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Game Theory and Peace Research: Professor Anatol Rapoport's Contributions

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Abstract
At the forefront of the game theoreticians who conceived of concepts that contributed to peace research and conceptualized strategies that could promote international cooperation, Professor Anatol Rapoport used simple game theory in the classroom to generate ideas about how to enhance world peace. The basic logic of game theory is explained using his game models of 'Chicken' and 'Prisoner's Dilemma'. Rapoport's revolutionary ideas about how to promote international and national cooperation are overviewed; for instance he developed a simple strategy, Tit for Tat, to help minimize conflict that won two computer tournaments, and he taught scholars to consider the risks of nuclear deterrence. He was one of North America's pre-eminent peace researchers and his legacy will live on for generations of future scholars and policy makers.

Keywords: chicken game, cooperation, game theory, peace research, prisoner's dilemma, Rapoport

Game theory is usually used to rationally and dispassionately examine the strategic behaviour of nations, especially superpower behaviour. Game models are used to describe and explain all types of situations, as well as to prescribe how rational leaders or countries should act in given situations. Economists have their own models of supply and demand and, similarly scientists and political analysts often use game theoretical models to understand the underlying structure of conflict. Dr. Rapoport's contributions to game theory were solidly in the area of peace research, an important sub-field of political science and international relations. Rapoport was a recognized leader in peace research world-wide. He was particularly well-known as one who was also highly respected in peace and conflict studies and in the military and strategic studies community.

This article explains how basic game theory—at its simplest level—was used by Professor Anatol Rapoport to generate ideas about how to enhance world peace. Rapoport was at the forefront of the game theoreticians who sought to conceptualize strategies that could promote international cooperation. Accordingly, the basic logic of game theory is explained using the game models of 'Chicken' and 'Prisoner's Dilemma'. These models were used by Rapoport in his books and lectures in simple and complex ways. Then Rapoport's revolutionary ideas about how to promote international and national cooperation are overviewed. He developed a simple strategy called Tit for Tat which won two computer tournaments. Rapoport suggested that applying his strategy to real-life problems could help prevent human vulnerability and minimize conflict. Finally, this article considers the inherent dangers of game theory and nuclear deterrence in the way that Rapoport taught young scholars to contemplate their risks.

Background of Anatol Rapoport

Dr. Anatol Rapoport was born May 22, 1911 in Lozova, Ukraine to a family of Jewish socialists that fled the Soviet Union while he was still a boy and settled in the United States. He went to school in Chicago and afterwards studied music in Vienna from 1929 to 1934. Until 1937 he was active as an international concert pianist and even in his later years as his memory waned, he could play the piano expertly from memory. He began a second study in mathematics at the University of Chicago (PhD in Mathematics, 1941). After military service Rapoport began his scientific career and research at the

Illinois Institute of Technology, Chicago, in 1946. From 1955 to 1970 Rapoport was professor at the Mental Health Institute of the University of Michigan. In 1970 he transferred as a professor of psychology and mathematics to the University of Toronto. Then he became the director of the Institute for Advanced Studies, Vienna in 1980. In 1984, Rapoport moved back to Canada where he was a long-serving professor at the University of Toronto; the co-founder of its Peace and Conflict Studies Program; and president of a well-known society that continues to debate, 'Science for Peace'. He died in 2007 in his 96th year.

Known worldwide as one of game theory's most pre-eminent theorists, Rapoport published more than 400 contributions to game theory, mathematical biology, semantics, systems theory, and peace research. He wrote two classic works: *Fights, games and debates* (1961) and *Prisoner's Dilemma: A Study in Conflict and Cooperation* (1965), and he wrote and edited many other books on game theory, the best known of which are: *N-person game theory: concepts and applications* (1970); *The big two: Soviet-American perceptions of foreign policy (1971); Conflict in man-made environment* (1974); *Game theory as a theory of conflict resolution* (1974); *The 2 X 2game* (1976); *Mathematical Models in the Social and Behavioral Sciences* (1983); and *Decision theory and decision behaviour: normative and descriptive approaches* (1989). Later in life, Rapoport contributed two seminal volumes to peace research: *The Origins of Violence: Approaches to the Study of Conflict* (1989) and *Peace: An Idea Whose Time Has Come* (1992). These ground-breaking texts continued to be used by students and scholars in the University of Toronto's program of Peace and Conflict Studies, which Dr. Rapoport co-founded, and they are still used in many other specialized peace and conflict studies programs.

According to the *Oxford International Encyclopedia of Peace*, Rapoport occupies an important place in the development of peace research. He emphasized the importance of pacifism—the refusal to participate in the system of war—and he focused on abolition of war including nuclear abolition. Professor Rapoport's contributions to the field of peace research were complex and manifold. As the model of a 'passionate, engaged intellectual' he contributed to system theory, game theory and the study of human cooperation. He believed that the systematic scholarly inquiry of peace research was powerfully important (Young, 2010). Rapoport also contributed to peace research by teaching that value-free research and positivism should be criticized. He believed behavioural science could not be value-free: “as a rule the assumptions made in natural science do not affect the material under study; in behavioural science they do” (Eckhardt 1983).

Rapoport became involved with peace research in the mid-1950s. He argued that scientists should work for peace and should not prioritize war, despite practical realities, especially regarding Vietnam from 1965 onward. His scholarly work was embedded in the multidisciplinary ideal and the behavioural revolution. His use of analytical tools, namely mathematics established the basis for a new criticism of deterrence theory. Rapoport joined his skills in mathematics and formal logic with those of biologist Ludwig von Bertalanffy, economist Kenneth E. Boulding and psychologist Ralph W. Gerard to found the Society for the Advancement of General Systems Theory in support of what came to be known as the systems movement. He took a non-realist approach to conflict and identified the creative exploration of analogies, especially those deducible from mathematical models. In the 1970s he was President of the Peace Research Society (International) and of the Canadian Peace Research and Education Association. He received the Lentz International Peace Research Award in 1975. The end of détente by the late 1970s and the intensification of Cold War dynamics during the Reagan years led him to intensify his search for peace research conceptions, proposing new forms of bipolar confrontation logic and common security. Rapoport was at the forefront of those game theoreticians who sought to propose alternative ways to conceptualize strategies that could promote international cooperation.

With the end of the Cold War and the collapse of the bipolar system, game theory lost much of its former popularity (McMillan, 1992; Powell, 1999) although it continued to preoccupy scholars and educators. This article explains how basic game theory—at its simplest level—was used by Rapoport to generate ideas about how to enhance world peace. Many of his books on game theory are difficult to understand from a mathematical perspective, but he believed the basic lessons of game theory could be taught to everyone using chalk and a blackboard. He was often found standing in front of the classroom at the University of Toronto, wearing a snappy blue beret, surrounded by clouds of chalk dust. He would draw the essential boxes that make up a matrix in game theory with so much vigour that his piece of chalk would break. Already in his eighties, he continued to teach part-time decades after official retirement.

The Basic Logic of Game Theory Using Two Game Models: Chicken and Prisoner's Dilemma.

Two game models were used by Rapoport in his books in complex and sophisticated ways. For those less well versed in mathematics—and in order to better appreciate Rapoport's fine contribution to peace studies – the models are explained here as he explained them during his first few lectures in the classroom. Then Rapoport's revolutionary ideas about how to promote international and national cooperation are overviewed. He remains well-known more than a decade after his death because he developed a simple game theoretical concept, called Tit for Tat (TFT) which won two famous computer tournaments. He suggested that applying TFT to real-life problems could help formulate preventive measures that reduce human vulnerability and minimize conflict. Finally, the essay reflects upon the inherent dangers of game theory and nuclear deterrence just as Dr. Rapoport taught many scholars to contemplate their risks. He felt very responsible to counsel students and scholars of peace research and game theory to be careful about wielding game theory's arcane language for nefarious ends.

Game 1: 'Chicken' or Deterrence Model

It is helpful to first explain the concepts of a 'matrix', and a 'payoff' with reference to the game of Chicken. The Chicken model was often used to illustrate the logic—or illogic—of deterrence strategy; however, it is also useful for explaining the basic logic of game theory and the 'minimax' principle.

Chicken was developed by Daniel Ellsberg, a strategic analyst at RAND, the American think-tank. He wanted to create a 'machine' for asking useful questions and for preliminary testing of alleged answers about nuclear deterrence. The model was based on a daredevil game played by teenagers in the United States. Two groups would pile into cars and drive full-speed at each other with their cars straddling the middle of the road. The first driver to swerve to avoid collision would be the loser, earning the nickname 'chicken'. But both drivers would be losers if they collided.

The choices that face both drivers—Rapoport called them Sam and Ivan (but they could be any other adversaries, like Donald Trump and Kim Jong Un)—can be illustrated using a rectangular box called a matrix. Sam's choices are listed in the horizontal rows, while Ivan’s choices are ordered in the columns vertically. In the simple two-player game of Chicken, Sam and Ivan each has two choices—to swerve or not to swerve—but there are four possible outcomes and four possible ‘payoffs’ for each player. A payoff is defined as the outcome of both players’ decisions.

Figure 1
‘Chicken’ or Deterrence Game

		Ivan (column)	
		Swerve (cooperate)	**Don’t Swerve (threaten)**
Sam (row)	**Swerve (cooperate)**	+1 +1	+10 -10
	Don’t Swerve (threaten)	-10 +10	-100 -100

To illustrate, let us assign some numbers for the possible payoffs for Sam and Ivan, and examine these payoffs closely:

1. If Sam decides to swerve off the road at the last second—but so does Ivan—both will be seen by their friends as lacking in courage—as ‘chickens’. But they do earn some status at least for playing the game—so we will give them each a single point or +1 (upper-left box)
2. If Sam swerves, and Ivan does not, then Sam looks like a chicken—in this case the payoff for Sam would be -10 points—and Ivan wins—let us say this is worth +10 points to him (upper-right box).
3. However, if Sam decides not to swerve, and Ivan swerves, Sam earns +10 points, and Ivan receives - 10 points (lower-left box).
4. But if both Sam and Ivan decide not to swerve, the rather grisly outcome could be calculated as - 100 points for Sam, and - 100 points for Ivan (lower-right box).

Evidently, the game of chicken was meant to mirror the calculations that the superpowers made about nuclear deterrence. In a situation of deterrence, both the United States and the Soviet Union (or North Korea) could threaten to 'go to the brink' and use nuclear weapons. But if neither backed down, there would be a nuclear war and both players would suffer enormous costs. The costs of playing the 'game' of deterrence would outweigh the benefits of going to the brink.

In this sort of situation, what might Sam or Ivan (or Trump or Kim Jong Un) decide to do? According to traditional game theory, Sam should make his decision by considering all the worst possible consequences of each of his choices. Then he should choose so as to avoid the worst conceivable outcome. In game theory this course of action was referred to as the 'minimax' or the 'maximin' principle (or the von Neumann principle). Sam should look for the payoff where his minimal payoff is maximal—in other words, he should try to make the best of the worst behaviour of his opponent.

As Dr. Rapoport pointed out, if both Sam and Ivan choose according to the maximin principle, they would both decide to swerve in order to avoid the worst pay-off—a perfectly rational solution. Similarly, game theorists pointed out that in a crisis situation, the enormous costs for the United States and the Soviet Union of carrying out a strategy of Mutual Assured Destruction (MAD) would not be borne by rational decision-makers. Thus, MAD would not be perceived by either side as a credible strategy of conflict avoidance because the costs of possible nuclear war far outweighed the benefits of going to the brink and threatening possible retaliation. Moreover, if MAD was not seen as credible, the Soviet Union might threaten a conventional or limited nuclear attack against Western Europe, knowing full well that the United States would back down because of the enormous costs of all-out nuclear retaliation. The problem, then, for game theoreticians became how to signal that the American nuclear threat was credible—that the United States would risk some measure of destruction, for example, for the sake of Berlin, Korea, or Cuba.

A few solutions to this conceptual conundrum emerged from game theory. As Rapoport pithily explained, the famous nuclear strategist Herman Kahn advised the following winning strategy: in full view of the opponent, tear off the steering wheel and throw it away. In this manner, the opponent will become convinced of your resolve, for now he knows that you could not swerve even if you wanted to. Taking this line of reasoning one step further, Kahn recognized that just as Sam, showing his resolve, yanks his steering wheel off, Ivan might get the same idea and do the same thing, creating a problem for both parties. As Rapoport explains, 'If one remembers that it is not only the two imbeciles' lives that are put on the line in the global game of chicken but practically everyone else's, one begins to realize the dangers involved in indulging in strategic analysis from only one strategist's point of view' (1971:180-81; 1985: 179-81). The basic question—how to credibly threaten to go the brink—continues to preoccupy game theorists concerned with making deterrence work (for example, Brams and Kilgour, 1988; Powell, 1990; Paul *et. al* 2009). But Rapoport was at the forefront of those who forthrightly argued that 'this fixation on the zero-sum paradigm, together with the inability to break away from the imperatives of individual rationality, prevent the military from designing a way out of the impasse created by the threat of total extinction' (1985: 180).

Deterrence and the Intellectual Poverty of Signalling Resolve in the Chicken Model

The problem of how to signal resolve in a nuclear deterrence situation will probably never be solved. How should the United States signal to an adversary, for example, that if it attacks—using nuclear, chemical or biological weapons—that the US may use its nuclear weapons? Nevertheless, game theoreticians have gone to great lengths to try to derive game-theoretical solutions to the problem. Rather than admit that the strategy of nuclear deterrence should be re-examined and revised, game theorists experimented with many possible solutions to the problem.

It was evident in his classes that Rapoport had little patience with the work by theoreticians who tried to formulate complex concepts (*e.g.* 'robust threats', 'probabilistic doomsday machine') and mathematical proofs (*e.g.* 'backward induction', 'conditional probability') to show that it can be rational, in certain circumstances, to issue a nuclear threat (Brams and Kilgour, 1988: 38-53, 74-94). While game theorists' attention shifted to modelling nuclear rivalry, deterrence theory, and crisis stability, including the effects of first-strike advantages, limited retaliation, and the number of nuclear powers in the international system on the dynamics of escalation, (for example, Harvey, 1997)

Rapoport broadened his academic focus to write books that explained theories of peace research, the origins of violence, and ideas about semantics and systems theory. He continued to publish extensive research on game theory but he embraced the game of 'Prisoner's Dilemma', rather than 'Chicken', in books like *Prisoner's Dilemma: A Study in Conflict and Cooperation* (1965); *The 2 X 2 Game* (1976); and *Mathematical Models in the Social and Behavioral Sciences* (1983). His major contributions to game theory revolve around the Prisoner's Dilemma (PD) model because it reveals, in devastatingly clear terms, the underlying structural conflict that bedevils most systemic-, state-, and individual-level conflicts.

Game 2: 'Prisoner's Dilemma' Model

Rapoport used the Prisoner's Dilemma game to neatly demonstrate how humans and nations can get into threatening sorts of situations—and how the structure of a situation can force everyone to continue to endure insecurity. The Prisoner's Dilemma model demonstrates that we can be caught in a dilemma, not because of evil or stupid leaders, but because of structural imperatives and thinking patterns that dictate choices where, in order to avoid the worst-case scenario, we end up in a less-than-optimal situation. In his own words, 'In the game called Prisoner's Dilemma, the rational choice of strategy by both players leads to an outcome which is worse for both than if they had chosen their strategies 'irrationally'. The paradox remains unresolved as long as we insist on adhering to the concept of rationality which makes perfect sense in zero-sum games but which makes questionable sense in non-zero-sum games. Thus the paradox forces a re-examination of our concept of rational decision' (Rapoport and Chammah, 1965: 13).

As Rapoport liked to explain in his classes, the original story of Prisoner's Dilemma was formulated in the early 1950s, and the problem it poses continues to preoccupy policy-makers and academics who think about decision-making. The parable goes something like this:

Two suspects are taken into custody and placed in separate cells. The prosecutor is port convinced that they are guilty of a specific crime but he does not have sufficient evidence to convict them at a trial. Accordingly, he gives each prisoner two alternatives: to confess—or not to confess—to the crime he is sure they have committed. He tells each of them:

‘If you do not confess—if you are silent—I will book you on the lesser charge of illegal possession of a weapon. You will get a sentence of 1 year in jail.’

‘But,’ he says to each of them separately, ‘if you both confess—if you both defect—I will prosecute you both but I will recommend less than the most severe sentence—probably each of you will be sent to jail for 5 years’.

Then the prosecutor goes on to say:

‘However, if one of you confesses and the other does not, then he who confesses will get lenient treatment because he provided us with evidence—only 3 months in jail—and I promise that the other prisoner, who does not confess and stays silent, will receive the maximum sentence—at least 10 years.’

The choices facing each prisoner can be illustrated using a matrix. At this point, Rapoport would give the prisoners the names of two erstwhile students in the classroom, but for the sake of clarity here, we will call them Arnold (A) and Bob (B). If we examine how Arnold (A) reasons, we can obtain insights into the way in which leaders, groups, nations, and international organizations can also find themselves in a Prisoner’s Dilemma.

To illustrate, let us assign some numbers for the possible payoffs for Arnold and Bob, and examine these payoffs closely in the matrix (Figure 2) on the following page:

Figure 2

Prisoner's Dilemma: Arnold and Bob in Jail

Bob (B)

Arnold (A)	**Cooperate (silence = C)**	**Defect (confess = D)**
Cooperate (silence = C)	B gets 1 year (-10) Both silent (C, C) A gets 1 year (-10)	B gets 3 months (-3) Bob confesses, Arnold is silent (C, D) A gets 10 years (-100)
Defect (confess = D)	B gets 10 years (-100) Arnold confesses, Bob is silent (D, C) A gets 3 months (-3)	Bob gets 5 years (-50) Both confess (D, D) A gets 5 years (-50)

-3 = 'best', most-preferred outcome
-10 = 'next best' or next-preferred outcome
-50 = 'next worst' outcome
-100 = 'worst' or least-preferred outcome

Arnold's Choices: Sitting Alone in Prison

Obviously, Arnold does not know what Bob is planning to do, nor can he communicate with him from his prison cell, so Arnold calculates as follows:

1. If I choose to be silent, and Bob does too, we will both get 1 year in jail (C, C box)
2. But if I am silent, and Bob confesses, then I get 10 years, and he gets only 3 months
(C, D box)
3. If I confess, and Bob does not, then I get only 3 months, and he gets 10 years (D, C box)
4. But if we both confess, then we both get 5 years (D, D box).

Thus, says Arnold to himself, if I want to avoid the worst outcome—that is 10 years—then I should not risk being silent. I should confess because the worst that can happen is that I get 5 years, and I might get only 3 months.

This is Arnold's reasoning (based on the minimax principle). But, unfortunately, Bob makes the same calculations. Bob also chooses to confess so as to avoid the worst-case outcome so both Arnold and Bob spend 5 years in prison—a sad ending to a metaphorical tale.

The principal lesson of Prisoner's Dilemma is that—despite the existence of a mutually preferable outcome (the CC box)—the rational calculations of both prisoners in favour of their own self-interest in avoiding the worst-case outcome dictates that both end up worse-off. The appeal of Prisoner's Dilemma lies in the fact that its underlying logic can apply to a wide variety of threatening situations. For example, the next matrix (Figure 3) demonstrates the same kinds of calculations leading to an arms race**.**

Figure 3
An Arms Race as a Prisoner's Dilemma

		Country B	
		Cooperate (low arms spending)	**Defect (high arms spending)**
Country A	**Cooperate (low arms spending = C)**	Country B Disadvantage (-10) (C, C) Arms Limitation Country A Disadvantage (-10)	Country B Advantage (+50) (C, D) Country A Serious Disadvantage (-100)
	Defect (confess = D)	Country B Serious Disadvantage (-100) (D, C) Country A Advantage (+50)	Country B (-50) (D, D) Arms Race Country A (-50)

+50 = 'best', most-preferred outcome
-10 = 'next best' or next-preferred outcome
-50 = 'next worst' outcome
-100 = 'worst' or least-preferred outcome

In this game, Country A would most prefer a situation where it has a superior weapons system to Country B. For instance, the superior weapons system could be advanced nuclear submarine technology or a sophisticated anti-ballistic missile system based in space. However, Country B sees a situation where Country A has superior firepower as its worst-case scenario; consequently, it develops its own weapons. These could be modernized anti-submarine warfare systems or thousands of decoys designed to trick tracking systems, satellites, and lasers in space. As a result, both countries become entangled in an arms race, although the costs of an arms race are higher than agreeing to some sort of arms limitation agreement.

It should be pointed out that in this simple Prisoner's Dilemma model, the two players need not be the obvious ones—the United States *versus* Russia. The parties could be India *versus* Pakistan; North Korea *versus* South Korea and Japan; or al Qaeda's network *versus* the United States and the NATO allies. Prisoner's Dilemma also describes many conceivable scenarios other than arms races. The choices facing Group A or Group B could be between:

- cooperating with other countries to impose sanctions against a violator country (*e.g.* cooperating to impose sanctions on Iran)—or defecting from an international agreement to impose sanctions (*e.g.* loosening trade restrictions with Iran's military regime).
- cooperating with other countries to limit weapons stockpiles (*e.g.* ratifying the Comprehensive Test Ban Treaty)—or choosing to export certain weapon systems (*e.g.* modernizing NATO's 'dual-use' weapons systems in Turkey)

Prisoner's Dilemma can apply to a myriad of particular cases, such as businesses cooperating together to reduce greenhouse gas emissions, governments seeking to control landmines, or the United Nations (UN) attempting to mobilize member states for peace support operations. The choices could be between:

- cooperating with an adversary to reduce forces and military equipment, such as cooperating with Russia to reduce NATO's weapons arsenal in Europe—or reneging from serious arms limitation talks, such as failing to honour the Intermediate Nuclear Forces Treaty

- cooperating with the general trends of arms control agreements, such as honouring the as-yet-unratified Comprehensive Test Ban Treaty—or choosing to modernize nuclear weapon systems, such as making plans to erect ground- and space-based ballistic missile defence systems and modernizing nuclear weapons arsenals
- cooperating with adversaries to negotiate peace agreements, such as cooperating among the NATO allies and Russia in order to pursue peace negotiations about how to deal with armed rebel groups in Ukraine's eastern area – or choosing not to negotiate peace agreements about how to deal with armed rebel groups, including for example rejecting the prospect of peace negotiations about how to deal with ISIS in Syria and Iraq among the NATO allies including with Russia and Syria's pro-Assad forces.

In all these cases there are great advantages to being the only one to defect, however, if both or all parties defect, it works out to everyone's disadvantage. Thus, Prisoner's Dilemma starkly illustrates how spirals of insecurity can develop. It shows how parties can be trapped in security dilemmas—not because of stupid or irrational calculations—but because of thinking patterns or 'decision rules' where each group seeks to avoid the worst-case scenario at all costs, and where each player is unwilling to risk the costs of cooperating if the other player also does not cooperate.

Rapoport's Contribution to Cooperative Game Theory

A great deal of scholarly work tests the intricacies of the Chicken and Prisoner's Dilemma games. For example, Jurišić et al., after reviewing the relevant literature up to 2012, concluded 'Prisoner's dilemma is still a current research area with nearly 15,000 papers during the past two years.' (Jurišić M, Kermek D, Konecki M, 2012; quoted in Rapoport, Seale and Coleman, 2015). Rapoport believed a basic understanding of both models' underlying logic could help devise creative strategies to promote international cooperation. As he repeatedly showed, a game theoretical framework can help generate useful ideas and unusual solutions that enhance human security. Taking a simple approach could help generate solutions and detect problems with these same ideas. His concept of 'Tit for Tat' was a very simple idea, yet it generated some amazing discoveries.

Rapoport's strategy of 'Tit for Tat' (TFT)

In his lectures, Rapoport explained the idea that costs and benefits need not be one-time pay-offs, but can be incurred or appreciated more than once over time. As he would ask, what happens if we play Prisoner's Dilemma over and over again? In other words, what happens if two players know that they will interact repeatedly? In game theory, this is referred to as an 'iterated' Prisoner's Dilemma.

To answer this question, political scientist Robert Axelrod invited experts to submit programs for a Computer Prisoner's Dilemma Tournament. He wrote a nine-page article in 1981 and a 1984 book with the same title, *The Evolution of Cooperation*, about the results. Decades later, the article is still one of the most cited articles ever published in the journal *Science* (Axelrod and W.D. Hamilton, 1981; Axelrod, 1984). Scores of game theoreticians continue to test his findings under various computer, human, and laboratory conditions (for example, Betz, 1991; Busch and Reinhardt, 1993; Simpson, 1990, 2001; Kretz, 2011; Axelrod, 2012; Hilbe C., Traulsen A., Sigmund K. 2015; Rapoport, Seale and Colman, 2015).

Axelrod first set up the tournament so that each computer program would interact with other programs, and each program would be matched against itself, as well as against Random—a program that randomly cooperated and defected with equal probability. In the first round-robin, each game consisted of exactly two hundred moves, there were 14 separate strategies, and the game was run five times so there were 240,000 separate choices. The strategy that won the tournament, because it attained the highest average score compared to any other entry, was the simplest of all the submitted programs. It was formulated by Rapoport. His strategy, Tit for Tat (TFT), began with a cooperative choice and then did whatever the other player did on the previous move. The reasons for the success of the strategy of TFT were that:

- it was nice by starting off with cooperation;
- it was retaliatory immediately in the case of defection—it defected once after each defection by the other;
- but it was forgiving if the adversary cooperated again
- and it was not too clever, but it was very clear—consequently, it was easy for other programs to figure out its strategy.

Then Axelrod ran another tournament. This time, however, all the participants knew TFT had won the first round so many tried to design entries to beat TFT. Strategies such as Stab in the Back defected on the last move; strategies such as Tester defected immediately; while Tranquillizer lulled the other player into cooperation, and then tried to get away with defection. In this tournament, Axelrod also remedied a problem arising out of the first round robin related to the finite number of moves. He was able to more closely mirror reality by ensuring that minor endgame effects were eliminated (e.g. in this round robin, the game did not end after 200 finite moves; instead, the end of the game was probabilistic with a .00346 chance of ending the game with each given move.)

In the second tournament, there were 63 different strategies, and more than a million plays. There were many programs designed to be nice and forgiving; while other programs tried to take advantage of others if they were nice and forgiving. Anyone could submit any program but only one person submitted TFT again—Anatol Rapoport. To everyone's surprise, TFT won the tournament once more. Thus, the success of TFT led to some simple, but powerful advice:

- Be nice;
- Practice reciprocity (*e.g.* cooperate if the other player cooperates but retaliate if they defect);
- Forgive;
- Try to be as clear as possible.

How might TFT be applied to international relations? First, if Leader A knows that Leader B will be around for a long time in the foreseeable future, they might conclude that it would be worthwhile to improve their long-term relationship. In game theoretical language, 'the shadow of the future' looms larger in an iterated game. And if there will be no foreseeable end to their relations, adopting a Tit for Tat strategy could be fruitful (Simpson, 2001b: 139-49). For more than thirty years, in hundreds of publications, social and behavioral scientists have propagated the conclusion that TFT is the appropriate strategy to follow in resolving conflicts in dyadic interactions that satisfy the assumptions underlying the iterated two-person PD game (Rapoport, Amman, 2015). 'New strategies are developed and old ones are reused in new areas. But basic rules for cooperation that were recognized by Axelrod in the first competition are still valid' (p. 1097).

The Inherent Dangers of Game Theory and Nuclear Deterrence

Dr. Rapoport made very clear in his classes that game theory is replete with abstract language and complicated numerical terms—concepts that can be used more to obfuscate than to clarify. Just as the language of nuclear deterrence and strategic thought uses many complicated concepts such as flexible response, bolstering and pre-emptive warfare (Simpson 1990, 2001b, 2009), game theoreticians have their own forbidding terms (e.g. Nash equilibria, pareto-optimal, non-zero-sum games). Rapoport cautioned that those who use game theory can experience a kind of thrill at being able to manipulate the language. And they can also mistakenly feel that they have nuclear weapons under control. Game theory veils the choices facing humans about their survival in innocuous quasi-mathematical language. By doing so, game theory desensitises policy-makers and scholars to the reality of what they are talking about—which is actually about using weapons and force to threaten, deter, and kill other humans. As he emphasized, 'Strategic science is what confers intellectual respectability on the military profession, deflecting attention from the concrete results of military activity—mass killing and destruction' (Rapoport, 1995: 169)

Dr. Rapoport taught generations of students' game-theoretical styles of reasoning to generate ideas about how to deal with the broad range of challenges to human security, such as armed intra-state conflict, gross violations of human rights, environmental degradation, and nuclear proliferation. He understood that for students, learning the language of game theory was useful if we want to understand the abstractions of strategizing—much like mathematicians or physicists have a shared language. A basic appreciation of game theory also helps to understand the rather skewed assumptions about 'rationality' that underlie traditional military thinking about deterrence strategy. Indeed, a basic grasp of game theory's underlying assumptions and oversimplifications helps develop sufficient game-theoretical parlance to ask uncomfortable questions of the proponents of deterrence, such as: 'Can we assume that decision-makers will act and make decisions rationally during a crisis, such as a nuclear war?' (Simpson, 2001a, 2009)

Moreover, Rapoport showed how game theory can be useful for generating creative strategies that can help cooperation emerge in a world without central authority—that is, in a world of supposed 'anarchy'. His strategy of TFT can be applied to a myriad of interactions between leaders, groups, countries, alliances, and international organizations. Taking remedial action—a Tit for Tat approach—based on game theoretical ideas may (or may not) help reduce all types of conflict. Scholars continue to challenge the generality of Rapoport's strategy and point out that TFT is restricted to a particular combination tournament format, criterion for success, and payoff values (Rapoport, Seale and Coleman, 2015).

As a famous scholar, Anatol Rapoport (1911-2007) contributed to many key concepts and terms in peace research, like conflict resolution, deterrence, militarism, pacifism and rationality and there remains wide agreement that as a public intellectual he made an enormous contribution to game theory, peace and conflict studies and strategic studies. He was one of North America's pre-eminent peace researchers and his legacy will live on for generations of future scholars and policy makers.

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