Book Review
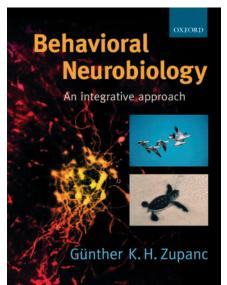
OPENING THE BLACK BOX

Behavioral Neurobiology: An Integrative Approach

By Günther K. H. Zupanc

Oxford University Press (2004)
360pp. ISBN 0-19-870056-3
£23.99 (pbk)

In *Behavioral Neurobiology: An Integrative Approach*, Günther Zupanc provides an excellent introduction to the field of neuroethology, the study of the neural basis of behavior. Traditionally, ethology (study of animal behavior) treats the animal as a 'black box' in which environmental information enters through sensory cells and emerges from effector cells as behavior. The physiological underpinnings that transform sensory information into behavioral output reside within the box. The advent of new tools and techniques has enabled researchers interested in the proximate causes of behavior to couple ethology with direct analysis of the neural mechanisms previously confined to the 'black box'.

Behavioral Neurobiology is a well-written, well-organized introduction to neuroethology and will serve well as an upper-division text for courses in this field. As stated by Zupanc, however, the text is not an exhaustive survey of animals and behaviors that have attracted the attention of neuroethologists. Rather, he focuses on individual studies that exemplify and define neuroethological research. To this end, he discusses truly integrative investigations, spanning broad levels of biological organization, from migratory behavior over thousands of kilometers to single ion channels and the amino acid sequences that form the basis of electrical excitability of individual neurons.

The book begins with an overview of the intellectual approaches to investigating the neural systems underlying behavior. Zupanc defines the goal of neuroethological research as searching for "a 'hardware' [proximate] explanation of behavior". He discusses the benefits of choosing the appropriate level of neural complexity to investigate as well as finding a model system amenable to neurobiological techniques. The importance of these concepts is reinforced in following chapters by the research examples Zupanc uses to discuss the current questions being tackled by neuroethologists.

In chapter two, Zupanc provides a history of the field of animal behavior and the initial attempts to relate brain activity to the control of behavior. This account focuses primarily on the development of ethology and behavioral psychology, describing the contributions of Conway Lloyd Morgan, B. F. Skinner, Niko Tinbergen, and Konrad Lorenz among others. After a brief mention of pioneering neurobiologists, Zupanc introduces several of the key figures that began applying the technological advances developed in neurophysiology laboratories to mechanistic questions in ethology. The combination of ethology and neurobiology in the laboratories of Karl von Frisch, Theodore Bullock, and their contemporaries led to the founding of neuroethology as a scientific discipline. The final focus of chapter two is the early work performed in these laboratories.

Building on the early work of behavioral neurobiology discussed in chapter two, Zupanc introduces concepts and experimental approaches used in both neurobiology and ethology. Although the text covers many basic concepts, a reader not already familiar with neurophysiology and general animal physiology will be at a major disadvantage as the discussion turns to detailed presentation of specific research topics. This is not surprising, considering the vast amount of information on nervous system function. Zupanc does direct readers to several of the neuroscience texts available to supplement this chapter. On the other hand, the discussion of animal behavior concepts and techniques are sufficient for non-behaviorists to grasp both the breadth and significance of the discussions that follow in subsequent chapters.

The next five chapters (4–8) cover sensory systems, motor output, central mechanisms

of sensory information, sensorimotor integration and neuromodulation. In contrast to traditional neuroscience texts that treat each of these systems as individual self-contained units, Zupanc emphasizes the relationship of each of these neural components as an integrative whole. He provides intriguing and interesting examples of how interactions with other neural components as well as the animal's environment affect how an animal tunes these systems. An example of this approach is the discussion of sensory perception in chapter four. Zupanc uses spatial orientation and sensory guidance as the framework to investigate how animals perceive their environment. Although this discussion hinges on an animal's ability to detect specific sensory cues, the cellular and neural mechanisms are directly tied to adaptive behavior involving the entire nervous system. This is most apparent in how Zupanc presents geotaxis in vertebrates and the interaction between gravity receptors and photoreceptors in the dorsal light response of angelfish. The theme of sensory perception continues with the neural mechanisms of echolocation in bats and frequency tuning of prey (noctuid moths) to counter the bats' use of ultrasound during hunting.

The remaining chapters of this portion of the book use various behaviors to illustrate the function of other neural systems. The control of motor output (Chapter 5) in frog tadpoles is used to introduce concepts such as central pattern generators, endogenous oscillators, and coordination of motor signals. Chapter six provides detailed discussions on prey and predator recognition in toads and sound localization in barn owls, illustrating central mechanisms of neuronal processing of sensory information. Zupanc then uses his field of expertise, the neuroethology of weakly electric fish, to cover sensorimotor integration through an intriguing discussion of the jamming avoidance response (Chapter 7). In chapter eight, Zupanc conveys the breadth of processes that can be altered and regulated by

neuromodulators, including the state-changes in the crustacean stomatogastric ganglion (STG), seasonal changes in chirping behavior of weakly electric knifefish, and hierarchical behavior in crayfish.

In chapters nine and ten, Zupanc effectively shows how understanding each of several neural components – and their integration – can lead researchers to ask more appropriate and focused questions, resulting in a more thorough understanding of an entire, often complex, behavioral pathway. He discusses two well-studied behaviors to illustrate this point. Chapter nine covers navigation necessary for large-scale migratory and homing behavior. The discussion covers several levels of biological organization including the life histories and timing of migratory and homing behavior, the mapping of long-distance migration and homing, the integration of multiple sensory cues used to guide navigation, and the genetics of migratory behavior. In chapter ten, Zupanc discusses the neuroethology of cricket song, including behavioral analysis of auditory communication, sensory perception, song production and genetic coupling of song communication. In addition, he covers new types of problems such as the biophysics of song production and the influence of environmental factors on song production and song recognition and how crickets cope with such influences.

Throughout these earlier chapters, Zupanc shows that neuronal plasticity is an integral component of the control and production of behavior. The final chapter (11) provides a detailed description of the neural mechanisms underlying plasticity. Zupanc uses two major model systems, the marine mollusc *Aplysia* and the mammalian hippocampus preparation, to illustrate cellular mechanisms of learning and memory. He discusses facilitation, sensitization, habituation, long-term potentiation, and the molecular mechanisms and signaling cascades

thought to be responsible for these various types of learning and memory.

In this text, Zupanc has followed the lead of Jörg-Peter Ewert (Neuro-Ethologie: *Einfürhrung in die neurophysiologischen Grundlagen des Verhaltens*; Springer-Verlag, 1976, translated to English and published in 1980) and Jeffery Camhi (*Neuroethology: Nerve Cells and the Natural Behavior of Animals*; Sinauer, 1984) in creating a platform from which students can be introduced to the fascinating field of neuroethology. The text is well organized (with the exception of the placement of several figures that appear in the book up to five pages before the corresponding discussion in the text) and is well written; the enthusiasm Zupanc has for the subject is readily apparent and helps to keep the reader's attention. The topics covered allow the instructor to easily insert, within a classroom setting, additional examples to enhance or contrast the discussion in the text. Zupanc also provides additional reading at the end of each chapter as places to begin a more detailed study of topics covered in the text.

This book successfully fills the demand for a current neuroethology text that can form the basis of upper-level undergraduate and beginning-level graduate courses focused on the neurobiology of behavior. The text, in combination with the material on a supplemental web site[1], will prove invaluable to instructors teaching this emerging field that combines ethology and neuroscience. Given the approachability with which Zupanc writes and the supplemental material he has provided, this book will also help individual researchers delve into the intriguing 'black box' opened by neuroethological research.

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