LATENT PERIODS AND SYNCHRONIZATION OF UNIT DISCHARGES OF THE VISUAL AND SOMATOSENSORY CORTEX IN RESPONSE TO CONDITIONING FLASHES

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According to the theory of the functional system [1] the integral behavioral act is based on integration of the special functions of many individual brain structures. One of the mechanisms of integration is the synchronization of processes of different localization [4, 5, 7, 8, 9], leading to a unified temporal structure of processes taking place between stimulus and response for the brain as a whole [2, 5, 6]. The synchronization of the discharges of many neurons in each of the processes making up the system is an essential condition for the development of the whole sequence of its mechanisms, for the degree of synchronization of presynaptic effects is an essential determinant of the response of the postsynaptic neuron [3]. This paper analyzes the possible causes of synchronization of unit responses of the visual and somatosensory cortical areas to a conditioning stimulus in the defensive behavioral act.

Experiments were carried out on 12 unanesthetized, unimmobilized rabbits fixed in a stereotaxic apparatus. The activity of two neurons in the visual and somatosensory areas of the rabbit cortex in response to a conditioning flash (0.3 J, 50 μsec) was recorded simultaneously by two glass microelectrodes (diameter of tip 1-2μ), filled with 2.5 M KCl solution. The unconditioned stimulus, electrical stimulation of the skin, was applied 600 msec after the flash through needle electrodes inserted under the skin. Unit activity, the EEG from the corresponding areas, and the EMG of the forelimb were recorded after amplification on magnetic tape and then reproduced on paper after reduction of the winding speed by 8 times. The activity of 61 pairs of neurons was recorded.

Summation of the evoked potentials and construction of poststimulus histograms were carried out on AI-256 or NTA-512B analyzers and the results were then photographed from the screen or led to a two-coordinate recorder. The epoch of analysis was 100 msec and it corresponded to the mean interval between the stimulus and the conditioned EMG response [2, 5]; the channel width on the histogram was 2 or 4 msec. The latent period of response of a single neuron was measured as the interval before the maximum of the poststimulus histogram plotted from 25 combinations. Histograms of distribution of the neurons by latency were plotted on the basis of these measurements.

Histograms of distribution of neurons by response latency are illustrated in Fig. 1; only neurons with a phase of activation within 100 msec were counted. The maxima of the probabilities of responses in both areas lay in the interval between 20 and 40 msec and amounted to 0.58 and 0.57 for the visual and somatosensory areas respectively. The earliest responses in the visual area (Fig. 1b) clearly prededed the earliest responses in the somatosensory area (Fig. 1a) by only 2 msec, and if the latent periods were estimated with accuracy of not more than 4 msec (Fig. 1c) the maxima of the histograms coincided. Since fluctuations of the latencies of responses of the same neuron in both the visual and the somatosensory areas were usually more than 4 msec, discharges even of those neurons whose mean response latencies differed considerably can be regarded as synchronized. These observations suggested that the possibility of synchronization of different neurons is embodied in the instability of their response latencies and they compelled a search for the cause of the variability of the latencies. Since synchronization of the discharges took place only in response to a meaningful stimulus, evoking the behavioral act [5, 7, 8, 9] and, consequently, synchronization is a requirement of integration, this raised the issue that the variability of the response latencies

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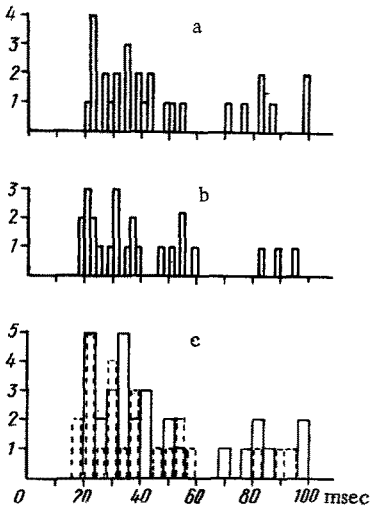

Fig. 1.

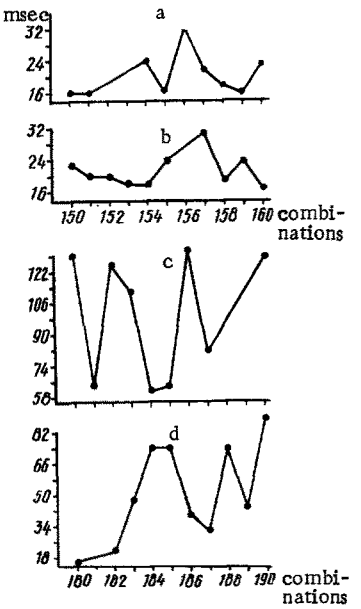

Fig. 2.

Fig. 1. Distribution of neurons by latencies of responses to conditioning flashes: a) in the somatosensory (n = 30), b) in the visual (n = 28) cortex; c) in the somatosensory (continuous line) and visual (broken line) cortex. Abscissa, latent period, msec; ordinate, number of neurons.

Fig. 2. Dynamics of response latencies of two simultaneously recorded neurons: a, c) latencies of unit responses to flashes in somatosensory, and b, d) in visual cortex. Electrodermal reinforcing stimulation, with an intensity of 45 V, was applied to the fore limb (a, b) and hind limb (c, d). Abscissa, serial No. of flash; ordinate, response latencies, msec.

might be the result of the different degree of involvement of the same neuron in the general integration when different synaptic inputs of the neuron are used. This hypothesis was tested by changing the reinforcing stimulus and thereby changing the properties of pretrigger integration. With a change in any parameter (intensity, localization) of the reinforcing current the response latencies to flashes with unchanged physical parameters in both cortical areas could vary significantly as regards both their mean amplitude and their stability (compare c and d with a and b in Fig. 2).

It can be concluded from the results described above that the response latency of the single neuron in the behavioral act is determined by the whole range of influences to which the neuron is subjected when included in the general integration of the behavioral act, and not by the number of synaptic relays or the length of the conducting fibers from receptors to recorded neurons. Synchronization of the discharges in brain structures, whether in the projection category or not with respect to the particular stimulus, is brought about by the specific organization of the heterogeneous influences on each single neuron.

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