HERBERT A. SIMON (1916 - 2001): THE SCIENTIST OF THE ARTIFICIAL

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Once upon a time when the world was young,
Oh best beloved.
There came to the banks of the Monongogo river,
All muddy and brown,
Oh best beloved,
A djinn who was one thing on the inside
But many things on the outside.

Allen Newell, 1987

With the disappearance of Herbert A. Simon, we have lost one of the most original thinkers of the 20th century. Highly influential in a number of scientific fields – some of which he actually helped create, such as artificial intelligence or information-processing psychology – Simon was a true polymath. His research started in management science and political science, later encompassed operations research, statistics and economics, and finally included computer science, artificial intelligence, psychology, education, philosophy of science, biology, and the sciences of design. His often controversial ideas earned him wide scientific recognition and essentially all the top awards of the fields in which he researched, including the Turing Award from the Association of Computing Machinery, with Allen Newell (in 1975), the Nobel prize in economics (in 1978), and the Gold Medal Award for Psychological Science from the American Psychological Foundation (in 1988).

While his research spanned a dazzling number of fields, his interests were by and large centred upon a single question, that of bounded rationality: How do human beings, in spite of their limited processing capacities, manage to make reasonable decisions? Or, to use one of Simon's favourite metaphors, how can one find a satisfactory path in a branching maze, in spite of limited access to information? This central question, which originated in his Ph.D. thesis on organisations (published in 1947 as *Public Administration*), is clearly apparent in most of his research, and is often combined with questions about the role of the environment in the adaptability of complex systems (these themes were developed in detail in *The Sciences of The Artificial,* 1969). Bounded rationality is also at the source of concepts such as heuristic search and satisficing (selecting solutions that are good enough, although perhaps not optimal), and was a strong motivation for the introduction of production systems in psychology; this strand of research, carried out in collaboration with the late Allen Newell, is described in detail in their classic book *Human Problem Solving* (1972).

Simon's fascination with human decision making found an important source of inspiration in the study of puzzles and games (in particular chess). How can human beings, in spite of their bounded rationality, become experts in these combinatorial tasks? Simon studied games from two main angles: artificial intelligence and psychology. His research into computer chess started in the mid-fifties in collaboration with Allen Newell and Cliff Shaw, at the time when they were also engaged in the development of the Logic Theorist and list-processing languages, which would later lead to the General Problem Solver. While their program did not reach a high standard of play, it allowed Simon to formalise several key ideas related to bounded rationality, such as the presence of goals, the dynamic adjustment of expectation, heuristic search, and satisficing. The concept of selective search was also explored in MATER, a program subsequently developed with Simon's son Peter and with George Baylor. MATER was able to solve relatively complex checkmating combinations by highly selective search, using a number of heuristics such as keeping checking, limiting the number of possible moves, and so on. Finally, moving into game theory, Simon developed a mathematical model to explain the concept of error in two-person games, based upon the idea that slight differences in the quality of moves chosen can cumulatively produce substantial differences in outcome (losing or winning the game).

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Simon's interest in computer chess was clearly motivated by his desire to understand the mechanisms of human thought, and not by ambitions to develop strong programs *per se*. Even so, some of his ideas were later used in developing top-level programs. The best example is perhaps Hans Berliner's HITECH, which illustrates the role of pattern recognition in heuristic search, one of Simon's key ideas. When DEEPER BLUE beat Gary Kasparov in 1997, Simon was both pleased and disappointed. He was pleased that his famous 1957 prediction – that a computer program would beat the World Champion within ten years – was vindicated; as he was quick to point out, 30 years rather than 10 years represents a rather small error factor. He was also disappointed, however, that an approach based essentially upon brute force, rather than heuristic search, did the job.

In the psychological study of games, Simon took up questions raised by the seminal research of Adriaan de Groot on perception, memory, and decision making in chess. In collaboration with William Chase, he carried out a number of experiments which were destined to have a tremendous impact on cognitive psychology in general and on the study of expertise in particular. With colleagues at Carnegie Mellon, he worked on several computer models of chess players' perception and memory, such as PERCEIVER, MAPP, and CHREST. In both his experimental and modelling work, Simon was interested in how humans' limited cognitive capacity can cope with the exponential complexity of chess, proposing that pattern recognition both made heuristic search possible and explained such phenomena as intuition. Chess was only one of Simon's many lines of research into human cognition, which included research on creativity, scientific discovery, imagery, problem solving, learning, and memory.

A striking feature of Simon's personality was his immense curiosity. For example, he was always keen to learn new languages, artificial and natural, to find the solution to (sometimes trifling) problems, to keep track of developments in almost any science. He was of course very well aware of his insatiable curiosity, and jokingly entitled one of the many talks he gave on the Carnegie Mellon campus "The cat curiosity couldn't kill." It is likely that he found as much pleasure in the search process as in the solution.

To his collaborators and students, meetings with Simon were a unique experience: the breadth and depth of his knowledge, as well as his ability to combine information from various fields, was amazing. His informal style and his generosity made you sometimes forget that you were talking to one of the greatest scholars of the 20th century. In spite of his fame, he would treat even the least experienced undergraduate with respect. He would patiently listen to the most naive argument, and had a unique way of answering awkward questions without offending his interlocutor. He was a charismatic public speaker as well as a skilled polemicist – a skill he had already perfected in his high-school years.

A self-declared workaholic, he would also expect strong commitment from his collaborators, not least in time spent on task – a direct application of his finding from expertise research that it takes at least ten years to become an expert. While generous with his collaborators and students, he could also be extremely impatient with bad ideas. In particular, he abhorred theories stated in vague and informal terms, and was tireless in trying to convince social scientists to use formal approaches, preferably computer modelling. In his last years, he sometimes expressed disappointment that some of his favourite ideas did not have the lasting impact he had hoped for: classical economics was still making strong assumptions of optimality, in spite of his work on bounded rationality, and information-processing psychology was being overcome first by connectionism, and then by the neurosciences.

In the final chapter of his autobiography (*Models of My Life*, 1991, p. 367), Simon reflected: "In describing my life, I have situated it in a labyrinth of paths that branch, in a castle of innumerable rooms. The life is in the moving through that garden or castle, experiencing surprises along the path you follow, wondering (but not too solemnly) where the other paths would have led: a heuristic search for the solution of an ill-structured problem. If there are goals, they do not so much guide the search as emerge from it. It needs no summing up beyond the living of it."

Born on June 15, 1916, in Milwaukee, Herbert A. Simon received his doctorate from the University of Chicago in 1943. In 1937, he married Dorothea Pye, with whom he would have an extremely happy relationship for almost sixty-five years. He held research and faculty positions at the University of California (Berkeley) and the Illinois Institute of Technology, before going to Carnegie Tech (later called Carnegie Mellon University) in Pittsburgh, where he remained active in research and teaching until the time of his death, on February 9, 2001.