Nobel Laureate
Herbert A. Simon

Pioneer of Artificial Intelligence and Trailblazer in Decision-Making

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Artificial intelligence is rapidly transforming the world we know. Suresh Sethi describes the fascinating career of Herbert A. Simon, a father of artificial intelligence, renaissance man, and true polymath who made pioneering contributions to fields ranging from economics to psychology and from management to the philosophy of science.

Herbert Alexander Simon was born on June 15, 1916, in Milwaukee, WI. In 1978 he was awarded the Nobel Prize in Economics[1] for his pioneering research into the decision-making process in economic organizations. His interests, however, went far beyond economics. Simon crossed disciplinary borders to influence many fields. His work expanded the information sciences beyond recognition, allowed computers to model the behavior of highly complex systems, and transformed psychology by exploring human information processing. A Royal Academy of Sciences citation described him as follows:

"Simon rejects the assumptions made in the classical theory of the firm of an omniscient, rational, profit-maximizing entrepreneur. Instead, he starts from the psychology of learning, with its less complicated rules of choice and its more moderate demands on the memory and the calculating capacity of the decision-maker. He replaces the entrepreneur of the classical school by a number of co-operating decision-makers, whose capacities for rational action are limited by a lack of knowledge of the total consequences of their decisions and by personal and social ties. Since these decision-makers cannot choose a best alternative, as can the classical entrepreneur, they have to be content with a satisfactory alternative. Individual firms, therefore, strive not to maximize profits but to find acceptable solutions to acute problems."[2]

Simon believed that scholars, in devising tools and techniques for modeling human behavior, had absurdly unrealistic expectations of the ability of humans to make rational choices. He argued that human rationality was bounded by the limits on available information and by the human mind's capacity for processing information. As Simon put it, "we need a less God-like, and more rat-like, picture of the chooser," adding, "decision makers can satisfice either by finding optimum solutions for a simplified world, or by finding satisfactory solutions for a more realistic world. Neither approach, in general, dominates the other, and both have continued to co-exist in the world of management science."

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The tools he developed throughout his career were designed to create just such rat-like models of how people solve problems.

Simon earned both his B.A. (1936) and his Ph.D. (1943) in political science from the University of Chicago. From 1942 to 1949, he worked as a professor of political science at Chicago's Illinois Tech, while transforming his doctoral dissertation into a book titled Administrative Behavior (1947).[3] Although Simon had been in his twenties when he wrote the original material, the book challenged, essentially successfully and correctly, much of the received administrative theory of the time and provided a new conceptual framework of decision making. In it, he proposed the concept of bounded rationality to describe the human decision-making process in which, although they intend to be purely rational, people use expedients other than those prescribed by global rationality to make choices – specifically, they tend to choose a merely satisfactory solution, rather than insisting upon the optimal one. And the idea of bounded rationality applies to organizational as well as individual decision making. Simon later coined the term "satisfice,"[4] a combination of "satisfy" and "suffice," to describe this process.[5,6]

During this period, Simon was also building his education in economics by participating in weekly seminars, organized by the Cowles Commission,[7] in which no fewer than nine future Nobelists participated.

In 1949, he moved to what is now Carnegie Mellon University to collaborate with George L. Bach, William W. Cooper, and others in using W. L. Mellon's gift of $5 million in endowment and $1 million for a building to create a new business school. Their goal was to construct an institution offering a foundation of studies in economics and behavioral science upon which business education could be built. With new management science techniques on the horizon and the emergence of the electronic computer, it was a heady time to launch such a venture. With the Graduate School of Industrial Administration, now the Tepper School of Business, they succeeded brilliantly.

Simon still felt the need for a better theory of human problem-solving. Around 1954, he and his doctoral student Allen Newell conceived the idea of writing computer programs to simulate problem-solving so they could better study it. That idea was the beginning. Simon's research interests turned toward computer simulation of human cognition, a quest that would continue for the rest of his life. Holding that the programs are the theory, he became a fierce advocate of computer programs as the best

formalism for psychological theories.

"Over the Christmas holiday, Allen Newell and I invented a machine that thinks!"

Simon also developed and popularized heuristic programming. In 1955-56, he and Newell devised Logic Theorist (LT), the first successful artificial intelligence (AI) program, which successfully proved the theorems of Russell and Whitehead's Principia Mathematica.[8] Simon was so excited by the work that he famously announced to his January undergraduate class, "Over the Christmas holiday, Allen Newell and I invented a machine that thinks."

By 1958, Simon had created another renowned program, the General Problem Solver (GPS). On the surface, both LT and GPS appeared to solve problems in much the same ways as humans. Simon insisted, however, that computer simulation was not an exercise in elaborating tautologies, but an empirical science that could teach us new and valuable things about ourselves and our world.

Beginning in the 1960s, Simon devoted his main research to extending the boundaries of artificial intelligence, particularly toward simulating human information processing, giving AI programs ever broader and less tightly structured tasks that called for increasingly substantial bodies of knowledge.

With a series of colleagues, Simon developed programs ranging from those that played chess, to the Elementary Perceiver and Memorizer (EPAM, co-created with Edward Feigenbaum) which simulated human sensory perception and learning, to BACON, which simulated the process of scientific discovery.

In 1972, he and Newell published a monumental book titled Human Problem Solving in which they introduced the notion of a program as a set of "production systems" or "if-then" statements. In 1975, they received ACM's prestigious A.M. Turing Award[9] for their basic contributions to artificial intelligence, the psychology of human cognition, and list processing. In light of his hugely influential work, Simon is justly considered one of the fathers of artificial intelligence.

Throughout his career, Simon believed that organization and structure were critical. Indeed, what his programs truly simulated was the structure of problem-solving. He concluded that human mental processes are hierarchical and associative. To replicate this hierarchical, associative model of the mind, Simon and Newell worked with J. C. Shaw (a programmer at RAND) to develop the first list processing language, IPL (Information Processing Language). While IPL was, in retrospect, a low-level assembly language for list processing, it was a major influence on the development of later list-processing languages, including Lisp itself.[10]

Since the days of Simon's early work, applications of AI have mushroomed. From Apple's Siri, which uses natural language processing, to Google's DeepMind, which uses deep learning, the impact of AI is ever increasing. In the business world, AI empowers businesses to work smarter and do far more with significantly less. AI reduces costs, increases efficiency, and boosts productivity while creating avenues for new products, services, and markets. According to IBM's 2021 Global AI Adoption Index, 31 percent of companies are now using AI while 43 percent are exploring its use. Interviews with business leaders, IT managers, executive advisors, analysts, and AI experts mentioned smarter supply chains, smarter and safer operations, quality control, optimization, targeted marketing, customer service and support, contextual understanding, and more effective learning as just some of AI's important applications.[11] A recent piece in The Economist considered the controversy that would ensue if the Nobel prize in physiology or medicine were awarded to a non-human, in short, to AI.[12]

Simon was a renaissance man, a true polymath, and a pioneer in artificial intelligence, computer science, decision making, economics, management science, operations research,[13] organizational design and behavior, production smoothing, and the philosophy of science. Few people in history have made scholarly contributions of such depth and breadth. His writing was concise and lucid. And although he was an affable man, in professional arguments he would not readily give an inch.

While at Carnegie Mellon, I had the good fortune to take Simon's course in Mathematical Social Sciences. There I discovered that Herb, as I came to know him, took pains to be extremely helpful to his students. One fine day, as I was crossing campus, I happened to encounter Herb. I spontaneously decided to ask him about an optimization problem I'd been working on and found to be unsolvable. He listened attentively, smiled, and said, "well then, make it simple." His glib response suggested a philosophy of research, that the way to solve some intractable problems is either to simplify them enough so that they become tractable, while retaining their essence, or to change your goal from optimizing to satisficing. Indeed, in his writings, Simon observed that in pure science, if scientists cannot

answer their initial question, they "can modify and simplify it until it shows promise of being answerable." In addressing a real-world problem, however, he pointed out that scientists "cannot substitute a simpler answerable question" if they cannot solve the one presented to them.

"To make interesting scientific discoveries, you should acquire as many good friends as possible, who are as energetic, intelligent, and knowledgeable as they can be."

In the coda of his autobiography, Models of My Life,[14] he also revealed the one heuristic that was of the first importance to all his work: "To make interesting scientific discoveries, you should acquire as many good friends as possible, who are as energetic, intelligent, and knowledgeable as they can be. Form partnerships with them whenever you can. Then sit back and relax. You will find that all the programs you need are stored in your friends, and will execute productively and creatively as long as you don't interfere too much. The work I have done with my more than eighty collaborators will testify to the power of that heuristic."

Herbert Simon died on February 9, 2001, having gone on to earn The National Medal of Science (1986),[15] The American Psychological Association's Lifetime Achievement Award (1993), the American Political Science Association's Dwight Waldo Award (1995), and the Institute for Operations Research and Management Science's John von Neumann Theory Prize (1988).[16] ■

Author Bios

Suresh P. Sethi is Eugene McDermott Chair Professor of Operations Management at The University of Texas at Dallas. He completed his PhD at Carnegie Mellon University under the supervision of Gerald Thompson, learned Mathematical Social Sciences from Herbert Simon while there, and has benefitted greatly from Simon's comments on his research over the years. He did his post-doctoral work with George Dantzig at Stanford University. In keeping with Simon's heuristic of having many colleagues to work with, Sethi has coauthored with almost 200 valued colleagues so far.

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Endnotes

1. [1]Officially "The Alfred Nobel Memorial Prize in Economic Sciences"
2. [2]http://werdet.atspace.com/bin/simonntation-speech.html
3. [3]The book was voted the fifth most influential management book of the 20th century in a poll of the fellows of the Academy of Management. https://en.wikipedia.org/wiki/Administrative_Behavior
4. [4]https://en.wikipedia.org/wiki/Satisficing, see also: https://uk.sagepub.com/sites/default/files/upm-binaries/25239_Chater~Vol_1~Ch_03.pdf, as well as: https://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.545.5116 and: https://doi.apa.org/doiLanding?doi=10.1037%2Fh0042769.
5. [5]In his 1956 article for the APA's Psychological Review, titled "Rational Choice and the Structure of the Environment," Simon described satisficing as follows: "Evidently, organisms adapt well enough to 'satisfice'; they do not, in general, 'optimize.'" And: "A 'satisficing' path, a path that will permit satisfaction at some specified level of all its needs."
6. [6]Herbert A. Simon: Models of Bounded Rationality. Volume 1: Economic Analysis and Public Policy. Volume 2: Behavioural Economics and Business Organization: 1982 (reprinted 1983), Cambridge, MA: MIT Press. 478, 505 pages
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13. [13]Simon's plenary address at the 1986 TIMS/ORSA Joint National Meeting: Two Heads Are Better than One: The Collaboration between AI and OR
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15. [15]https://www.nsf.gov/od/nms/recip_details.jsp?recip_id=323
16. [16]https://www.informs.org/Recognizing-Excellence/Award-Recipients/Herbert-A.-Simon,