The Condor 97:286–287

BOOK REVIEWS

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AVIAN VISION

Vision, Brain and Behavior in Birds.—P. Zeigler and H.-J. Bischof [eds.]. 1993. MIT Press, 414 p.

Due, in part, to the absence of a neocortex, the assumption has often been made that as a group, birds are inferior to mammals. Indeed, one of the most pejorative epithets in the English language is the term, "bird brain." Yet, neurobiological and behavioral evidence have consistently failed to support such an inference; to the contrary, the combined sensory and behavioral capabilities of avian species often surpass those of mammalian species.

Clearly, vision is the dominant sense of birds. Most species are strongly diurnal in habit and possess excellent visual acuity, color vision and visual discriminative capacities. Not surprisingly, a large proportion of avian neural resources are devoted to visual processing in the guidance of behavior. A large and varied research literature based upon experimental, developmental and ecological investigations has revealed a high degree of complexity in avian central visual pathways. The domestic pigeon has received the greatest share of attention in laboratory-based experimental investigations; and most behavioral studies have used the pecking response as the primary indicator of discriminative and perceptual functions.

The present volume provides both an overview of the current state of knowledge with regard to the neural correlates of vision and visually guided behaviors in birds. Twenty-two chapters are subdivided into five major sections dealing successively with the avian eye, the functional organization of central visual pathways, developmental processes and plasticity, neural mechanisms in visuomotor control, and visual cognition. A brief introduction has been provided at the beginning of each major section to orient the reader and provide a bit of integrative material, which otherwise is lacking from the volume.

"The Avian Eye View" contains several noteworthy chapters, including one by Martin on physiological optics, and a second by Varela, Palacios and Goldsmith on color vision. Both are quite comprehensive and informative, particularly from comparative and ecological perspectives. The latter chapter includes recent evidence for the presence of ultraviolet-sensitive pigments in many avian species, and raises the still-unresolved question of how such UV sensitivity is utilized. Current speculation about function is yet to be replaced by experimentally tested hypotheses with regard to this newly discovered dimension of avian photoreception, that also exists in several other nonmammalian species.

The section entitled, "Functional Anatomy of the Avian Visual System," focuses upon the topic of avian-mammalian homologies in the organization of central visual pathways—a search that has motivated several decades of neuroanatomical, neurophysiological and lesion-behavioral investigations. Shimizu and Karten describe the well-established evidence that avian and mammalian forebrains are organized quite differently. They further suggest that comparisons should be made *not* between avian telencephalic nuclear regions and mammalian cortex as a whole, but between specific neuronal populations within individual laminae of neocortex and discrete, nonlaminar nuclear groupings within the avian forebrain. Also, Engelage and Bishof provide an extensive review of the retino-tectal and tecto-thalamo-telencephalic visual pathways. The avian tectofugal system is critical for color, brightness and pattern discrimination and probably mediates the greatest portion of visual processing in most species. Yet, according to Hodos, the functional contributions of the thalamofugal pathway remain poorly understood, particularly in relation to vision in the frontal field of view. Indeed, the thalamo-telencephalic system may be specialized for either the frontal or lateral field of view depending upon the behavioral and ecological profile of any given species. Lateral visual field dominance tends to occur in fruit and seed-eating birds, while frontal-field specialization occurs primarily in raptors and birds of prey, most of which have two foveas in each eye.

Several chapters presented in the section on "Development of the Avian Visual System" emphasize the extent to which avian species have long been favorites of developmental neurobiologists, although much of the neuroanatomical research has concentrated upon embryonic rather than postnatal development. Fontenasi and co-authors review the recent literature on maturation, plasticity and organizational aspects of the development of central visual pathways. Embryonic development of the chick visual system also has been extensively utilized in studies of neuronal pathfinding and the ontogeny of retinotopographic representation in the highly laminated optic tectum. Mey and Thanos provide an excellent review of this rather complex research area with regard to hypotheses, theories and recent empirical findings.

The section entitled "Visuomotor Mechanisms" covers the visual guidance of behavior and compensatory visuomotor reflexes in birds. The significance of this research area is underscored by Zeigler's succinct statement: "The immensely sophisticated visual apparatus of birds is, ultimately, at the service of its motor systems." Zeigler and coauthors provide an extensive review of sensorimotor mechanisms mediating the response topography of visually guided ingestive responses, using the domestic pigeon as a model species. Three distinct components comprise this consummatory response chain—pecking, grasping and mandibulation—all are elicited by different sensory cues that involve different motor control systems at different levels in the central nervous system. One of the most

fascinating chapters in this section is by Katzir, who describes the visuomotor correlates of "piscivoury" (predation on fish) in water birds and how various species deal with the challenge of vision in two different optical media of water and air.

The final section is devoted to "Vision and Cognition," and includes such capabilities as object recognition, memory, problem solving and concept formation. Bingman surveys the role of the hippocampus in spatial memory, ranging from such behaviors as migration and homing to the storage and recovery of cached food. The dorsomedial forebrain of birds is generally considered to be homologous with the hippocampal formation of mammals, and numerous interconnections exist from the avian hippocampus to telencephalic visual areas. Lesions of hippocampus disrupt the recovery of stored seeds in some passerine species and affect spatial navigation in homing pigeons. Finally, Watanabe and co-authors review the evidence that pigeons can form and use concepts, but suggest that the data are best characterized as "patchy" and inconclusive. While birds are clearly capable of remarkably fine discriminations, concept formation, per se, appears to be slow and something of a "cognitive last resort."

Vision, Brain and Behavior in Birds, although not encyclopedic in scope, does provide a rather broad survey of the state of current knowledge from some of the most active areas of research on bird vision. In general, the contributions are well-written and should be readily accessible both to specialists and non-specialists, alike. A broad range of readers with behavioral, biological, zoological and/or neurobiological interests will find this compendium to be a source of new information from a variety of modern experimental and ethological approaches to understanding the visual control of behavior in the avian brain.—KATHERINE V. FITE, Director, Neuroscience & Behavior Program, University of Massachusetts/Amherst 01003.