McCorduck's *Machines Who Think* after Twenty-Five Years

Revisiting the Origins of AI

Philip Mirowski

■ *Machines Who Think: A Personal Inquiry into the History and Prospect of Artificial Intelligence,* Pamela McCorduck, San Francisco, California, Freeman, 1979, 375 pp., ISBN 0-7167-11135-4.

Over the course of the last half-century, a number of books have sought to explain AI to a larger audience and many more devoted to writing the formal history of AI. It is a tribute to her powers of observation and her conversational style that none has really proven more successful than Pamela McCorduck's *Machines Who Think,*[1] now approaching the quarter-century mark. Currently, it is the first source cited on the AI Topics web site on the history of AI. Based on extensive interviews with many of the early key players, it managed to forge the template for most subsequent histories, in the sense of providing them both the time line and the larger frame tale. The time line consisted of an extended prehistory, encompassing isolated attempts to mechanize thought and construct various automata, all treated with bemused condescension; a turning point located with pinpoint precision at the Dartmouth summer conference of 1956; and then an upward trend, punctuated by periodic bouts of soul searching. The frame tale provided therein was basically that AI was "an idea that has pervaded Western intellectual history, a dream in urgent need of being realized" (p. xii) and that this innate primal urge to build little simulacra of ourselves (along with the obvious fact of the technological development of the computer in World War II) was and is sufficient to explain the rise of the new science. The primary principle of selection governing her account is that AI "did not originate in the search for solutions to practical problems.... I like to think of artificial intelligence as the scientific apotheosis of a veritable cultural tradition" (p. 29).

These principles of selection produced a sleek narrative that was very internalist,[2] which is perhaps one reason the story line has been very popular in pedagogical contexts, such as textbooks.[3] However, recent historical research, which includes a reexamination of McCorduck's own interview transcripts, has begun to uncover other possible narratives, especially ones not so intent on portraying the genesis of AI as occurring in splendid isolation from other disciplinary innovations growing out of WWII and, in particular, one more closely bound with certain specific applied concerns found in that era. McCorduck conceded in her book that her account was unabashedly personal and impressionistic, but she did not reveal the extent to which it had been colored by her own close personal relations with some of the early members of the Carnegie Mellon University Computer Science Department. In its execution, *Machines* tended to be dominated by the viewpoint of Herbert Simon in ways both big and small. In everything from its elevation of the symbol-processing approach to center stage (already somewhat outdated by the later 1970s), to its expressions of disdain for philosophers, to its treatment of John von Neumann's later position on computer intelligence as somehow perversely misguided, to the choice of the Dartmouth conference as the pivotal event in the history of AI, the text is redolent of Simon's exuberant opinions and personality. However, there was one observation made by Simon (as well as his collaborators) that unaccountably receives no attention in the book. As Simon admitted numerous times, both in interviews and in print,

> The history of AI goes back ... almost to the beginnings of operations research. It is instructive to look at that early history in order to see why the two disciplines did not develop more nearly synchronously and with closer relation to each other.... [I]n the decade after 1955, the tools of AI were applied side by side with OR tools to problems of management.... [T}hese pioneering applications of AI methods to management were not followed up. After about 1960, AI and OR went their separate ways; whole new generations of scientists trained in these disciplines were largely unacquainted with the techniques provided by the other (Simon 1987, pp. 8, 10).

In her interviews, J. C. Shaw, the joint author with Simon and Allen Newell of the LOGIC THEORIST, explicitly rejected McCorduck's frame tale: "I saw artificial intelligence not as the threat continually written about in science fiction, but rather as a way of going beyond the limits of operations research and the well-specified problems that could be run on computers [at that time]."[4] Perhaps because they suggested an entirely different genre of history of AI than the one she had envisioned, McCorduck passed such comments by and chose not to follow up on them when they popped up in the interviews. The only times operations research gets mentioned in her text is in a comment about the early work of Charles Babbage (p. 24) and in an acknowledgment in passing that the notorious Newell-Simon paper on the future successes of AI was originally delivered to the Operations Research Society of America (Simon and Newell 1958). McCorduck's preferred narrative was that a different motley of fields, mostly those associated with the natural sciences—primarily computer design, cybernetics, mathematical psychology, and formal logic—all contributed component themes to the nascent science but that no single discipline managed to decisively shape the subsequent trajectory of early AI. Her treatment of cybernetics is particularly notable in this regard, given that the rejection of cybernetics in the format of repudiation of concern with the embodiment of the architecture of intelligence in actual machines constituted one of the foundation stones of her account as well as buttressed her identification of Marvin Minsky, John McCarthy and Newell and Simon as her main protagonists; cybernetics constituted the failure that pointed the way forward for AI.[5]

Although the origins of any novel research program often have their roots buried deep and wide in previous inquiries, the suppression of the role of operations research in the genesis of AI has had important consequences for subsequent comprehension of the goals and ambitions of the early community—and even for the relative significance of certain events for the history of AI. Of course, the path to understanding this alternative version of the history of AI passes directly though the history of operations research, something we cannot even begin to recount here.[6] Nevertheless, the implications of the operations research connection do go some distance in helping to explain all sorts of phenomena left dangling by McCorduck as well as providing a different perspective on some of the systemic controversies that have persisted in AI down to the present.

First, there are the fundamental contours of the early history of AI that are left unexplained by McCorduck but are illuminated when viewed through the spectacles of operations research. There is, for example, the timing of events, as hinted by the earlier quote from Simon. The advent of AI was not a simple function of computer technology passing a certain threshold of development but, rather, the result of a split from operations research of certain research themes because of some perceived dissatisfaction with prior operations research approaches. Operations research had prided itself as providing scientific expertise for decision making by experts external to the organization being studied, be the client the military or the modern corporation. By the mid-1950s, operations research had enjoyed some successes in applications but was in danger of being relegated to the lower rungs of the organizational hierarchy, consigned to provision of specialized services, on a par with accountancy or personnel management. Newell and Simon in particular argued that if operations research were to become relevant to the highest reaches of the bureaucratic hierarchy, it would have to extend the realm of competence of the operations researcher to expertise in the intuitive and creative side of the scientific process, dealing with the ill-structured problems and strategic orientations that were the bread and butter of the chief executive officer or the four-star general. They called for a new discipline to concern itself with problem solving in these alternative settings, dubbing it "complex information processing." The name never really caught on, but the attractions of the term *artificial intelligence* had more than a little to do with the predicament bequeathed by operations research.

Newell and Simon felt that the way to make maximum inroads into areas left untouched by operations research was to remain studiously ambiguous about the primary goals of early attempts to imbue computers with the notoriously elusive virtue of "intelligence." On the one hand, they often portrayed their objective as the simulation of aspects of human intelligence to such a refined degree that the computer might "replace" human beings, in the sense of occupying their bureaucratic locations within an army or corporation; they were enthusiastic about the bureaucratic model of organizations to such an extent that Simon's own heuristic guide in his research was to portray the human mind as itself a bureaucratic hierarchy in miniature, as revealed in his celebrated lectures *The Sciences of the Artificial*. This side of Simon became known as the cognitive psychologist, and it is the vision of AI that provides the backbone for McCorduck's version of the history. It is also the side that garnished all the cultural dissension from the 1960s through the 1990s, from Hubert Dreyfus to John Searle to Roger Penrose. On the other hand, there was also the more pragmatic side to Newell and Simon, the one that sought to provide their clients with discrete programs that would serve primarily to augment human intelligence; that is, more precisely, to provide computer technologies that would assist their users in carrying out their bureaucratic tasks, whether or not they actually mimicked human cognition. It was this side of the history that was altogether banished by McCorduck, with her peremptory dismissal of "solutions of practical problems"; she closed her lone chapter on "applied artificial intelligence" with the comment, "any intelligent program that replaces professionals at what they do and get well-paid for ... is going to meet mighty resistance. But the facts

are that no resistance has been recorded because no one has had the resources to attempt a large-scale transfer from the laboratory into the field" (p. 301). It was arguably this side of the history of AI that had been the most successful in maintaining the support of client groups as well as absorbing the vast bulk of programming effort. This segment of the science adopted as its manifesto the famous J. C. Licklider (1960) paper entitled "Man-Computer Symbiosis." It was also the version of *intelligence* that von Neumann (another major figure in American operations research) adopted as his holy grail in the last decade of his life; moreover, it explains why both Minsky and McCarthy began their careers with such close ties to von Neumann, only to later repudiate these early enthusiasms. Von Neumann did not oppose AI tout court, pace McCorduck; he was only skeptical about the simulacrum account of its goals. Newell and Simon believed that the best way to get a new scientific discipline off the ground was to remain determinedly agnostic about these goals for as long as possible, and to blur the distinction between scientist and engineer.[7] Others, such as Minsky, tended to wax ironic concerning the distinction: "Newell and Simon have always pretended that they are interested in how humans work and we have pretended that we didn't care very much about that because it wouldn't help much in getting a general theory of intelligence anyhow."[8] The term *artificial intelligence* encapsulated this program of ambiguity better than other neologisms, and this creative obfuscation of goals was provided by the problem situation in operations research and not by formal logic, computer design, or mathematical psychology.

The roots of AI in operations research not only shed light on the capacity of the early discipline to productively straddle the science-engineering divide but also go some distance in explaining other key aspects of the history that McCorduck elides. For example, there was the fact that AI had to find its initial university location in such unusual units as business schools or departments of communication, viz., existing operations research sites, not to mention withstanding some initial hostility from electrical engineers and computer scientists. Further, there was the overwhelming dependence of the early AI profession on military funding and, in particular, on the Defense Advanced Research Projects Agency (DARPA) from 1962 to 1975. This dependence becomes comprehensible once one realizes that Marvin Denicoff at the Office of Naval Research and Licklider at DARPA were seen as operating out of the operations research arms of their respective organizations and that they sold their enthusiasms as making useful contributions to decision theory, command, control, communications and logistics rather than having some innate urge to produce simulacra of humans.[9] Indeed, McCorduck's history entirely skirts the central importance of the RAND Corporation for many of the earliest protagonists of AI. Far from this being an accident, RAND was the premier incubator for the development of operations research and systems analysis in the United States in the 1940s to 1960s and, thus, contained the densest concentration of computer programmers in the world in the early 1950s. Indeed, one could make the case that the pivotal spatiotemporal event for the precipitation of AI out of the motley of diverse fields having something to do with the computer was not at all the Dartmouth Conference—McCorduck does acknowledge the disappointment of McCarthy, Minsky, and Newell with their Dartmouth experience with a tinge of perplexity—but rather the previous convocation of the Applied Robotology team at RAND in 1950 and its offshoot, the Systems Research Laboratory. Merrill Flood had already thrown down the gauntlet in 1951:

> [N]obody really knows anything about consciousness. Now the purpose of Robotology is to take a hard problem such as this one of consciousness, or a relatively easy one like the learning problem—I can feel the psychologists shudder as I say this—so that a mixed team can be truly scientific in their work on them. Robotology, then, is a way of solving the communication problem in the sense that we don't just let people talk philosophy, or methodology, or just plain hot air; they must talk in terms of something to be put into the design of an object (p. 34).

McCorduck makes much of the statement that it was only Newell and Simon who had a working program to present to the public at the Dartmouth conference, but it was developed at RAND, where there was already a well-established ethos of having to put your ideas into code before you could claim to have made a real contribution to the science of intelligence.

Another peculiarity of the early history of AI that is explained by the operations research connection is the seeming retardation of the uptake of AI in Great Britain, a fact noted in passing by McCorduck (p. 68). Even though Alan Turing's 1950 paper is sometimes treated as the first calling card for the discipline of AI, and some maintain it was the British who wrote the first working program to play a game of checkers, and British activity in cybernetics initially outstripped efforts in the United States in the 1950s, it is the general consensus that British pursuit of AI was retarded for at least a decade, if not more, in comparison to U.S. efforts. This curious

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turn of events is best accounted for by the differential status of operations research in the United States and Great Britain in the 1950s and 1960s. In Great Britain, operations remained stubbornly "low tech," confined to rough-and-ready optimization techniques and hands-on data collection; moreover, British operations research did not exhibit the ambitions to scale the bureaucratic hierarchy that I attributed to Simon and Newell earlier. In the United States, operations research more readily embraced the computer both as a tool and a template of the theory of organization, which rendered the computational approach to intelligence more attractive to the existing client base of the operations researchers.

There were further technical consequences of the initial incubation of AI within the operations research community as well—formal and mathematical aspects that McCorduck did not cover. For example, more recent scholarship has begun to take note of the structural similarities between the modeling choices made by Simon and Minsky and the formalisms then current in game theory and decision theory. Search over decision trees in the form of exploration graphs, minimax versus alpha-beta procedures, strategic trade-offs between the position evaluation function and complexity of the problem representation, various attempts to formalize information in a game-theoretic context—the family resemblances to formalisms innovated in operations research were quite pervasive. Likewise, early AI was closely tied to various forms of war gaming (and, thus, to the lucrative developments of computer gaming and the entertainment industry) that itself was indebted for its existence to operations research. One upshot of this suppressed connection is that AI owed at least as much in the way of inspiration to a specific subset of postwar social sciences as it did to the natural science concepts celebrated by McCorduck.

Thus, we come to the final consideration that revisions in the genealogy of AI discussed earlier might indeed have some conceptual significance for modern practice, contrary to what the bulk of contemporary scientists might believe. Although there are many schools within contemporary AI research, one popular way of organizing the canon has been to recast the sequence of topics in AI as progressively more complicated models of various kinds of agents with varying degrees of perception, action, and autonomy. Indeed, since the 1980s, the AI community has opened up an extensive dialogue with game theorists, economists, and a host of other social scientists who claim possession of elaborate theories of agency.[10] From the current viewpoint, this move is best understood as a return to a situation that was disrupted during the 1960s: The researchers in AI and operations research share so much in the way of heritage that it was only a matter of time before they realized that their commonalties more than outweighed their differences.

Notes

1. The other serious history that aimed to cross over into a popular account was Crevier, D. 1993. *AI*. New York: Basic. More scholarly accounts have been provided by Arthur Norberg, Brian Bloomfield, James Fleck, B. J. Copeland, Jon Guice, Paul Edwards, and a host of others.

2. *Internalist* is a term of historiography. It means that the trajectory of an intellectual discussion is driven exclusively by contributions narrowly construed as taking place within a discipline or discourse community.

3. For example, Nils Nilsson (1998).

4. Interview transcript, Pamela McCorduck with J. C. Shaw, June 16, 1975, p. 31.

5. Some recent reconsiderations of the thesis of assertions of failure of cybernetics are Pickering (2002); Bowker (1993); and Heims (1991).

6. For some background, see Mirowski (2002); Fortun and Schweber (1993); Rau (1999); and Johnson (1997).

7. See Newell's admission of this fact in Crevier (1993), p. 258.

8. Interview transcript, Pamela McCorduck with Marvin Minsky, October. 12, 1974.

9. See Denicoff in Bartree (1989) and Norberg and O'Neill (1996).

10. The extent to which these claims are valid is open to dispute. See Mirowski (2002).

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Philip Mirowski is the Carl Koch professor of economics and policy studies and fellow of the Reilly Center for the History and Philosophy of Science at the University of Notre Dame. He is the author of *Machine Dreams* (Cambridge, 2002), *Science Bought and Sold* (Chicago, 2002), and *Effortless Economy of Science?* (Duke 2003). His recent work ranges from a history of early AI to documentation of the effects of the recent commercialization of science policy. His e-mail address is mirowski.1@nd.edu.