The associative responses (AR) of the frontal areas of the cat cerebral cortex were investigated. It is suggested that they are the result of dispersed heterochronous activation of cortical dendrites. The first, positive, component of the AR reflects postsynaptic hyperpolarization of dendrites, which is accompanied by moderate depolarization of the body of deep pyramidal cells. The latter, responding to a second afferent volley leading to a negative phase throughout the cortex, generates impulses forming a complex heterogeneous efferent volley along descending pathways. These centrifugal influences give rise to action potentials of the skeleton muscles. Repetitive rhythmic stimuli produce habituation of AR and muscle responses, which was not noted for primary responses (PR). The characteristics of AR and muscle responses reflect the main properties of the orientational reflex. It is suggested in this connection that the AR of the frontal area are an electrical expression of activation of the functional system of the orientational reflex. Unlike the PR, the AR do not reflect physical or spatial characteristics of the stimulus but display a dependence on its "novelty." Apparently the informational significance of the AR is determined primarily by the novelty of the stimulus.

INTRODUCTION

The associate responses (AR) of the cortex are one of the indicators of convergence of afferent influences on brain structures [34, 35, 19, 5, 8, 6, 20, 1]. Even now there is no doubt about their separation into an independent category of cortical phenomena [7, 18]. Moreover, it has been found that the AR recorded from different cortical association areas greatly differ from one another in their properties [28-32, 2, 20-22, 13-25]. Therefore, AR should be differentiated depending on the structure from which they are recorded. Of special interest in this connection is the frontal cortex of cats, which simultaneously has properties of the projection area of the motor analyzer and properties of a typical polysensory association structure [29, 36, 12]. The need arose for studying the genesis of "frontal" AR and their specific significance in the overall activity of the brain.

METHOD

The experiments were carried out on cats narcotized with chloralose. The cortical mechanisms of the origin of the AR were investigated by the method of layer-by-layer focal recording. A tungsten electrode in glass insulation (tip diameter 5-7μ) was fastened in the micromanipulator of a stereotaxic apparatus. The depth of recording the AR was determined by the readings of the micromanipulator, and then, after brief anodic electrolysis at the recording point, it was determined histologically on Nissel-stained sections.

The electrode was implanted at the focus of maximum activity in the rostromedial portion of the posterior sigmoid gyrus [10]. The pass band of the ac amplifier was set within 10-3500 Hz, which made it possible to record the impulse activity of the neuronal groups along with the total processes.

The AR were compared with the primary responses of the corresponding area and with the muscle responses recorded electromyographically.


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RESULTS AND DISCUSSION

As the rule, the associative responses to light arose with different latent periods, the maxima of their distribution curve corresponded to 18-23 and 35-45 msec (Fig. 1A). The latent period of the corresponding primary responses (PR) was 12-15 msec. Such a distribution of the AR is probably related with heterogeneity of subcortical afferent activation [3, 4]. The short-latent AR evoked by a light flash were characterized by the presence of the first negative deflection; the long-latent AR were represented by a high-amplitude, positive-negative complex (Fig. 1A). The total duration of the AR was greater than that of the PR. In immobilized, nonnarcotized cats AR were recorded which consisted of a high-amplitude positive-negative wave with a latent period of 36-38 msec [26]. Associative responses to a clicking sound arose with a latent period of 9-12 msec and the PR with a latent period of 7-9 msec. The AR consisted of a low-amplitude, positive-negative wave with a subsequent second slow positivity (Fig. 1A). In nonnarcotized cats the AR to sound were recorded 16.7 msec after stimulation and consisted of initial negativity followed by a positive-negative wave.

Statistical analysis of the data revealed a high variability of the parameters of the AR and absence of a correlation with the parameters of the corresponding PR. Thus, whereas the coefficient of variation (v) for an AR evoked by a light flash at the focus of maximum activity of the frontal area of the cortex was 10.5 and at the periphery of the area 26.4%, for the PR of the occipital cortex it was equal to 7.4%.

Figure 1B (left) shows the recordings of the AR evoked by a light flash (energy 3.5 J; duration, not more than 50 μsec) recorded from different cortical levels. These AR have a more complex formula than the AR recorded by means of the usual macroelectrode (tip diameter 300 μ). With a surface lead, which was accomplished by a fine electrode, an AR was recorded which consisted of a positive and a negative phase. The amplitude of the positive phase diminished with depth of the electrode into the cortex, and the wave, which was noted upon transition to the negative phase, increased. Nevertheless, reversion of both phases of the AR throughout the entire diameter of the cortex was not observed. When the electrode was at a depth of 1900 μ, impulse activity of neurons was recorded between the V and VI cortical layers at the site of the wave upon phase transition. A negative phase of the AR of rather high amplitude arose throughout the diameter of the cortex (Fig. 1B). As measurements showed, the differences between the latent periods of the AR...