AI & SOCIETY, Vol. 3, Number 4, October – December 1989, pp. 365-369

Book Reviews

The Making of Cognitive Science. Essays in Honor of George A. Miller, William Hirst, editor (1988), Cambridge University Press, New York, New Rochelle, Melbourne, Sydney. 284 pages. ISBN 0 521 34255 4.

Computer Models of Mind. Computational Approaches in Theoretical Psychology, *Margaret A* Boden *(1988), Cambridge University Press, Cambridge, New York, New Rochelle, Melbourne, Sydney. 289 pages. ISBN 0 521 24868 X hard covers; 0 521 27033 2 paperback.*

The establishment of cognitive science as a research area in its own right is a recent phenomenon. A decisive step (perhaps *the* decisive step) was taken when the Sloan Foundation decided in 1976 to give massive financial support to a programme in this field, committing itself first to a sum of aup to fifteen million dollars, which was later increased to twenty millionm dollars. The foundation of specialized journals and scientific societies is a good measure of the degree of professionalization and specialization of research. The journal *Cognitive Science* was started in 1977, and a society of the same name was founded in 1979. In the 1980s, departments of cognitive science were set up in a number of universities, mainly in the United States, and new chairs were created to take care of the new field of research. The tempo at which all this happened stands in need of explanation. Why did these events occur, more or less simultaneously, in so many places in such a short time?

The beginnings of an answer, at least, can be found in the volume brought together by the psychologist William Hirst: *The Making of Cognitive Science. Essays in Honor of George A. Miller*. The volume makes it clear that George Miller has done at least as much as anybody else to establish cognitive science as a fild of research in its own right. As he himself formulated it in 1979: “I have been working toward a cognitive science for about twenty years before I knew what to call it” (quoted from Hirst, p.vii).

The Hirst volume is divided into six parts, covering some of the stages on the way towards the kind of cognitive science we have today. *Part 1*, “Mathematical Psychology”, deals with Miller’s work in the Psychological Laboratories at Harvard in the late forties and fifties. Immediately after the publication of Shannon’s mathematical theory of communication, Miller started applying it in psychology. The best-known result of these efforts is probably Miller’s paper “The magical number seven, plus or minus two: some limits on our capacity for processing information”. The paper was read to the Eastern Psychological Association in 1955, it was published in the *Psychological Review*

in 1956, and some twenty years later it had become the single most often quoted paper in cognitive psychology. “Every student of cognitive psychology has been exposed to it, and many psychologists, including myself, have been profoundly influenced”, to quote from one of the commentators in the present volume (George Sperling, p. 71).

Part II, “The Center for Cognitive Studies”, and *Part III*, “Psycholinguistics”, deal with aspects of the work done in the sixties in the Harvard Center for Cognitive Studies. The centre was founded by George Miller and his colleague Jerome Bruner in 1960, and quickly became a centre for interdisciplinary work. The advisory board included people like W. V. Quine, the philosopher; Roman Jakobson, the linguist; Roger Brown, the psychologist and linguist; H. Stuart Hughes, the historian; Fred Mosteller, the mathematical statistician; and John Carroll, the educational psychologist. The list of fellows in the first few years included names like Noam Chomsky, Roman Jakobson, Nelson Goodman and Benoit Mandelbrot, amongst others.

In *Part IV* of the Hirst volume, entitled “Studying the lexikon”, the one-sided interest in syntactical matters has been abandoned in favour of the exploration of semantical issues. We have now arrived at the seventies, and the scene has shifted from Harvard to Princeton and The Rockefeller University. In *Part V*, “Cognitive neuroscience”, we find Miller taking part in the foundation of yet another research programme and in the formation of another research institute, the Cognitive Neuroscience Institute at Cornell University Medical College, together with the neurologist Michael S. Gazzaniga. And in the *last part* of the book, with the title “Cognitive science”, we find the philosopher Gilbert Harman describing how he and George Miller formed a Program for Cognitive Science as well as a Laboratory of Cognitive Science at Princeton in 1986.

The volume as a whole is a rather delightful mixture of anecdotal material and fairly heavy-going summaries of a number of research projects. George Miller, the central figure in this account of the rise of cognitive science, emerges as a lively and energetic researcher, always on the search for new mathematical tools of psychological research. Jerome Bruner characterizes him in the following way: “George Miller’s genius (whatever else may constitute it) rests upon an uneasy susceptibility to troubles in the domain of the epistemic. It is like an allergy. Let there be a pollen of doubt in the epistemological atmosphere, and he sneezes. But that does not capture it. It isn’t that he sneezes. He moves to where theaction is” (p. 92).

The development sketched by the contributors to the Hirst volume can be described as a drama in three acts: first, the demise of behavourism in psychology and early attempts to fill the resulting gap with research programmes based on mathematical information theory; then a number of attempts to create a scientific psychology based on recent developments in linguistics (transformational grammar etc.); and lastly, attempts to integrate psychology into a wider framework referred to as “cognitive science”. The key word here is “science”. Behind the successive efforts to create a scientific psychology lies a certain kind of ideal of science, a vision of an experimental science based on mathematical models. The field of research which is called “cognitive science” today would, however, seem to be an expression of hope rather than a description of

achievements. T quote Gilbert Harman, the area called “cognitive science” forms “a significant pattern of interaction” rather than a resaerch tradition based on shared paradigms (Hirst, p. 265ff).

Margaret Boden’s *Computer Models of Mind* is based on the same ambition to create a truly *scientific* psychology. Her book is a survey of the field which she refers to as “computational psychology”. Computational psychologists are said to share at least three assumptions: The assumption that every psychological phenomenon is generated by some effective procedure, some precisely specifiable set of instructions defining the succession of mental states within the mind; the assumption that the mind can be conceived of as a representational system seeing psychology as “the study of the various computational processes whereby mental representations are constructed, organized, interpreted, and transformed”; and the assumption that neuroscience can be handled in a computational way (“asking what sorts of logical operations or functional relations might be embodied in neural networks”) (Boden, pp. 5-6).

The survey of the achievements and prospects of computational psychology thus delimited falls into three parts: first, there is a couple of chapters on vision, then there are two chapters concerned with language-understanding (both syntax and meaning are dealt with), which leads on to two more chapters concerned with problem-solving and learning. In a final chapter, the question “Is computational psychology possible?” is raised, discussed and answered (in the affirmative).

The various chapters are all very clear and precisely formulated, and include sensible, critical assessments of what has been achieved so far – which is, after all, not that impressive to those who are not part of the game. But Margaret Boden ends on a cautiously optimistic note: “if the excessive optimism of the honeymoon period (thirty years ago) has been tempered by experience, that also was only to be expected … Confidence, rather than mere hope, is the attitude appropriate to future partnerships of like kind”, as she puts it on the last page of the text (p. 264). Indeed, she sees the computational approach psychology as the only possible one. “If a psychological science is possible at all, it must be capable of being expressed in computational terms.” And as a result of her survey, she asserts that “attention to precise theoretical detail is not a passing fancy, a trendy fad …, but an endurable contribution to psychological science. It has provided a standard of rigour and clarity which must make us permanently dissatisfied with less” (p. 262).

Given this ideal of science, with its emphasis on computability, mathematical rigour and precision, D. Marr’s work on vision stands out as the paradigm par excellence (*Vision: A Computational Investigation into Human Representation and Processing of Visual Information*, 1982). According to Marr, an adequate psychology must consist of work on three interrelated levels. The most abstract level (which he referred to as the “computational” level) consists of a mathematical characterization of the task to be investigated, “an abstract formulation of the information-processing task which defines a given psychological ability, together with a specification of the basic computational

constraints involved") (Boden, p. 50). The second ("algorithmic") level consists of a specification of how the task is actually performed in human beings (or animals, if that is the field of investigation). The third level ("the hardware-level") is concerned with the neural mechanisms which embody the functions specified at the other two levels. This kind of schema is the backbone of the scientific psychology Margaret Boden is hoping for. Again and again, she emphasizes the need for task-identification à la Marr; again and again,she emphasizes the need for rigorous formulations (by which she means mathematical or logical formulations) and the necessity of experimental testability. Not that she is prepared to swallow the details of Marr's own theory of vision, for instance. Marr suggests that the basic task of vision is 2D-to-3D-mapping, without even reffering to the eye in his abstract delimitation of the task of vision. As Boden points out, "it is not obvious that Marr's characterization actually does identify the basic purpose for which the visual system has evolved" (in the lower animals, in the highest animals, in human beings) (p. 53). But she endorses Marr's general strategy, which she sums up succinctly in the following way: first you derive psychological hypotheses from highly abstract (and optimal) mathematical criteria, and then you modify them by physiological or psychological knowledge (p. 60).

Boden is very good at raising questions. Most of the chapters begin with a series of questions which inform current work on vision, language understanding, problem solving etc. In the chapter on "parsing natural language", she starts off with questions like the following: Are syntactic transformations necessarily involved or not when we understand a simple sentence like "Just off to buy Ruskin's birthday card"? Does the hearer assign a syntactical structure to every sentence, including this one? If so, is the syntactic analysis made before the interpretation of the words in it, or are syntax and semantics employed simultaneously? And what does one understand about the speaker in understanding his or her words? And so on.

In general, it would seem that the questions are much bigger than the answers provided by computational psychology. This might lead to cautious optimism with regard to future achievements (as in Boden's case). ("As for specific theories, we have seen that current computational approaches will very likely not suffice, and that different types of models will be developed in the future" (Boden, p. 264). Or, alternatively, this might lead to cautious pessimism with regard to the adequacy of the kind of ideal of science which informs the whole field of computational psychology and probably the whole field of cognitive science at the present. After all, syntactical and semantical analysis of the kind which can be performed by a suitable computer programme is a rather far cry from the cultural understanding involved in our everyday understanding of a sentence like "Just off to buy Ruskin's birthday card". In order to understand a sentence like this, you have to be familiar with a number of cultural practices (like our birthday celebration institutions) and their place in the wider setting of our form of life.

Instead of dogmatic pronouncements on these issues, I should like to end these reflections on the state of the art of computational psychology and suchlike with two or three questions: To what extent can man adequately be regarded as an information-processing being? What else are we? And to what extent can we adequately describe and explain

ourselves if we restrict ourselves to the kind of ideal of science currently informing the field of cognitive science?

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