's dilemma". In a prisoner's dilemma, individual rationality ends up leading to collectively sub-optimal outcomes. That is, both parties would be better off if they cooperated, but the overriding rational incentive is for each party to not cooperate, or to "defect". An example of this that is canonical is the case of two criminals caught by the police and separated into two separate interrogation rooms. Each prisoner is separately given a deal: inform on your accomplice and you will get a lighter sentence. If neither criminal says anything, they will both go free; however, if both parties inform then both will go to jail. It looks like the best thing to do is to "cooperate" and keep your mouth shut. Still, you know that if you keep your mouth shut and your partner squeals, you will be much worse off. If you squeal and your partners say nothing, you will be much better off. The Nash equilibrium strategy for both parties is to defect, leading to the worst possible outcome. To many, this is a deeply paradoxical and troubling result. The idea of well functioning individual rationality leading to sub-optimal outcomes seems to undermine the effectiveness of rationality in general.

Flood wanted to test his little game to see how real people would actually respond in experimental prisoner's dilemmas. He recruited two colleagues, John Williams and Armen Alchian to play one hundred prisoner's dilemmas to see how they would behave. What he found was that the Nash equilibrium, mutual defection, was only played fourteen out of one hundred times.

Many people think that all different kinds of moral and political situations are prisoner's dilemmas. For instance, many "free rider" situations work like prisoner's dilemmas. Some have even tried to explain the difference between conservatives and liberals by examine their propensity to cooperate and defect in prisoner dilemma games. During the 1950s and 1960s, many scientist and policy makers viewed international conflict, especially nuclear conflict as a kind of prisoner's dilemma. This model, however, would prove to be less helpful that originally thought. Nuclear war, as Russell would later suggest, is more properly modeled as a different kind of game.

Chapter 7 1950

Chapter 7 1950 Summary and Analysis

In the fall of 1949, good evidence began to trickle in that the Soviet Union had finally built their first atom bomb. The days of American nuclear monopoly were over. At first it took awhile for Truman and others to believe that the Soviets had been able to build the bomb. Most knew that the Soviet economy was very small and poorly managed compared to the American economy and the idea was that the Soviets would not have the know-how to build something as complex as the nuclear bomb. Eventually, though, good evidence came in that the Soviets did indeed have the bomb. Development of the new, super, hydrogen bomb that would be more powerful than the original atomic bomb proceeded in the United States, hoping to get a strategic edge over the Soviets.

The debate about preventative nuclear war began once again in earnest once the Soviet Union acquired the bomb. Harold Urey, one of the key developers on the hydrogen bomb, advocated publicly for the development of a world government by any means necessarily to prevent full-scale nuclear war. Klaus Fuchs, a German-born physicist working in Britain was found to be a Russian spy who had leaked key atomic secretes to the Soviet Union, allowing the Russians to speed up their development of nuclear weapons. The environment of espionage and the fear of Russian nuclear weapons created an atmosphere of hysteria and paranoia. In 1950, the communist state of North Korea invaded South Korea, sparking the Korean War. Many, including General Douglas Macarthur, believed that the use of nuclear weapons in Korea could be justified to prevent a victory by the North Korean and Chinese forces. Von Neumann also began to advocate the explicit use of a surprise attack on the Soviets. He also developed a strategy for implementing this surprise attack.

This issue really came to a head though later in 1950 when Francis Matthews, the Secretary of the Navy, gave a talk in Omaha Nebraska. The talk had truly bizarre elements, including a claim that the United States was the true protector of the Holy Grail and Ark of the Covenant. The claim that stirred up debate and fear in both the United States and the Soviet Union was his final argument that the United States should act as an "aggressor for peace" and launch an all-out surprise attack on the Soviet Union to neutralize the Communist threat once and for all. His comments were a public relations nightmare, but he was not the only public figure to advocate first strike at this time. Strangely enough, neither Truman nor anyone else at this time really knew how many bombs the United States had at her disposal. A study was commissioned and it was discovered that in 1947, the US had about seven bombs, and in 1950 she had between three to six hundred. Most of these bombs were relatively small and the delivery mechanisms were untested. It turns out the preventative war would have been logistically impossible given the number of bombs available. By the time that the United States actually developed the capacity for preventative nuclear war, the arsenals of weapons had grown so large on both sides that nuclear war would be unthinkable.

Chapter 8 Game Theory and its Discontents

Chapter 8 Game Theory and its Discontents Summary and Analysis

Midway through the 1950s, the initial interest in game theory had began to wane. Many saw the assumptions of game theory as unrealistic and callous. The games modeled perfectly rational, but seemingly inhuman, amoral players. Also, the public mind had begun to associate game theory with the RAND corporation and John von Neumann, who they saw as Machiavellian amoralists advocating nuclear war. Researchers interested in game theory began to shift away from pure mathematics into an experimental approach of how actual humans behaved in game situations.

The most exciting of these studies in the Ohio State studies in the 1950s and 1960s. Ohio State students were put in prisoner's dilemma situations. One subject was placed in a room with a two buttons and was asked to push one of the buttons. The red button corresponded to the cooperation strategy, whereas the black button corresponded to the defection strategy. The subjects were awarded money in each situation, depending on the payoffs of the game. The researchers found that defection was overwhelmingly the most popular strategy. Even when, after several rounds, players were allowed to meet with each other and discuss strategies, defections dominated. Even when the game was changed into a game where there is no cost to cooperating, even possibly, the students continued to defect. Variations on this study have been run over the years to see if there is a difference in behavior between women and men, the educated and the uneducated, racial differences, or any kind of other noticeable difference. Regardless of the variable, though, the results are the same: people overwhelmingly defect. There several possible reasons for this. One is the logic of the game itself, as we have seen, tends towards defection. The other is that students may see the game as a game and may focus on "winning" rather than on maximizing payoffs. Whatever the explanation, the Ohio State studies go a long way to confirm, in the minds of many, the original pessimism about human rationality that the prisoner's dilemma suggests.

Chapter 9 Von Neumann's Last years

Chapter 9 Von Neumann's Last years Summary and Analysis

In the late 50s, von Neumann spent much of his time on the hydrogen bomb project. Although von Neumann was instrumental in the development of the digital computer, at the time of his work on the hydrogen bomb, the advanced, modern, digital computer did not really exist. The calculations were so difficult that von Neumann speculated that a computer would be necessary to complete the bomb. His speculation turned out not to be entirely correct and he was able to do the calculations himself over a period of six months. At this time, von Neumann was also a very adamant advocate of extensive testing of nuclear weapons. In this he differed from many of his colleagues who were worried about the secondary effects of nuclear testing. Von Neumann also worried about he possibility that the Soviet Union might be able to engage in a first strike that would go unnoticed for long enough to make a second strike ineffective. To solve this problem, John developed the SAGE (Semi-Automatic Ground Environment) that could effectively detect nuclear detonation.

As he began to age, however, von Neumann became increasingly pessimistic about the role of technology in modern society. He realized that technology, especially military technology, was advancing to the point where a small group of individuals armed with nuclear bombs could do serious damage. Despite his own role in the development of these weapons, von Neumann speculated that the proliferation of nuclear weapons would lead to warfare that would devastate the globe.

In 1954, President Eisenhower appointed Von Neumann as Atomic Energy Commissioner. At the time, von Neumann was spending most of his time consulting with large industry, leading many to suggest that John had let his scientific talents go to waste. During this time, though, talks of nuclear disarmament began to circulate, though it was unclear how to actually proceed with the talks. In 1955, von Neumann slipped and fell, and when the doctor investigated him, the doctor found that he has advanced prostate cancer. The cancer greatly affected his work, and in 1956 he was permanently confined to a wheelchair. As von Neumann began to deteriorate, his mind and intelligence were the first things to go. He suffered great anguish from this, and his last moments were painful and spent in spiritual and mental agony. Before he died he converted to Catholicism, though many believed his conversion was insincere as he had been a life long atheist. He died on February 8, 1957.

Chapter 10 Chicken and the Cuban Missile Crisis

Chapter 10 Chicken and the Cuban Missile Crisis Summary and Analysis

Although Bertrand Russell had famously advocated preemptive nuclear war against the Soviets he later, famously, disavowed that original proposal. When Russell originally advocated preemptive war, the United States had a monopoly on nuclear weapons. Russell saw that if both the United States and the Soviet Union possessed nuclear weapons, an all-out nuclear war could lead to a complete atomic holocaust that would encompass the entire world. Russell advocated threatening the Soviets with an attack if they did not agree to join a world government. Once the Soviets had nuclear weapons, and especially once the nuclear arsenal were composed of hydrogen bombs, the plan became ineffective. Russell then became a vocal advocate of complete nuclear disarmament.

Although many at the time considered nuclear warfare to be a kind of prisoner's dilemma, Russell was the first to suggest that it was really a game of chicken. In a game of chicken, two people drive cars head-on towards one another. The first person to swerve to avoid collision is the "chicken" and loses. If neither swerves, both cars collide and both people die. Alternately, if both parties swerve, neither is the chicken. Chicken has interesting properties that differ form prisoner's dilemmas. In a prisoner's dilemma, the best strategy for either party is to defect. In chicken, the best strategy is to do the opposite of what your opponent does, while avoiding collision. In this game, swerving or cooperating, is the equilibrium solution. This game is similar to the "volunteer's dilemma", or a public goods game. In this game, it is better that a certain event occurs but better if the player does not have to cause the event. The phone is ringing in a house with two people, both people want the phone to stop ringing, but neither wants to take the trouble to get up and actually pick up the phone. Both these dilemmas have interesting properties and they are widespread in everyday life.

One public example of a nuclear game of chicken was the Cuban Missile Crisis. During this crisis, the United States and the Soviet Union were poised on the edge of war, with both sides threatening the other if the other didn't back down. Both countries didn't want war, but neither side could back down without losing face or looking like a "chicken". Later it was discovered that Russell might have played an instrumental and maybe unintentional role in the solution of the crisis by giving the Soviets a way to back down without losing face. One strange property of a game of chicken in what is known as the "madman strategy". If we assume our opponent in a game of chicken is irrational or suicidal, we will assume that they will be less likely to swerve, and hence we will be more likely to swerve. Because of this, there is an incentive for both parties to appear crazy to give their threats more credence.

Chapter 11 More on Social Dilemmas

Chapter 11 More on Social Dilemmas Summary and Analysis

Although Prisoner's Dilemmas and, to a lesser extent, Chicken get most of the attention, there are many other kinds of two-person non-cooperative games. In two-person games that are symmetric, that is, where no player has an advantage, there are four separate payoff situations and hence four separate games: Deadlock, Prisoner's Dilemma. Chicken, and Stag Hunt. Each of these games has its own unique properties and strategies.

Deadlock is similar to Prisoner's Dilemma, except that in Deadlock there is no reason to cooperate. Unlike Prisoner's Dilemma, there is no advantage to cooperation unless the other player cooperates and, hence, defection is the only reasonable strategy. Stag Hunt is probably the most interesting of the symmetric dilemmas. Also known as an "assurance game", Stag Hunts exist when there are large mutual gains from mutual cooperation and smaller gains from mutual defections, but very little gained in asymmetric defection. That is, while both parties would gain the most from cooperating, they only gain when the other player cooperates. The idea comes from Rousseau, who tells the story of an early society where two hunters are deciding what to hunt for the day. They can either hunt Stag or Rabbit. To hunt stag, they need to both decide to hunt stag because two people can only hunt stags. If they hunt stag they will return home with significantly more meat than if they hunt rabbit, but rabbit only requires one person. The worst situation is where one person decides to hunt stag and the other hunts rabbit.

Many situations in real life are like a stag hunt. The key to cooperation in a stag hunt is being able to trust that the other player will cooperate. There are also several asymmetric games, such as the game of "Bully", a cross between Deadlock and Chicken.

Many people, unsatisfied with the pessimistic results of the Prisoner's Dilemma, have attempted to "solve" it by proving, somehow, that it is rational to cooperate in prisoner's dilemmas. All of these solutions involve some sort of error, though the most popular is the "repeated games" solution. While it is best to defect in a one-shot prisoner's dilemma, there may be reason to cooperate if one expects to play the same game over and over. Still, it is best to defect in the last round, since there will be no more repeated intersection after that round. The problem is, though, that given backwards induction, if we know that our partner will defect in the final round, it is rational to defect in the second to last round and all the way down to the first round. At least logically, repeated play is not a solution to the Prisoner's Dilemma.

Chapter 12 Survival of the Fittest

Chapter 12 Survival of the Fittest Summary and Analysis

In the 1980s, game theory took an unexpected turn as researchers in biology and sociology began to try to use game theory for their own purposes. In biology, game theory was used to model "evolutionarily stable strategies". A stable strategy was a strategy that can continue in its given population. While evolution is not about "winning", it is possible to think of organisms or genes as having a kind of strategy for reproduction and survival that can be replicated and passed on to the next generation. Strategies that are successful are stable over many generations. Nature is constantly changing. Landscapes and ecosystems will change in size temperature and will also vary in terms of predators and prey. An organism that can survive over long periods of time has developed a strategy that is stable in the sense that it can adapt to changing circumstances.

Evolutionary game theory posed a problem for the Prisoner's Dilemma. In one sense, defections seem like an evolutionarily stable strategy; however, we know that humans do, in fact, cooperate in large groups. The question is, how did cooperation evolve given that defection is not a stable strategy?

In an effort to solve this problem, a political science professor at the University of Michigan, Robert Axelrod, engaged in a series of "tournaments" in the early 1980s to see if he could find an evolutionarily stable strategy in a Prisoners Dilemma. Axelrod asked scientists from around the world to submit computer strategies for repeated prisoners dilemmas that would be pitted against each other in a round-robin computer environment. The payoff from the game would be represented as points from interactions. Each program would play 200 hundred rounds against the other programs. The strategy that won the tournament is known as tit for tat. The strategy is simple. In the first round, the strategy cooperates and then does whatever its opponent does. Though the strategy doesn't always win, it is the most successful strategy and one of the simplest. It also has the advantage of embodying some intuitive aspects of human psychology and a notion of fairness. Axelrod argued that the cooperation might have evolved through the evolution of a tit for tat strategy in human psychology. There is some psychological and historical evidence as well as some examples of animals that display a tit for tat like behavior in certain situations that require cooperation. In any case, Axelrod had introduced and interesting "solution" to the prisoner's dilemma by applying notions from biology to a traditional problem in game theory.

Chapter 13 The Dollar Auction

Chapter 13 The Dollar Auction Summary and Analysis

As we have already seen, von Neumann was deeply pessimistic about the possibility of peace in the nuclear age. He was not the only one to share this sentiment. Many others found the logic of escalation in conflict inescapable. Some wondered if game theory might be able to model more accurately non-rational and even neurotic thinking and strategies. One example of deeply irrational behavior can be seen in the dollar auction.

The dollar auction is a game invented by Martin Shubik. Shubik was a RAND employee who enjoyed working on game theory and trying to design games with interesting mathematical properties that people could actually play. The dollar auction is just such a game. The idea of the dollar auction is simple. One person offers to sell a dollar to the highest bidder. The only problem is that the second highest bidder must also pay whatever they bid. So if one person bids $.25 for a dollar and another bids $.22, both parties will have to pay. Imagine that someone has bid $1.00 for the dollar but that another person had previously bid $.99. The person who loses will now have to pay the $.99 even though they get nothing in return and will, hence, have an incentive to bid $1.01 and so on. It turns out that people will regularly pay more than $5.00 for a dollar in a dollar auction game.

What this game shows is that sometimes incentives in the game can actually lead to outright irrationality. Unfortunately, dollar auctions are quite common in real life. Anytime someone decides to sit through a bad movie because they have already spent so much time already on it, they are in a dollar auction. Similarly, political lobbying and campaign contributions are dollar auctions. Staying in a bad marriage or bad job are also dollar auctions. Of course, if you are in a dollar auction, the only real way to win is to stop playing. The problem is to determine whether the case really is a dollar auction though.

Although many people have tried to "solve" the prisoner's dilemma, Shubik argues that the solution just is the problem, that is, the game shows that it is rational to defect in one-shot prisoner's dilemmas. He argues that this is hard for people to accept, but that doesn't make it any less true. It is hard to accept that, in a vacuum, a feather and a bowling ball will fall at the same rate, but it is still true. Game theory shows us something interesting: the intractability of conflict. The solution to games like the prisoner's dilemma is not to play them in the first place.

Characters

John von Neumann

John von Neumann was a Hungarian born mathematician who, along with his partner Oskar Morgenstern, developed game theory. In addition to his development of game theory, von Neumann was said to have contributed to every major area of mathematics. He was also instrumental in the development of the modern computer and played a key role in the development of the atomic bomb and the hydrogen bomb.

John von Neumann's family was Jewish, but after he left first Hungary and then Germany for the United States, he married his first wife and converted to her religion, Catholicism. Despite his nominal conversion, he was a practicing agnostic his entire life until his deathbed conversions to Catholicism.

John von Neumann spent most of his career at the Institute for Advanced Studies at Princeton in the company of luminaries such as Albert Einstein, Kurt Godel, and John Nash. John also spent time at the RAND Corporation and consulted for various governmental and business concerns during the later part of his life. During the last few years of his life, he was appointed as the head of the Atomic Energy Commission. Despite his seemingly amoral attitude to nuclear war and conflict, he was deeply disturbed by the implications of the weapons he had helped to develop later in life. His last months were spent in the hospital as his mind deteriorated while he died of prostate cancer. He was apparently a hard drinker and lively joke teller, particularly fond of limericks.

Bertrand Russell

Bertrand Russell was one of the most revered and important philosophers of the twentieth century. His early contributions include his derivation of all mathematics from principles of logic, which, though later undermined by Kurt Godel, was still an important development. He also was instrumental in developing and popularizing modern formal logic and set theory. His less academic accomplishments include a widely read and highly readable history of philosophy and an introductory work on the major problems of philosophy. Along with his friend and colleague G.E. Moore, Russell was responsible for many of the early developments that would become Anglo-English analytic philosophy.

In addition to his work in philosophy, Russell was an incredibly dedicated and active public intellectual who advocated for peace and nuclear disarmament. Though his principle work was done in the early twentieth century, Russell was active in the peace movement until the late 60s in his opposition to the Vietnam War. Russell was also interesting in that, unlike some of his colleagues at Cambridge, he was a vocal critic of communism. Russell was a left-wing socialist, but one who adamantly believed in individual rights and democracy. However, much as he attacked the United States, he was clear to make sure that he was not advocating communism.

Russell is descended from a venerable and aristocratic whig/liberal family. He was, in fact, Lord Russell; his family had been a prominent member of the House of Lords during the liberal governments of the nineteenth century. His tutor, though only for a while, was actually John Stuart Mill.

David Hilbert

David Hilbert was one of the greatest mathematicians of the twentieth century. A German, he hoped eventually to set Mathematics on firmly axiomatic foundation, a project that he never accomplished and that Godel showed to be impossible. He was von Neumann's teacher.

Bela Kun

Bela Kun was leader of the Hungarian communist movement and eventually president of the Hungarian communist state in 1919. The communist regime was a disaster and short lived.

J Robert Oppenheimer

A theoretical physicist, Oppenheimer is best known for his role in leading the "Manhattan Project" that developed the first atomic bomb. Good first with von Neumann, Oppenheimer was associated with communists and later found it hard to get a job.

Kurt Godel

A great mathematician who worked with and knew von Neumann at the Institute for Advanced Studies. He developed his famous "incompleteness theorem" that showed mathematics could not be derived from a small number of axioms.

Albert Einstein

Colleague of von Neumann's at the Institute for Advanced Studies, Einstein was best known for his general and special theories of relativity

Merrill Flood

Merrill Flood was a RAND Corporation mathematicians who, along with a colleague developed the Prisoner's Dilemma game.

John Nash

A Nobel prizewinning mathematician and colleague of von Neumann who developed a way to find equilibrium strategies for n-person games known as a Nash Equilibrium.

Armen Alchian

An eminent economist and founder of the "UCLA" school of economics that popularized institutional analysis. Alchian was one of von Neumann's colleagues at RAND and participant in the earliest Prisoner's Dilemma experiment.

Objects/Places

Prisoner's Dilemma

A Prisoner's Dilemma is a game that was developed by Merrill Flood in which two people, though better off if both cooperate, have an overriding incentive to defect.

Zero-sum Game

A zero-sum game is a game where for one person to win, another must lose. Most sports such as football are zero-sum in this way. In contrast, a positive-sum game is a game, which both players can win.

Minimax Theorem

A theorem proved by von Neumann that showed any two-person, zero-sum non-cooperative game had a solution.

Budapest

Budapest is the capital of Hungary and the childhood home of von Neumann.

Institute for Advanced Studies

An institute near Princeton developed so that top scholars could concentrate on research with each other without having to teach.

Pure Strategy

A strategy is the set of moves that a player will make during the game. A pure strategy is a strategy that is completely defined over the entire game.

Mixed Strategy

A mixed strategy is used when there is no pure strategy in a game. A mixed strategy combines different pure strategies based on the probability of their effectiveness based on the payoff in the game and assumptions about other players.

Saddle Point

A saddle point is equilibrium of strategies in a two-player game.

The RAND Corporation

A "think tank" founded by a joint government and industry concern in the 1950s. The RAND Corporation, during the 1950s did research on a variety of topics and housed some of the greatest minds of the age.

Operation Crossroads

Operation Crossroads was a series of naval nuclear tests at the Bikini islands in 1946.

Think Tank

A non-university research institution where scholars can focus on questions often related to public policy.

ICBM

An Inter-continental Ballistic Missile, the delivery device of thermonuclear warheads. Rockets either launched from land or from submarines.

Nash Equilibrium

A Nash Equilibrium is a strategy in a n-person game where the player has "no regrets"; that is, they cannot improve their position though a unilateral shift in strategies.

N-person Game

An n-person game is a game with n players where n is any number.

MIRV

A Multiple Independent Reentry Vehicle that allows multiple individually target warheads to be located on one ICBM.

Themes

The reality of conflict

One of the important themes that come out of this work and out of game theory itself is the reality and ubiquity of conflict. Games like the prisoner's dilemma show that conflicts between people can be very difficult to solve, and in the case of the prisoner's dilemma, it is effectively impossible to solve. We want to think that if only people would think rationally, they would see that cooperation is more beneficial than defection, but the prisoner's dilemma show that it is impossible, in some cases, to rationally demonstrate the value of cooperation. This is such a strong conclusion that, as the author shows, a cottage industry has grown up to show that someway or somehow, prisoner's dilemmas can be solved. To realize that prisoner's dilemmas cannot be solved is to realize something more valuable than any "solution" could possibly be, it is to realize that cooperation and mutual gain in interaction is a kind of accomplishment. While it may seem natural to cooperate in many different situations, we know that cooperation is not beneficial across the board. We need institutions and norms in place that encourage cooperation and punish defection to get us out of the defection trap that the prisoner's dilemma shows is all too common. To recognize the reality of conflict is to recognize that many disputes cannot be solved by thinking harder or by talking; rather, the payoffs of the game must be changed so that instead of playing a prisoners dilemma or a game of chicken, the parties are playing games that have cooperative solutions.

Individual rationality and collective irrationality

Aside from the reality of conflict that game theory can show us, one of the other truly disturbing results is the way individual rationality can subvert individual goals and lead to outcomes that look collectively irrational. In a prisoner's dilemma, both parties would prefer to cooperate, but given the logic of the game, it is rational for each party to defect, leading to an outcome that looks collectively irrational. This is also often true in assurance games or stag hunts as well. It is common, when shown the results of a prisoner's dilemma, to think that someone has reasoned poorly, but, in fact, this is the opposite of the case. The problem with the prisoner's dilemma is that ideal rationality, perfect reasoning, leads to the suboptimal conclusions. The project that goes all the way back to Thomas Hobbes, the attempt to show that individual rationality proves the value of cooperation looks to be mistaken. The question then becomes, "how is collective rationality or cooperation possible?" One suggestion from Axelrod is that repeated interactions of prisoner's dilemma can benefit from a tit for tat strategy that is relatively stable: stable enough to lead to cooperation. Another strategy is to turn prisoner's dilemmas into Stag Hunts. A stag hunt can be "solved" so long as some external authority can require or signal cooperation. In fact, this is often what our institutions do. As with the dollar auction though, there is no way to reason yourself out of a prisoner's dilemma. We may be able to use our reasons, however, to recognize when we are in prisoner's dilemma and to try to change those situations into Stag Hunts or other kinds of games. As in the dollar auction, the only way to really win a prisoner's dilemma is not to play.

The dangers of amoral public policy

One theme that comes through in Prisoner's Dilemma is the dangers of adopting game theory as a normative rather than a descriptive approach to public policy. Normative approaches tell us what we "should" do, whereas descriptive approaches tell us what we actually do. Game theory is a simplified, sometimes accurate, model of actual human behavior and situations. Insofar as the model is exactly like reality, it may provide normative guidance, but often reality is not exactly like the model. Many times, not all of the payoffs are included in the game. Sometimes we may think we are playing one game, while in fact we are playing another. Also, some games have many, even infinite, Nash equilibrium strategies. When looking at public policy, we often need to consider much more than just how to "win."

In the cold war, as this book shows, sometimes people involved in public policy mistook descriptive for normative theorizing. The RAND Corporation, for instance, studied life after nuclear war and several thinkers, including von Neumann, suggested that preemptive nuclear war was the only way to win. Russell, an outlier in this story, realized later that preemptive war was impossible and argued that the only way to really win was to disarm. His strategy may not have been correct, but his appraisal of the situation seems to have been more prescient than some of his contemporaries. Even if disarmament was not feasible, mutually assured destruction and brinksmanship were also unstable strategies. Ironically, later developments in game theory showed the truth of much of these thoughts, though they were not available at the time.

Style

Perspective

William Poundstone, the author of Prisoner's Dilemma, is an American author who has written several books on scientific topics. Although this is a book at least partially about game theory, it is clear that the author has a broader interest in the topic than just the mathematics of game theory or the lives of those who developed it. He is interested in the way that game theory views the world and the way that the particular lens of game theory, which sees the world as a series of amoral conflicts, has affected the actual world.

Throughout the book, von Neumann and other mathematicians are subtly contrasted with Bertrand Russell, the philosopher. The effect is to suggest that Russell was an intelligent man with no illusions who, nevertheless, approached the world in a moral way. Russell, unlike von Neumann, was concerned with how he would affect the world and sought to be a force for good rather than destruction. Part of the perspective that the author is trying to suggest is that game theory can help us to understand social problems that involve conflict, but that it may not provide many, if any solutions. The book is written for the lay audience, and the author attempts to make many of the seemingly abstract and complex issues in game theory understandable and relevant to the general audience. He does this effectively, though there is clearly some amount of suspicion directed at those that invented and used game theory in the 1950s and 60s.

Tone

This book is attempting to do more than one thing and, hence, it has more than one tone. A third of the book or so is a rather straightforward biography of John von Neumann. Another third is a history of the cold war and the intellectual establishment that arose during the cold war to deal with the threat posed by nuclear warfare. Another third is devoted to looking at how game theory in general and prisoner's dilemmas in particular can illuminate problems in human society and action.

The biographical part of the book has a tone that is similar of many biographies of great and interesting men. It is primarily an anecdotal style of biography, and von Neumann is presented through a series of interesting and illuminating anecdotes. The history portion of the books is told in a tone of a surprised and perplexed observer. Central historical phenomena are not mentioned at all, while the author comments on interesting but minor points that relate to his central concern. The most interesting part of the book in terms of tone is the more abstract thread that deals with game theory itself. Here the author does a good job of explaining complex mathematical theories in a tone that is accessible to the general audience. His tone here is conversational and straightforward. Jargon is avoided unless absolutely necessary and examples from everyday life abound.

Overall, the tone of the book is a sum of the different tones employed in the different narrative threads. The book is anecdotal, serious in its historical sections, and conversational but intelligent in the sections on game theory. Sometimes, often, the tones overlap as the narrative threads overlap.

Structure

The structure of Prisoner's Dilemma reflects the fact that there are three distinct but related narrative threads present in the book: a biography of von Neumann, an idiosyncratic history of the cold war, and an explanation of game theory and its applications. The book starts off as a straightforward biography of von Neumann for several chapters before incorporating the other elements of the story. This can be kind of jarring, as chapters will sometimes include events that occur later than events in chapters to come. For instance, the chapter on the development of the RAND Corporation starts in the mid forties and ends in the 1960s. Most of the next couple of chapters occurs in the 1950s, however. This effect can be a little disconcerting and, overall, it blunts the narrative force of the book somewhat.

Each chapter has a general theme, but within chapters there are several sections that have their own sub-themes. Most of the time these sub-themes flow together to form a coherent narrative, but this is not always the case. When the narrative doesn't work, the book can begin to seem disorganized and the reader can, rightfully, wonder what the point of the particular section is in the larger whole. For the most part, though, the author avoids this problem and the chapters do show a general progression in time through the book. In the same way that many of the earlier chapters are devoted specifically to the life of von Neumann, many of the later chapters focus solely on the intricacies and later developments in game theory.

Quotes

"If you say why not bomb them tomorrow, I say why not today? If you say at 5 o'clock, I say why not one o'clock?"
Chap. 1, p. 4

"all science, all human thought, is a form of play."
Chap. 3, p. 39

"Chess is not a game."
Chap. 3, p. 44

"To many, the RAND Corporation epitomizes modern Machiavellianism."
Chap. 5, p. 84

"...the Minimax solutions of zero-sum games qualify as equilibrium points, but Nash's proof says that non-zero-sum games have equilibrium points too."
Chap. 5, p. 99

"...no matter what course you take, you wonder whether you have chosen correctly."
Chap. 6, p. 121

"The question, then, is not how many complete bombs existed, but how many could have been assembled if necessary."
Chap. 7, p. 161

"Game theory was deprecated, distrusted, even reviled."
Chap. 8, p. 167

"The iterated prisoner's dilemma has become such a popular subject for psychological studies that political scientist Robert Axelrod dubbed it the 'E. Coli of social psychology.'"
Chap. 8, p. 173

"Like the prisoner's dilemma, chicken is an important model for a diverse range of human conflicts."
Chap. 10, p. 197

"it will be too late to cry over lost hair after your head is cut off."
Chap. 10, p. 205

"...the peculiar thing about a stag hunt is that it shouldn't be a dilemma at all."
Chap. 11, p. 219

Topics for Discussion

Explain the difference between Deadlock and the Prisoner's Dilemma.

Explain the difference between Chicken and the Stag Hunt.

What is peculiar about the Dollar Auction?

Give an example of a social dilemma that you think up. Is it similar to any of the established dilemmas?

Why is chess not a game in von Neumann's sense?

Is nuclear warfare a zero-sum game? Why or why not?

Explain Russell's argument in favor of preemptive nuclear war.