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R.P. Kesner and D.S. Olton (Eds.) Neurobiology of Comparative Cognition (Hillsdale, NJ and London, 1990) pp. xii + 476, £19.96 (paper) £25.00 (hardback).

The introductory chapter here is a re-statement, with responses to subsequent critics, of the arguments put forward by Hodos and Campbell (H&C) in 1969 in an article subtitled "Why there is no theory in comparative psychology". The editors suggest, with good reason, that a book with this title is a logical and necessary step to take in the search for relations between cognitive and neural function, but are frank in admitting that it is not possible to place the heterogeneous chapters collected here in any principled theoretical framework. However, all the chapters function as useful literature reviews of circumscribed areas, and the absence of significant general theory is no fault of the editors.

The book is organized into sections on communication, learning and memory, and spatial abilities, with some coverage of the animal kingdom from *Aplysia* to people, without any attempt to be comprehensive. Under communication there are chapters on human language, vocal communication in primates and bird song, but nothing on invertebrates (bee dancing, crickets, pheremone tracking) or lower vertebrates (frogs and geckos have interesting vocalizations) or on olfactory communication in mammals, which would have implications for theories of forebrain evolution and might at some stage relate to the large amount of current work on the hippocampus. For learning and memory we have non-human primates, reptiles, rats, fish, honeybees and *Aplysia* — humans and birds are notable absentees, while spatial organization is examined in people, other primates, the rat, and birds — no invertebrates or lower vertebrates, although it is arguable (see Gallistel, 1990) that spatial abilities are an evolutionary imperative for all mobile species. It is noticeable that amphibians are not here at all. There isn't a great deal of work on learning and memory in frogs and toads, possibly because they don't rely much of these things, but research such as Ewert's on toads would have fitted well into this context. These chapters do not therefore amount to a significant work of reference such as Ebbesson's volume (1980) on the vertebrate telencephalon, which is a pity, since, in the absence of any unifying theory, taxonomic comprehensiveness could have been a useful substitute.

It is also arguably a corollary of H&C's demolition of the phylogenetic scale and the concept of anagenesis (progressive evolutionary improvement), although they themselves say that investigators are free to study any animals they choose and to group their data in any way that seems reasonable, in order to correlate structure with function. This is in practice what investigators do anyway: the thrust of H&C's theme is that there should be no implicit assumption of higher and lower kinds of cognition when comparing species. No one is guilty of that in this book. Comparisons are made but fairly superficially: "comparative" as used in the title has come to mean "studied in some convenient animal". Similarities as opposed to contrasts between species are more evident, as in the existence of "higher" kinds of classical conditioning in invertebrates, and the emerging suggestions of consistency in the function of the hippocampus and amygdala (or structural homologues) in rats, pigeons, primates and people. There are two neural-net-style models of hippocampal function in primates and rats, and fleeting references to connectionist suggestions for the relation between neural processing and cognitive function, but no systematic review of this topic. H&C's emphasis on the adaptation of species to niches, irrespective of ancestry, would suggest optimality approaches and an examination of behavioural ecology, but there is little sign of this strand of investigation making contact with neurobiological issues.

In all, both editions seem reasonably priced, and, despite the gaps, the book contains a useful range of information. I share the editors' hope that it stimulates more research into the neurobiology of animal cognition, and look forward to the more systematic comparative analysis contingently promised for its next edition. Brief comments on the individual chapters follow.

Communication

Gordon provides a stodgy and traditional review of Broca's and Wernicke's aphasia, computed tomography scan studies, and the fractionation of language deficits after brain damage, without mentioning (as Hughlings Jackson did a century ago) that Broca's and Wernicke's areas are where one would predict they should be from knowledge of non-human mammalian brains (for example, Broca's area is adjacent to the representation of the vocal organs in motor cortex). However, the evidence reviewed by Jurgens suggests that in non-human primates perception and production of vocalization is to a large extent controlled subcortically or by primary cortex (to use Jackson's term, it is not "re-represented" in secondary cortex), and is predominantly unlearned. By contrast, Williams claims baldly that "Bird song is learned during development". This is an oversimplification, since the proportion of learned and unlearned elements varies for unknown reasons with species, but Williams provides a detailed account of behavioural and anatomical determinants of song in the zebra finch. H&C provocatively suggest earlier that birds should be put in the same grade as primates, on the grounds of bipedalism and audio-visual expertise, and a third human-like feature is functional lateralization of vocalization (and of other things such as imprinting: the work of Horn and others is not mentioned) although no anatomical correlate of this has been discovered in the brain (peripheral musculature is asymmetrical in some species).

Learning and memory

Murray concentrates on the structure-function relations in the case of the hippocampus and amygdala and cross-modal or modality-specific memory tasks in primates (delayed matching to sample or conditional discrimination) and draws a distinction between "supra-modal" memory such as spatial memory or semantic mapping, for which the hippocampus is critically important, cross-modal memory (the amygdala) and intra-modal memory (both structures). Powers notes that brain/behaviour studies of learning in reptiles are few in number, and suggests on limited evidence that a forebrain cholinergic system is involved in associative processes in this class, as in birds and mammals. On the other hand, the literature on the neurobiological memory in rats is voluminous. Kesner reviews it, and finds significant parallels between rats, birds, monkeys and humans in the role of the hippocampal formation, judiciously combining the ideas of Olton, Rawlins, and O'Keefe and Nadel to suggest that this part of the brain codes information in terms of both spatial and temporal attributes, and is involved with working or "data-based" memory as opposed to reference or "expectancy-based" memory. Overmeier and Hollis make a strong case in a long chapter that the effects of telencephalic ablation on fish behaviour can inform learning theory, by supporting the modularity of cognitive function: instrumental conditioning generally, and avoidance conditioning in particular, is strongly impaired, but not Pavlovian conditioning or simple escape behaviour. Menzel's chapter on learning and memory in honey bees is as long as those on fish and rats combined, and concludes with some thoughts on the design principles necessary to enable a brain of less than 106 neurons to generate the data it contains. These may include: separation between plastic and non-plastic behavioural routines; the use of pre-ordained cues and facilitated associations; special-purpose compromises and approximations. Byrne reviews analyses of the neural and molecular events underlying learning in *Aplysia* and other gastropod molluscs, and speculates (safely, one suspects) that the critical distinction between simple and complex examples of learning will be found at the level of the neural network rather than the level of basic cellular mechanisms.

Spatial organization

Despite H&C's strictures, it will be apparent that the ordering of chapters in the sections reflects the phylogenetic discredited scale, albeit in reverse. We thus jump from Aplysia to Oliver Sach's man who mistook his wife for his hat, who begins Friedrich's inconclusive chapter on human spatial impairments. There follows an exciting pair of chapters in which Rolls assembles neural and behavioural evidence for the theory that the primate hippocampus is organized as auto-associative matrix memory, using Hebb-modifiable synapses between the CA3 cells, and Leonard and McNaugton do something very similar, more exhaustively, for the rat hippocampus. Lastly, Bingman briefly reviews evidence on homing pigeons: hippocampal ablation produces robust retrograde loss of memory for landmarks, and although the precise implications of this are unclear there is obviously scope for eventual detailed comparisons of avian and mammalian brain function.

A nice touch from Leonard and McNaughton is that, although rats have poor visual acuity by the criteria of primate edge-detectors, natural environments have power spectra dominated by low spatial frequencies, where rats have in fact greater contrast sensitivity than primates: we should be surprised that they use the visual modality to guide spatial choices in laboratory place-learning. This lesson prepares us for Bingman's evidence that homing pigeons, despite having olfactory bulbs that are small by mammalian standards, make use of available odour cues when initially orienting homewards from an unfamiliar location.

References

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