Symposium 2

Behavioral analysis of sensory function: active and passive electrolocation

Introduction to Symposium 2

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A universal problem in the study of behavior is to explain how sensory experience guides the orientation and movements of animals. Predators respond to stimuli from their prey, parasites respond to stimuli from their hosts, conspecifics respond to communication signals from each other, and all animals respond to changes in stimuli from the environment. The sense organs play two key roles in these responses. First, they orient the present and future behavior of an animal with respect to the spatial positions of a stimuli received from the environment. Second, they play a key role in identification of the stimulus and the selection of an appropriate behavioral response from an available repertoire.

In this symposium we focus on the first sensory role: orientation of responses to environmental cues, and we ask the question, "How do animals orient their behavior relative to the spatial position of a stimulus?" Even a single cell organism can be guided by a variety of sensory cues, including chemical, light, tactile and even magnetic, so there are many general principles that can apply to many different organisms at different levels of organization (see Schöne 1984). Our principle focus is on the electrosensory modality, however, as it relates to other similar orientation mechanisms.

The first behavioral function to be ascribed to electroreception in weakly electric fish was active electrolocation (Lissmann 1958; Lissmann and Machin 1958). Lissmann and Machin showed that both the South American fish, *Gymnotus* and the African species, *Gymnarchus* could be conditioned to respond to the presence or absence of a conductor or insulator hidden inside a ceramic water filter, and that the fish's ability to discriminate was based on sensing the distortions of the fish's own field from its own electric discharge. Like echolocation in bats and whales, the other major active sensory systems, "electrolocation" in weakly electric fish, as it came to be known, depended on the organism emitting a signal, and then detecting objects in the environment through reafferent sensory input. We now define active electrolocation as the detection and localization of objects in the environment through the use of reafferent electrosensory information.

Soon after Lissmann's behavioral results were announced, physiological and anatomical results, reported by S. Hagiwara, Per Enger, and by Thomas Szabo gave new insights into the neural basis of responses to electrical stimuli, both modulated and unmodulated by objects (Hagiwara et al. 1965a, b; Enger and Szabo 1965). We now know that the sensory processing of the active electrosensory information takes place in the electrosensory lateral line lobe (ELL) (Bastian 1986c). The earlier symposium on the ELL is a timely update on just how far we have come in our understanding of these mechanisms.

While Lissmann and others speculated that electric fish may also use passive electrolocation': the sensing and localization of objects in the environment through exafferent electrosensory information, it wasn't until Kalmijn (1971) demonstrated passive electrolocation in sharks and rays that it became clear how important the passive mechanisms must have been in the evolution of the electric sense among vertebrates.

The overall theme of this volume is the contributions of electrosensory systems to neurobiology and neuroethology. This symposium takes recent behavioral studies in electrolocation and makes comparisons with localization in other, more familiar, senses such as audition or the lateral line. The lateral line system can be used for accurate determination of direction from surface waves. Some animals, like *Xenopus*, can learn to discriminate different frequencies and directions of surface waves (Coombs et al. 1989). A few species of surface feeding fish, like *Pantodon*, can determine both the direction and the distance of a surface wave sourve (Bleckmann et al. 1989; reviews in Coombs et al. 1989). Recently, some of the more remarkable examples of sound localization specializations come from the barn owl (see Konishi, this volume, for references). Today the electrosensory system and the barn owl sound localization system invite comparison.

The symposium begins with a discussion of electrolocation and an update on passive electrolocation by Hopkins. It turns next to the work of von der Emde, who makes comparisons between active electrolocation in fish and active echolocation in bats. Konishi then takes a comparative look at the barn owl sound localization system and the electrosensory system of *Eigenmannia* and looks for common themes in the information processing of the two systems. The symposium ends with some new behavioral data on active electrolocation by Gary Rose.