ELECTRICAL RESPONSES FROM THE LATERAL-LINE NERVES OF FISHES

V. Responses in the Central Nervous System*

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(Accepted for publication, March 9, 1934)

Descriptions of nerve impulses discharged from lateral-line nerves of trout and catfish have been presented in previous papers (Hoagland, 1932–33 *a*, *b;* 1933–34 *a*, *b*). A vigorous repetitive discharge of impulses, independent of all external stimulation, has been found to occur over the lateral-line nerves—apparently produced by continuous chemical reactions in the sensory cells (neuromasts) of the lateral-line system. The frequency of the impulses has been found to be modified by mechanical and thermal stimulation of the neuromasts.

Experiments with certain fresh water fishes other than trout and catfish previously failed to show any nerve impulses in lateral-line nerves, either of the "spontaneous" variety or in response to external stimulation of the neuromasts. The procedure previously employed involved dissecting free 1 to 2 cm. of the nerve and drawing it across electrodes connected to the recording system. It was pointed out (Hoagland, 1932–33 *b*) that this treatment might render very delicate nerves inactive. Heavily scaled fresh water fish that have been examined seem to have tenuous and poorly myelinated lateral-line nerves compared to the larger and stronger lateral-line nerves of trout which have very small scales, and to those of catfish which have no scales at all. That this explanation of the absence of activity is probably correct is indicated by the fact that by a modification of the original procedure, I have found it possible to obtain the repetitive discharge of impulses, in the absence of external stimulation, in goldfish and in perch. Responses have been obtained from the lateral-line nerves of these fish by careful exposure of the nerves and by slipping concentric micro electrodes under them *in situ*. Out of seven goldfish lateral-line nerves, three clearly gave the spontaneous responses. Similar responses were obtained from four out of six lateral-line nerves of perch,

* The expenses of this work have been defrayed, in part, by a grant from the Permanent Science Fund of the American Academy of Arts and Sciences.

despite the fact that these nerves are extremely small and delicate. Stroking the flank and flexing the the trunk augmented the responses.

By the use of concentric micro electrodes it has been possible to follow the discharge of the lateral-line nerve into the central nervous system of trout, catfish, goldfish, and perch. Twenty-three fishes were tested. The electrodes are made according to the general method first used by Adrian and Bronk (1929). A fine glass-sheathed silver wire is inserted into the tube of a No. 24 hypodermic needle, the silver core thus acting as one lead and the steel needle as the other. The electrodes are connected through resistance-coupled amplifiers to an iron armature oscillograph and to a loud speaker. The silver core electrode was connected to the grid of the first valve and the tube of the needle was grounded.

The fishes were either anesthetized with chlorotone or, for the most part, immobilized by severing the spinal cord just posterior to the medulla. Results were the same in both cases. Care was taken to assure against the recording of muscle action currents.

A certain small amount of electrical activity was found in some of the fishes in the forebrain and tectum. This may have been due to injury, or to spontaneous central discharges. It did not seem to be correlated with illumination of the eyes. Massive continuous discharges of impulses were found in the tuberculum acusticum, in which the lateral-line nerve terminates. This discharge was silenced on one side by severing the ipsilateral lateral-line nerve but remained on the other side as long as the lateral-line nerve on that side was active. A vigorous discharge of impulses was also found in the cerebellum corresponding to the incoming discharge of lateral-line impulses. The cerebellar activity was diffuse. Severing one lateral-line nerve produced a fairly uniform decline in the impulses throughout all regions of the cerebellum. Cutting both lateral-line nerves silenced the cerebellum as well as the tuberculum acusticum.

The spontaneous discharge of trout lateral-line nerves has been found in certain cases to be synchronous (Hoagland, 1933–34 *b*). The synchronization produces a distinct note from the loud speaker. The synchronized discharge was found to enter the tuberculum acusticum where the synchronization ceased, the impulses on reaching the cerebellum being quite arhythmic.

When the electrodes were placed in the brain at the place of entrance of fibers supplying the neuromast groups of the head, no evidence of spontaneous discharge was found—suggesting that the

facial neuromasts may have functions different from those along the trunk.

These experiments support the notion that discharges from the lateral-line receptors have a tonic reinforcing rôle in postural and swimming reflexes (Hoagland, 1933–34*a*), in addition to serving as pressure and probably as thermal receptors. The continuous engagement of groups of neurones in the tuberculum acusticum with the reception of the spontaneous discharge is also suggestive in connection with the demonstrated inhibition of auditory responses of catfish which possess functionally intact lateral-line systems (Parker and Van Heusen, 1917).

SUMMARY

Records of spontaneous discharge of nerve impulses, similar to that previously described in catfish and in trout, have been obtained from lateral-line nerves of goldfish and perch, by the use of concentric micro electrodes slipped under the nerve *in situ*. These impulses have been followed into the central nervous system. They enter the tuberculum acusticum and thence apparently spread diffusely through the cerebellum. Cutting the lateral-line nerve on one side silences the ipsilateral tuberculum acusticum, but only reduces the intensity of ipsilateral cerebellar activity. Cutting the remaining lateral-line nerve silences activity throughout the tuberculum acusticum and the cerebellum.

The maintenance of tonic activity in the tuberculum acusticum by way of lateral-line discharge may account for the inhibitory effects of the lateral-line system on auditory responses.

CITATIONS

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