FUNCTIONAL RELATIONS BETWEEN THALAMIC INTRALAMINAR NUCLEI AND CAUDATE NUCLEI DURING MOTOR PROGRAM FORMATION

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The results of previous investigations by the present writers [1, 2, 5, 7] and others [8-10] reveal a need to study cerebral structures in the course of their interaction, for this not only forms the basis of adaptive activity of the organism but it also determines the character of possible pathology of that activity [3]. Using a model of the defensive avoidance reflex we discovered a number of features governing the formation of intercentral integration within analyzer structures in the brain stem, subcortex, and cortex, and in the reticular formation and caudate nucleus on the basis of which it was postulated that individual brain formations become involved in the mechanism of a behavioral act in stages. However, the contribution of the above-mentioned structures to the organization of intercentral integration and possible variants of their interrelations during motor program formation remain largely unexplained.

The aim of this investigation was to analyze the role of the caudate nucleus and thalamic intralaminar nuclei (central lateral and paracentral nuclei) in intercentral integration forming many alternative programs. This study continued the investigation of the formation of integral behavior as a process based on dynamic integration of various structures located at different brain levels, and the character of their functional interaction at different stages of adaptive behavior.

EXPERIMENTAL METHOD

In experiments on dogs with chronically implanted electrodes the EEG and evoked potentials (EP) were recorded simultaneously from various brain structures of the visual system, caudate nucleus, thalamic intralaminar nuclei (central lateral and paracentral nuclei), and the motor cortex. Flashes were used as the conditioned stimulus, and supraliminal nociceptive stimulation of the dog's right forelimb as the reinforcing stimulus. EP were recorded on a multichannel loop oscillograph (transmission band up to 2000 Hz, time constant up to 1 sec). Amplitude-time parameters of EP were analyzed on photographic paper. Parameters were calculated by means of "Classimat" (West Germany) television image analyzer. A P 60 60 Olivetti (Italy) minicomputer was used for digital data processing. A semiautomatic EP processing program compiled by junior scientific assistant V. I. Derevyagin was used to calculate latent periods of EP, and amplitudes, durations, and areas of the main negative component of EP. To determine the character of the relationship between neurophysiological processes in the various brain structures tested, correlation analysis of the bioelectrical processes was carried out: Correlation scatter diagrams were plotted and coefficients of correlation and mean values and standard deviations for compared variables were calculated.

EXPERIMENTAL RESULTS

The latent period of EP as off-response to the first presentations of the conditioned stimulus in the thalamic intralaminar nuclei was considerably shorter in its mean values than in the caudate nucleus. Analysis of the scatter diagrams in the initial period of motor program formation, before any goal-directed motor responses had occurred, showed that changes in EP latency of the on-response to the conditioned stimulus obeyed a linear relationship in the two structures compared (Fig. 1a).

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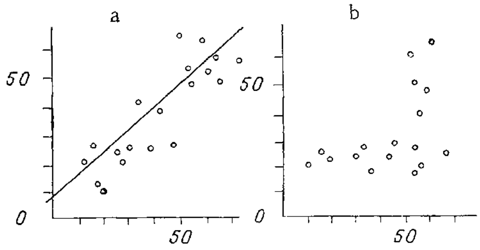

Fig. 1. Scatter diagrams of EP latencies in intralaminar nuclei (abscissa) and caudate nuclei (ordinate). a) Stage of formation, b) stage of stabilization of defensive behavior.

During the next period of alternative program formation, when the first motor responses were exhibited, although they did not always lead to adequate problem solving and were characterized by a wide variety of their course, definite changes in EP latencies were found in the caudate nuclei and intralaminar nuclei. Mean EP latencies in these two brain structures no longer obeyed a linear relationship (Fig. 1b). This situation was accompanied by wide scatter of the time of appearance of EP in the caudate nuclei and intralaminar nuclei in response to separate presentations of the conditioned stimulus. For instance, whereas EP appeared in the intralaminar nuclei after latent periods of about 25-50 msec, in the caudate nucleus the latent period could vary widely — from 20 to 60 msec. Meanwhile, if the latent period of EP in the caudate nuclei was 30-40 msec, in these cases the latent period of EP in the intralaminar nuclei varied within wide limits — from 10 to 60 msec.

Analysis of scatter diagrams of the amplitude of the negative component of EP showed that these parameters were greater on average in the intralaminar nuclei than in the caudate nuclei. Analysis of scatter diagrams of the duration of this same negative wave of EP showed that this parameter is less in the intralaminar than in the caudate nuclei.

Analysis of scatter diagrams of correlation between the areas of the negative component of EP showed wide variability of activity of the intralaminar nuclei in the initial period of motor program formation. Two types of responses were discovered rather later in the caudate nuclei: with a small and large area of the negative wave.

In the initial period of alternative program formation synchronized activation of the intralaminar and caudate nuclei thus takes place. Evidence that this is possible is given by data on the close correlation between nonspecific thalamic nuclei and caudate nuclei, of both functional [11, 12] and morphological [1, 2] character. Consequently, the possibility was confirmed that homogeneous and cyclic excitations can take place between nonspecific thalamic structures and the caudate nuclei, and as the experiments showed, this is clearly demonstrated at the beginning of conditioned reflex formation. Later, during gradual formation of the motor program, when the role of the motor cortex in intercentral integration becomes increasingly evident and when the motor responses often do not correspond to the task in hand [7], interaction between thalamic intralaminar structures and the caudate nuclei becomes less "designated" and is evidently mediated through cortical or other structures. The results of acute experiments confirm this possibility [4]. Definite reciprocity of the afferent inflows into these nuclei, specifically of those inflows that are formed under the influence of interaction between conditioned and reinforcing stimuli, arises under these circumstances. This may indicate differences in the character of involvement of these two groups of nuclei in intercentral integration. During this period two types of responses are observed in the caudate nuclei: those with a small and those with a large area of their EP.

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