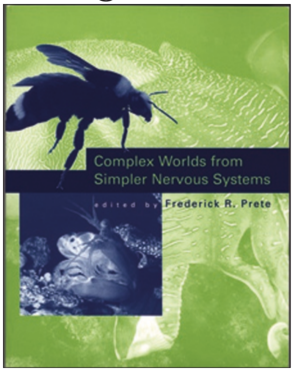
# Seeing the world through eyes of another kind




**Complex Worlds from Simpler Nervous Systems**

**Edited by Frederick R Prete**

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**Reviewed by Ron Hoy**

This book's title is somewhat misleading: "complex worlds" really refers to "visual worlds," and "simpler nervous systems" really means "visual systems," with more emphasis on what goes on in the eyes (some of which are anything but simple) than in the brain. However, in the tradition of neuroethology, these wonderful visual systems are discussed within the fascinating context of the behaviors of animals, mostly invertebrates, with the interesting exception of the toad. The chapters of this multi-authored contribution, edited by Frederick R. Prete, cover areas that have not been over-exposed; indeed, quite the opposite. There is a freshness about these topics, and the authors write with an infectious enthusiasm and devotion to their animal subjects. We do not see the standard model systems (flies, worms, zebra fishes and mice) in these pages, and the book is the more valuable for it—this is a celebration of comparative sensory biology.

How do the visual worlds of this odd, mixed bestiary of terrestrial and aquatic animals compare with our own? Let's consider the ways of a particularly interesting group of jumping spiders, the genus *Portia*, studied by Robert Jackson and David Harland in their chapter, which is a highlight of the book. These arthropods have a pair of large, frontal eyes that are endowed with a lens and retina system like ours, rather than with the compound eyes of their vast arthropodian brethren. Like our retina, there are fovea-like zones of higher acuity, and most remarkably, *Portia's* retina moves about to scan the visual field, analogously to the saccadic movements of our primate eyes. The visual world of jumping spiders is colorful, but coded differently from ours. Moreover, it appears that jumping spiders couple this visual virtuosity with a remarkable degree of spatial learning—the spiders inspect, size-up and seemingly work out the three-dimensional lay of the landscape to plan complex paths and approaches to best attack their prey. Apparently, these little creatures have evolved something akin to procedural memory!

Another invertebrate group that has converged evolutionarily on a vertebrate-like eye are the cephalopods: the octopoda, squids and cuttlefish. These marine creatures have long been known to be capable of relatively complex learning and memory tasks, and their brains have captivated many a zoologist since the great J.Z. Young, discoverer of the squid giant axon. While octopoda may have vertebrate-like eyes, they seem to lack color vision, but have a highly developed sensitivity to polarization, which may solve similar problems for the animal. Authors Gleadall and Shasar make clear that the visual virtuosity of the cephalopods is combined with behavioral plasticity in the sense that they are demonstrably good learners.

Invertebrates with eyes (and presumably visual worlds) different from our own include honeybees. Bees surely discriminate colors and use this ability to find flowers and other sources of nectar and sugar. Their waggle-dances back at the hive communicate the location of feeding patches and indicate a certain level of associative learning. In their account of visual learning, Zhang and Srinivasan describe the incredible ability of bees to learn about their environment from cues so disparate that the learning reflects, as the authors assert, a cognitive capacity. What makes the work of Zhang and Srinivasan so impressive is their application of standard methodologies used by cognitive psychologists to test the learning abilities of vertebrates, including primates. Thus, bees can learn to negotiate complex mazes and to perform delayed match-to-sample (a favorite of primatologists), symbolic matching and categorical perception tasks. For many neuroscientists, this chapter will be a revelation.

For eyes truly alien to our own, consider the stomatopod mantis shrimp, so named for its raptorial forelegs, which make it a formidable predator. For starters, whereas human color vision relies on just 3 photopigments, mantis shrimp have 12, spanning a spectrum enlarged to accommodate ultraviolet sensitivity. They are also endowed with exquisite polarization sensitivity. Now, toss in the ability to move the eyes, chameleon-like, independently of each other—each eye serving as a monocular range finder—and you have a visual system that only an MIT roboticist would have imagined. As Cronin and Marshall point out, this system is just beginning to be understood, and many intriguing problems await future investigators.

The only chapter on a vertebrate animal is J.P. Ewert's on motion perception in toads. It is appropriate in a book with chapters on human-like eyes in invertebrate animals that the vertebrate visual system selected would function quite differently from those of mammals, at least insofar as motion detection goes. Frogs and toads do not make eye movements, so scene-scanning saccades are absent. Their eyes reside stalk-still in their heads, and they apparently see things only when they move. However, the toad visual system seems to be acutely tuned to object motion, and the visual dimensions of salient targets (those that get the toad's attention) are quite precisely specified. The chapter summarizes Ewert's dedication of a lifetime's work on the toad visual system.

Finally, this book is graced by a lovely forward from Mike Land, who is arguably the author of the feast. This book will be of greatest interest to neuroscientists interested in cognitive processing in sensorimotor systems, in evolutionary neuroscience and in robotics. If biomimicry is a fertile research strategy for adventurous engineers, this book points the way to some fascinating animal models. Readers looking for something off-beat to pique their interests, too, should check out *Complex Worlds from Simpler Nervous Systems*. ■

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