

Enchanted Looms

Conscious networks in brains and computers

The title of this book was inspired by a passage in Charles Sherrington's *Man on his Nature*. When that famous physiologist died in 1952, the prospects for a scientific explanation of consciousness seemed remote. *Enchanted Looms* shows how the situation has changed dramatically, and provides what is probably the most wide-ranging account of the phenomenon ever written.

Rodney Cotterill bridges the gap between the bottom-up approach to understanding consciousness, anchored in the brain's biochemistry, anatomy and physiology, and the top-down strategy, which concerns itself with behaviour and the nervous system's interaction with the environment. Equally at home describing the intricacies of neural networks, the methods of monitoring brain activity and relevant aspects of psychology, the author argues that an explanation of consciousness is now at hand, and extends the discussion to include intelligence and creativity. Those who believe that their conscious selves control their bodies will be shocked to learn that even our spur-of-the-moment decisions are made unconsciously – that we are merely captive audiences of our own muscular acts. The remarkable thing is that the underlying deterministic mechanism requires that we be conscious. Evolution's boldest trick greatly increased our competitive edge, by giving the body a conscious servant. The fascinating thing is that this ultimately opened the flood gates of our culture and our technology, including – soon – consciousness in computers.

This beautifully written and illustrated book will be valued by scientists and general readers alike for its easy access to one of science's last great challenges. It will change forever our view of consciousness, and our concept of the human being.

Born near Jamaica Inn in Cornwall, Rodney Cotterill spent his early years on the Isle of Wight, and he was educated at University College London, Yale and Cambridge. Originally a physicist, he gradually extended his interests to the biological domain and he now specializes in biophysics at the Danish Technical University, where he has been a professor for the past three decades. Prior to that, he spent five years at Argonne National Laboratory, near Chicago, and he has had two briefer periods as visiting professor at the University of Tokyo. He has been studying the human brain since the mid-1980s, and has concentrated particularly on the neural correlates of consciousness and intelligence. He is also interested in the possibility of simulating consciousness with a computer; he holds a patent in this area, and is currently involved in an industrial collaboration which aims to introduce artificial consciousness to the Internet. *Enchanted Looms* is Professor Cotterill's third popularization, his previous books being *No Ghost in the Machine* (1989) and *The Cambridge Guide to the Material World* (1985), which one reviewer referred to as an instant classic. He is a fellow of the Royal Danish Academy of Sciences and Letters and also of the Danish Academy of Technical Science. When not researching, teaching or writing, he enjoys sailing and choral singing.

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Frontmatter

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for all who care for the mentally infirm

Should we continue to watch the scheme, we should observe after a time an impressive change which suddenly accrues. In the great head-end which has been mostly darkness spring up myriads of twinkling stationary lights and myriad trains of moving lights of different directions. It is as though activity from one of those local places which continued restless in the darkened main-mass suddenly spread far and wide and invaded all. The great topmost sheet of the mass, that where hardly a light twinkled or moved, now becomes a sparkling field of rhythmic flashing points with trains of travelling sparks hurrying hither and thither. The brain is waking and with it the mind is returning. It is as if the Milky Way entered upon some cosmic dance. Swiftly the head-mass becomes an enchanted loom where millions of flashing shuttles weave a dissolving pattern, always a meaningful pattern though never an abiding one; a shifting harmony of subpatterns. Now as the waking body rouses, subpatterns of this great harmony of activity stretch down into the unlit tracks of the stalk-piece of the scheme. Strings of flashing and travelling sparks engage the length of it. This means that the body is up and rises to meet its waking day.

Charles Scott Sherrington (*Man on his Nature*)

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Preface

One cannot lightly borrow a phrase from someone else's famous literary work and use it as the title for one's own book. The idea of the brain's neural networks functioning like an enchanted loom has long held a magnetic fascination for me, as it no doubt has for others. But appropriating it for a title brings a heavy responsibility; there is the obvious danger that one could be perceived to be sully something precious. Charles Sherrington was one of the towering figures of twentieth century physiology, and if I say that I have sensed his presence while writing this book, let me hasten to add that this does not imply that I would anticipate his approval. On the contrary, the writing has been accompanied by an increasing feeling of misgiving.

For a start, I could not hope to write to Sherrington's own exacting standards. Even more seriously, my reading in the subject has led me to a mechanistic view which I suspect Sherrington would not have wanted to share. His spirit continues to be with us, not the least because so many of his scientific descendants are still living. Benjamin Libet, for example, whose work is so prominent in this book, was an associate of John Eccles, and Eccles himself was one of Sherrington's students. Eccles espoused a form of dualism, as is well known, and my most recent contact with Libet left me with the impression that he entertains the idea of free will. These beliefs are shared by many, of course; indeed, they appear to enjoy the support of common sense.

Looking back on our species' earlier attempts to explain the objects and phenomena in Nature, it must be admitted that we have an indifferent

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track record, when it comes to popular opinion. Common sense has often proved to be an unreliable servant in such matters. We once believed the Earth to be flat, with edges that threatened the too-adventurous voyager. Later, when its true shape was becoming appreciated, we still perceived the Earth as the centre of the Universe, around which the other celestial bodies dutifully rotated.

As our myths gave way to more rational interpretations, anthropomorphic images were replaced by less romantic concepts. Helios had to defer to a thermonuclear reaction, and Thor's hammer and anvil saw themselves superseded by electrical discharges within and between clouds of water vapour. A major contribution to the gradual decline in the supernatural view has been our increasing acceptance of things and agencies that lie beyond the scope of the unaided senses. Organisms and forces that we cannot see have become an unavoidable part of our daily lives.

Even our perception of ourselves and our origins has undergone radical change. Vague ideas about the mixing of blood have long since been replaced by the statistical principles first elucidated by Mendel, and many had reconciled themselves to Darwin's view of evolution well before John Scopes stood trial in Tennessee in 1925. The biological revolution, bolstered by the advent of molecular biology, has now progressed so far that molecular cartographers are well along on an expedition that will chart our genetic territory in its entirety, down to the last base pair.

Along with such issues as the origin of the Universe, the nature of time, and the relationship between the four fundamental forces, consciousness is fast becoming one of the last major bastions of mystery. And because it strikes even closer to home than those three other puzzles, there are many who feel that it ought to be out of bounds. The researcher is all too aware that the scientific boon can become the environmental bane – the researching paragon, the researching pariah. Our minds are the human dimension of the environment, of course, and there must be many who regard the type of work discussed in this book as a form of spiritual pollution.

There has indeed been a sharp rise in the public's awareness of research on the brain. This has come about through the collective effects of a number of factors, not the least of which has been the increase in television coverage of the subject. Just as important has been the emergence of the new term 'neural network'. The successes scored by the computational strategies associated with this term have been winning them considerable financial support, from both the public and the private sectors, and this has naturally provided them with much visibility. Given that research funding has otherwise been meager of late, this development has been a most welcome one.

There has been a disadvantage to these advances, however, for it has led to much confusion about what is actually being achieved. The difficulty stems from the term itself, because it can easily mislead people into thinking that great strides are being made in understanding real biological brains. Unfortunately, that has not been the case, and some of those working in this area have not always taken sufficient care to draw the distinction between

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computational strategies inspired by the brain and the actual neural networks that we have in our heads.

I have written this book in an effort to help clarify this matter. The text makes what I believe to be the necessary distinction between the different areas of activity which could claim a place under the neural network banner. I hope that the divisions thus advocated will not be perceived as being too pedantically delineated. The book has been set down in this manner because my own experiences in recent years have led me to believe that the misunderstanding is both real and deep.

This approach, which I have not encountered elsewhere, will hopefully help to elucidate these matters. The brain-inspired strategies are sufficiently exciting in their own right, and they have no need of the cheap plaudits that have sometimes come from those who mistakenly believed that such endeavours were contributing to the understanding of the real brain. And by pointing out the difficulties that still confront those who, contrariwise, are trying to understand the genuine article, I hope that this will lead to a better appreciation of their uphill struggle.

The key issue addressed in the book is, of course, consciousness. I must confess that the starkly reductionist picture of this phenomenon that emerged during my evaluation of a large corpus of research data has come as a considerable shock. When I started to write this book, almost a decade ago, I was still reasonably sure that Nature had earmarked a volitional role for consciousness. The strong indications are that this is not the case, and I must admit to being disturbed by such an idea. I cannot help wishing that Sherrington was still alive today, so that we could all benefit from his own views as to what the enchanted loom appears to be doing for us, and indeed to us.

Rodney Cotterill

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