computing. Yet, it is an absorbing snapshot of a particular subject's influence in the evolution of science, engineering and technology of computing! It is a book that can be read by the informed; it needs to be studied by those who want to be informed—rather like a box of assorted chocolates for schooling a gourmet's palate. For those who wish for a guide, *Essays in Computing Science*, edited by Hoare and Jones, published in the same series, provides the origins of the flavours embellished in this assortment.

This book contains invited contributions from 25 eminent computing professionals, as a collective offering of tribute to Professor C. A. R. Hoare on his sixtieth birthday; they all have either collaborated with him, or have been deeply influenced by him—the associations range between 15 and 40 years.

Only two articles, respectively by Jackson and Welsh, are entirely informal in their presentation; both deal with concerns in software development processes, applicable in industrial contexts, in terms of scale of effort. They are full of insights for the practitioner. The rest require increasing appreciation of mathematics in the service of formal clarification of the nature of computing, a constant in the classical pursuits of Hoare.

Four papers, those of Brookes, He, Roscoe and Stoy, build with Hoare's Communicating Sequential Processes (CSP) to respectively deal with fairness, hybrid systems, model checking and providing semantics of a dataflow language. The papers of Abramsky and Jones extend process algebras in different directions; Dahl and Lamport separately deal with shared resources in concurrent computations. Rabin and Lehmann revisit the Dining Philosophers Problem infusing symmetry in a fully distributed solution. On a separate track, the papers of Lampson and May deal with design of computing technology. All these papers deal with parallelism in different forms.

The papers of He and Zhou present different ways of dealing with hybrid systems, common in engineering systems; both have roots in Hoare's early contributions in this area. Two papers, of Hehner and Gordon, relate computing with the passage of time, using Hoare-Logics in different ways.

Hoare's diligence in designing good notations is motivation for several contributions. Dijkstra presents several examples which bring out the inevitability of design choices in well-designed algorithms, noting that the supposed complexity of understanding imperative computation is superficial, for it is actually minimal in the illustrated cases. Power series abound in complexity studies and Knuth explores a notation for coefficients of their terms to facilitate their manipulation. Misra explores notation for describing synchronous parallel algorithms in a recursive style which is still amenable to efficient implementation on given interconnection networks.

Having started with an axiomatic basis for imperative programs, Hoare went on to define data abstractions in that framework. His work on correctness of data representations and his subsequent work in algebraic formulation of properties of notations for computing (and illustrations of the value of category theory for further refinement of this understanding) are reflected in three papers dealing with data abstraction. Burstall and Diaconescu look at hiding and locality of behavioural specification of objects using category theory. Goguen and Malcolm do so too. Tennent explores the difficulty of proof of correctness of data representations in Algol like languages.

Two papers, by Bird and de Moor and by Morgan respectively, look at calculi for derivation of programs. Gries derives a version of Quicksort using his idea of coordinate transforms to layer design decisions relating to representations (and discovers that the engineering he had hoped for in this version eludes him; instead, Hoare's original version performs better!).

Bjorner presents a model-based formulation of geometry and kinematics in VDM.

For most people, including this reviewer, this is a book to study—for it presents hooks into the many directions of research on the semantics of computing. That Hoare should be in the thick of all these movements is testimony to his insight in being right the first time, so many times. His classicism, commitment and humanity come through all the dedications and acknowledgements in these papers. Indeed, they have been felt by all who have come into contact with him. One can only be enriched by such exposure, and become better by attempting to imitate and emulate his work.

I'm sure that all of us who have had good fortune to be influenced by him join in this salute on this occasion, and, as Milner says in his Foreword to the book, look forward to more insights and delightful reading from him in the years to come.

KESAV V. NORI
*Tata Research Development and Design Centre
Pune, India*

BARBARA VON ECKARDT
What is Cognitive Science? MIT Press. 1993. ISBN 0-262-22046-6. $47.50. 466pp. hardbound.

The book discusses the question given by the title in 9 chapters. Chapter 1 sketches what is called research frameworks and describes what is taken to be a characteristic contribution to the field of cognitive science, work on human imaging by Kosslyn and others. Chapters 2 and 3 present what is proposed to be the research framework of the field in terms of its domain and what is called the computational assumption. Chapters 4–8 discuss what is called mental representations, first in relation to representations quite generally and then with a view to Peirce's theory of signs. Chapter 9 relates the field to other fields, such as neuroscience.

As one approach to the main question the author spends long chapters in trying to answer such questions as: Is there an agreed Research Framework of Cognitive Science? Clearly the idea is that the establishing of such a framework is required in order to make whatever is done by people who say they work in cognitive science scientifically respectable. The trouble is that this idea lacks support in the facts of scholarly/scientific activities. Quite commonly significant scientific contributions do not place themselves within any particular 'field' or 'science'. As just one example, where did Watson and Crick's work on the structure of DNA belong, in chemistry, or in biology, or in genetics? No one can tell; the question is insignificant.

Similar insignificance is found for issues of detail. For example, on pages 50f the so-called substantive assumptions of the field are spelled out in terms of four statements and several constraints given by a number of distinct properties. But then it is immediately said that 'it is characteristic of empirically oriented work in cognitive science ... that fundamental theoretical notions are often used without being explicitly explicated or grounded in a foundational way.'. Thus the question of substantive assumptions is explained to be just insignificant.

The discussion comes closer to being interesting where cognitive science is said to be concerned with describing cognition in terms of computing. However, again the attention is directed into some barren areas. Some of them relate to the issue of 'mental representations'. Here the author spends much effort and many pages on trying to draw on Peirce's general ideas of signs. However it seems rather obvious that this theory, which has at its core the three separate items, sign, interpretant, and interpretation, cannot be helpful in case of whatever may be meant by mental representations, where the sign and the interpretation, whatever they are and assuming they could be distinguished, are taken to be items of the same person's stream of consciousness. Another barren area is the author's lengthy hairsplitting argumentation around senseless scenarios, so-called thought experiments.

The inconclusiveness of these discussions suggests that the root of the difficulty is the computer inspired adoption of a notion of representation as the core element of descriptions of mental phenomena. This difficulty is closely related to the problem of meaning in linguistics. Such a view of the situation seems beyond the horizon of the author, however.

A more interesting issue is the aspect of the world that in cognitive science supposedly will be described in terms of computing, called cognition. However, this is hardly touched at all; apparently it is taken to be too obvious to deserve even the scantiest description. Further it is taken to be obvious that whatever is meant by the word cognition can be investigated without any attention to 'human phenomena other than cognitive (such as the emotions)', and it is assumed that it makes obvious sense what shall be meant by cognition in a machine.

All these assumptions seem to this reviewer to be entirely problematic. More particularly I find it unacceptable that serious discussion of cognition, supposedly an aspect of mental life, is conducted without explicit placing of that aspect in the context of mental activity more generally. An obvious such context is presented by William James in his *Principles of Psychology* from 1890. But such context is ignored by the present author.

In trying to characterize what it means for a 'theory' to be computational the author discusses the idea of data structures. The clarification fails, however, first in the paraphrase of Wirth's description of the structures of Pascal, which suffers from confusion of such notions as dimensions, and then again in the attempt to accommodate connectionist machines, which concludes in an open question.

Much of the discussion is centered around crucial formulations around the word 'is', typically in what is called the linking assumption C1 on page 50: 'The human, cognitive mind/brain is a computational device (computer);'. The author appears not to have noticed that, 'is' being the most ambiguous word of English, confusion will often ensue when it is used in a scientific context. Thus the present example most likely will be taken by the ordinary reader to express a metaphysical doctrine, and thus perhaps be beyond what is intended by the author. If instead the phrase is taken to be descriptive, i.e. if 'is' is taken to stand for 'may from a certain point of view be described as', what looks like a major problem of metaphysics dissolves into useful sense.

The most interesting part of the book is the account of the results achieved by Kosslyn and associates, which indicates that successful description may be obtained by the sort of approach discussed in the book. It would have been preferable to have accounts of many more such projects, instead of the metaphysics and the excursions into doubtful theories of science. The sort of restrictions discussed in the book may perhaps be useful in focusing the effort of particular research projects. Taken as prescriptions or criteria of projects they can only lead to barren sectarianism.

PETER NAUR
University of Copenhagen

HOJJAT ADELI AND SHIH-LIN HUNG
Machine Learning: Neural Networks, Genetic Algorithms and Fuzzy Systems. John Wiley and Sons. 1995. ISBN 0-471-01633-0. £36.95. 211pp. hardbound.

There is a current explosion of growth in the number of books being published on Neural Networks and Machine Learning. A situation has arisen which is similar to that which existed 10–20 years ago concerning introductory books on Computer Science. Nearly all of those books contained much material explaining the binary arithmetic system and elementary set theory. There was great repetition and not much cross referencing.