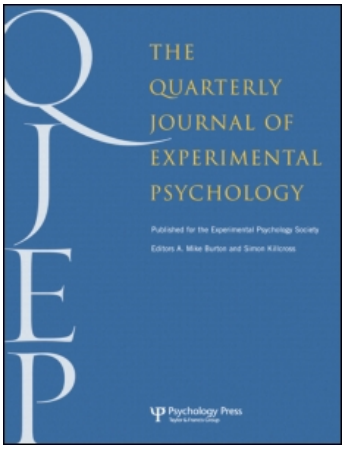

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Book Review

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Book Reviews

Churchland, P.S., & Sejnowski, T.J. (1992). *The computational brain.* Cambridge, MA: Bradford Books/MIT Press. Pp. xi + 544. ISBN 0–262–03188–4. £35.95 (Hbk). 0–262–531–208. £17.95 (Pbk).

This is a clearly written, compelling book. It does not shy away from equations, but their meaning is always spelled out so readers without a mathematical background should have no problems with them. Likewise, the psychology, physiology, and anatomy to which those equations are applied are clearly described for the non-specialist. The availability of a reasonably priced paperback edition gives the book great potential as a recommended text for courses in computational neuroscience, yet I have reservations about it.

In part, my reservations stem from the quality of writing—it is just too good, too convincing. It is not a question of being presented with facts or arguments that are wrong, but rather one of emphasis. Churchland and Sejnowski are rather polemical in their advocacy of the use of the error back-propagation artifical neural-network training technique as a method of discovering optimal arrangements of synaptic strengths which allow networks with given arrangements of neurons to solve particular problems. This approach is used to great effect a number of times in the book. We see how finding orientation-sensitive neurons in a network need not imply that the system is adapted to detect edges, it may just as well be part of a system that computes shape from shading. The same technique is used in networks that much more closely model known biology to explain the initially counter-intuitive role of interneurons in local bending reflexes in the leech and the locus of adaptation in the human vestibulo-ocular reflex. These are good examples that can easily convince us that the brain is indeed best understood as an error-minimizing system. Churchland and Sejnowski recognize that this approach could be critized for being adaptationist—for assuming that evolutionary adaptation produces the best of all possible worlds, to paraphrase Gould, Lewontin, and Voltaire. Having recognized this pitfall, they nevertheless appear to make the tacit assumption that computation is optimized by adaptation, albeit perhaps adaptation by learning rather than natural selection.

Although mechanisms of synaptic change are discussed at length, the constraints these mechanisms place on the possible computational expression of adaptations is neglected. One explanation for this stance might stem from the authors' assertion, at the beginning of their chapter overviewing computation, that looking up the answer to a problem in a table (or equivalent procedures such as using a slide-rule or ready-trained neural network) *is* computation. It might be argued that table-look-up in itself is not computation, it merely provides access to computation that took place when the table was constructed. The "table-look-up is computation" position allows Churchland and Sejnowski to discuss computation without directly confronting the limitations of the mechanisms that allow that computation to be implemented. The use of error minimization to explain neural computation also assumes that the circuit is the appropriate level of description of that computation. There is, however, a growing body of evidence, with its roots in EEG recording but now utilizing multiple single-unit recording, MEG, and optical and radio-thermal imaging of neural activity, which suggests that neural computation might sometimes be explained in terms of the bulk proper-

ties of networks of neurons. To be sure, these properties are determined by the architecture and strengths of connections between neurons, but the patterns of activity concomitant with stimuli and behaviours are most simply explained in terms of the properties of an approximately continuous neural medium rather than the individual synapses between pairs of neurons.

I would not like to give the impression that the book is dominated by back-propagation or that Churchland and Sejnowski wilfully ignore examples calling for alternative modes of explanation. In addition to the examples I mentioned above and the excellent introductions to neuroscience and computation in networks, there are also discussions of temporal issues in computation and representation (generating motor programmes with coupled oscillators, synchronized activity, and adaptation in the hippocampus), representational hierarchies and prosopagnosia, neurophysiological mechanisms of synaptic adaptation, distributed representations and hyperacuity, the development of ocular dominance columns, and vector averaging in superior colliculus and motor cortex. The breadth of these topics and the clarity of their discussion can only add to the attractions of this book.

I hope I have not dissuaded anyone from reading this excellent book. I do, however, feel that the reader should be prepared to add a little of their own scepticism to balance the book's optimism and clarity of argument, which might just be a little too convincing!

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Aggleton, J.P. (Ed.) (1992). *The amygdala: Neurobiological aspects of emotion, memory and mental dysfunction.* New York: Wiley-Liss. Pp. xii + 615. ISBN 0-471-30825-0. £54.00 (Pbk). ISBN 0-471-56129-0. £98.00 (Hbk).

Despite the fact that it is nearly 200 hundred years since the first anatomical description of the human amygdala, it is only relatively recently that a detailed picture of its cytoarchitecture, connections, and possible functions has begun to emerge. As recently as 30 years ago, the role of the amygdala was widely believed to be restricted to its association with the olfactory system and the modulation of hypothalamic function. It is now evident that the amygdala is involved in a panoply of complex behaviours and cognitive functions. Recent progress towards an understanding of the neurobiology of the amygdala has been substantial, and knowledge about this structure appears to be increasing exponentially. Thus, this volume has made a timely appearance, since, as the editor points out in the Preface, the last book about the amygdala (Ben-Ari, 1981) was published more than a decade ago. It is pleasing that the paperback edition has appeared so soon after publication of the hardback, the price of which must have severely restricted its potential market.

The aim of this book, which largely succeeds, is to provide an up-to-date account of the current status of amygdala research by drawing together contributions from what is now quite a disparate field (I have to admit that I had not previously considered that the amygdala might play a role in stomach pathology!). The book can be said loosely to comprise three sections. The first section understandably deals with the anatomical organization of the amygdala, its cell types, intrinsic connections, and the distribution of monoamines and neuropeptides within the structure. It is to the editor's credit that the nomenclature for the amygdala outlined by Amaral et al. in chapter 1 has to a large extent been adopted by all of the other contributors. The second and largest section of the book examines the role of the amygdala in a variety of behaviours and cognitive functions. Neurophysiological recording and stimulation techniques, lesions, and behavioural/neuropsychological testing have been used for the analysis of the amygdala's role in simple conditioning and other aspects of learning and memory, conditioned arousal and fear, reward, sensory information proces-

sing, emotional and social behaviour. The final section of the book investigates the role of the amygdala in temporal lobe epilepsy, schizophrenia, and dementia, predominantly Alzheimer's disease. Although this section is currently the shortest, it is evident that in a similar volume produced ten years hence it would be safe to predict a relative enlargement, if current progress in the understanding of the role of the amygdala in neurological disease is maintained.

The editor has gathered together an impressive "cast list" of contributors, who by and large write authoritatively within their own specialist research area. The standard of writing is high, and the balance of facts, ideas, and suggestions for future research generally makes for informative and enjoyable reading. Although the transitions between the chapters are not seamless, they do fit together reasonably well. However, some attempt at a synthesis of current knowledge of amygdaloid function, either by the editor or multi-authored, would have been welcome. My only other reservation about the content of the book is that despite the fact that the amygdala is a phylogenetically old brain structure, there is no information about its evolution or about its role in animals "lower" than primates and rodents. Such information about the amygdala or its homologues in animals with simpler behavioural repertoires may be an important aid to understanding amygdaloid function.

This volume will be of interest to a wide variety of students, research workers, and possibly clinicians. It lends itself to being used as a reference (through the reasonable index), it is enjoyable to dip into chapter by chapter, and I suspect that it will be read "cover to cover" by more than a few. In short, it is an essential addition to the library shelves, and I suspect that in its paperback form it will achieve a much wider readership.

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REFERENCE

Ben-Ari, Y. (Ed.) (1981). *The amygdaloid complex*. Amsterdam: Elsevier.

Macphail, E.M. (1993). *The neuroscience of animal intelligence. From the seahare to the seahorse.* New York: Columbia University Press. Pp. xxv + 506. ISBN 0–231–06144–7. $75.00/£35.00 (Hbk).

From the late 1970s to the present, a handful of topics have preoccupied behavioural neuroscientists concerned with cognitive function: associative and non-associative learning in *Aplysia* and *Hermissenda*, the role of the cerebellum in classical conditioning, long-term potentiation, spatial information processing in the hippocampus, and the role of the hippocampus in memory in general. This book is a thorough review of current work on the neural basis of cognitive function, concentrating on these central areas of research. Some of Macphail's previous syntheses of research in animal learning and cognition have earned him the reputation of a maverick. He is well known for advocating the view that ". . . there *are* no differences in intellect among nonhuman vertebrates . . ." (Macphail, 1987). But the present volume is a much more mainstream endeavour. Despite the "animal intelligence" of the title with its echoes of Spearman, Macphail adopts no strong theoretical position in this book and, instead, guides the reader through the tumultuous marketplace of theory and experimental results that characterize the field, letting data for the most part speak for themselves. It is an instructive trip, sometimes exciting and sometimes discouraging. The neuroscience of animal learning and memory has generated an enormous amount of information in a few decades but paradoxically provides us with few firm conclusions about how the nervous system learns and remembers.

The book opens with an historical introduction, running from Galen to Lashley. I would like to have seen more reference to the historical sources, for those interested in plunging into the origins of the field, but this section nevertheless sets the scene well. Macphail then develops the argument that behavioural neuroscience has three goals with respect to cognition: neuroanatomical localization of function, identification of physiological substrates, and the definition of cognitive functions. The first goal, though sometimes an end in itself, is really a preliminary to the next two. Attaining the second goal of understanding the neuronal and synaptic machinery that mediates plasticity is probably how most behavioural neuroscientists would describe their work. But Macphail believes that ". . . behavioural neuroscience consists in doing psychology with the aid of physiological techniques", and that the most important thing behavioural neuroscience has to offer is a better way of identifying and describing the component parts of cognitive activity. The double dissociation paradigm, for example, provides evidence that the cognitive functions dissociated are neuroanatomically and psychologically distinct, and this, according to Macphail, is a significant advance over psychological theorizing based solely on intuition and the observation of behaviour.

Much of the material is approached from the point of view of an outside observer. Macphail's own work on the avian hyperstriatum is scarcely mentioned. But the outside observer's stance is important, because it frees Macphail of commitment to any particular paradigm or theory. Many researchers will find that Macphail discusses their experimental results without necessarily adopting their interpretations of the results, but this, of course, is how a critical review should proceed. Macphail sticks to the laboratory and to standard models of learning, memory, and cognition. There is no mention of the neurobiology of song learning or imprinting, for example, although a final chapter on "Unexplored Avenues" examines recent work on homing and cache retrieval by birds and computational models of association and categorization in the hippocampus.

Macphail grapples bravely with theory and data concerning the role of the hippocampus and neighbouring cortex in memory. Research in this area provides one of the best tests of how well behavioural neuroscience is doing in attaining its goal of defining cognitive functions. The problem at present is that many different definitions of cognitive function emerge from experimental data on the effects of hippocampal and temporal lobe lesions, most of them variations on a theme, but some clearly very different parsings of cognitive activity. The distinctions between locale and taxon, working and reference memory, episodic and semantic memory, configural and simple associations, explicit and implicit memory, declarative and procedural memory, among others, will be familiar to most readers. Macphail provides a systematic and critical review of competing models, organized according to the experimental data that they can accommodate and the data that they cannot. According to Macphail's analysis, the declarative/procedural distinction of Squire and Zola-Morgan seems best able to totter across the finish line, but even it is badly winded by the end.

The review of work on cellular and sub-cellular mechanisms of habituation, sensitization, and conditioning in *Aplysia* and *Hermissenda* is equally systematic and critical. Macphail, like many others, is impressed by the wealth of findings and the level of analysis but is left not yet convinced that synaptic mechanisms identified in the "squishies" can account for conditioning phenomena in general.

Our generation is probably witnessing the birth of behavioural neuroscience, much as de Vries, Bateson, and Morgan witnessed the birth of genetics at the beginning of this century. Contemporary work on invertebrates, the cerebellum, and the hippocampus may appear to later generations as passably good first attempts, successful perhaps at identifying some basic questions and sketching in outline a few of the mechanisms. There are intelligent and knowledgeable researchers who are sanguine about the importance of LTP, the hippocampus, and conditioning in marine mollusks, and others who are utterly dismissive. My own view is that species differences in cognitive mechanisms will turn out to be more important than Macphail's analysis would suggest. We are some way from identifying universal molecular mechanisms of cognition. Neurophysiological

models of cognition like those proposed for hippocampal function may perform poorly at integrating experimental results from humans, monkeys, and rodents because cognition in humans, monkeys, and rodents consists of very different components.

How well does the neuroscience of animal intelligence, as a field, do in achieving Macphail's three goals of localization, identifying mechanisms, and defining cognitive functions? It is clear that some cognitive functions are highly localized (and the current excitement over functional MRI is excitement over the possibility of achieving better localization). It is at present possible to identify and measure a variety of neuronal and synaptic events that are correlated with experience-dependent changes in behaviour. Finally, it has become the norm to seek neurophysiological guidance in theorizing about the component parts of cognitive function.

Who should read this book? It is probably too heavy going for even advanced undergraduates, though selected sections could be used to provide comprehensive introductions to particular topics. Graduate students who wish to know what has been uncovered so far in the search for the neural basis of animal cognition will find the book very useful, as will researchers who may know some but not all of this terrain. Anyone teaching behavioural neuroscience will find it a useful reference work and a helpful bench-mark with which to compare their own readings of this enormous literature.

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Macphail, E.M. (1987). The comparative psychology of intelligence. *Behavioral and Brain Sciences*, 10, 645–695.

Mackintosh, N.J. (1994). *Animal learning and cognition.* London: Academic Press. Pp. xviii + 379. ISBN 0–12–161953–2. $59.95 (Hbk).

Learning and cognition in species other than humans is of little interest to the majority of psychologists. It is difficult to be certain about the basis for this indifference—perhaps they believe that learning in non-human animals does reflect nothing more than changes in the strength of stimulus–response (S–R) habits, or perhaps they have preconceptions about the sorts of topics addressed by those who study non-human animals. Whatever its source, this indifference will hardly be shaken in those taking only a fleeting glance at the opening chapter titles in *Animal Learning and Cognition*: "Instrumental conditioning" (Dickinson), "Pavlovian conditioning" (Hall), "Reinforcement and choice" (Williams), and "Discrimination and categorization" (Pearce). This is a pity, because, as Morris and Shettleworth both remark in later chapters, the treatment of these topics is nowadays far richer than many introductory psychology texts would lead one to expect. Indeed, in many ways, the chapters by Dickinson, Hall, Williams, and Pearce exemplify this richer treatment. To take but one example: A hungry rat pressing a lever for a food reward might seem to be simply responding on the basis of an S–R habit—the sight of the lever (S) eliciting the response of lever pressing (R). However, in his analysis of instrumental conditioning, Dickinson argues that rats' behaviour often reflects the acquisition and interaction of knowledge about (1) the action (lever press)–outcome (food) relationship and (2) the current desirability of the outcome.

The opening chapters, including Mackintosh's introduction, provide the reader with an excellent primer in animal learning and cognition in the context of relatively simple conditioning procedures. However, subsequent chapters clearly mark this volume as having a broader appeal than to psychologists interested in animal learning: Morris presents a refreshingly sober appraisal of the role of activity-dependent synaptic plasticity in learning; Shettleworth considers whether "naturalistic learning" phenomena (e.g. imprinting, song learning, and social learning) are fundamentally different from the phonomena observed following simple conditioning procedures; Gallistel describes how animals use temporal and spatial information; Gordon and Klein explore the role of contextual cues in determining the retrieval of associative knowledge; and Shanks presents an analysis of contingency effects in human associative learning. The remaining chapters—one by Heyes and the other by Rumbaugh and Savage-Rumbaugh—focus on two aspects of non-human primate behaviour. Heyes examines, and finds wanting, evidence taken by others to support the claim that non-human primates attribute mental states to other organisms; Rumbaugh and Savage-Rumbaugh recount their attempts and those of others to teach primates language.

The diverse nature of the topics covered in this volume and the eminence of the participants will undoubtedly make it a very useful source-book for students from a variety of disciplines. Even those whose primary concern is the human condition could well find something to challenge their indifference towards the study of animal learning and cognition.

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