

SECONDARY RESPONSES OF THE POSTERIOR VENTRAL NUCLEUS OF THE CAT THALAMUS

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Secondary responses of the posterior ventral thalamic nucleus and somatosensory cortex were investigated in acute experiments on cats anesthetized with hexobarbital. These responses were found to arise independently in the cortex and nucleus. Secondary responses to splanchnic nerve stimulation were shown to be more widely represented and more stable than those to somatic stimulation. Data in the literature and analysis of the results suggest a possible reticular mechanism of origin of these responses.

The principles of organization of the projection systems of the brain have been investigated in detail mainly by analysis of the spatial distribution of primary responses (PRs). A closer study of the functional organization of these systems requires analysis of the whole combination of electrical responses evoked by afferent impulses. The late or secondary responses (SRs) are of great interest in this respect, for they are regarded as a reflection of intimate processes of analysis of incoming information [1]. Most investigations of SRs have consisted of a description and analysis of cortical potentials [1, 3, 7, 9, 11]. There is less information on thalamic SRs. SRs in the thalamic nuclei are known to be connected with either nonspecific or associative structures [3, 8]. Reports on SRs of the specific relay nuclei have only begun to appear comparatively recently. Andersen et al. [5, 6] have analyzed the sequence of positive and negative waves following the PRs of the ventro-basal complex and which reflect cyclic changes in excitability. Durinyan [2] made a detailed study of evoked potentials of this nucleus and as a result isolated zones of SRs located at the periphery of the areas of representation of different parts of the body and of the viscera. These responses had a longer latent period and a higher amplitude of their negative phase and were followed by additional waves. The SRs reflected the intensity of stimulation, the level of anesthesia, and other effects connected with changes in the functional state of the system clearly enough. Particularly clear SRs were recorded in response to stimulation of visceral afferent nerves.

EXPERIMENTAL METHOD

Acute experiments were carried out on 22 cats anesthetized with hexobarbital (80-100 mg/kg). Potentials were recorded by a monopolar technique from the surface of the cortex and from the posterior ventral nucleus (PVN) in accordance with the coordinates of Jasper and Ajmone-Marsan's atlas, in response to single stimulation of the contralateral forelimb and hindlimb nerves and the splanchnic nerve.

EXPERIMENTAL RESULTS

In response to single stimulation of the somatic or visceral nerve and PVN with a square pulse, besides the PR a later negative or positive-negative wave was recorded with a latent period of 40 to 80 msec, duration 50-150 msec, and amplitude up to 500 μ V. These responses appeared under the same conditions as cortical SRs in responses of the Forbes [11] type, described in animals under deep barbiturate anesthesia. In the present experiments, besides SRs from PVN, SRs also were recorded from the surface of the cortex,

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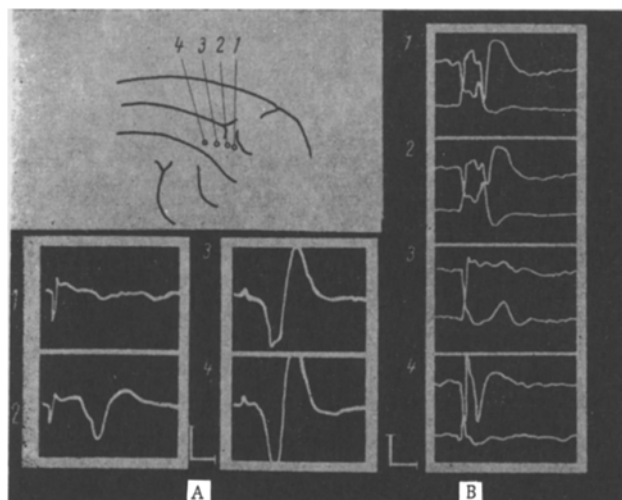


Fig. 1. Secondary electrical responses of the somatosensory cortex: A) change in configuration of potentials depending on place from which they are recorded on the cortical surface; numbers denote recording points and corresponding potentials. Calibration: 50 msec and 250 μ V; B) relations between potentials recorded in cortex (top curves) and in thalamic relay nucleus (bottom curves). Explanation in text. Calibration: 50 msec and 250 μ V.

and in their configuration and temporal parameters they corresponded with Forbes' responses. The SRs recorded were widely represented in the cortex although they varied in intensity at different points. As Fig. 1A shows, no SRs were found in the center of the zone of forelimb representation in somatosensory area I; the farther the recording electrode was moved toward the periphery of the area, parallel with the decrease in amplitude of the PR, a late wave resembling the PR in shape, but differing from it in its much longer latent period and duration of its phases, appeared and increased progressively in size. Similar potentials with a latent period of 70 msec have been observed in the visual projection cortex [7]. Investigations [9] have shown that although SRs of the visual cortex differ from Forbes' responses in their localization, their origin is the same, i.e., they arise through the participation of nonspecific systems. The similarity between the temporal parameters and conditions of origin of the thalamic and cortical SRs raise the question: are these phenomena dependent upon one another or not? Simultaneous recordings from the cortical surface and PVN shows (Fig. 1B) that SRs arise in PVN and the somatosensory cortex evidently independently. The amplitude of the cortical SR is independent of the amplitude of the SR from PVN (Fig. 1B, 1, 2). A cortical response may be absent during development of the thalamic response or it may be recorded even in the absence of a thalamic response (Fig. 1B, 3, 4). The SRs from PVN, like cortical SRs, cannot follow frequencies of stimulation higher than 4 Hz. In the graph in Fig. 2 the recovery cycles of the PRs and SRs to stimulation of the forelimb during conditioning stimulation of the splanchnic nerve are shown. As the graph shows, with an interval of 300 msec between conditioning and testing stimuli the amplitude of SR is restored to 90% of its initial level. Complete restoration takes place at 320-350 msec. The recovery cycles of the SRs, like their parameters, were very variable. The value of each ordinate was obtained by averaging the results of 20 measurements, and in individual cases the amplitude of the SR could be restored by 150 msec, while in other cases the SR remained completely blocked until 350 msec. If paired stimuli were used, the SR to the testing stimulus was blocked regardless of the nerve to which the conditioning stimulus was applied, so long as it evoked an SR. On the other hand, the appearance of a PR to the testing stimulus did not prevent the development of an SR to the conditioning stimulus (Fig. 2A). The amplitude of the SRs recorded from PVN during somatic stimulation depended essentially on the place from which they were recorded. No SRs could be recorded at the focus of maximal activity and in the zone of the PR. As the electrode was shifted toward the periphery of the area of representation the amplitude of the PR decreased while that of the SR increased progressively (Fig. 2B, below). A different picture was

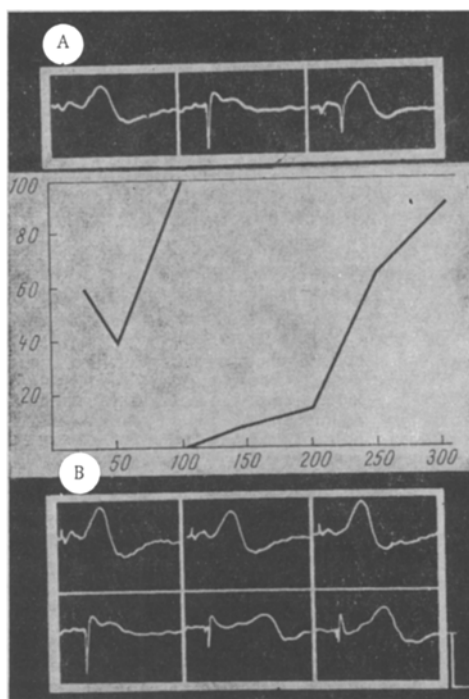


Fig. 2. Secondary electrical responses of thalamic relay nucleus. A: above) relations between responses to conditioning and testing stimuli, below) graphs of reproducibility cycles of primary and secondary responses. Abscissa, interval between stimuli (in msec); ordinate, reproducibility (in percent); B) changes in configuration of potentials in relation to point of recording in nucleus. Above) during splanchnic nerve stimulation; below) stimulation of forelimb. Calibration: 50 msec, 250 μ V.

observed during splanchnic nerve stimulation (Fig. 2B, above). In that case, SRs could be recorded at all points in the area of representation and their amplitude was not significantly changed with a move from one point to another. Under the same experimental conditions the stability of the SR during stimulation of the splanchnic nerve was appreciably higher than during stimulation of the somatic nerves.

These facts can be explained on the assumption that the zone of the PR for the splanchnic nerve occupies a much smaller volume in the nucleus than the zone for the somatic nerves [2, 4]. The ratio between periphery and center for the splanchnic nerve is thus greater than for the somatic nerves, and since the SRs arise at the periphery the probability of recording an SR during stimulation of the splanchnic nerve is higher than during somatic stimulation. The sharply different recovery cycles, the absence of mutual blocking, and the reciprocal relations observed during movement toward the periphery of the area of representation (for somatic nerves) suggest that the PRs and SRs in PVN are different in nature. The SRs of PVN are evidently due to the arrival of impulses through the multineuronal networks of the reticular formation.

Besides the properties of the SRs described above, other evidence in support of this hypothesis is given by the nature of the secondary Forbes' responses in the cortex, which can be regarded as definitely reticular in origin [8, 10].

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