Review of: *The Mind’s New Science: A History of the Cognitive Revolution* (by Howard Gardner, New York: Basic Books, 1985. 423 pages) first appeared in *Philosophia* Vol. 17, No. 2 (1987) pp. 209-216.

Cognitive science is one of the success stories of the past decade, with departments sprouting like mushrooms. The discipline is a hybrid of AI (artificial intelligence), cognitive psychology, anthropology, philosophy, linguistics, and neuroscience, and as such it has a fascinating (if young) history. Howard Gardner has written a history of this new science. It is fair to say that as a popularization of cognitive science the book succeeds extremely well, though as serious history of science the book does not succeed as well.

Gardner does a nice job of surveying this very broad field. In Chapter One he characterizes cognitive science as involving four tenets: a commitment to intentionality as an explanatory construct at the psychological (as opposed to the neurophysiological or social) level; the view that the digital computer is central to understanding the human mind; the view that any successful cognitive science must draw upon the resources of many fields; and the view that the agenda of cognitive science has on it the classical epistemological questions.

Chapter Two contains a concise history of psychology from the cognitivist perspective. Early in this century researchers wanted to investigate scientifically traditional epistemological concerns such as the nature of thought, language and rationality. But their empirical approach rested upon introspection. The behaviorists rebelled against that: methodologically, behaviorists have a commitment to overt observable behavior as the only sort of evidence allowable in psychology; metaphysically, behaviorists oppose positing mental entities (plans, desires, ideas, and so on), as explanatory factors in psychology. Gardner rightly acknowledges that in a real way behaviorism was progressive: it did counteract a tendency to very vague and speculative theorizing about "will" and "faculties." But the price was high: the baby of cognitive phenomena (language acquisition, inference, planning and so on) went out with the bathwater of introspection.

Gardner picks as the opening shot of the cognitive revolution Karl Lashley's talk before the 1948 Hixon symposium (attended by von Neumann and a number of other luminaries). Lashley challenged behaviorism. He urged that intentional factors had to be taken into account in any adequate explanation of language acquisition and use. In arguing that linguistic behavior cannot be explained by the behaviorist S-R model Lashley anticipated the Chomsky/Skinner debates. Lashley put forth a view of the central nervous system as an ever active system composed of interacting subsystems. Again, Lashley was anticipating a later crucial concept: the concept of modularity. Gardner finishes the chapter with a sketchy but adequate review of the key early inputs to cognitive science: mathematical logic (especially Turing's work); McCullock's neuronal model; von Neumann, Weiner and Cybernetics; and Shannon's information theory.

In Chapter Three Gardner continues his sketch of the early history of cognitive science. He sets the September 1956 symposium on information theory held at MIT (attended by Chomsky, Simon, George Miller, and others) as the birthplace of the subject. The late fifties and early sixties were a time of intellectual ferment: AI emerged as a discipline, and key work was being done in neurophysiology. In 1960 the Center for Cognitive Studies was founded at Harvard by Jerome Bruner and George Miller, and there was a shift away from behaviorism to a frank embrace of "plans," "goals," "images," and other highly mentalistic entities. One sign of a maturing discipline is the appearance of texts, and the first text in cognitive psychology was Ulrich Neisser's *Cognitive Psychology* in 1967. In 1972 Newell and Simon published *Human Problem Solving.* In the late sixties and early seventies there was an explosion of literature in cognitive science, and the journal *Cognitive Science* was founded. In 1975 the Sloan Foundation decided to fund the nascent science, and the influx of funds established the field's independence.

Gardner then begins to survey the various cognitive sciences. In Chapter Four, philosophy is surveyed. There is a quick and reasonably accurate summary of the views of Descartes, Kant, the logical positivists, Russell, the ordinary language philosophers, and especially useful discussions of Rorty, Fodor, Dennett, and Putnam. Gardner treats philosophy, it is comforting to note, seriously if a bit patronizingly: "Rather than being the ultimate arbiters, or the ultimate victims, of scientific work, philosophers have been (and will continue to be) important handmaidens in the scientific study of cognition." (p. 54) But his view that philosophers need to be more sensitive to empirical findings is surely not implausible.

In Chapter Five Gardner gives a more detailed account of recent trends in psychology. He covers the work by Miller in the mid-1950's which indicated that there are limitations to human information storage (with short-term storage capacity as low as seven). He also discusses the work of Colin Cherry and Donald Broadbent in the late 1950's, who were influenced by information theory, and who showed by some very pretty experiments that the intake and storage of information by the mind is limited. Broadbent was the first to use flowcharts to describe the information flow in the human being, (i.e., the flow from the senses to a short-term store, to a selective filter, then to a limited-capacity channel, to an output system and a long-term store). Jerome Bruner's 1956 classic *A Study of Thinking* is also discussed. All of this work was as empirical and experimental as behaviorism, but in this work the participants are viewed as active information processors and problem solvers, not mere SR engines.

Gardner then jumps backwards in time to give a thumbnail sketch of the history of psychology from the 19th century (Helmholtz, Brentano) to Piaget. He views Brentano — who emphasized intentionality as the mark of the mental — as the spiritual ancestor of all cognitive scientists. Wundt's laboratory is discussed, as is the work of Ebbinghaus (who shifted research from how the subject feels to how he performs in an objectively measurable way). Also discussed is the Wurzburg school, which focused on information structuring in perception, a topic of much current interest. Of course behaviorism is covered, but only briefly. More attention is paid to Gestalt psychology and how it differs from today's cognitive psychology. Gardner also discusses the work of Frederick Bartlett (on memory and the transmission of stories) and Jean Piaget (whose "genetic epistemology" is very congenial to cognitive scientists, although the details of Piaget's view have not held up to the test of experiment).

The work by Gestalt psychologists and others like Bartlett and Piaget was more or less isolated from the mainstream of psychological theory, which was predominantly behaviorist especially from the thirties to the late fifties. What got cognitive science moving was the rise of computer science and information theory. Gardner discusses the recent work by Roger Shepard and others. He finishes the chapter by discussing some of the recent criticism raised against the whole enterprise of cognitive psychology.

Chapter Six is in my opinion the best in the book. It summarizes the history of AI, work which is probably unfamiliar to most philosophers. Again, Gardner starts by describing a seminal conference: the 1956 seminar at Dartmouth, attended by John McCarthy, Marvin Minsky, Herbert Simon and Allen Newell. He notes an important distinction between the weak and strong conceptions for AI. The weak conception of AI is that the goal of AI should be to devise computer programs that mimic the ways human beings carry out cognitive tasks. The strong conception is that the programmed computer actually has cognitive states. It is the strong conception of AI to which philosophers such as Hubert Dreyfus and John Searle object.

After giving a short history of the digital computer, Gardner discusses some of the key successes in AI. Early on, Newell and Simon devised the Logic Theorist program which proved theorems from Whitehead and Russell's *Principia Mathematica*. (Indeed, the Logic Theorist devised a proof of a theorem even more elegant than the original proof). Gardner also discusses the General Problem Solver, a more ambitious program that, while not ultimately successful, generated a fruitful line of research. Less well known to the general public is Marvin Minsky at MIT, who has been the mentor of many AI researchers. One is T.G. Evans, who devised a

program that solves analogical puzzles at the level of the average high school student. Another is Daniel Bobrow who did the same for algebra word problems.

Gardner reviews other AI successes: DENDRAL (a program for analyzing chemical compounds); ELIZA (a program that mimics dialogues between therapists and patients); and SHRDLU (the first "expert system" — a program that focused on a limited domain). SHRDLU was a new paradigm in AI — it marked a change from looking for general problem solvers to looking for narrowly focused problem solvers for particular domains.

Gardner also considers attacks on AI research. Joseph Weizenbaum's view is that AI technology is dangerously seductive, tempting us to abdicate our responsibility for decision- making. Hubert Dreyfus, a phenomenologist, has a different criticism, viz., that human knowledge is wrapped up with the human biological and social condition, and that any rules- based epistemology is bound to fail. But phenomenology is not a very compelling point of view, so Dreyfus' criticisms are not widely regarded as conclusive. A third sort of critique of AI is offered by James Lighthill, who criticizes the disparity between the initial hope and the actual success of AI.

Although the early high hopes were disappointed, by the late seventies AI was flourishing. Economically, AI is now very big business. And scientifically, AI has scored notable successes in the realm of perception of decision-making. These recent developments are covered well.

Gardner finishes the chapter by discussing the recent criticisms of AI raised by Searle.

In Chapter Seven there is a solid review of modern linguistics, mainly focused on the work of Chomsky. Chomsky's 1957 classic *Syntactic Structures* and his attacks upon Skinner and behaviorism are reviewed. Especially nice is the discussion of the implications of Chomsky's views for psychology: Chomskian psychology is innatist and unabashedly mentalistic.

Gardner reviews earlier linguistics, including de Saussure, Roman Jakobson and the Prague School, Leonard Bloomfield, Edward Sapir and his student Benjamin Lee Whorf, and Zellig Harris. The chapter finishes with a discussion of the evolution of Chomsky's thought (from the 1957 *Syntactic Structures* to the 1965 *Aspects of the Theory of Syntax* to his more recent work on universal grammar) and the impact of his work on other areas of cognitive science.

Chapter Eight is devoted to a review of Anthropology as a cognitive science. Gardner begins with Lucien Levy-Bruhl, who wrestled with the question whether primitive people are "pre-logical," i.e., think in a different way from moderns, or whether instead of difference between primitive and modern thinking is merely a matter of degree. There follows a concise history of modern anthropology: Edward Tylor, Franz Boas, Radcliffe-Brown, Malinowski, Levi-Strauss, and Sperber are all discussed. Especially crucial from Gardner's point of view is Levi-Strauss' insistence that to understand social reality we need to understand the way the human mind organizes experience. Levi-Strauss felt that there are only a limited number of ways the human mind can work, that it comes equipped with "custom universals" that get combined in various ways. This sort of thought underlies his treatment of mythology. Gardner respects Levi- Strauss' work as a cognitive scientist, but acknowledges that many others doubt its value.

Gardner concludes the chapter with a discussion of cognitive anthropology and ethno- science.

Chapter Nine is another outstanding chapter. It covers the history of modern neuroscience. The review starts with Karl Lashley, who explored the use of the lesion method of experimentation, in which an area of the brain is destroyed and then the resulting impairments are identified and observed. Lashley's 1929 classic *Brain Mechanisms and Intelligence* attacked the view that specific areas of the brain are tied to specific skills, memories, thoughts, and so on. His work posed a challenge for localization theories and reductionism generally. Lashley's view was one of equi-potentiality: the ability of other areas of the brain to take over when one area is destroyed. Lashley argued against a naive equation of the brain with the digital computer, or neurons with switches. Instead, he argued that the brain is more analog than digital and that we need to think statistically to understand neuronal behavior. Lashley was especially critical of the behaviorist view that there are "reflex arcs" or specific neural ties between stimulus and response.

More recent work has shown the brain to be more localized than Lashley believed. But Lashley's tendency to reject simple reductionism and his willingness to use concepts such as "plans" or "structures" cleared the way for cognitive scientific concepts.

Gardner spends a fair amount of time on the history of early neurophysiology from Descartes to Broca, based on a very nice distinction between localism and holism, with those of the localist perspective being most inclined to reductionism. By the 1940's researchers were looking for a compromise between localism and holism. One such attempted synthesis was Donald Hebb's *The Organization of Behavior*. But despite Hebb, in the late 1950's the issues began to be resolved more in the favor of the localists. David Hubel and Torsten Wiesel conducted experiments (which later won them the Nobel Prize in physiology) on perception in cats. They were able to isolate sets of cells in the cortex that identify horizontal and vertical movement. Again, Roger Sperry's work on brain lateralization is evidence for localism. And the recent research by Eric Kandel on learning in snails is very reductionist in spirit. (Some learned behavior in snails is traceable to as few as 50 neurons. Learning seems to involve altering the effectiveness of preexisting pathways).

Gardner finishes the chapter with a defense of the view that even if localism is closer to the truth than holism, reductionism should be resisted so as to keep open lines of fruitful research.

In Chapter Ten Gardner takes up the recent history of work by cognitive scientists on perception. He quite rightly focuses upon the path breaking research by the late David Marr. Marr was trained in neurophysiology and in the late sixties studied the function of the human cerebellum. In 1973 he joined the AI lab at MIT where he worked until his death in 1980. Marr rejected the notion of direct perception in favor of "symbolic descriptions." Under his theory of vision, the brain does not construct an image (say, of external objects in space) all at once. Rather, the brain computes a series of symbolic representations or "sketches": a primal sketch, which represents only basic geometric features and shading; a "2.5-D" sketch, which represents surface features such as shape, depth, and the position of the object from the viewer's frame of reference; and the finished 3-D sketch, which represents volume, solidity, and the coordinate system from the objects point of view. Marr held a very modular view of vision, with different modules being responsible for computing motion, color, depth, and so on.

Gardner finishes the chapter by discussing the research done by Marr's competitors such as James Gibson.

In Chapter Eleven the research on mental imagery is reviewed. Cognitive scientists are more inclined than are philosophers to believe that mental images exist and are worth studying. Especially interesting is the work by Stephen Kosslyn, who is concerned to prove empirically the existence of mental imagery, and delineate the major properties of the imaging system. Gardner also presents the criticisms of Kosslyn's views by Zenon Pylyshyn and others. There is a vital

issue at stake: do cognitive scientists need to postulate imagistic knowledge as well as propositional? And yet if we accept the criticisms of images, then why stop there? Propositions are not much less dubious from the philosophical point of view.

The last few chapters cover theories of classification and of rationality. I found the review of the literature testing Whorfs hypothesis enjoyable (it turns out that the hypothesis doesn't hold up very well). Johnson-Laird's and Amos Tversky's research on how far people depart from standards of rationality is well explained, although the review is less useful to philosophers only because they are familiar with that body of literature already.

It should be clear from the foregoing summary that Gardner has produced a very useful popularization of a rapidly evolving new field. However, as serious history of science the book is inadequate. For one thing, the book jumps from recent history to current theoretical disputes to distant history in a very abrupt and disjointed fashion. Far too many topics are introduced to allow proper historical development. And the book's quality is very uneven, with some chapters (especially the ones on AI and neuroscience) being of much higher quality than others.

Most disturbing is the Whiggishness of the work. Certain tenets are laid down which define cognitive science, and researchers are assessed on the basis of how much they contributed to the field so defined.

Yet, I don't wish to be churlish. Gardner's book is fascinating and clearly written. It is especially useful to those philosophers who wish to quickly survey an important new field.

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