Comments and Communications

Traveling Waves in the Brain[1]

In an earlier paper (GOLDMAN, S., VIVIAN, W. E., CHIEN, C. K., and BOWES, H. N., *Science*, 1948, **108**, 720) equipment for electronic mapping of the electrical potential at the surface of the skull has been described. In this paper it was stated that area displays of the instantaneous skull potentials could not readily be interpreted because of the speed of the activity. Subsequent work in cleaning up residual artifacts has clarified these pictures. The taking of motion pictures of the activity and their display at slow motion (by a 4: 1 ratio) has added further information, so that it is now possible to give a first report of the results.

In the observed area displays, there is some activity of rise and fall in potentials, which apparently occurs at irregular times at isolated electrodes. Less frequently the activity of a large part of one of the hemispheres of the brain seems correlated. The most striking activity, however, is that of traveling waves across the skull. Some traveling waves cross the entire skull, often crossing the central fissure. If all sixteen electrodes are placed above the general outline of a single occipital or temporal lobe of the brain, it may be seen that there are traveling waves within the single lobe. In a single lobe the traveling waves often show a rotational (or circular) path which has never been noticed in the case of waves crossing larger areas of the brain. Within the same lobe there are successively clockwise and counterclockwise rotations, interspersed with straight motions at various angles. The frequency of rotation of the rotatory motion is approximately 9 per sec.

The traveling wave phenomena are much more pronounced when the eyes are closed than when they are open. It was therefore thought at first that the single lobe effects, such as rotational motion, might be characteristic only of the occipital lobes, where they were first observed. This, however, turned out not to be true, since the same type of single lobe phenomena, including rotational motion (but of reduced voltage), occurs also in the temporal lobes. Surprisingly enough, the traveling wave activity in the temporal lobes also becomes much more pronounced when the eyes are closed. This would appear to indicate that when the eyes are closed in a wide-awake individual (holding the hands in front of the open eyes to keep out light has the same effect as closing the eyes), the entire brain changes its type of activity, becoming more active internally. If the individual becomes drowsy, the amplitude of the traveling wave activity is greatly decreased. No characteristic individual activity was observable in the frontal lobes.

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Tests were made with visual and auditory stimuli to see whether they gave rise to traveling waves. In the case of an auditory stimulus, an effect could be observed in the pattern, but it was stationary and localized. No effect whatever could be observed in the pattern when a visual stimulus was brought into the field of vision. This was undoubtedly due in part to the crudeness of the test.

The major part, at least, of the traveling waves may be identified with the alpha rhythm. This is indicated by their frequency and their variation of intensity with time, and with opening and closing of the eyes. The suggestion, often made, that the alpha rhythm represents a scanning operation in the brain appears, as a gross interpretation, to be borne out by the observed pictures. This is particularly true for the single lobe pictures, as might be expected. We have, however, no experimental information as to the physiological nature of this operation, nor do we yet really know that the fundamental nature of these traveling waves is that of a scanning process.

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Louisiana Oyster Production

In a recent article (*Science*, 1948, **108**, 484) the writer made the following points: the Fish and Wildlife Service has not collected annual fishery statistics on the Gulf Coast every year due to lack of funds; the federal oyster statistics prior to 1930 are about 35% exaggerated when given in pounds; state and federal statistics show no evidence of decline in Louisiana oyster production; oyster production of other Gulf states combined has declined 78% since the 1920's; and the misgivings expressed by Walter A. Chipman, Jr. (Oyster Institute of North America Trade Report No. 91, June, 1948; mimeographed) over the threatened "existence of the large oyster industry of that state" (Louisiana) were unfounded.

In a rather curious reply, which avoids mention of the points I made, Chipman (*Science*, 1949, **109**, 210) says, "Even though the total production remains stable or actually increases, it must be realized that this situation results from expansion of the industry through use of undeveloped grounds, of which Louisiana has an abundance, and of better utilization of producing grounds. It does not negate the fact that a continuing unexplained mortality may prevent the production from reaching even higher levels. Furthermore, once the expansion is completed, this mortality may then result in decline as the adverse factors causing this mortality continue and spread to other areas. This latter possibility has been in the minds of Louisiana oyster conservationists for some time. Because they are progressive and look into the future, they have good reason for alarm."

This contradicts none of the facts I previously presented. Alarm over the failure of the Louisiana oyster