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ELSGML 2001/04/10 Prn:25/04/2001; 11:44 by:ML p. 1

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Book Review

Cognitive Science: Real or Imaginary?: Review of *The MIT Encyclopedia of The Cognitive Sciences* edited by Robert A. Wilson and Frank C. Keil ☆

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In the late 1940s, through the initiative of John Bates, a group of mainly young physiologists, engineers and mathematicians founded a select dining club in London to discuss ideas and issues relating to Cybernetics. The Ratio Club, as the group became know after the second meeting, normally gathered in a room in the National Hospital where, after a meal and drinks, participants "... would turn in their easy chairs towards a blackboard where someone would open a discussion ..." [2]. Members included Alan Turing, Grey Walter, W. Ross Ashby and Horace Barlow who all made major contributions to embryonic AI and/or neuroscience. Bates was no doubt spurred into action by the very recent publication of Norbert Wiener's *Cybernetics* [20], although only "those who had Wiener's ideas before Wiener's book appeared" qualified for membership of the club [2]. While the British and American Cybernetic movements developed in parallel, and to some extent independently (Ashby had been publishing formal theories of adaptive behaviour since 1940 [13]), they had in common a very strong commitment to interdisciplinarity. The explicit goal of the British movement, to a large extent shared by their American colleagues, was to understand the mechanisms underlying the production of adaptive behaviour in animals and humans; to lay bare the workings of central nervous systems. This, they believed, would involve the development of formal theories of intelligence and cognition. A central tenant of the Cybernetics movement was that this task was best approached by merging ideas from biology, engineering and mathematics in a cooperative attempt to build new and powerful conceptual frameworks. Crucial to this endeavour was the conviction that animals, including humans, should be understood as adaptive machines and that solutions to the problem of how brains produce adaptive behaviour would necessarily entail (at least implicit) specifications for building artificial brains. As well as being potentially useful, these artificial brains would be used to test theories [14].

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0004-3702/01/$ – see front matter
PII: S0004-3702(01)00097-2

S0004-3702(01)00097-2/SSU AID:1815 Vol.●●●(●●●) AIJ1815 P.2 (1-4)
ELSGML 2001/04/10 Prn:25/04/2001; 11:44 by:ML p. 2

The very field of study, the explicitly interdisciplinary approach, and the central role of mechanistic machine-testable theories and models, all mean that Cybernetics largely prefigured not only AI, but Cognitive Science. For what is Cognitive Science, or The Cognitive Sciences, that it or they deserve or need a label separate from their constituent disciplines, if not to emphasise interdisciplinarity, shared questions and shared frameworks? Of course Cybernetic work tended to be couched in terms of information theory, dynamical systems and other related mathematical formalisms [15,18], with major concerns including the development of adaptive systems based on self-organisation and brain-like mechanisms [12,18], and the construction of whole artificial creatures behaving in the real world [19]. After years of neglect, following the almost total domination of representational symbol processing approaches, all of these themes have re-emerged very strongly in contemporary AI and Cognitive Science [3–5,11,17] giving the field new impetus and direction. There are now real opportunities to be exploited as AI and Neuroscience show signs of some convergence and even serious engagement [1]. However, although the interfaces between traditionally defined scientific disciplines have often proved profoundly fruitful, interdisciplinary research programmes are not easy to maintain given the natural burrowing tendency of most scientists and the many barriers that tend to grow up between research areas. Which is where *The MIT Encyclopedia of The Cognitive Sciences* (MITECS), edited by Robert A. Wilson and Frank C. Keil, might come in as a useful resource.

The Encyclopedia is available in several formats: a thousand pages plus breeze block of a book, a CD ROM and a web-site. The editors have decided to carve up the Cognitive Sciences into six sub-fields: Philosophy, Psychology, Neurosciences, Computational Intelligence, Linguistics and Language, and finally Culture, Cognition, and Evolution. The book is organised around 471 cross-referenced alphabetically arranged short articles preceded by longer introductory essays on each of the six sub-fields. The essays are written by the volume's advisory editors while several hundred authors, most well know in their own areas, have contributed the short articles.

Such a project is clearly a massive undertaking, so what is the point? Why pull this great mass of diverse material under one roof? In the preface Wilson and Keil list their three main objectives. The first is to fill what they perceived was a gap for a single work covering the full breadth of the Cognitive Sciences. The second is to represent the diversity of positions and changes in focus found across the range, and throughout the history, of the constituent disciplines. The third is to highlight links between the various Cognitive Sciences; to try and capture 'a rich and multidimensional landscape of interconnected ideas'. Apart from the laudable educational aspects of these objectives, there are more complex undercurrents. An underlying motivation seems to be to demonstrate that while there are genuinely cooperative interdisciplinary attempts to understand various facets of cognition, there are many areas where individual cognitive sciences operate independently, seemingly ignorant of each other. Hence an important implicit aim of the project, although unspoken, must be to catalyse and encourage new strands of cross-disciplinary research.

The academic Cognitive Sciences market is already well served by various in-depth and authoritative overview cum reference works. Osherson's *Invitation to Cognitive Science* series [9], comprising a wide range of medium length essays, Richard Gregory's now aging but still very readable encyclopedia format *The Oxford Companion to The Mind* [8],

S0004-3702(01)00097-2/SSU AID:1815 Vol.●●●(●●●) AIJ1815 P.3 (1-4)
ELSGML 2001/04/10 Prn:25/04/2001; 11:44 by:ML p. 3

Gazzaniga's edited collection of essays *The New Cognitive Neurosciences* [7] and Michael Arbib's excellent *The Handbook of Brain Theory and Neural Networks* [1] all spring to mind. So what is different about MITECS? It is unique in its combination of enormous scope and easy accessibility: the articles are generally very concise, provide useful lists of references and are written for specialists and non-specialists alike. The introductory essays are useful in their own right, giving even-handed sensible overviews of their areas, while a noticeable effort has been made to provide historical context and point out interdisciplinary links. The web-site version of MITECS also has some interesting advantages as a research resource. Hyperlinks are a very convenient way of following article cross-references and useful additional links to other related web-sites have been placed at the end of many of the articles. The web-site is also organised differently from the book—rather than being presented as one alphabetically ordered block, the entries are divided into six subsections, corresponding to the sub-fields marked by the introductory essays. This acknowledges, perhaps, that entry into the material is usually from the standpoint of a particular discipline. It certainly makes exploratory browsing easier.

Despite a clear and successful editorial effort to make the vast majority of entries in MITECS accessible across disciplinary divides, many articles are written from far too insular a perspective. Too often major interdisciplinary connections are missing, diminishing the most important potential outcome of the project: to facilitate cooperative multi-perspective work—to help keep the cognitive science movement alive. For instance, the entry on naïve physics is written entirely from a psychology perspective, with no reference to the considerable amount of related work in AI. The multisensory integration article is an informative overview of mainstream neuroscience findings and positions, but makes no mention of related issues in AI and robotics. Finally, to pull out another example at random, the entry on multiagent systems is a good introduction to the work of the distributed AI community, but misses an opportunity to point out relationships with work in Artificial Life and Theoretical Biology. The frequency of these missing links is high enough to provoke the suspicion that few scientists working in the areas covered by MITECS are practicing interdisciplinarians, and indeed that the very idea of The Cognitive Sciences is more about potential than reality. I believe that this potential is worth pursuing and, despite its flaws, recommend MITECS as a very useful research resource.

More than a decade ago, in his fine exploration of the then burgeoning cognitive science movement [6], Gardner asked if neuroscience would devour the entire field. His answer was no, for the same reasons that he could see no prospects for a single unified discipline: there will always be separate subject areas, we will always need diverse multi-level descriptions and explanations. However, each of the sub-fields must be open to enrichment, and even fundamental change, by allowing tools, metaphors and concepts to cross the disciplinary boundaries. This is exactly what happened in a very deep way half a century ago under the umbrella of the Cybernetics movement. The courses of Neuroscience, AI and Computer Science were significantly formed from within that rich cross-fertilising group. The recent surge in discoveries and new understandings coming from within the ever growing field of neuroscience is starting to reveal a complex picture involving subtly interwoven electrochemical processes employing various levels of modulation and reconfiguration [16]. It is a picture that I believe can only be brought into focus through the cooperative efforts of experimentalists and modellers [10]. Such collaborations are already providing

S0004-3702(01)00097-2/SSU AID:1815 Vol.●●●(●●●) AIJ1815 P.4 (1-4)
ELSGML 2001/04/10 Prn:25/04/2001; 11:44 by:ML p. 4

new insights and methods for the AI effort [1], and may finally expunge the over reliance on computation as a framework to understand and build intelligence. More than fifty years ago, the core members of the Ratio Club believed the central problem in understanding intelligence was that of unravelling the mechanisms underlying the generation of adaptive behaviour, and that this could only be done in an interdisciplinary way. This surely remains true, but the opportunities are far richer today.

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