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**Review of Margaret Boden,
'Mind as Machine: A History of Cognitive Science'**

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Margaret A. Boden, *Mind as Machine: A History of Cognitive Science*, 2 vols., Oxford: Oxford University Press, 2006, xlvii+1631, cloth \$225, ISBN 0-19-924144-9.

1.

Mind as Machine is Margaret Boden's opus magnum. For one thing, it comes in two massive volumes of nearly 1700 pages, in large format and densely printed—the whole must be around one million words. The bibliography alone, modestly entitled "References", is 130 pages long with over 4000 entries. (One hopes it will be made available online; perhaps together with Chrisley 2000.) But it is not just the opus magnum in simple terms of size, but also a truly crowning achievement of half a century's career in cognitive science. We must be grateful that someone of Boden's standing actually got down to write up systematically at least a little part of what she has learned, to pass it on to us. And we must be grateful that she has so much to say. Anyone will profit from the clarity in context that Boden provides. Her impressive learning is evident at every turn, everything is deeply understood and thought about, almost everything important seems to have been read and incorporated, down to very recent and still forthcoming literature—this is not a history of things past but an overall account of the discipline as it stands now.

2.

So much for the good news. The bad news is that this is not a book for you. Neither is it for me, or for anybody else, in a word: it is not a book for readers. Not that it is badly written, quite the contrary, the prose flows with an ever so professional eloquence. The problem is that no-one, neither the author nor the press, has really considered the question who should read this and why.

For one thing, you cannot read it whole because that's too much, but neither can you read it in parts, since you will not find a section on a particular issue you are interested in—though you will probably be able to locate relevant parts with the help of the subject index and the extensive cross-references.

You cannot say that you have not been warned, however, the book starts with the remark: "This is a historical essay, not an encyclopedia: it expresses one persons' view of cognitive science as a whole." (xxxiii) Boden writes down what she wants to say, not what people might want to read. Fair enough.

The book is organized in two volumes and 17 chapters. After a preface with an autobiographical sketch, the first chapter introduces the problems and the next three chapters chart the development of minds in machines from early automata to computers and other cybernetic mechanisms. Chapters 5 and 6 set the theoretical stage for the possibility of a cognitive science proper, from where we move on to three chapters on core disciplines of cognitive science: cognitive psychology, cognitive anthropology and cognitive linguistics. The second volume starts with a discussion of classical AI in chapters 10 and 11, then two chapters on connectionism and the attempts for a unified AI. Chapter 14 takes a deep breath and looks at the neurosciences, followed by a chapter on A-life. The last full chapter on the philosophy of cognitive science is followed by an outlook in chapter 17 "What's Next?"

The overall structure is thus a pre-historical start and then a separate treatment of each sub-discipline—each of which is not chronological but rather organized around central ideas and their emergence. In her introductory discussion of the problem of organizing the book (p. xxxiii-xxxvi), Boden does not tell us what structure she settled for, and why. Perhaps this is indicative of a deeper problem of a lack of unity and a single thread to follow (which explains the many cross-references). What were the other options? Presumably one could have structured chronologically or thematically as well. Both of these have obvious problems in a history of cognitive science, so to a large extent the jungle that Boden presents us with is just how things are—and she hasn't found a machete or a map but rather takes us through the place on many crisscrossing little paths.

To walk along on these paths of the "historical essay" is highly entertaining and at every turn there is something to discover with a guide like this; there is interest at every branch and leaf of the jungle. And there is occasion for many anecdotes and asides on matters that had to be said, for some reason.

For example, chapter one sets the scene and Boden says she hopes every reader will read this chapter completely (p. xxxiv). So we get an introduction to "Mind and its Place in Nature" and to "The Scope of Cognitive Science", which is probably what we were hoping for. But the next 30 pages, two thirds of the chapter, are an essay on the philosophy of the history of philosophy (including asides on funding of arts in the US and other matters). For whom?

Generally, one often feels not so much guided through the jungle but rather just walking along the author talking intelligently to herself. There is often no helping hand for the ignorant reader; there is no overview, no timeline, no recommended literature, no reference to other historians, etc. The structure must be discovered by the readers; sometimes it is actually hidden deliberately. Try to guess what is discussed in the chapter with the following section headings: 'Lighting the Fuse', 'Infant Implementations', 'Attack Without Apology', 'Lamps Invisible', 'Behind the Scenes', 'Centre-Stage', 'The Worm Turns', 'A la recherche ...', 'Still Searching', 'Philosophers Connect'. Now, what is it? Of course, it's Connectionism! Perhaps the last one gives it away, but are these useful headings for the reader? (Chapter 11 was 'Of Bombs and Bombshells' and 13 will be 'Swimming Alongside the Kraken'—elementary!) You can see the table of contents online at <http://fds.oup.com/www.oup.co.uk/pdf/0-19-924144-9.pdf>

3.

So, what is it that holds the history together? Boden endorses the tradition that defines the cognitive sciences with the help of *computational* concepts, but I wonder how sustainable that idea really is, today. The only precise notion of computation is that of algorithmic digital computation, covering all and only the Turing-machine computable. But, as Boden herself notes, this "doesn't cover cybernetics, nor even connectionist AI"; so, she proposes to use a "wider notion" (p. 13), and even suggests that it is silly to limit computing to Turing's notion: "To restrict 'computation' or 'cognitive science' only to Turing computation and GOFAI is as unreasonable as restricting 'physics' to the mathematics available to Galileo." (p. 1418)

But is there really a wider notion that is still a computational notion and that can serve as a foundation for the cognitive sciences? There are way too many senses of "computation" floating around. (I counted 9 different ones even in an exchange between Pinker (2005) and Fodor (2005), for example.) Boden's (second) alternative proposal is that computing is "whatever methods are actually used in computer modeling" (p. 1416)—which sounds circular. The third proposal she

herself admits to be the most unclear: "to present computation as intentional, and meaning as computational" (p. 1418). Is there anything better?

A popular idea is that computing is somehow "information processing". But information processing could take many forms, some of which are not digital computation. So, what distinguishes computation from other forms of information processing—some of which may even be input-output equivalent? Surely this must be the mechanism by which it achieves that processing: namely computation. The only other option is to declare that computing and information processing are one and the same. But then, as in any very wide notion, one is faced with the prospect of pancomputationalism, the idea that everything is a computer (see, for example, Dodig-Crnkovic 2007). The dilemma is that the thesis "the mind is a computer" becomes trivial if understood with pancomputationalism, and not generally shared (in fact false, in my opinion) if understood as digital computation.

What remains of computing in the wider sense beyond digital algorithms is really the mechanical procedure, the machine. That idea that "Maybe Minds are Machines too" (ch. 4; p. 168ff) may have been revolutionary at a time, but is it not too broad and too banal to do a job by now? Boden does not think so: "... the huge attraction of the field [cognitive science] lies largely in its promise to help solve one of the greatest philosophical puzzles of all: the mind-body problem." (p. 1337; cf. p. 8f)) But what is that problem supposed to be, after the death of dualism and behaviorism? To be sure, there are many interesting problems in this vicinity, such as how thinking one thing can cause me to think another ('mental causation'), or how my knowing that I have an experience relates to my having it; but one overarching problem? If there is a puzzle, then it is how certain natural systems bring about certain properties, but that's not a philosophical puzzle; it is a conventional research program, not different, in principle, from any other.

To sum up: the computer metaphor will not hold the cognitive sciences together. In a narrow sense, much of cognitive science has nothing to do with computing, while in a broad sense of "mechanical" the computing metaphor is nothing special to cognitive science. It is used everywhere, from cell biology to economics: everything is computing.

4.

Cognitive science is dead, long live cognitive science! The various disciplines will split into an interdisciplinary cooperation (perhaps rather like the social sciences). Look at what is happening at CogSci conferences: cognitive psychology with a

decoration of some other disciplines. The Neurosciences have long found their own turf and confidence, they only need occasional contact when things are to be interpreted on a higher level. Linguistics and Anthropology have taken what they needed from the cognitive turn and carry on. AI has become a successful engineering discipline, largely detached from any cognitive ambitions—though these are still hovering around and may come back once one is able to do more. And Philosophy? Well, as Fodor and LePore said (about semantics) the “terms of the agreement are” that the others “do the work and the philosophers do the worrying.” (1991, p. 329) (I am from that camp myself, I hasten to add). So, the philosophers have an interest in an encompassing discipline to worry about, and the psychologists in one that they can own, but the other disciplines will remain just loosely connected.

This does not mean there is no cognitive science; we should rather continue the excellent trans-disciplinary cooperation that has worked so well for decades. It certainly does not mean that the lack of coherence is something Boden should have resolved. What it indicates, however, is that one cannot just assume that the extant coherence of the discipline will take care of the coherence of a book on its history. Boden’s opus magnum definitely gathers the many strands and allows a deeper understanding of the family resemblance, but it ultimately struggles with the loose ties that hold the family together.

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