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SOME OBSERVATIONS ON THE SUPERIOR COLLICULI OF THE CAT BY J. ALTMAN

BY

H.-L. TEUBER

WITH 3 FIGURES

Some Observations on the Superior Colliculi of the Cat by J. ALTMAN[1]

Communicated by

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With 3 Figures

The observations I should like to communicate to you in this discussion on the optic tectum were made by Dr. JOSEPH ALTMAN in the course of his work for a doctoral dissertation[2]. Dr. JOSEPH ALTMAN undertook these studies for three reasons:

1. Just as Professor DOTY, he believes that the optic tectum may play a greater role in the visually-guided behavior of carnivores and primates than has usually been assumed. His electrophysiological and subsequent anatomical studies were preliminary to behavioral experiments which are now in progress; his current work is concerned with changes in visual performance after removal of the superior colliculi and adjacent structures.

2. The superior colliculi raise a particular problem for correlating structure and function, because of their lamination. As WALLS (*2*) has pointed out, such lamination is found in neuroretina, superior colliculi, lateral geniculates and cortex; eventually, we should be able to account for the "purpose" of these laminar arrangements.

3. Lastly, there is the recurrent problem of the interaction which one assumes exists between superior colliculus and visual cortex. In his somewhat preliminary electrophysiological studies (in deeply barbiturized animals), DR. ALTMAN found no direct signs of such interaction, but subsequent investigation of anatomical connections, by means of the Nauta stain, revealed a definite corticifugal pathway (ALTMAN and CARPENTER, in preparation). However, these recent studies with the Nauta stain did not disclose any corticipetal fibers from the cat's superior colliculus to its visual cortex.

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[2] This dissertation was cosponsored by Dr. LEONARD I. MALIS, Mount Sinai Hospital, New York City.

Now to the electrophysiological observations: They were all made on barbiturized cats with macroelectrodes, as well as tungsten microelectrodes prepared according to HUBEL's method (tip diameter: 0.5 to 2 μ). I shall briefly describe four of Dr. ALTMAN's findings, viz.: 1) latency differences between superior colliculi and visual cortex; 2) differences in the shape of evoked potentials in superior colliculus and visual cortex, respectively; 3) evidence for some definite ipsilateral representation in the superior colliculus in addition to the well known contralateral projections; and 4) changes in the nature of collicular responses when recorded from progressively deeper lamina of this structure.

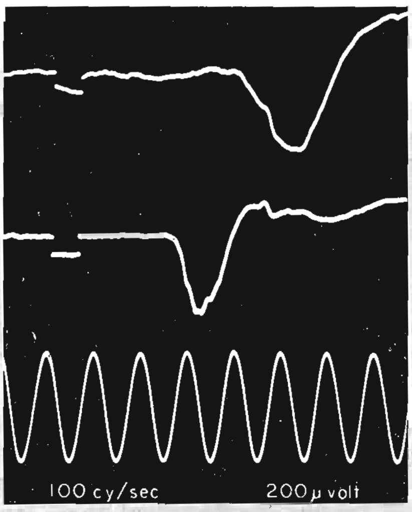

Fig. 1

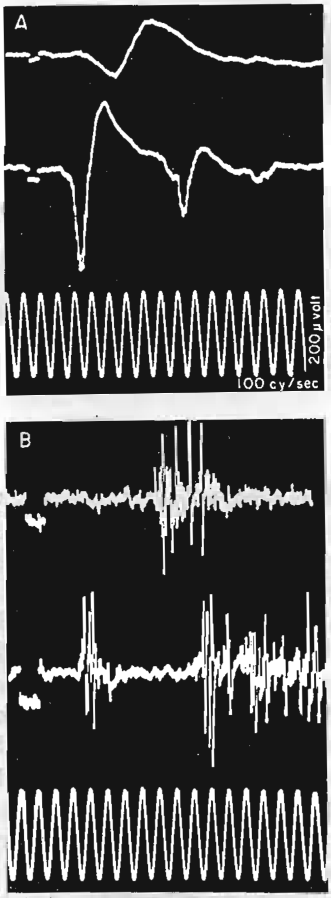

Fig. 2

Fig. 1. Simultaneous recording of evoked response to a 5 msec. flash (as shown by stimulus artifact) to the cat's eye. Upper trace: macroelectrode recording from superior colliculus; lower trace: corresponding recording from lateral gyrus.

Fig. 2. Cortical and collicular response to light (5 msec. flash). *A* Simultaneous recording with macroelectrode in both structures: upper tracing, collicular response, lower tracing, cortical responses (lateral gyrus). *B* Microelectrode recordings: upper tracing, collicular responses, lower tracing, cortical responses (lateral gyrus). Calibration in *B*: 200 cy/sec.

1. Latency of collicular and cortical evoked potentials. In deeply barbiturized cats, the mean onset latency of evoked potentials to light was 36.5 msec in the superior colliculus and 27.0 msec in the cortex (see Fig. 1). The average difference in latency (9.5 msec), between simultaneously recorded collicular and cortical responses, was a constant which seemed independent of the absolute latencies of the two kinds of response. When photic stimulation of the retina was replaced by direct electric stimulation of the optic nerve, the results were essentially the same: although absolute latencies were correspondingly decreased, the latency difference between collicular and first cortical response remained around 7 msec. Apparently, the difference in latencies reflects a *slower conduction rate in retino-collicular fiber systems as compared with that in the retino-geniculo-cortical path.* This difference in conduction velocity must be considerable since the retino-geniculo-cortical pathway is much longer than the retino-collicular path, and interrupted by a synapse. A maximal conduction rate of 5 m/sec was calculated for the retino-collicular fibers. This conduction velocity is actually markedly lower than the

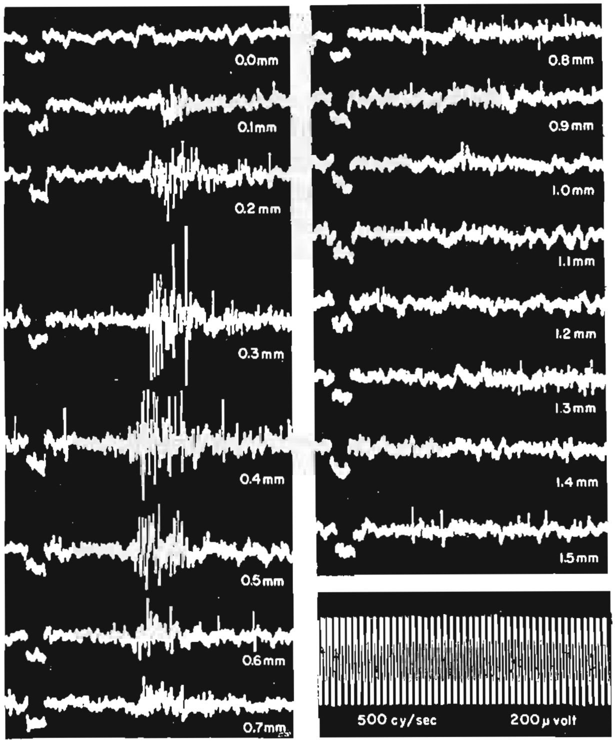

Fig. 3. Microelectrode recordings from increasing depths of superior colliculus. For details, see text.

lowest conduction velocity recorded by MARGARET LENNOX (*1*) in the optic tract after optic nerve stimulation.

2. Shapes of collicular and cortical evoked potentials. As fig. 2 shows, stimulation of the cat's eye by a single flash evoked a single potential in the colliculus, in contrast to the well known sequence of waves in the visual cortex. The average duration of the single wave in the colliculus was considerably longer (24 msec) than the duration of the initial cortical wave (10.8 msec).

3. Ipsilateral and contralateral representation in the superior colliculi. Macro- as well as microelectrode recordings revealed definite evidence for ispilateral representation in the cat's superior colliculus. Evoked responses to stimulation of the contralateral eye were always larger in amplitude when recorded with macroelectrodes, indicative of the greater number of crossed representations.

However, there were evoked responses (recorded with macroelectrodes) as well as unit responses (obtained with microelectrodes) indicative of a sparse pathway from retina to ipsilateral colliculus.

4. Changes in unit responses on penetration of superior colliculus. As a microelectrode traverses the colliculus from upper into lower lamina as shown in Fig. 3, one observes marked changes in the unit responses that can be obtained at the different depths indicated. Briefly, the most superficial electrode placements record the majority of unit responses that are modifiable by light presented to the eyes or by electric stimulation delivered to the optic nerve. These electrode placements seem to coincide with the stratum griseum superficiale. As is evident from Fig. 3, such responses are no longer found at greater depth, i. e., more than approximately one millimeter beneath the surface of the superior colliculus. Below this one encounters evoked potentials, but no individual units which could be driven by photic or optic nerve stimuli. This region may be identical with the stratum opticum. Still farther down one enters a region in which evoked potentials are shallow; at this depth one observes units that fire spontaneously, but there are no units whose activity could be modified by stimulating the eye or optic nerve.

In additional experiments, a tentative classification of collicular units has been established by Dr. ALTMAN. In essence, he found five types of collicular cells that could be driven by light, namely units firing with short latency; units firing with long latency; units firing to light on only; units firing to light on and light off; and units inhibited by photic or optic nerve stimulation.

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