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Potentials from the Isolated Forebrain and Potential Summation in the Isolated Brain of Catfish.

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Electrical responses of smooth wave form from the midbrain and vagal lobes of the completely isolated brain of the goldfish *(Carassius auratus* L.) have been described by Adrian and Buytendijk.[1] These waves were apparently periodic states of negativity in the vagal lobes relative to an earthed electrode, and occur at a frequency roughly corresponding to the normal opercular beat. Adrian and Matthews,[2] working on electrical waves from the anesthetized cortex of the rabbit, varied the distance between balanced electrodes and found that the long, smooth waves require large areas for their propagation. They concluded, as I have found using a single grid electrode, that the smooth wave contours are summed potentials of relatively short duration. For recent reviews of the extensive literature on electrical waves of central origin see Kornmuller,[3] Jasper,[4] Prosser.[5] It is generally conceded that the spontaneous discharges in the central nervous system have their origins in the nerve cells (Adrian and Buytendijk[1] Bartley and Bishop[6] Adrian and Matthews[2]; and the reviews just cited). Hoagland[7] has presented evidence indicating that the alpha waves from the occipital cortex of man arise as "relaxation oscillations" at frequencies directly proportional to the rate of the respiration of the cortical tissue.

After cutting the cord posterior to the medulla, brains of catfish, *Ameiurus nebulosus* (LeSueur), were removed and placed on a glass plate moistened with isotonic NaCl solution (0.089 N). This solution bathing the tissues prevents drying and sustains the activity. Records obtained from brains bathed with catfish blood serum did not differ from those obtained when isotonic saline was used. I am informed that according to Gerard (Symposium discussion), who

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1 Adrian and Buytendijk, *J. Physiol.*, 1931, **71**, 121.

2 Adrian and Matthews, *J. Physiol.*, 1934, **81**, 440.

3 Kornmuller, v. A. E., *Biol. Rev.*, 1935, **10**, 383.

4 Jasper H., *J. Gen. Psychol.*, 1936, **14**, 98.

5 Prosser, C. L., *Cold Spring Harbor Symposia*, 1936, Vol IV (in press).

6 Bartley and Bishop, *Am. J. Physiol.*, 1933, **103**, 173.

7 Hoagland, H., *Am. J. Physiol.*, 1936, **116**, 604.

has obtained records from frog brains, isotonic NaCl bathing the brain gives essentially the same sort of records obtained when the brain is bathed with Ringer's solution. The dissections were performed with as little traumatic effect as possible. When care is taken to preserve the respiratory movements and blood supply until the operation is almost complete, the most stable and enduring preparations are obtained. Injuries to nuclei generally result in total lack of spontaneous activity. About half of the brains examined were found to be inactive. Oscillations were obtained from some 30 brains.

Continuous records were made on paper tape with a Garceau ink-writing undulator and amplifier system. The undulator records (Figs. 1 and 2) were then photostated or traced. The time constant of the amplifier was such that a sustained pulse of 10 to 100 μv. fell to zero in approximately 200 milliseconds. Some damping of the waves due to properties of the undulator was observed. However, comparisons of the undulator records with the direct coupled amplifier records which Adrian and Buytendijk[1] obtained with a Matthews oscillograph show much similarity.

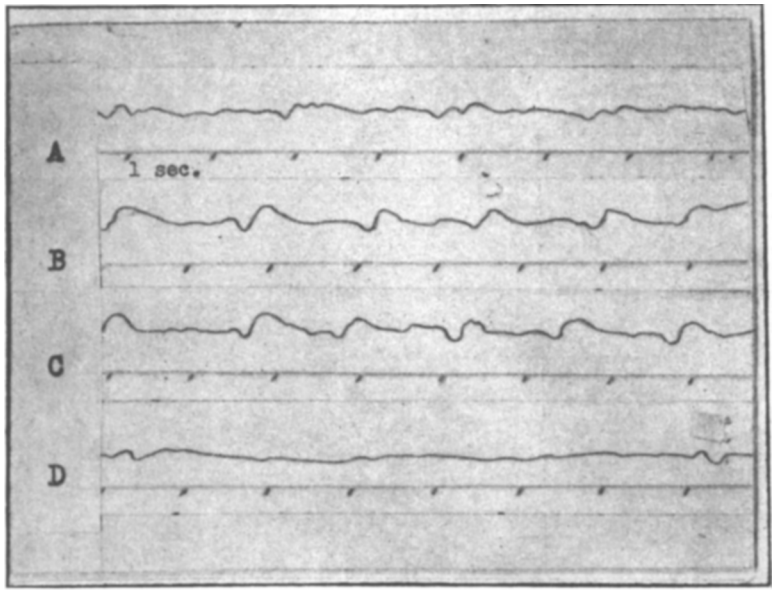

FIG. 1.
Spontaneous discharges from the intact and isolated cerebral component of the catfish forebrain. A, period of relatively asynchronous activity; B, the typical smooth wave from the intact forebrain; C, the isolated response; D, decreased potentials after isolation of 3.5 minutes.

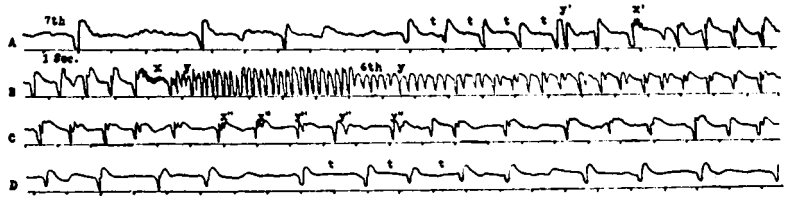

FIG. 2.

A continuous record (A-B-C through D) of electrical oscillations from the cerebral lobe region of the isolated catfish brain. t, the typical discharge from the cerebral lobe; y' and x' show regions of instability and precursors of change; x, summation within the typical wave form; y, period of reorganization of the summed potentials; x'' and y'', regions of greatest summation and reorganization.

Cotton wick electrodes were attached to chlorided silver loops and saturated with isotonic saline. The grid wick electrode was placed lightly on the surface of the tissue; the placement of the earthed electrode had no effect upon the wave form, thus indicating that all the electrical changes recorded apparently take place under the single grid electrode. When the waves were in progress, crushing the tissue, or the application of formalin abolished them.

Frequently when electrical responses had ceased in the medulla and midbrain, it was possible to secure rhythmical responses from either the distal (olfactory) component, or the mesial (primitive cerebrum) component of the forebrain. Records from these components showed considerable differences in form. The cerebral component gave waves resembling the smooth midbrain waves described by Adrian and Buytendijk,[1] while the olfactory component produced waves similar in form to the discharges from the medulla recorded by these workers.

Isolation of the forebrain, accomplished by severing with a sharp scalpel, often does not stop the rhythmical responses, which may continue for 5 or 6 minutes (Fig. 1-C) before decreasing in amplitude and frequency (Fig. 1-D) and finally disappearing entirely. The disappearance of these waves is probably similar to the gradual disappearance of the spontaneous potentials which occurs in the visual cortex of the rabbit after cutting and ligation as observed by Bartley and Bishop.[6]

It is interesting to note that when there is a gradual decline in the amplitude and frequency of the major discharges, there often appears between these discharges a series of minor deflections (Fig. 1-D and Fig. 2-A) which are comparable to other rhythmical discharges sometimes observed in the series of waves.

Because the condenser system employed maintains a D.C. pulse for a maximum of 200 milliseconds, and the discharges which sustained the slow waves were frequently more than 1000 milliseconds

in duration, it was evident that these slow waves were summed potentials.

The smooth, rhythmic waves infrequently showed disintegration and reconstruction periods. Figure 2 is illustrative of these transitions, and suggests that the waves are sustained in their various forms when these summing potentials are repeatedly synchronized and combined in their various complex forms according to their own shifting phase relations.

Summary. 1. Rhythmic electrical potentials of from 10 to 180 μv. have been recorded from the isolated olfactory and cerebral lobes of the forebrain of catfish. The "spontaneous" potentials from the 2 different regions differ in form. 2. The smooth wave contours of the central nervous system are apparently complex summed potentials of many smaller oscillations.

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Higher Resistance of Rats Fed Casein Than Those Fed Vegetable Proteins.

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(Introduced by F. F. Tisdall.)

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Although it has been well established that rats fed a vegetarian diet are inferior to those fed an omnivorous diet both as regards body weight and lactation,[1] little is known as to their relative resistance to infection. Chen and Li[2] found that when rats fed a vegetarian diet made up of wheat, millet, soy bean and peas, and others fed an omnivorous diet of wheat, milk powder and fresh vegetables were infected with hog cholera bacilli I.P., 84% of the former and 42% of the latter died. When pneumococci (Type I) were injected subcutaneously, more of the omnivorous (77%) than of the vegetarians (56%) died, but according to these authors this difference is not great enough to be significant statistically. We thought it of interest to test the resistance of rats fed diets varying only in the types of protein which they contained. The diets were constituted as follows:

[1] Editorial *J. Am. Med. Assn.*, 1935, 105, 488.

[2] Chen, T. T., and Li, C. P., *Chinese J. Physiol.*, 1930, 4, 59.