WAYS OF THINKING: The Limits of Rational Thought and Artificial Intelligence, László Méro, Singapore, World Scientific Publishing Co Pte Ltd, 1990, 235 pgs plus bibliography and index. ($24US).

We use it for everything: writing programs, planning programs, ie, everywhere where creative thinking is to be organized and subsequently the result should be applied to practice.' Even more: 'With the aid of expert systems, the mentally handicapped children will become clever, complex diseases can be diagnosed, the United States will seize world power and escape nuclear catastrophe'

'If the king is the fifth generation of artificial intelligence, then he is stark naked, at least to his ankles, but below his ankle he wears a pair of highly polished decorative shoes called expert systems.' Even more: 'At present the expert systems on the market contain no artificial intelligence whatever.'

These two contrasting sets of evaluations suggest that opinion is considerably divided about the promises and limitations of artificial intelligence. This very readable and highly enjoyable book explores the arguments and issues underlying the debate about the efficacy of artificial intelligence. The book will be of great interest, not only to computer scientists, mathematicians, engineers, psychologists, philosophers, biologists, and other experts in the field, but also the person without any background in computer science.

The author is an Associate Professor at Lorand Eotvos University in Budapest, Hungary and has spent over a decade in various artificial intelligence projects. In recent years and having experienced some persistent limits in the standard methods of artificial intelligence, Professor has in recent work and in this book turned his attention to human thinking and cognitive psychology. Consequently, he has since 1984 been at the Department of Experimental Psychology where his research has focused on physophysics and the analysis of human thinking and decision-making procedures.

WAYS OF THINKING is divided into three parts: 1) the diversity of thinking; 2) the building blocks of thinking; and 3) the strength of diversity.

Chapter 1 utilises a number of very interesting examples to illustrate the similarities and differences between the formal logic of computers, everyday logic utilised in working out real-life problems, gender differences in thinking, and 'trance' logic or the mechanisms of reasoning observed in altered states of consciousness.

Chapter 2 is entitled 'Common sense' and it demonstrates how even the most simple, common sense human activity is inherently complex as demonstrated by attempts to replicate such activities using artificial intelligence. Included in the examples are Joseph Weizenbaum's program called ELIZA which was designed in 1966.

'The learning component of ELIZA contains a collection of patterns and a collection of answers corresponding to the patterns. The answering component analyzes the text written by the conversational partner, and tries to fit it into one of the elements of the collection of patterns. When the program has finished that, it replies to the partner with one of the answers belonging to the given pattern.'[1]

Despite the fact that the program could produce some amazingly lifelike conversations, its inventor remains today one of the harshest critics of artificial intelligence.

Where ELIZA attempted to mimic normal conversation, Kenneth Colby's PARRY attempted to simulate the insane mind rather than the normal one. Despite fooling a number of practicing psychiatrists, PARRY was no more successful at simulating the abnormal mind than ELIZA was at simulating the normal one. Méro concludes that the important lesson to be learnt from these experiences is 'how easily we can see meaning in something which has none. It seems to be an important characteristic of our intellect that we project it to anything we possibly can.'[2] As such, these AI programs say more about the nature of human beings than they do about the possibilities of AI.

Chapter 3 is entitled 'Puzzles and Science'. The author uses the analogy of a puzzle to introduce Kuhn's *The Structure of Scientific Revolutions*[3]. While searching for scientific knowledge is much akin to searching for the solution of a puzzle, it is also true that existing paradigms predispose us to look for answers in particular places.

Basically, science behaves as the drunkard who is intensely looking for something under the street lamp. Asked by a policeman what he is looking for, he says that he has lost his keys further up in the dark alley, and is looking for them. "But why are you looking for them here?" --asks the policeman. "Because only here are the lights on!."

Still the behaviour of science is not illogical. Several times we have seen in the history of science that when the brightly lit areas are sufficiently scrutinized, quite good conclusions can be drawn regarding the characteristics of the dark areas as well. As a matter of fact, these conclusions are often better than groping about in the dark.[4]

Chapter 4, 'Ways of thinking in different cultures' highlights the cultural differences in our ways of 'knowing', something which many in the area of AI perhaps fail to take sufficiently into account.

The ways of thinking in different cultures differ considerably from each other -- probably this is the reason why they can be so easily caricatured. Where the policemen are British, the engineers are German, the organizers are Swiss, the cooks are Hungarian and the lovers are

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1 p. 27.

2 p. 33

3 T. Kuhn, *The Structure of Scientific Revolutions* (1962) (Chicago, Chicago University Press).

4 p. 41.

French, life is Paradise there. But where the policemen are German, the cooks are British, the engineers are French, the organizers are Hungarian and the lovers are Swiss, life is a nightmare.[5]

As the above quote illustrates, this chapter provides a delightful introduction to the philosophical debate between holism and reductionism. Simplistically put, holists contend that the whole is greater than the sum of its parts. A song is more than a sequence of notes, a cathedral more than a pile of stones arranged in a particular way. Reductionism involves the belief that the whole, while it may be a separate quality distinct from the parts, can nevertheless be perfectly understood by a study of the constituent parts. The basis of most Western science generally and cognitive science (from which derives the artificial intelligence movement) is reductionism. Méro suggests that 'man's everyday thinking is holistic, rather than reductionist.'[6] Moreover, this thinking is culturally diverse (contrast Eastern mysticism with the scientific rationalism of the West). The author queries whether these cultural differences establish limits to the efficacy of artificial intelligence.

Not only does thinking have cultural overtones, but it can also takes place in a 'tangled hierarchy' of concepts. This feature of human thought is the subject of Chapter 5 'Levels of thinking.'

Part II the 'Building Blocks of Thinking' begins with Chapter 6, 'Cognitive schemata'. The human brain is literally bombarded with millions of stimuli. Schema describe a mechanism, possessed by humans, of organising these stimuli into structures which impose some sense and system on incoming messages by choosing to focus on some stimuli and ignoring others. As the author puts it:

There is a saying: I believe what I can see. But the reverse is perhaps even closer to the truth: we can see only what we believe. We are able to perceive whatever our schemata make possible for us. Seeing is believing. Science is no exception: this is how paradigms can guide research.

Bertrand Russell writes in his book *My Philosophical Development:* "It seemed that animals always behave in a manner showing the rightness of the philosophy entertained by the man who observes them. This devastating discovery hold true over a wider field. In the seventeenth century, animals were ferocious, but under the influence of Rousseau they began to exemplify the cult of the Noble Savage. ... Throughout the reign of Queen Victoria all apes were virtuous monogamists, but during the dissolute 'twenties their morals underwent a disastrous deterioration. . .Animals observed by Americans rush about frantically until they hit upon the solution by chance. Animals observed by Germans sit still and scratch their heads until they evolve the solution out of their inner consciousness. I believe both sets

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5 p. 45

6 p. 52.

of observations to be entirely reliable, and what an animal will do depends upon the kind of problem that you set before it.'[7]

While various investigators have created their own separate concepts the schemata share many similarities and often 'may facilitate identifying the thinking phenomena that exist in real life, just as the large descriptive systems of biology have helped identify the newly discovered animal and plant species.'[8]

Chapter 7 is entitled 'The magic number seven' and treats the search in science for organising principles, models which help further our understanding. These models evolve from existing paradigms. One of the models of thinking which has been developed in cognitive psychology is that of man as an information-transmitting device. '[T]echnical sciences have acquired abundant knowledge about similar devices And why not suppose that in this way we can gain deeper insight into the phenomena of human information processing'.[9] The reference in the title to the number seven, refers to the work of G. A. Miller who found that people are limited in their capacity to take in new information to about seven units of information, whether those items be seven words, seven numbers or seven well known phrases. This model of human information processing was further developed with the concept of short term memory and long term memory.

This leads to the question raised in succeeding chapters, 'how many schemata do we have in our minds - in our long term memory? Here the author refers to some fascinating research on the memory of chess grandmasters, who it is estimated, have between 50-100,000 schemata at their disposal. The superior ability of grandmasters lies not in their ability think ahead more moves, nor to think faster. The advantage of grandmasters lies instead in their ability to recognise positions, patterns or schemata from previous games in the chess literature. Remarkably, this number is also the 'same as the number of words and phrases used by the best authors and poets, which is also estimated to be several tens of thousands. the total number of Chines writing characters also fall in this range: it is about 80,000. Only the best specialist (we can say, grandmasters) of Chinese writing know and can actively use most of that total. Thus Méro surmises that

(1.) The amount of cognitive schemata necessary for the different levels of competence can be easily estimated in certain professions, and such estimations result in highly similar orders of magnitude in the different domains.[10]

In the case of the chess grandmaster and the 'grandmaster' in other professions, his or her tens of thousands of schemata is separated from everyday language.

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7 pp. 85-86. in Bertrand Russell, *My Philosophical Development* (1959) (Allen and Unwin), p. 129.

8 PP. 88-89.

9 p. 90.

10 p. 234.

We understand the works of science by the aid of our professional minds and place them in the system of our professional schemata. This is why most professional works are unintelligible and boring for outsiders: they do not understand the language in which it is written.[11]

Some grandmasters, however, rather than being engaged in a particular profession, possess grandmaster level schemata in areas close to human life. The example is given of Don Juan or Casanova who were grandmasters of social contact. This view is also echoed in the recent writing of John Gardner and his theory of 'multiple intelligence'. Also, cultural differences exist and 'the separation of professional and everyday languages is not as pronounced in some cultures, ie 'the enlightened master may feel the unity of the world, and the cessation of every differentiation.'[12]

In Chapter 13 the author further develops the chess example in considering the possibilities of artificial intelligence in the development of chess computers. It seems that the first chess computers offered so much promise that Herbert Simon predicted in 1958 that within ten years a chess computer would be world champion. Yet, here we are in 1991 and despite millions of dollars having been spent to develop bigger, more sophisticated and faster machines, a chess computer has rarely defeated any grandmaster, less more the world champion. Why is it that a chess program can be developed which reaches the level of candidate master, but not the grandmaster level? Méro suggests that:

the main reason of failure may be rather that grandmasters really cannot impart their intuitive knowledge in a formal way. Practically, knowledge engineers ask them to regress to the lower level of when they were only candidate masters and when they were more or less fully aware of what they knew.[13]

In other words, the knowledge of the grandmaster is largely intuitive and based on high level cognitive structures which cannot be recreated by lower order rules. This phenomenon is not only true of chess but appears to hold for all fields of endeavour. Thus, for example, the program MYCIN which gives expert advice in diagnosing and treating bacterial diseases has reached the level of the average general practitioner, but failed to match that of the specialist.

Part III of the book is entitled 'The Strength of Diversity'. Its chapters develop the theme that the strength of rationality is that it appeals to pure reason and is devoid of subjective, emotive, intuitive and irrational elements. Mankind, however, is not a creature of pure reason and our higher order schemata are owe more to mystical than rational elements. Thus, there exists at the highest meta-levels of human cognition an amazing commonality between an Einstein and a William Blake, between the scientist and the poet, even though their fields of expertise appear worlds apart.

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11 p. 133.

12 p. 134.

13 p. 160.

Man has succeeded in creating and utilizing the peak products of rationality, i.e. science, mathematics and formal logic. At the same time he is still suffering from neurosis, and his high-level cognitive schemata are not based on pure rationality. He easily orients himself in his complex everyday environment, and is able to solve problems of reasoning that stump even the largest computers of today; at other times, however, he makes rude errors in judging very simple events, as we have seen.

This duality is also reflected in psychological theories. On the basis of his detailed knowledge and thorough observations, Piaget describes how and through what stages a helpless child who understands nothing of the world around him becomes a rational adult who airily possesses and uses the means of formal thinking, and who thinks in abstract operations. Freud depicts a much less respectable picture of man; in his view an adult is also at the considerable mercy of his irrational wishes, instincts and only seemingly forgotten and passed traumas of his childhood. . . .

Our schemata determine what we can and cannot perceive in our environment, and the schemata of science also determine the results we can achieve at all. If we study the stages through which man understands his physical and social environment, formal logic will provide an excellent external method of observation. the extent to which our behaviour corresponds to the logic of the things around us is objectively measured by the extent to which it meets the expectations of formal logic. If, however, our aim is to describe our irrational acts and our neuroses, then, by their nature, the rules of formal logic will barely make their way. Both kinds of observation may be perfectly objective and correct, just as the very same animals proved to be gallantly kind-hearted or aggressively selfish, reassuringly monogomous or fatally volatile in the light of different observations.[14]

The limits of artificial intelligence are therefore inextricably linked with the limits of rational thought, of pure reason. At the same time we must recognise that there exist other types of thinking, other references, which help us solve problems which are not capable of being solved by pure logic. In Western societies, especially there is a danger of yielding too much 'authority' to science, even if its findings contradict our intuition. We fail to understand or lose sight of the fact that

we are capable of comprehending complexity which is about tens times as great, through intuition, with our inexact heuristics, compared to what we can express by purely rational means. The diversity of thinking and the alteration among reference systems are essential in cognition and expression.[15]

I for one thank Professor Méro for this timely reminder. I only hope that I have conveyed, in this review, a little of the flavour of his truly enjoyable and thought-provoking book.

Review by Eugene Clark, Lecturer in Law, University of Tasmania.

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14 p. 188-9

15 pp. 234-235.