Electroreception in the Corpus Cerebelli of the High Frequency Electric Fish *Eigenmannia virescens*

Joseph Bastian

Department of Neurosciences, School of Medicine and Neurobiology Unit, Scripps Institution of Oceanography, University of California, San Diego, La Jolla

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Summary. 1. Evoked potentials as well as single unit responses show that the caudal lobe of the cerebellum of *Eigenmannia* receives input via the electroreception system. Many of the responding cells had properties similar to those typical of Purkinje cells. The cells probably receive input from specific receptive fields, however precise localization of these fields was not achieved.

2. Graded deformations of the electric field produced by the fish as well as artificial fields applied around a fish whose electric organ was silenced caused graded responses in the cerebellum. Responses to both stimulus types were usually phasic with a time constant of decay of about 3.5 sec, increases as well decreases in firing frequency were observed. The latency of the neural responses decreased as stimulus strength increased, ca. 20 msec being the shortest latency observed.

3. The minimum voltage gradient necessary to cause a change in the firing frequency of a cerebellar cell was about 100 μV/cm, for a fish whose electric organ was silenced, and the changes in spike frequency were approximately linearly related to the logarithm of the stimulus intensity. The neurons responded best to stimuli having a frequency near to what the fish’s electric organ discharge frequency would have been. All cells seen within an individual responded best to this same frequency, but the frequency preferences between individuals varied according to the discharge frequencies of the individuals.

4. Units were encountered in the same brain area which responded to passive changes in the position of the tail in the electrically silent fish, these have tentatively been categorized as proprioceptors. A number of these cells also responded in a typical way to electroreception input giving a population of cerebellar neurons with a bimodal input.

Introduction

In all of the vertebrate central nervous systems no structure is as well understood in terms of principal neuronal pathways and neuronal interactions as the cerebellum. However despite the relatively advanced knowledge of the design and physiology of this structure, it has proved difficult to show specific roles for the cerebellum in terms of the animal's capabilities. It is generally agreed that this area of the brain is involved

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in the fine control of various movements and correlations have been
drawn between its degree of development and the complexity of the
sensory inflows associated with the analysis of the animal's posture
(Eccles, 1969).

The most striking hypertrophy of the cerebellum occurs among the
electroreceptive fishes. Both active electric fish, those that generate a
field with an electric organ and simultaneously measure it with specialized
sense organs, as well as those non-electric fish that have specialized
organs for detecting the very small naturally occurring electric fields
in their environment, possess a well developed cerebellum. Since the
electrosensory system develops as a modification of the lateral line
system, which is one of the most important of the primitive inputs
to the cerebellum, it is not surprising to find the hypertrophy of this
brain area. However there is little physiological evidence linking the
cerebellum to the electrosensory system. Bennett and Steinbach (1969)
have shown that the command signals that eventually activate the
electric organ of mormyrids are simultaneously projected to many parts
of the cerebellum and proposed that this can exert a gating effect
on the sensory inflow from the electoreceptors themselves. Enger and
Szabo (1965) have shown that units in the lateral line lobes of gymnotids
are involved in the electrosensory system and that these units respond
to field distortions caused by various objects. Nicholson et al. (1969)
have also shown that cells in this brain area in elasmobranchs are also
sensitive to externally imposed electric fields. However, no responses
to electrosensory input have yet to be found in the corpus cerebelli.

It is possible that these fish could present a good opportunity to
study how the cerebellum operates on input from a relatively unexplored
sensory system, and since recently much quantitative information about
how the electrosensory systems are used in the animal's lives has become
available (Scheich et al., 1973; Scheich and Bullock, in press; Kalmijn
and Bullock, in press; Heiligenberg, 1973; Hopkins, in press), we may
be able to assign new details to the role of the cerebellum in the lives
of these fish.

Methods

The weakly electric fish, Eigenmannia virescens, was used exclusively in this
study. Specimens usually ranged in size from 10 to 20 cm. Single unit recordings
from the corpus cerebelli were made under two different experimental conditions.
A. Unanesthetized, electric organ normal: In this case animals were initially dis-
sected under the influence of the drug MS 222 (Tricain methanesulfonate) roughly
100 ppm. Approximately 20 min were allowed to pass between the end of the
dissection and the start of the experiment so that the effects of this anesthesia
had passed off. In early experiments it was found that this drug depressed the