CHARACTERISTICS OF FUNCTIONAL INTERACTION BETWEEN THE PARIETAL AND MOTOR CORTEX

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KEY WORDS: Nonprojection areas of the cortex; projection areas of the cortex; interaction between cortical areas; intercortical integration.

Investigation of mechanisms of intercortical integration depends on the prior elucidation of interconnections between parts of the neocortex which differ in modality and hierarchic relations. However, despite intensive studies of this problem [1, 2, 6, 8-11], many of its aspects are still undefined and require detailed elucidation. This applies equally to effects of nonprojection areas, including the parietal and motor areas, on each other.

The study of the character of interaction between the latter was the aim of the present investigation, in which, to obtain a deeper understanding of the problem, the writer's earlier data on interaction between projection zones and with the parietal region were analyzed for the purpose of comparison with the results of the present investigation.

EXPERIMENTAL METHOD

Acute experiments were carried out on 16 adult cats of both sexes. Methods of recording evoked potentials (EP), of local cold blocking of the cortex, and of peripheral stimulation of the visual and somatic systems were described in detail previously [4, 5]. EPs were recorded from the parietal and motor areas before and after reversible cooling, and also in one structure after cooling of the other.

EXPERIMENTAL RESULTS

After local cold blocking of each of the neocortical formations to be studied, sharp changes were found in EPs in the uncooled region. For instance, the action of cold on the motor area led to significant transformation of EP in the parietal cortex, which began very rapidly (after 15-30 sec) and were observed throughout the cooling process, which continued for 30 min (Fig. 1). A similar picture was observed in the motor cortex after cooling of the parietal cortex (Fig. 2). The distinguishing feature of the dynamics of the positive (P_1) and negative (N_1) waves of the early component of EP was the alternate increase and decrease in their amplitude (Figs. 1 and 2). These changes in the early component of EP were found regularly in all experiments. However, they were characterized by great variability and aperiodicity of their course, not only in different experiments, but actually in the course of each observation. This applies equally to transformation of the late component of EP, and in particular, of the second positive wave (P_2). Its amplitude also rose or fell alternately (Figs. 1 and 2): In the latter case P_2 could disappear, and be replaced usually by a new negative wave (N_n), which was absent during spontaneous activity. All the changes in EP described above were clearly detectable in response to the arrival of both somatic (Fig. 1) and visual (Fig. 2) impulses in the motor or parietal area.

The results are evidence of well-marked regulatory interaction between the parietal and motor areas, characterized by a complex multidirectional effect, including both facilitatory and inhibitory influences, and a pulsating, aperiodic type of course. This interaction, which was found equally quickly and clearly during multisensory stimulation, can be defined by its appearance as modality-nonspecific.

Meanwhile, despite the features of similarity listed above, the mutual effects of the parietal and motor areas on each other differ.in value, as will be clear from the character of the decrease and increase in EP in

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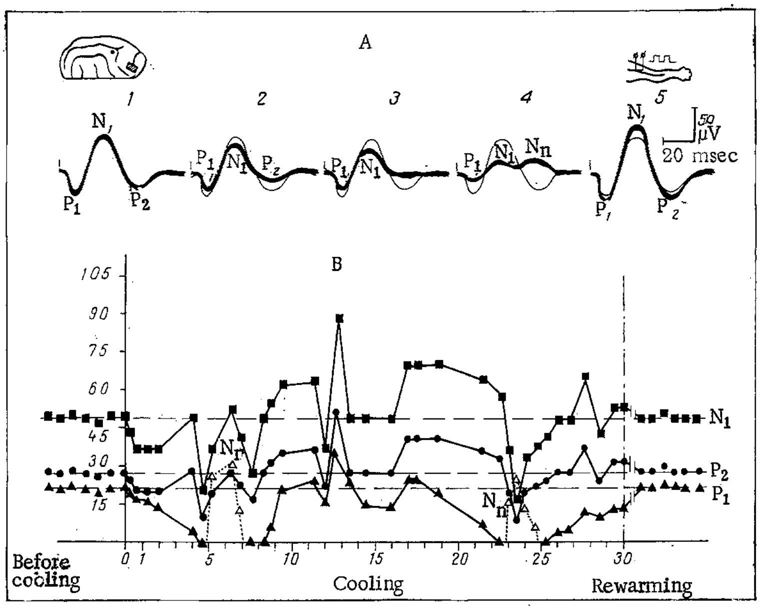

Fig. 1. Changes in EP in parietal cortex during cooling of motor area. P_1) positive wave of early components, N_1) its negative wave, P_2) positive wave of late component of EP, N_n) new negative wave replacing P_2. A) Character of dynamics of EP. 1) EP initially, 2-5) during cooling: 2) decrease in EP, 3) disappearance of P_2, 4) appearance of N_n, 5) increase in EP. Thin line in 2-5: diagramatic representation of initial EP. B) Graph showing changes in amplitude of individual EP waves. P_1) filled circles, N_1) Filled squares, P_2) filled triangles, N_n) empty triangles. Broken lines denote corresponding mean levels of P_1, N_1, and P_2 before cooling. Abscissa, duration of cooling (in min); ordinate, amplitude of EP (in μV). Diagram of brain shows area cooled (rectangle) and recording point (dot). Somatic stimulation. Cat No. 39.

each intact territory of the neocortex. In the motor cortex a decrease in the early component was accompanied in more cases than in the parietal area by disappearance of P_2 and by the appearance of N_n (Figs. 1 and 2), i.e., cooling of the parietal region had a stronger inhibitory effect on the motor area than the opposite effect. In fact, reorganizations of EP of this kind are evidence of the inhibitory action of the cooled region on the intact, effective through deep brain structures [4, 5], where facilitatory corticofugal influences on incoming impulses are abolished by local cold blocking of the cortex (a decrease in EP) and, as a result, their intrinsic activity is liberated (appearance of N_n). The process of the increase in EP in the regions compared also differed. In the parietal cortex the early and late components of EP often exceeded the background response as they increased (Fig. 1). This phenomenon was not observed in the motor cortex, where both components of EP, as they enlarged, as a rule did not reach the background level, sometimes by a considerable margin (Fig. 2). Deficiency of afferentation in the motor area during cooling of the parietal cortex thus took place always, whereas in the parietal cortex it was found to a lesser degree and was combined with processes of exultation.

It can be concluded from the facts discovered in these experiments that the influence of the parietal cortex on the motor cortex is stronger than the opposite effect. In the discussion of these data it is important to bear in mind differences in the functions of these zones of the neocortex. In the present writer's view [3] the parietal association area is predominantly concerned with the creation of efferent synthesis and plays a relatively minor role in the direct formation of motor acts, for it transmits the information it has processed to other zones of the cortex and, in particular, to the motor cortex. Conversely, in the motor area there is close overlapping of afferent and efferent projections [1, 2, 7], as a result of which it has been called an integrative-triggering zone [1]. This region occupies a special position in the hierarchic structure of the cortical zones, as the site of most intensive convergence of influences from various subcortical and cortical regions of the brain; signals of different genesis and functional importance necessary for realization of its triggering mechanism – its participation in the formation of motor acts – flow into this region as into a funnel. This evidently

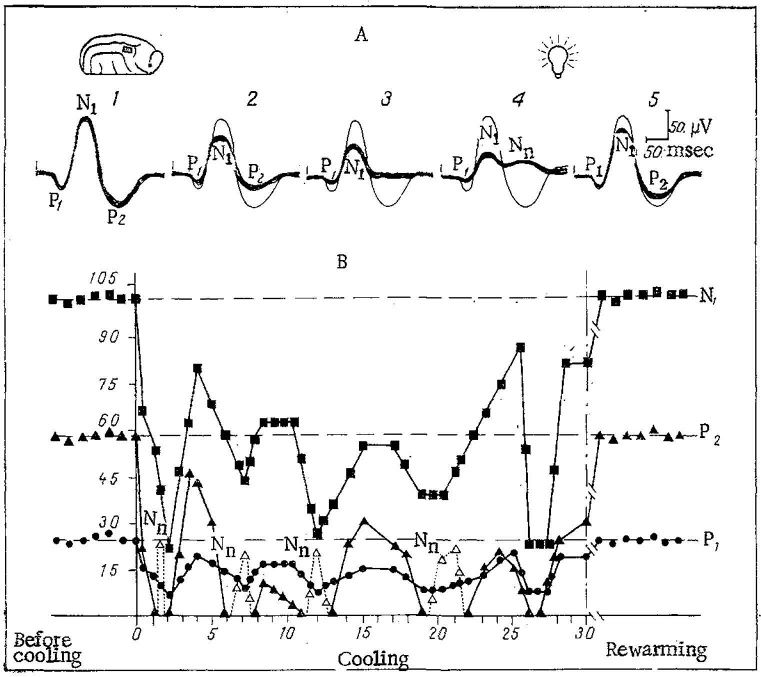

Fig. 2. Character of changes in EP in vocal cortex during cooling of parietal area. Legend as in Fig. 1. Visual stimulation. Cat. No. 40.

explains the fact that the afferentation deficiency induced by cooling the parietal region significantly affects the sensory supply to the motor cortex; in other words, the parietal region performs the role relative to the motor cortex of an important "supplier" of afferentation. The motor cortex, on the other hand, is less involved in sensory provision for the parietal cortex, but it evidently is more concerned as a "regulator," a structure participating in correction of the functional state of this part of the neocortex.

Differences between interaction of the parietal and motor areas compared with other types of combined activity of cortical formations, such as parietal with projection areas or the latter with each other, must also be emphasized. [Their interaction has been examined by the writer previously [5], and two different types were found. However, on that occasion attention was not directed to certain important aspects from the standpoint of the present investigation: 1) during nonspecific interaction between different projection zones with each other or with the parietal cortex, activated by signals inadequate for the projection zones – a relatively small decrease which is observed in both components of EP in the above-mentioned structures during local cooling of each of them is evidence of their comparatively minor role in combined sensory provision. Meanwhile, during modality–specific interaction between one or another projection zone and the parietal area, activated by signals adequate so far as that projection zone is concerned, the considerable decrease in the early component and transformation of the second positive wave of EP in one of them during cooling of the other suggests an important role for these cortical areas in the sensory provision for both. 2) The presence of only a decrease in EP, and, moreover, only up to a certain time limit, in all cases after which they are preserved at the same modified level, indicates regulatory interaction in the same direction between these areas; it is manifested only as a facilitatory influence on them, which is not pulsating but tonic in character, and which has initially a dynamic, followed by a static, type of course.

Interaction between hierarchically different regions of the cortex is thus essentially regulatory and constant; as a result of it, local excitation of one or another group of cortical structure is maintained. In each concrete case, however, activation arriving in one region from the other may play an unequal role in the sensory provision for the former and may differ in the type of its course; in that way the complex and diverse mutual influences that depend on the modality or functional specificity of the neocortical zones studied and their importance in cortical integrative activity are determined.

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QUALITATIVELY SIMILAR EFFECTS OF MICROIONTOPHORETIC APPLICATION OF CORTICOTROPHIN AND HYDROCORTISONE TO HIPPOCAMPAL AND HYPOTHALAMIC NEURONS IN RABBITS

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The work of H. Selye [11] laid the foundations of extensive research into the role of pituitary-adrenal hormones in adaptive mechanisms aimed at increasing the resistance of the body to stresses of varied origin. However, the problem of the reverse effect of adrenocortical and pituitary hormones on the CNS in stress has been incompletely studied. In particular, we do not understand the reasons for the difference and similarity between the effects of corticoids and corticotrophin (ACTH) on nerve cells in different parts of the brain. All that is known is that, with an increase in the concentration of corticoids and ACTH in the hypothalamic region in experimental animals, secretion of anterior pituitary hormones is inhibited and this leads to corresponding weakening of the secretory activity of the adrenal cortex [5-7, 9].

The object of this investigation was to study differences and similarities in the character of the effect of ACTH and hydrocortisone on spontaneous unit activity in the hypothalamus and in limbic structures of the brain such as the septum and hippocampus which play an important role in the regulation of secretion of pituitary-adrenal hormones. The method of microiontophoretic application of hormones to the surface of the nerve cells to be studied was used in the investigation, so that the presence of true sensitivity of a particular nerve cell to the hormone applied could be more definitely decided.

EXPERIMENTAL METHOD

Responses of 79 neurons in the hypothalamus and in the region of the septum and dorsal hippocampus to application of ACTH and hydrocortisone were studied in acute experiments on 20 adult male rabbits fixed in a stereotaxic apparatus. Microiontophoretic applications of the substances [4] were made by means of multiple-barreled glass microelectrodes [1]. Bovine ACTH in a concentration of 0.5 mM and hydrocortisone hemisuc-

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