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Tit for Tat and Beyond: The Legendary Work of Anatol Rapoport

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Abstract

This article pays tribute to Anatol Rapoport. Rapoport's contributions spanned scientific disciplines and included the application of mathematical models to biology and the social sciences, alongside metatheoretical work bridging semantics, ethics, and philosophy. Known for formulating the "Tit for Tat" strategy, his approach to game theory reflected a nuanced understanding of knowledge, wisdom, and ethics; the differences, for example, between modeling behavior—what works as an algorithm in a structured game—and solving complex human social interactions. While developing a science of human conflict, Rapoport focused on simple ideas to promote cooperation; his ultimate goal was to foster world peace. A career overview alongside testimonials by scholars and family provide a glimpse of Anatol Rapoport, the scientist and the person. The legacy and thinking of Anatol Rapoport continue to resonate and reverberate today whenever we conduct rigorous scholarship toward transforming conflict into peaceful harmony, whether among people or nations.

This article celebrates the scholarly contributions of Anatol Rapoport, the Lifetime Achievement Award recipient for the International Association for Conflict Management (IACM) in 1996. Rapoport was a leading figure in systems sciences, studies in conflict and cooperation, and peace research. While his formal academic training was in mathematics, his writing was also eloquent and innovative when it focused on metatheoretical ideas and philosophy. His research spanned scientific disciplines through pioneering

This article would not be possible without the vision of Michael Gross, who as editor in chief of *Negotiation Conflict and Management Research* (*NCMR*) initiated and stewarded the series of articles celebrating the legacy of recipients of the International Association for Conflict Management's Lifetime Achievement (Gross, 2016) and Jeffrey Z. Rubin Theory-to-Practice Awards (Gross, 2018). It was an honor supporting Michael's vision while I served as president-elect, president, and past president of our association, and a privilege to author one of these articles. What began as one more contribution to the association became a personal journey along which I discovered the breadth and depth of Anatol Rapoport's achievements. The intellectual journey went far beyond what I remembered from the days as a student and junior scholar reading his work. Moreover, this glimpse of Anatol Rapoport, the person, has been inspiring. I am indebted to Anatol's family for insights into his life and career, and in particular to Anthony Rapoport for helping me navigate this path, as well as contributing a testimonial, included here, to his father's approach and thinking. Thank you also for sharing family photos of Anatol Rapoport. I am grateful to colleagues in the field who provided personal testimonials to the work of Anatol Rapoport: Robert Axelrod, Andreas Diekmann, Spyridon Kotsovilis, Scott Page, Iain Paterson, and Markus Schwaninger. Thank you also to Martin Kocher, Thomas Koenig, Matthew Lassiter, Severin Matiasovits, Amnon Rapoport, and James Wall for your insights. It has been a pleasure working with Mary Catherine Moeller and Corey Seeman from the University of Michigan, whose expertise led to the discovery of and access to materials at our libraries. Thank you also to Marnee Gamble, special media archivist at the University of Toronto Archives. Thank you to Michael Gross for stewarding this article, to the *NCMR* reviewers for constructive feedback and to colleagues who provided a friendly review of the article. Finally, thank you, reader, for your curiosity and motivation; I hope you enjoy this article and that it inspires you on your journey.

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work applying mathematical models to biology and the social sciences. However, in models that offer strategies within games mirroring competitive, socially interdependent scenarios, Rapoport did not have mechanistic role-players in mind, but real people: "One cannot play chess if one becomes aware of the pieces as living souls and of the fact that the Whites and the Blacks have more in common with each other than with the players. Suddenly one loses all interest in who will be champion" (Rapoport, 1964, 195). When considering strategy and conscience, according to Rapoport, there is an essential incompatibility. Studying game theory is not just a game. While Anatol Rapoport focused on simple ideas and strategies to promote cooperation in game models, his paramount aspiration was to advance world peace.

To complement rather than extensively review what has been written by Anatol Rapoport and what has been written about him, I envisioned this celebratory article as a conversation. It begins with a history that introduces you to Anatol Rapoport and delineates his career trajectory. Following a brief section highlighting his Tit for Tat legacy, the article continues with personal reflections intended to spark ongoing scholarly conversations and impact.

Personal History and Career Overview

Rapoport's motivations were inextricably grounded in his personal history and career, which spanned geographic boundaries and professional domains. His autobiographical books—*Certainties and Doubts: A Philosophy of Life* (2000) and *Skating on Thin Ice* (2001)—and an autobiographical sketch, together with my conversations with his family,[1] provide insights into his scholarly endeavors. The locations and dates in the following overview of Anatol Rapoport's life allude to a witnessing of conflict and war that seems beyond comprehension (these include both World Wars, the Russian Revolutions and Civil War, the Cold War, and Vietnam). Still, Rapoport's life was marked with peaceful interludes that reflect his appreciation of the beauty and aesthetics of humanity.

Anatol Rapoport was born on May 22, 1911, in Lozovaya, Russia. He was an only child and was educated by his parents, Boris (b. 1888) and Adele (b. ~1886), both Rapoports (first cousins), themselves self-taught. Demonstrating an early aptitude for music, he began playing the piano at age five. Chaotic conditions following the revolution drove the family from place to place until they succeeded in emigrating to America, where they settled in Chicago in 1922. Anatol graduated high school in 1927, third in a class of 170, and in the following year won first prize—a grand piano—in a piano contest in Chicago. In 1929, he went to Vienna to study music, receiving a diploma in composition, piano, and conducting from the Staatsakademie für Musik und darstellende Kunst (State Academy of Music and Performing Arts) in 1933. He held well-received debut concerts as a pianist in Austria, Hungary, Italy, and Poland; given his Jewish background, and with Hitler in power, Germany was closed to him. During this period, he lectured and wrote about music (Rapoport, 1932a, 1932b, 1932c, 1933). Rapoport returned to the United States in 1934 to pursue his music career. He performed at Studebaker Theater and Orchestra Hall in Chicago, and his debut in New York was in Town Hall. Although the reviews were flattering, rather than waiting for the next season to see if engagements would materialize, he moved to Mexico City where he performed, lectured, and taught. On his return to New York, his music career did not develop in the direction he had hoped it would. He decided to return to Chicago, completing his undergraduate degree in June 1938. He spent the summer of 1938 cycling in Europe, a trip that included a visit to an exhibit the Nazis put on in Vienna, about which he wrote an article (for details, see Rapoport, 2000, 63–64). He returned to Chicago to pursue his graduate degree. As a graduate student, he still had minor musical engagements, but his career shifted from music to mathematics.

[1]Autobiographical sketch (c. 1988), http://anatolrapoport.net; and personal communication, Anthony Rapoport, February 2019. See also information at https://discoverarchives.library.utoronto.ca/index.php/anatol-rapoport-fonds, https://discoverarchives.library.utoronto.ca/index.php/rapoport-anatol, and Anatol Rapoport Personal Records, B2005-0018, University of Toronto Archives and Records Management Services https://discoverarchives.library.utoronto.ca/downloads/anatol-rapoport-fonds.pdf

Studying under Nicholas Rashevsky, a pioneer of mathematical biology and biophysics (for a career overview, see Cull, 2007), Rapoport earned a doctorate in mathematics at the University of Chicago in 1941, passing his final oral examination on December 5. Days after earning his PhD, he volunteered for service in the navy (the attack on Pearl Harbor was on December 7, 1941). Rejected for near-sightedness, he engaged as a civilian instructor of aviation cadets at Maxwell Field, Alabama, to teach mathematics and physics. Receiving a commission as first lieutenant in June 1942, Rapoport served in Alaska as a liaison officer between the U.S. and Soviet air forces. The lend-lease operation supplied allies, in this case the Soviets, with transport and combat planes. Planes were flown to Fairbanks by American pilots, whence the Russian pilots flew them to Nome (the last landing in North America) and eventually across the Bering Strait to Welkal, then several stops onward to serve in the battles of Stalingrad and Voronezh. In Fairbanks, Rapoport gave instructions in Russian from the control tower. Promoted to captain and transferred to Nome, he became the supply officer at the base, in addition to his duties as control tower officer and interpreter.

In Alaska, Rapoport developed close friendships and engaged in ideological conversations about who would emerge as leader of the democratic world after the war. In Nome, some of these friends were killed in crashes. It is in Nome, too, that he discovered the field of semantics. The book *Science and Sanity* (Korzybski, 1933) was lent to him by a civilian who worked at the infantry base. He came across the book *Language in Action* (Hayakawa, 1941) by coincidence: After the Battle of Midway, when the Japanese invasion of Alaska was no longer expected, the book was among the items left behind by the infantry brigade. It was a dog-eared copy on a dusty shelf, which Rapoport appropriated. Inspired, he wrote about his experience teaching physics to aviation cadets and mailed the article to Hayakawa, who agreed to publish it in a new journal on semantics (Rapoport, 1944). On leave in Chicago, he met Korzybski and Hayakawa in person. These ideas spurred Rapoport's first book as well as a collaboration with Samuel Ichiye Hayakawa that lasted over twenty years. He admired his contribution: "S.I. Hayakawa has done more than any man, perhaps than any combination of men to bring some of the most important ideas of our time within reach of millions of people. These ideas have to do with language, with what we do with it, and with what it does to us" (Rapoport in Morain, Morain, Johnson, & Rapoport, 1963, 393). Toward the end of the war, Rapoport volunteered for another overseas assignment and headed across the Pacific and Indian Oceans to Dacca (now Dhaka, in Bangladesh), where he served as supply and evacuation officer. Demobilized in 1946, he returned to academic life. For a brief period, he taught mathematics at the Illinois Institute of Technology.

Rapoport joined the Committee of Mathematical Biophysics (later named the Committee of Mathematical Biology) at the University of Chicago in 1947. He published his first scientific papers focusing on mathematical models of parasitism (an association between two species in which one benefits and one is harmed) and symbiosis (both species benefit from the association) in the *Bulletin of Mathematical Biophysics* (Rapoport, 1947a; 1947b; 1947c; Rapoport & Shimbel, 1947). He continued to collaborate with Hayakawa on semantics and philosophy. He published his first book in 1950, *Science and the Goals of Man* (Rapoport, 1950), which focused on the responsibility of the scientist as a human being and as a member of a world community devoted to the enlightenment and integration of humanity. Rapoport's conception of science contained an ethical component. He continued exploring semantics, philosophy, and science in the book *Operational Philosophy* (1953a) and article *What is Semantics?* (Rapoport, 1952a). This work "addressed the question of whether human or social values can have a common basis, independently of modes of thoughts or feelings originating from different cultures" (Schwaninger, 2007, 655). During this period, at a social gathering at Hayakawa's home, he met his future wife. Anatol Rapoport married Gwen Goodrich in 1949. They shared a political outlook, a thirst for knowledge, and delight in family life. Rapoport proposed to Goodrich on New Year's Eve and went through the same ritual at 6 p.m. on every December 31.

In 1954, Rapoport was awarded a year's fellowship at the newly founded Center for Advanced Studies in the Behavioral Sciences (CASBS), at Stanford University, where he concentrated on mathematical

biophysics. Founded by the Ford Foundation, the center reflected an optimism that social science could advance human welfare.

> . . .It was at the Center that AR [Anatol Rapoport] met with several social scientists who were to play a leading role in the rapid development of the American school of social science during the 1950's and 1960's. This development was characterized by two strong tendencies. One was an extension to the behavioral sciences of methods heretofore confined to the natural sciences (rigorous empirical testing of theories, mathematization). The other was an increasing appreciation of the growing importance of value-oriented social science, opposing the conception of all science as value-free and therefore morally neutral and merely instrumental. According to the latter view, the scientist's job was confined to showing how to reach given goals (without taking the responsibility of inquiring by whom and for what these goals are given) and eschewing any attempt to indicate what the goals of any social policy or, indeed, of science itself (regarded as a human activity on the global scale) should be. (excerpt from autobiographical sketch, c. 1988; http://anatolrapoport.net)

Together with the biologist Ludwig von Bertalanffy, the physiologist Ralph Waldo Gerard, and the economist Kenneth Boulding, Rapoport was a founding member of the Society for General Systems Research, later renamed the International Society for the Systems Sciences. He published work focusing on information, networks, and modeling contagion (Rapoport, 1952b, 1953b, 1954, 1955, 1957a), and the articles Lewis F. Richardson's Mathematical Theory of War (Rapoport, 1957b) and Scientific Approach to Ethics (Rapoport, 1957c). During these years, and during the next chapters of his career, Rapoport also dedicated himself to raising his three children with Gwen Rapoport: Anya (b. 1952), Alexander (b. 1957), and Anthony (b. 1962). Rapoport joined the faculty of the University of Michigan (see Figure 1) in 1955, where he was one of the first three faculty members of the Mental Health Research Institute (MHRI) in the Department of Psychiatry.

At the University of Michigan, Rapoport shifted the focus of his research to war and peace, conflict, and conflict resolution. He devoted himself to what he called the three arms of the peace movement: peace research, peace education, and peace activism. Rapoport made seminal contributions to game

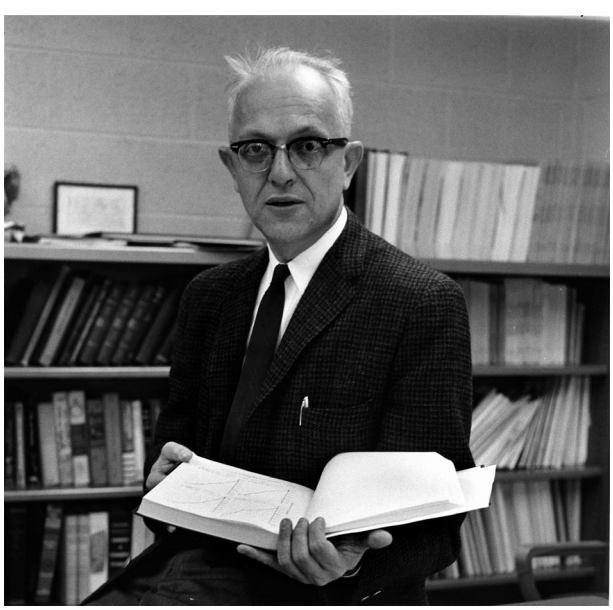

Figure 1. Anatol Rapoport at the University of Michigan, c. 1960s. (Source: HS19035, U-M Alumni Association Individual Photos, Bentley Historical Library, University of Michigan).

theory and published multiple books, including *Fights, Games, and Debates* (1960).[2] Experiments conducted with Albert Chammah at MHRI in 1962–64 were reported in their book *Prisoner's Dilemma: A Study of Conflict and Cooperation,* as well as in journal articles (Rapoport & Chammah, 1965a, 1965b, 1966). Rapoport also collaborated with others to better understand motivations and strategic approaches to games (Pilisuk, Potter, Rapoport, & Winter, 1965; Pilisuk & Rapoport, 1964; Rapoport, Chammah, Dwyer, & Gyr, 1962; Rapoport & Dale, 1966a; 1966b) and published seminal papers including *the use and misuse of game theory* (Rapoport, 1962) and *escape from paradox* (Rapoport, 1967a).

Rapoport engaged not only in teaching and research, but also in peace activism: "Hard as I tried during my first years at Michigan to confine criticisms of strategic-thinking to the strategists' own ground, the moral and emotional issues could not be avoided when the U.S. launched air strikes against North Vietnam, initiating ten years of horrendous destruction" (Rapoport, 2000, 136). Rapoport was actively engaged in activities on campus. Rapoport played an instrumental role in organizing the first teach-in (a creative alternative to a teaching strike; it included lectures and seminars) that took place at the University of Michigan[3] on the night of March 24–25, 1965, from 8 p.m. to 8 a.m. About 3,000 students showed up. The teach-in concept quickly spread to American and Canadian campuses; a national teach-in was held on May 15, 1965, in Washington, DC, with a telephone-hook-up broadcast of the proceedings to about fifty universities. Beyond his research and teaching, Rapoport continuously engaged in policy discussions; he also played the piano on campus, from time to time (see Figure 2). On the topic of the Vietnam War and the environment, he spoke passionately, participating in a panel discussion at Hill Auditorium at the University of Michigan during the 1970 environmental teach-in (see Figure 3). Rapoport's comments from March 12–14, 1970 were published (Rapoport, 1970a; see also Rapoport, 1970b).

Figure 2. Piano recital at the University of Michigan, c. 1970. *Source:* Rapoport family photos. Possibly Pilot Program Piano Recital on April 12, 1970, 2:00 p.m. at the Red Carpet Lounge, Alice Lloyd Hall; retrieved from Day Calendar in The Michigan Daily: https://digital.bentley.umich.edu/midaily/mdp.39015071754035/715.

[2]A fight is a sequence of interacting stimuli and reactions, which are neither planned nor conducted rationally. A game is a rationally conducted conflict, characterized by specified constraints governing the means employed in the pursuit of goals. The objective of a debate is neither to eliminate nor to defeat opponents by a superior strategy, but to change the way opponents think and thus convince them.

[3]For more about the 1965 Teach-In at the University of Michigan, see Rapoport (1965) and online information: http://michiganintheworld.history.lsa.umich.edu/antivietnamwar/exhibits/show/exhibit/the_teach_ins/first_teach_in

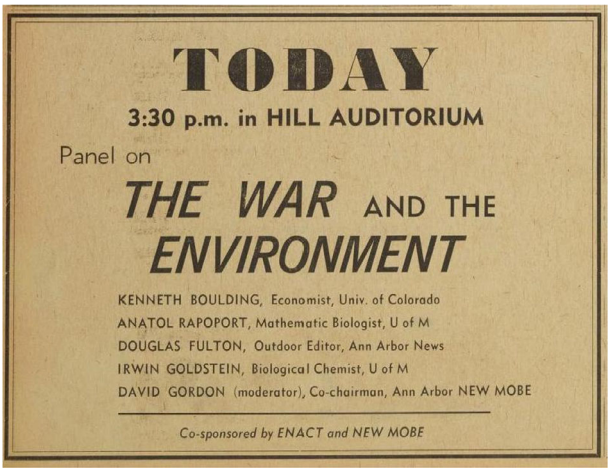

Figure 3. Environmental Teach-In at the University of Michigan. (Source: *The Michigan Daily*, March 13 1970 (vol. 80, issue 132), Page 8, retrieved from Michigan Daily Digital Archive https://digital.bentley.umich.edu/midaily/mdp.39015071754035/476).

The *Michigan Daily* (in a column by Hannah Morrison from March 15, 1970) summarized his presentation as follows:

> Rapoport, a mathematic biologist, defined pollution as an "excess of waste spewed out by man's technology. The reason everyone likes talking about the evils of pollution is because they all agree on it," he said. "It also keeps people's minds on the government's sins of omission rather than their sins of commission—to the government's satisfaction." Rapoport also said the semantic environment needs changing just as much as the biological and physical surroundings. "It is much harder to clean up the semantic environment—the poison secreted in conventional wisdom—than the others. It legitimizes war as an instrument of foreign policy and convinces that killing and making paupers constitutes defense of freedom," he said.

The passion with which Rapoport and his colleagues spoke is described in an article in memory of his good friend, colleague, and fellow peace activist Kenneth (Ken) Boulding[4] (Rapoport, 1997). The four-day environmental teach-in at the University of Michigan in March was organized by students in Environmental Action for Survival (ENACT) as a precursor to the national Earth Day demonstration, which mobilized twenty million participants on April 22, 1970.[5]

In 1970, Rapoport decided to leave the United States. The decision was complex. While Rapoport did find a niche in academic life with colleagues who shared his values, to oppose international policy required, in his words, "political organization and intense continual public protest. A way out was to go to live in a country that was not committed to a messianic role—a small peaceful country with no aspiration to major power status" (Rapoport, 2000, 144). Initially, the plan was to move to Denmark, where he had recently spent a sabbatical. However, in the end the family emigrated to Canada, where he joined the faculty at the University of Toronto as a professor of mathematics and psychology. Rapoport wrote four books in the six years until his official retirement: *The Big Two: Soviet-American Perceptions of Foreign*

[4]Ken Boulding and Anatol Rapoport were close friends and colleagues for over 40 years. Rapoport discusses their intellectual affinities, peace activism, and friendship, in an article published in the *Review of Social Economy* (1997). Elise Boulding, Ken's wife, received the IACM LAA in 2000 (see Boulding et al., 2016) several years after Anatol Rapoport. You can hear excerpts from the War and the Environment panel, Teach-In on the Environment at the University of Michigan, March 1970, AV Identifier 8738-SR-101-1-1, WUOM records, Bentley Historical Library, University of Michigan at https://bentley.mivideo.it.umich.edu/media/1_au47ei3b (retrieved 25 October 2019; Boulding ~minute 2; Rapoport ~minute 35).

[5]To learn more about the Environmental Teach-In see Rome (2013) and online historical archives at: http://michiganintheworld.history.lsa.umich.edu/environmentalism/exhibits/show/main_exhibit/earthday/day-one-of-enact-s-teach-in

Policy (Rapoport, 1971) on confrontation; *Conflict in Man-Made Environments* (Rapoport, 1974a) on a systemic approach to large scale conflict; *Semantics* (Rapoport, 1975); and *The 2 × 2 Game* on the 78 species of the simplest conceivable games, published with colleagues from Michigan (Rapoport, Guyer, & Gordon, 1976). After mandatory retirement at age sixty-five in 1976, Rapoport continued to teach at the University of Toronto.

Over the years, and particularly following his retirement, Rapoport was a visiting professor in many universities and centers around the world, including Berlin and Hiroshima. A book titled *Mathematical Models in the Social and Behavioral Sciences* (1983; first published in German as *Mathematische Methoden in den Socialwissenschaften, Physica-Verlag,* 1980) grew out of courses Rapoport had given as a guest professor at the Institut für Höhere Studien (IHS) in Vienna. In 1979, Rapoport was invited to serve as IHS director (1980–83) and was made an honorary professor at the University of Vienna. The institute was founded in 1962–63, following an initiative by Paul Lazarsfeld and Oscar Morgenstern, who convinced the Ford Foundation to provide a generous grant. The goal was to develop a new generation of social scientists in Austria.[6] The idea to establish a "Ford Center" in Vienna can be traced back to a conversation Anatol and Paul had at the California Ford Center in 1954–55. Rapoport's contributions to the espoused cultural values and norms of IHS faculty, students, and staff around pursuing interdisciplinary research and fostering collaborative mentoring were influential and lasting (Martin Kocher, IHS director, and Thomas Koenig, head of strategy and scientific services at IHS, personal communication, March 26, 2019). Yet, his academic goals as director became entangled in a political reality of institutions and organizations in Austria, which he had not anticipated (Rapoport, 1993, 2000, 153–57).

During their four-year stay in Vienna, Anatol and Gwen spent summers in Toronto (where he continued to teach) and became familiar with the newly formed organization Science for Peace. He was elected president of Science for Peace in 1984 and subsequently served in different roles in this organization. Gwen did administrative work and edited the newsletter. In 1984, Rapoport was appointed professor of peace studies at University College, University of Toronto, where he initiated what would evolve into a four-year degree program in peace studies. He published the book *General System Theory: Essential Concepts and Applications* (Rapoport, 1986) and with his son, Anthony, the book *Canada and the World: Agenda for the Last Decade of the Millennium* (Rapoport & Rapoport, 1992). In his book *Peace: An Idea Whose Time Has Come* (Rapoport, 1992), the institution of war is theoretically conceptualized as a system and metaphorically as an organism (with the aim of inducing an insight). Rationales supporting the continued existence of war as an institution are framed as superstitions; with science, these superstitions could be discredited in an irreversible process (Eckhardt, 1983; Rapoport, 1989, 1992). The institution of peace as a system is ripe for research, teaching, and implementation; in his words, "The idea is ready to take off and become a dominating component of the human condition" (1992, 5).

Rapoport continued to teach in Toronto until 2000. He always continued to write, including autobiographically infused books such as *Certainties and Doubt* (2000), *Skating on Thin Ice* (2001), and *Conversations with Three Russians—Tolstoy, Dostoevsky, Lenin: A Systemic View on Two Centuries of Societal Evolution* (2003, 2005). During this period of their life, Anatol and Gwen enjoyed their role as grandparents, of Leo (b. 1987) and Brenagh (b. 1999), while staying involved with their community of scholars, musicians, and friends. Anatol Rapoport died on January 20, 2007, in Toronto, Canada at the age of 95.

The period of history Rapoport lived through—from 1911 to 2007—bears witness to his deep understanding of forgiveness as well as a fundamental commitment to fostering cooperation to resolve conflict and build peace. The optimism with which Rapoport approached the most complex social challenges facing humanity is remarkable.

[6]To learn more about the history of the Institut für Höhere Studien (IHS), see: https://www.ihs.ac.at/about/history/

Rapoport's "Tit for Tat" Legacy

Anatol Rapoport published many books and hundreds of articles during his career, yet he is remembered by many for formulating the "Tit for Tat" strategy to the Prisoner's Dilemma game. I dedicate a section of this article to this legacy.

In the newly emergent field of game theory (von Neumann, 1928; von Neumann & Morgenstern, 1944), scholars became fascinated in better understanding zero-sum and non-zero-sum games (e.g., Braithwaite, 1955; Harsanyi, 1961; Harsanyi, 1962; Luce, 1959; Luce & Raiffa, 1957; Nash, 1950, 1951, 1953; Raiffa, 1953; Rapoport, 1960; Rapoport & Chammah, 1965a, 1965b; Schelling, 1956, 1958, 1960; Shapley, 1953; Shubik, 1964; Suppes & Atkinson, 1960; Williams, 1954). Rapoport recounts the history of the Prisoner's Dilemma: "Game 14-6 is well known in game-theoretic literature. It was discovered in 1950 by M. M. Flood and M. Drescher" (Rapoport, 1989, 296). Results of these first experiments were reported in the U.S. Airforce Project Rand Research Memorandum: "I have long felt that the axiomatic structures developed by von Neumann–Morgenstern, and by others, should be tested for applicability and usefulness in controlled experimental situations—and I have called such activity *experimental games*" (Flood, 1952, 3). The Prisoner's Dilemma "anecdote is attributed to A. W. Tucker" (Rapoport, 1974b, 17), and the first detailed analysis of this specific two-person no-constant-sum game appeared in Luce and Raiffa's book *Games and Decisions* (1957). "Possibly a decisive impetus to experimental work was given by a paper by Schelling, published in 1958. At any rate, it seems that the first experiment since Flood's was performed by Deutsch in 1958" (Rapoport, 1974b, 20). Rapoport notes that he began his own systematic experiments with the Prisoner's Dilemma in 1962.

Rapoport carried out extensive theoretical and empirical studies on the Prisoner's Dilemma, in part with Albert Chammah (e.g., Rapoport & Chammah, 1965a, 1965b, 1966), and wrote extensively about 2×2 and n-person games (e.g., Rapoport, 1960, 1966, 1970c, 1974c, 1988; Rapoport, Diekmann, & Franzen, 1995a, 1995b; Rapoport, Frenkel, & Perner, 1977; Rapoport, Guyer, & Gordon, 1976). In the concluding remarks of the book *Prisoner's Dilemma* (Rapoport & Chammah, 1965a, 206–8), opportunities for innovative future research included the idea of studying the strategy of one player (a confederate/stooge) as the independent variable. Among the strategies that could be tested, they describe five: (a) The stooge always plays C; (b) the stooge always plays D; (c) the stooge randomizes choices; (d) the stooge plays a Tit for Tat strategy[7]; and (e) the early moves become the principal independent variable—for example, varying the length (N) of an initial sequence of cooperation versus defection prior to Tit for Tat to test questions such as: "How large must N be for the tit-for-tat strategy to become ineffective in eliciting cooperation (we assume the one hundred percent tit-for-tat strategy will elicit cooperation rather effectively)?" (208). They note that "as the name implies, a tit-for-tat strategy is one which apes the other player: one plays whatever the other played the last time" (Rapoport & Chammah, 1965a, 207). This mimicry is a hallmark of the strategy's simplicity and recognizability.

To gain a better understanding of the dynamics of cooperation and competition in socially interdependent settings, such as the iterated Prisoner's Dilemma game, Robert Axelrod—a political scientist at the University of Michigan—invited scholars to participate in a computer tournament (Axelrod, 1980a; 1980b). Of the 14 entries in the first tournament, the winner was

> "TIT FOR TAT submitted by Anatol Rapoport of the Department of Psychology, University of Toronto. This rule is only four lines long in FORTRAN. It cooperates on the first move, and then does whatever the other player did on the previous move. It has a long history, since it can be identified with the ancient lex talionis or an eye for an eye." (Axelrod, 1980a, 21)

[7]The Tit for Tat strategy begins with cooperation (referred to as C), and then cooperates if the other player cooperates or competes if the other player competes (a competitive choice, or defection, is referred to as D).

In stark contrast to the escalation of conflict reflected in an ongoing retaliatory pattern of an "eye for an eye," Tit for Tat is unforgiving for one move but then is totally forgiving of an isolated competitive choice, thus perhaps opening the door to shift from conflict management to conflict resolution (Ben-Artzi, Cristal, & Kopelman, 2015). The signal of opening from the first move with cooperation carries a message of peaceful intentions. However, "who would care to infer from the effectiveness of Tit-for-tat the advisability of guiding one's life by an eye-for-an-eye principle?" (Rapoport, 1974b, 29).

Remarkably, in a second tournament (Axelrod, 1980b), Tit for Tat, once again submitted by Anatol Rapoport, was the winner. It competed with 61 other submissions by programmers who were familiar with Tit for Tat and yet were unsuccessful in writing code for a decision rule that would outwit it in this context. Of the 63 decision rules that competed (including a random algorithm), Tit for Tat was most successful in this environment. The structure, computer codes, analyses, and discussion of both tournaments are described by Robert Axelrod in two articles published in 1980 in the *Journal of Conflict Resolution* (Axelrod, 1980a; 1980b). Axelrod summarizes that what accounts for the robust success of the Tit for Tat algorithm is its combination of "being nice, retaliatory, forgiving, and clear. Its niceness prevents it from getting into unnecessary trouble. Its retaliation discourages the other side from persisting whenever defection is tried. Its forgiveness helps restore mutual cooperation. And its clarity makes it intelligible to the other player, thereby eliciting long-term cooperation" (Axelrod, 1984, 54). Forgiveness of this nature, however, may not be so simple when implemented by a person versus a computer algorithm; it requires mindfully transforming and aligning one's emotions with one's strategy (Kopelman, 2014)—a challenging endeavor in contentious situations. From his early publications, Rapoport derived two principles (Schwaninger, 2007): (a) cooperation among individuals can be stable or unstable and (b) cooperation can breed a "dividend."

The Tit for Tat algorithm reflected Rapoport's deep understanding of non-zero-sum games *and* his beliefs about people and the pursuit of cooperation. Rapoport cautioned about the pitfalls of the rationality that is based on self-interest:

> . . .That an exceedingly simple strategy got a higher score than all the sophisticated ones may have seemed surprising. But the really surprising result was that TIT FOR TAT did not beat a single strategy with which it was paired. It either got the same score or a lower score. How, then, could it win the contest? The answer is clear. Recall that all the strategies had to play against all. The "clever" ones designed to beat other strategies may have beaten them, but they, in turn, were also beaten by others. In this way, they reduced each other's scores. TIT FOR TAT cannot get more D's than any strategy it is paired with (since it starts with C and plays D only after the co-player has played D). But it cannot lose by more than one play. The "clever" strategies can lose more when matched with equally "clever" ones including themselves. (TIT FOR TAT matched with itself plays 100% C; so that both it and its "alter ego" get a high score.)
>
> The lesson drawn from this experiment sounds like a paradox: in weakness there is strength. TIT FOR TAT seems "weak" because it can't beat any other strategy. But the "strong" ones beat each other, and it comes out the winner.
>
> The relevance of this lesson to the present international situation should be evident. Conventional wisdom has it that the stronger a country is militarily, the more "secure" it is. This simplistic idea is what drives arms races. If being stronger than B makes A secure, then being stronger than A makes B secure. As a result, each country tries to be stronger and as the other grows stronger, each gets less secure. Today the destructive power of the global arsenal is thousands of times greater than it was forty years ago. Hardly any one would argue that every one is thousands of times more secure than forty years ago.
>
> It is argued that the present dangerous situation has arisen because there is a lack of "trust" among nations, particularly among adversaries. That is correct, as far as it goes. Game models like Prisoner's Dilemma are instructive because they point up precisely why lack of trust leads to outcomes that are bad for both sides. Lack of trust is not the whole story. The main trouble lies in the mistaken belief that "rational" choices are those that seem to be in one's own interest. The notion of "national interest" is based on this idea. As we have seen, the choice of D

> in Prisoner's Dilemma seems eminently rational, since it leads to a payoff that is larger than the payoff associated with C regardless of how the co-player chooses. Yet the reasoning leads to an outcome that is bad for both.
>
> "We shall require a substantially new manner of thinking," wrote Einstein, "if mankind is to survive."
>
> Prisoner's Dilemma provides a simple but dramatic demonstration of the sort of thinking that must be changed in the nuclear age: the manner of thinking that continues to identify rationality with pursuit of self interest. Entrenched in the world of power politics, this manner of thinking now threatens the human race with extinction.
>
> (Rapoport, A. Unpublished manuscript or notes from lecture; Source; Anthony Rapoport; for more unpublished works see http://anatolrapoport.net and archived materials at the University of Toronto)

Rapoport's ideas appear to be as relevant today as when he wrote them, and the need for lessons to be learned regarding conflict, cooperation, peace and sustainability as prevalent.

Rapoport was frequently asked how he came to discover the "unbeatable" strategy for playing iterated Prisoner's Dilemma. He pointed out that Tit for Tat is far from unbeatable and that it cannot beat any strategy in a paired encounter. It won in the round-robin contests of Axelrod's tournaments mostly because two programs (called "kingmakers" by Axelrod; 1980a, 10) enabled Tit for Tat to amass many points. Thus, what survives over time in a field of multiple strategies (e.g., a duel with three or more people) may not be a winning strategy in other settings; in Rapoport's words, "Moral: at times in weakness there is strength" (Rapoport, 2000, 152). The strategy also may not transfer beyond the domain of games, as he discusses in a seminal article published in *Scientific American,* titled "The Use and Misuse of Game Theory" (Rapoport, 1962), in "Chicken à la Kahn" (Rapoport, 1968), and as he consistently reiterates[8] in his books.

Scholars and practitioners inspired by the Tit for Tat strategy have not always recognized or adopted Rapoport's nuanced perspective on economic games. In the book *Fights, Games, and Debates* (Rapoport, 1960), he emphasized:

> I do not believe, of course, that a pair of differential equations (or a dozen) can explain an arms race or the outbreak of war fever. But the approach of the social physicist should remind the political historian and the social moralist that there *may* be social forces operating which are as blind and as powerful as the atmospheric factors which determine the weather. (359)

And:

> At present game theory has, in my opinion, two important uses, neither of them related to games nor to conflict *directly*. First, game theory stimulates us to think *about* conflict in a novel way. Second, game theory leads to some genuine impasses, that is, to situations where its axiomatic base is shown to be insufficient for dealing even theoretically with certain types of conflict situations. These impasses set up tensions in the minds of people who care. They must therefore look around for other frameworks into which conflict situations can be cast. Thus, the impact is made on our thinking processes themselves, rather than on the actual content of our knowledge. (242)

Conceptually and pragmatically, Rapoport explicitly highlighted the gaps between game theory and recommendations to people or groups facing potential conflict.

The Tit for Tat strategy for fostering cooperation in socially interdependent settings has inspired businesspeople and diplomats worldwide for generations. The findings of the Axelrod tournaments are foundational topics of courses in economics, experimental psychology, and political science at universities around the world.[9] And they continue to pique the interest of scholars; for example, in 2015, Amnon Rapoport, Darryl Seale, and Andrew Coleman published an article, "Is Tit-for-Tat the Answer? On the

[8]See, for example, discussion of differences between Rapoport's approach and that of Herman Kahn, discussed in Rapoport (1989, 285, 336-38).

[9]For an overview, see Tobin (2019), https://heritage.umich.edu/stories/the-prisoners-dilemma/.

Conclusions Drawn from Axelrod's Tournaments." Amnon Rapoport—a post-doc of Anatol Rapoport[10]—studied the Tit for Tat strategy prior to the Axelrod tournaments (Rapoport 1967b; Rapoport & Movshowitz, 1966) and was among the competitors in the original tournament. With two colleagues, Amnon Rapoport recently raised questions about Tit for Tat that suggest qualifying the recommendations commonly assumed by researchers and practitioners. The 2015 article reanalyzes the original data, highlighting how the efficacy of Tit for Tat was contingent on the design of the tournament, the criterion used to determine success (maximizing point differential), and the particular values chosen for the Prisoner's Dilemma payoff matrix. While clarifying potential boundary conditions for the strategy's effectiveness in the Axelrod tournaments, it questions whether in "weakness" there is "strength," and suggests cautionary wisdom for policy when drawing conclusions from this paradigm to complex international conflicts. This research (Rapoport, Seale, & Coleman, 2015; see also Simpson, 2016), and countless articles in this domain, demonstrate the pervasiveness of Anatol Rapoport's lasting contribution; over half a century later, it is central to scientific discussion of theory and practice.

If I have caught a glimpse into Anatol Rapoport the person, I would venture to say he would have greatly enjoyed reading scholarly critiques of the effectiveness of Tit for Tat (especially when articulated as a debate) and discussing with scholars—both researchers and practitioners—ideas for how current and future research endeavors might collectively enable a more peaceful world.

Imagining a Conversation with Anatol Rapoport

Scientific discussion matters most when we can translate theory into practice. What do we mean by "theory"? What do we mean by translating to "practice"? These two words reverberate like an unabated storm. Anatol Rapoport provides a look into such questions:

> There are two suffixes in our language (and similar ones in other European languages) which suggest organized knowledge. One is the venerable, academic "ology," that reminds one of university curricula and scholarship. The other is the energetic and somewhat mysterious "ics," which has a connotative flavor of magic. Where "ology" suggests academic isolation (ichthyology, philology), "ics" suggests a method of attack on life's problems. It contains a faint throwback to the ancient dreams of the philosopher's stone and of "keys" to the riddles of the universe. Ancient words ending in "ics" are mathematics and metaphysics. Of more recent origin are economics, statistics, semantics, and cybernetics. It is usually easy to satisfy someone's curiosity about an "ology" and quite difficult to do the same for an "ics." (Rapoport, 1952a, 12)

Anatol Rapoport made a tremendous academic contribution to theory *and* an impact on practice. He was a brilliant and modest person. At the awards dinner of the International Association for Conflict Management (IACM) during the 1996 annual conference in Ithaca, New York, James (Jim) Wall presented Anatol Rapoport with the association's Lifetime Achievement Award[11] (see Figure 4) for his contributions to the field. Jim remembers:

> I picked him up at the Syracuse airport and we had a wonderful conversation on the drive to Ithaca. I recall how modest he was, which was reflected in the resume he handed me. It was about 3/4 of a page long. There was no big ego here. The hotel had given him a terrible room, but when I said I would get it changed, he insisted that it was fine. He would relax and read a book he had brought. (Jim Wall, personal communication, March 3, 2019)

[10]Amnon Rapoport informed me that he and Anatol explored family origins but could not establish whether they were related to each other (personal communication, 2019). Sharing a surname and a first initial, and not having a middle name, brought forth humorous moments and continues to challenge journals citing the work of Amnon and Anatol, both as "Rapoport, A." The possible exception is an article they coauthored (Rapoport, Rapoport, Livant, & Boyd, 1966).

[11]To learn more about this award, past recipients, and the articles celebrating the contributions of award recipients, see Gross, 2016.

Dr. Rapoport received the Life Time Achievement award. He has had a long and distinguished career. Since 1984, he has worked as Professor of Peace and Conflict Studies at the University of Toronto.

Figure 4. Anatol Rapoport receiving the Lifetime Achievement Award at the International Association for Conflict Management (IACM) conference in Ithaca, New York, 1996; Anatol Rapoport with Jim Wall, president of IACM in 1995–1996. *Source:* IACM *Signal Newsletter* 12, no. 1, 1996; page 1.

Tricia Jones (IACM president, 1996–1997) noted Rapoport's comments on receiving the award: "His erudition was exceeded only by his eloquence and charm" (Jones, 1996, 2). Many scholars have been inspired by Anatol Rapoport's scientific contributions (see the obituary written by Markus Schwaninger in 2007), including a Festschrift on the occasion of his 75th birthday edited by Andreas Diekmann and Peter Mitter (1986).

To provide a unique lens for celebrating Anatol Rapoport's contributions and impact, I invited several people to engage with us through personal memories and reflections. I invite you now to imagine that you are having a conversation with these people about Anatol Rapoport, the man and his work. Perhaps the conversation is over a good cup of Viennese coffee (similar to the freshly ground coffee I am drinking in Ann Arbor, Michigan, while writing on a very cold winter's day in 2019); or maybe, where you live, a different drink characterizes informal conversation among friends seeking to "learn" and "do good" in the world. You also might enjoy listening to a piano sonata to enhance an appropriate setting while reading the following ensemble of voices.

Anthony Rapoport

I reached out to Rapoport's family and connected with Anthony (Tony) Rapoport, one of Anatol's sons, who is a musician in Toronto. He shared with me valuable resources, including unpublished works of Anatol Rapoport that he assembled online (see Figure 5), inspiring my journey of crafting this article. I believe you will be touched, as was I, by Tony's memories and interpretation of his father's wisdom and kindness:

My earliest memories of my father, Anatol Rapoport, are all associated with fun: he had a very engaging manner with young children, which I experienced as an adult when my nephew and daughter were small. He loved nonsense, especially rhythmic jabber. He also loved making up fantastical bedtime stories, with loose connections to familiar things, but no limits of plausibility. One particularly memorable series featured Morris the Tire, whose late career protecting a wooden wharf in Copenhagen from docking ships was preceded by all kinds of adventures.

Another early memory, which I took as a matter of course in childhood but astonished me when I looked back, is that he was always available. Although he worked long hours at home, writing, I always knew I could have his attention for anything that was on my mind. If he was particularly involved in something, I might hear, "Just a moment," but I was never put off for long.

His marriage to my mother was traditional in key ways: for most of their life together, he worked outside home far more than she did, while she looked after childcare, domestic tasks and finances. Her career as a prominent co-op organizer, and even her activity as a fine amateur pianist, were left behind after marriage.

My father was a very significant mentor to me in music, politics, and most aspects of my intellectual development. His love for original ideas was infectious, as was his combination of intellectual rigor and open-mindedness.

As my ability to think independently developed, I was often drawn to challenge him on whatever differences of philosophical opinion or values I could come up with. I would invest a great deal of emotion in these arguments, in great need of ways to prove myself. Later, after I gained some distance from these struggles, I was surprised to learn from my mother that my father had a long-standing love of argument, and was known in his younger days as a fiercely combative debater.

I feel the most distinctive aspect of my father's thought was his ability to make meaningful connections between ideas in widely divergent disciplines. The key elements in his approach were general systems and general semantics. General systems begins with the idea that everything is connected to everything else, and then develops theory to distinguish meaningful connections (isomorphisms) from superficial ones. General semantics is a philosophical approach to meaning which draws attention to the ways in which language can obscure reality, when purely verbal constructs are mistaken for objective experience.

Using intellectual tools based on mathematics, science and the humanities, my father was fundamentally concerned with deep moral questions of justice and survival. Although a reluctant pessimist, he believed that the scientific outlook could form the basis for a unity of humanity which would enable us to solve our most serious problems. My life so far has been far easier than his, so I find it easier to be hopeful about humanity's prospects. But the basis of my worldview is very similar: things are the way they are because they got that way. Despair may be reasonable, but there's no percentage in it.

Anthony Rapoport, musician (March 2019; Toronto, Canada)

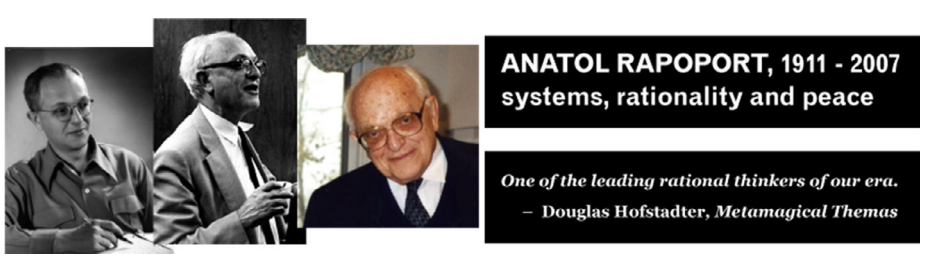

Figure 5. Top header from the website http://anatolrapoport.net/ assembled by Anthony (Tony) Rapoport to showcase unpublished works by his father, Anatol Rapoport. Pictures here are images of Anatol Rapoport at various ages (from left to right: c. 1942, c. 1970, c. 2000)

Markus Schwaninger

Academic life, for those who are lucky, includes friendships that feel similar to family. Markus provided a window into his unique relationship with Anatol Rapoport—a relationship he continues to cherish—as he fondly shared memories of his mentor:

> Everyone has a few treasured individuals in his or her heart, and so do I. Anatol Rapoport, my dear friend and mentor, is there: his spirit is with me forever.
>
> His awesome intellect is proverbial, but he was more than a cognitive athlete. Anatol was a king in the realm of spirit. Yet his exceedingly powerful brain was only one component; a great heart was the other.
>
> Personally, I am fortunate and grateful to have met Anatol. It was a huge privilege getting his advice in matters of research and life in general. And it was most enjoyable being together or corresponding with him or simply having fun, exchanging jokes and listening to his incredible stories.
>
> We sustained that correspondence via handwritten letters and emails over many years. This was both exciting and utterly instructive. I learnt a lot. It was always amazing how Anatol, despite all of his obligations, enjoyed life and conveyed a notion of its beauty and easiness, even though he knew the other side as well. At some point, I sent him a palindrome,[12] just for joy. Anatol's prompt reply was "I was a collector of palindromes . . . ," followed by the funniest sample I had ever seen: his favorite, a whole sentence that one could read backward or forward, either way coming up with the same sequence of letters and words. It was very complex, but he simply quoted it off the top of his head: "Loofahs in a violin? In a gap in my hymn? I, Paganini, Lo, I vanish—a fool."[13]
>
> His famed commitment to peace and other humanitarian issues emanated from his love—a profound sentiment he carried for both individuals and humanity as a whole. But in no way was he a "Gutmensch," one of those who think they are superior because of their self-declared humanitarian engagement. Anatol was humble. Given his towering mind, he would lift every conversation to delightful heights. Yet, he never made you feel inferior. He would treat you as equal, elevating your self-confidence, sharing his wisdom, and stimulating your thinking.
>
> A case in point was his way of sharing that wisdom. He was a Visiting Professor at our University on a number of occasions, and he also delivered a magisterial public lecture, which was the integrative bracket around a series of talks on Knowing and Believing. Lively conversations were a source of wealth for his interlocutors. Audiences worldwide reveled in the depth of his thinking. Despite the richness of his vocabulary, his speech was jargon-free as were his writings. In his later works the sensitive reader will "hear" a scientist, a philosopher and an artist speaking with one and the same voice. This is the case, for example, in his last book (*Conversations with Three Russians,* 2005), "a fascinating sum of insights" (Felix Philipp Ingold on the book cover) and synthesis of his thinking.
>
> Anatol claimed to be "a pessimist," which he defined as "an informed optimist." This was in line with his approach to discourse, both critical and constructive: the depth of his questions, a constant scrutiny of assumptions, and the invention of new solutions. He always strove, or should I say "rebelled," for the progress of the world, in an eschatological dimension. Beyond the academic discussions, Anatol showed a lifelong commitment

[12]A word or sentence that makes sense if read forward or backward.

[13]Rapoport's requisite explanation: "A 'loofah' is a sponge, used in bathing, etc. The story condensed in the palindrome is the following. After the defeat of Napoleon, the allied powers attempted to restore the *ancien régime* in Europe. In particular, the playing or singing of the Marseillaise was prohibited. Paganini defied them and played the Marseillaise at every concert, wildly applauded by the 'left.' The monarchists decided to stop him somehow. While he was out of his dressing room, they undercut the strings of his violin. So when he started the programme with the Marseillaise, the strings burst. He had to stop (that was the 'gap in his hymn'). He took the violin backstage to put new strings on it, but he had to leave to go to the toilet, and while he was away the gendarmes stuffed his violin with loofahs. So his Marseillaise was again interrupted. This explains the first part of the palindrome: 'Loofahs in my violin? In a gap in my hymn?' So when he stopped the second time, having discovered loofahs in his violin, he was so embarrassed that he sank through the ground utterly mortified exclaiming, 'I, Paganini, Lo, I vanish—a fool!'"

to humanistic and social causes, palpably so in his fiery speeches, a sample of which he delivered in Neuchâtel[14] at the age of 87.

Finally, Anatol and his wife Gwen were together for almost 60 years. They both were extremely strong personalities. They were complementary, inseparable; indeed, they were one. Conversing with them at their home in Wychwood Park, and wherever we met, was a gift.

I miss them!

Markus Schwaninger, professor of management at the University of St. Gallen (March 2019; St. Gallen, Switzerland)

Iain Paterson

Highly engaging conversations with Iain in March 2019 in Vienna sparked memories of the days when Anatol Rapoport served as director of the Institut für Höhere Studien (IHS).

My abiding impressions when I arrived from Scotland as a new assistant professor were of a distinguished academic with wide-ranging knowledge and commitment to mathematical/empirical analysis in social sciences. At IHS in Vienna these concepts were well-represented by political science, sociology, economics, and business studies (operational research). He said once that he would have wished psychology to have been included as a faculty.

His approach to open questions was integrative, his style collegial. Social choice, decision and game theory were examples of common denominators for IHS studies. His own tit-for-tat strategy for the iterated Prisoner's Dilemma was entered and won Axelrod's competition at this period.

I got a glimpse into his multi-talented background of mathematics and music when he invited colleagues to a convivial evening at his apartment, which was also a family get-together: musical virtuosity provided a link between their past and present in Vienna, it would seem.

Looking back, his principled stance against the co-option of party politics into scientific endeavour turned out to be a cathartic moment for the Institute, which can be set alongside the sadness felt at his too short stay as Director.

Somehow it seemed appropriate for him to be linked to Peace Studies in his subsequent station, even though I did not know then the broad extent of his active biography.

Iain Paterson, consultant, macroeconomics and economic policy group at IHS Vienna (March 2019; Vienna, Austria)

Andreas Diekmann

Andreas joined the IHS as an assistant professor in the sociology department in 1980—the same time Anatol Rapoport was appointed as the institute's director. He participated in Anatol's small decision theory research group and engaged in collaborative research mainly with Peter Mitter, head of the mathematics and computer department. Several years later, Andreas and Peter coordinated a festschrift honoring Anatol's work (Diekmann & Mitter, 1986). Delighted to contribute to this conversation, Andreas Diekmann shared memories from Vienna and beyond, a narrative that demonstrates how Anatol touched people and impacted future generations of scholars.

Anatol became my post-doc teacher in game theory and decision theory at the IHS. It was a delight to attend his lectures and seminars, to listen to his ideas, explanations, and anecdotes. His teaching talents always

[14]Namely, an international Conference on Systems Theory in 1998, sponsored by the Swiss Science Council, held at the University of Neuchâtel, where Rapoport gave the final lecture—a synthesis of all contributions delivered over a whole week.

impressed me. No slides, no PowerPoint, but chalk and blackboard. And, by the way, he taught at the institute in the German language. Moreover, he was a brilliant and charismatic speaker at conferences.

His office door was always open and, in our conversations, he immediately created a warm atmosphere. Our small interdisciplinary research group was a team of five: psychologists, mathematicians, sociologists. We conducted small experiments testing concepts such as the Shapley value, the core, and other concepts of cooperative game theory. He was very fond of a conflict game which I suggested (the "volunteer's dilemma game") and he wrote a kind introduction to my 1985 paper in the *Journal of Conflict Resolution* [see Diekmann, 1984, 1985; Rapoport, 1985, 1988].

I loved reading Anatol's papers and books, his work in game theory as well as his philosophical work ("Operational Philosophy," "Science and the Goals of Man," "The Big Two," etc.). He was extremely creative, universally educated, and a pioneering researcher in many fields—he was a real genius!

Shortly after beginning at the institute, Anatol published his excellent book on "Mathematical Methods in the Social Sciences." The first edition of the "Mathematical Methods" appeared in German; thereafter, he translated his book into English. Although he had administrative duties as director of the institute, he never neglected his scientific work.

He was a "morning man" and started writing papers and book manuscripts before six in the morning. Usually, he appeared in his office at the institute after three hours of writing, at 9 a.m.

There was the mathematician, the psychologist and social scientist, and there was the musician, the pianist. I remember his birthday party when he turned 70 in 1981. The Rapoports' apartment in Schottenfeldgasse in the sixth Vienna district near the institute was not spacious enough for all the guests (all employees and students were invited). So, he celebrated twice: first with guest names beginning with the letters A to K, thereafter with names L to Z. He finished both parties with a fulminant piano concert. He was a professional, classical piano player (educated at the Academy in Vienna long before the war).

With all his duties, there was not so much spare time. Nevertheless, he liked to play chess with the institute's custodian, Herr Auner. Also, Gwen and Anatol visited the Vienna theaters, concert houses, and the opera house as often as possible. Anatol himself had fun inventing new games (we played his game "concept" at a dinner party in the Rapoports' apartment), and he told me that he recorded all games of Scrabble with his wife, Gwen —for later linguistic research he planned to do!

His opinions on matters of peace and conflict were firm and unshakable. He was known as a heavy critic of nuclear armament in the Cold War era. In the early eighties the peace movement was rising all over Europe because of the deployment of nuclear missiles in the East and West. One time I asked him to give a speech at the "Rotstilzchen" club (Red Rumpelstiltskin), a somewhat rotten pub mostly visited by long-haired leftist young people in the fifth Vienna district. He immediately agreed and told me, "Wherever you want me to give a peace talk, either in the street or in a pub, I will do so."

He was a science man but also, in the best sense, a *Homo politicus,* deeply concerned with topics that really mattered.

In celebration of Anatol's 75th birthday, Peter Mitter and I organized a conference and edited a Festschrift. This collection of papers,[15] many of them authored by eminent scientists and friends of Anatol, appeared in "Paradox Effects of Social Behavior: Essays in Honor of Anatol Rapoport" [Diekmann & Mitter, 1986].

Many of his books were translated to German by his friend Günther Schwarz, Editor of the Darmstädter Blätter. There were other translations as well, including Chinese (by the way I met the Chinese translator and editor of

[15]All papers are for download here: http://www.socio.ethz.ch/spieltheorie/vlib.html

Conversations with Three Russians in Beijing; Gwen asked me to deliver the English edition to Beijing on my travel to China in 2008), Japanese, and Russian.

Over the years, I had the pleasure of hosting Anatol at several institutions. In 1989, thanks to an initiative of Munich mathematical sociologist Rolf Ziegler, he was appointed the Eric-Voegeling guest professor at the University of Munich. I invited him for lectures and presentations to the Mannheim Center for Survey Studies and to the University of Mannheim (Germany). He graciously gave a public speech at my city of birth, the Hanseatic City of Lübeck. Also, I invited Anatol several times as a guest professor to the University of Bern (Switzerland). We had a joint research project funded by the German Science Foundation (DFG).

I visited the Rapoport family in Toronto almost every year since the early nineties. I miss the many inspiring conversations with Anatol and Gwen at lunch time or over dinner in their home at Wychwood Park, Toronto. His wife Gwen was a sociologist gifted with a brilliant intellectual mind and a very kind heart. I remember the Rapoport house as a lively place of intellectual exchange and warm hospitality, visited by guests from all over the world.

In 2008, a year after he passed away, the section "Model Building and Simulation Methods" of the German Sociological Association established the Anatol-Rapoport prize. This prize, in memory of Anatol Rapoport, continues to be awarded bi-annually for the best paper on innovative applications of mathematical and statistical models in social science research.

Andreas Diekmann, professor emeritus of humanities, social and political science at ETH Zurich (April 2019; Zurich, Switzerland)

Spyridon Kotsovilis

As one of Anatol's last students, Spyridon was delighted to provide a glimpse into their professional relationship and friendship. He also highlights Rapoport's contributions to peace studies and complex systems.

Nothing would have been least expected yet most rewarding for a University of Toronto freshman from Athens, Greece, full of seemingly contradictory interests ranging from physics and mathematics to history and literature, than enrolling in Anatol Rapoport's "Introduction to Peace and Conflict Studies." His class was a brilliant survey of the numerous dimensions of violence and how it manifests itself in international politics. The course was complete with references to evolutionary biology, German literature, classical music, and mathematical concepts, which weaved a kaleidoscopic, comprehensive picture of conflict. This introductory class served as a gateway to the namesake program he founded at University College, and to a long cherished mentorship and friendship.

As I described him to my parents in a letter shortly after matriculating, Anatol Rapoport was a "walking encyclopedia, a true polymath—*un homme universel*—and a genius," and I could not get enough of his time. Every week I attended his office hours and, as no other students made use of them, spent all the time expanding, gradually, the range of conversational topics, from the Soviet Union's doomed fate, to Austro-Hungarian tactics in WWI, to the Allied strategic bombing campaigns in WWII, to chess, artificial intelligence, consciousness, Plato, Goethe, Tolstoy, and the existence of God. His knowledge was not only immense but also systematic, and most importantly—especially for a scientist and educator—anchored in a deep sense of morality stemming from his strong abhorrence of violence, militarism, and war.

Soon, office hours were not enough, and to complete our talk he would ask me to walk him to the subway station, then to "come for tea at home," and then to "visit for dinner." Before I knew it, I had been welcomed into the wonderfully unique universe of the Rapoport family—his brilliant spouse, Gwen, and their three children (all accomplished in their chosen métiers). Their small house was within a Toronto park founded in the late 19th century as an artists' colony and inhabited by other luminaries, such as Marshall McLuhan.

After my undergraduate years, we would often exchange letters and speak over the telephone; every time I visited, I was invited to stay with the Rapoports. As my own academic path and interests began to take shape, this

original exposure to, and the subsequent interaction with Rapoport's conceptual, methodological, and ethical approach to science began to bear fruit. While still at the University of Toronto, I participated in his Prisoner's Dilemma experiments, which were run after class. I was moved to study game theory and other rigorous scientific methods, which proved essential in my academic trajectory.[16] My undergraduate and graduate work, which focused on the nexus between social psychology and heuristics to explain cognitive dimensions of ethnic conflict in the Balkans, was inspired by Rapoport's focus on group psychology and decision-making.[17] Finally, my studies at the Santa Fe Institute, doctoral thesis at McGill University, and subsequent work examined mass behavior in democratizing mobilizations from a complex networks perspective, and in this line of research Rapoport's earlier works on modeling contagion (Rapoport, 1957a) and stochastic learning (Rapoport & Chammah, 1965a) also proved instrumental.

In retrospect, I can clearly see that in all the academic steps I have taken, Anatol Rapoport has left an indelible mark. This has been so in three aspects. First, methodologically—through his multidisciplinary and systems approach. Seeking and identifying common properties of different phenomena and concepts, Anatol Rapoport became a pioneer in general systems theory, which is a forerunner of complexity theory. His systematic, formal approach to studying such interconnections was crucial for my own understanding of the political events I was to study and, more broadly, for comprehending an increasingly interdependent, complex world.

Second, epistemologically and ethically—through his unwavering dual commitment to the pursuit of truth through science, and to the research of causes of conflict. Through his work and social involvement (Vietnam War teach-ins at the University of Michigan in Ann Arbor; his part in "Science for Peace," etc.), Anatol Rapoport was the embodiment not only of solid, innovative social science but also of its use for a higher purpose. In his words, Rapoport perceived "the role of the scientific outlook as a foundation of a better future for humanity" (Rapoport, 2000, 179). My own involvement with Doctors without Borders, parallel to my academic work, reflects his worldview.

And finally, pedagogically—through his unique example of an educator who not only advanced knowledge but taught, inspired, and transformed his students and colleagues alike. I recall in one of our conversations his mention of returning problem sets back to his mathematics students, until they solved them correctly, even if that meant everyone received an A. In fact, that was the objective, the essence, of his teaching: not to take a snapshot of students' aptitude at a given time, but to help them see, learn, and master. If that took spending 90 minutes every week discussing all kinds of topics with a young Greek undergraduate student, and then forging a long friendship with him, so be it.

As I find myself back teaching at the University of Toronto, I can only pay forward to my own students the enormous debt I have been fortunate to owe to Anatol Rapoport.

Spyridon Kotsovilis, Department of Political Science, University of Toronto Mississauga (April 2019; Toronto, Canada)

Robert Axelrod

I invited Robert (Bob) Axelrod to share his reflections on the contributions of Anatol Rapoport.

I didn't know Anatol Rapoport personally, but he had a major impact at four stages of my career. I owe him a great debt. As an undergrad math major, I was looking for something useful to do with my education. Once I was exposed to game theory, I was hooked. Rapoport's *Fights, Games, and Debates* (1960) was very helpful in extending my horizons beyond the rational choice framework that dominated game theory then (and now, for that matter). While I was pursuing a PhD in political science, Rapoport's *Strategy and Conscience*

[16]Rapoport's book *Fights, Games, and Debates* (1960) remains an influential and deeply original contribution in political science.
[17]Prior to peace and conflict studies, Anatol Rapoport had been cross-appointed to the University of Toronto's mathematics and psychology departments; in this way, he effortlessly straddled disciplines at every institution he was affiliated with, such as Stanford University and the University of Michigan.

(1964) was a second contribution to my career. His book gave me a powerful critique of defense intellectuals who were elaborating the strategy known as Mutual Assured Destruction. This was especially helpful because I happened to have a summer internship at the time with Rapoport's main villain, Herman Kahn.

When studying non-zero-sum game theory, I became fascinated with the iterated Prisoner's Dilemma as a test bed for the understanding of how to promote cooperation among egoists. So had Rapoport. Like Rapoport, my main intellectual motivation during the Cold War was to see what could be learned that might help avoid the catastrophe of nuclear war. Along with Albert Chammah, Rapoport published by far the best empirical and theoretical analysis of the game in *Prisoner's Dilemma* (1965). This provided ample evidence about how students would play the iterated version of the game, and also provided some nice analytics of the possibilities. Rapoport's third contribution was that his book with Chammah left me wondering what the best strategy would be to play the iterated Prisoner's Dilemma with other, more or less sophisticated players. The work of Rapoport and Chammah helped clarify for me that trying to analyze how humans play the game would not be sufficient, because humans tend to become bored and will try almost anything now and then. That led me to see that what was needed was an analysis of strategies that were designed to be effective. That in turn led me to conduct tournaments for the iterated Prisoner's Dilemma based on submissions from people who understood the game.

I invited Rapoport to submit Tit for Tat, and he agreed. This was his fourth contribution to my career. It should be noted that his submission came with the proviso that he personally didn't want to recommend Tit for Tat to anyone. But the result was that Rapoport's entry was the winner of both rounds of the computer tournament because it was so effective at eliciting cooperation from a very wide range of submitted strategies. I told the story in my *Evolution of Cooperation* (1984), a book for which I am now best known.

Robert Axelrod, professor of political science at the University of Michigan (February 2019; Ann Arbor, Michigan)

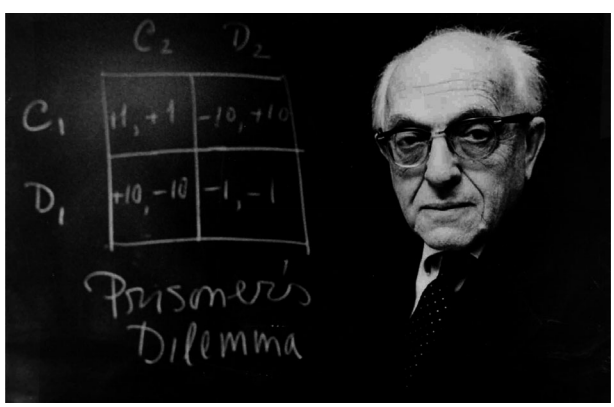

Figure 6. Anatol Rapoport next to blackboard with Prisoner's Dilemma, c. 1986. (Source: Rapoport family photos; possibly at the University of Toronto).

Scott Page

Beyond the Prisoner's Dilemma and Tit for Tat (see Figure 6), Scott provides an eloquent articulation of Rapoport's approach to modeling.

Rapoport belonged to a cohort of scholars who used mathematical models to interrogate large questions such as when markets work (Arrow), why central planning might not (Hurwicz), how society organized itself (Schelling) and how organizations functioned (March). Rapoport's concern was peace, and how to achieve it.

Rapoport's interest in peace led him to also study conflict and the use of models to explain war and to offer strategies for peace. My intersection with Rapoport's thinking and writing lies not in any particular research, but in the art and practice of modeling. Here, Rapoport also took on big questions.

What do and can models add to our understanding of the world? How can we use models to guide action? And given the complexities of the world, how can models help us to construct behaviors, laws, and institutions that, in general, produce better outcomes for all?

The ways in which Rapoport interpreted and applied models differ markedly from the practices of modern scholars. Specifically, he would contemplate the various purposes of a model in a single paper. Models can be used to help us reason, to explain data, to act, to predict, to design, to communicate, or to just explore. Rapoport sometimes uses all of these functions of models in a single paper. Read, for example, his analysis of Lewis Richardson's war model (Rapoport, 1957b). Rapoport takes the assumptions seriously. He reasons through them. One can almost imagine him tossing a piece of chalk back and forth in his hands as he investigates what a differential equation really means. He analyzes how well they can explain the data. Rapoport saw game theory not as a collection of answers to specific questions or situations but as a way to uncover deep relationships and to create categories. Thus, chess and Go both involve large state spaces, sequential moves, and perfect information. Poker includes a move by nature—the deal of the cards—and therefore induces a distinct set of strategic considerations.

Rapoport was a pioneer in mathematical modeling. And we are fortunate that someone of his breadth, energy, and subtlety of mind was among the early modelers. His ability to see individual models, as well as classes of models, as applying broadly helped to create a playful culture within the modeling community. This "one to many approach" has yielded huge dividends. It has obliged us to imagine the spread of products, memes, and customs using models from epidemiology, and to apply measures of network centrality across a variety of fields. These exercises do not provide definitive answers or point to specific actions or institutional designs so much as they help us to think.

Rapoport took joy in the construction and analysis of models. But he did not take any one model that seriously. What he did take very seriously was the thinking that the use of models produced. That he devoted much of his intellectual life to this pursuit has been to our collective benefit.

Scott Page, professor of management and organizations, complex systems, political science, and economics at the University of Michigan (March 2019; Ann Arbor, Michigan)

Concluding Remarks

It is a privilege to assemble these memories and testimonials honoring the contributions of Anatol Rapoport. While reading his books and crafting this article, I found myself wishing I could invite him to my house for a good cup of Viennese coffee. We might have confirmed that in the 1930s Anatol crossed paths with my grandfather, Josef Koppelmann, in Vienna,[18] around shared music endeavors. If I could ask Anatol a research-related question, it would be about the impact of culture on decision-making in socially interdependent settings. How does a *culturally informed logic of appropriateness* (Kopelman, 2009; Kopelman et al., 2016), versus a logic of rationality, resonate with his understanding of human behavior in fights, games, debates, and beyond? How might it help understand and promote mutually

[18]My father, Raoul Kopelman, remembers the name of Anatol Rapoport—the pianist—mentioned at home when he was a child in Vienna; many years later, when my father came to Ann Arbor in 1966, he was intrigued to hear about Rapoport—the professor—at the University of Michigan. I discovered this when my father read an initial draft of this manuscript. The journey of writing this article has been marked with multiple personal touch points. One magnificent moment along this journey was listening to the Wiener Symphoniker in the Großer Saal, Musikverein (https://www.musikverein.at/konzert/eventid/36639) on March of 2019; Anatol Rapoport performed in the Grosse Musikverein-Saal on March 17, 1932. I am indebted to Dr. Severin Matiasovits of mdw - Universität für Musik und Darstellende Kunst Wien (https://www.mdw.ac.at/), who kindly shared a copy of the concert program: Anatol Rapoport played the Piano Concerto No. 3 in D minor, Op. 30, composed in 1909 by Sergei Rachmaninoff.

beneficial economic outcomes to foster the well-being of individuals and groups in a sustainable environment?

If you had an opportunity to meet with Anatol Rapoport, what would you ask him? I invite you to pick up one of his books, formulate a question, and then, rather than having an imaginary conversation, invite one of your colleagues out for a drink. Consider your question with respect to both "ology" and "ics" and enjoy a conversation that will spark energy on your scholarly path.

For what does it take to be a scholar? Perhaps it is not too different from what it takes to be a musician. In the words of Anatol Rapoport, back in 1932 in Vienna[19]:

> Somebody said: "It takes three to make music—one to compose, one to interpret, one to conceive." I would say that the embodiment of the three might become the ideal artist-musician. To record the movements of his soul by dead symbols, to put living force into the symbols, and to translate the resulting sounds back into emotions, not merely the ability to do it—the longing to do it, would mark one an artist-musician. (1932a, 7)

Transferring this analogy from the world of music to that of science, being a true scholar would mean being a theorist–practitioner. This would be a person who embodies the integration of knowledge, the creation of valuable innovative research, and the application of this research to improve our natural and social state of being. Each encounter with a colleague could spark a metalevel conversation to address the dynamic equilibrium of challenges and opportunities we face, and spur us to continuously work to co-create flourishing peace.

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[19]The Vienna of *The World of Yesterday* (Zweig, 1942).

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