DISTRIBUTION OF SPECIFIC SIGNALS OF DIFFERENT MODALITIES WITHIN THE PARIETAL CORTICAL ASSOCIATION AREA IN CATS

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KEY WORDS: parietal cortical association area; peripheral stimulation; stimulation of thalamic relay and associative nuclei; distribution of specific afferentation within the parietal cortex.

It has been shown [9, 13] that the late component of associative responses (LCAR) recorded during stimulation of different modalities in the parietal region of the cortex in conscious and chloralose-anesthetized cats, and which is formed by impulses of nonspecific origin, spreads diffusely over the surface of this cortical formation. Pentobarbital anesthesia, which blocks conduction of signals generating LCAR, at the same time optimizes the arrival in the parietal cortex of specific signals which, as our data [7] show, during stimulation of different sensory systems evoked a well marked early component of associative responses (ECAR), masked by the LCAR under the experimental conditions described above. During peripheral somatic stimulation in different parts of the body (fore- and hindlimbs, trigeminal nerve) the ECAR, unlike the LCAR, is maximally represented in the zone of the parietal region that borders on the corresponding projection zone of the somatic system, and diminishes with increasing distance from this projection zone. Meanwhile, the maximal ECAR to peripheral visual stimuli is recorded in the middle part of the parietal cortex [6].

In the present investigation, which was devoted to the further study of the topography of specific heterogeneous signals in the parietal cortex, we examined the character of distribution of ECAR to peripheral stimuli and also to stimulation of the thalamic relay and associative nuclei, which transmit impulses of different sensory modalities.

EXPERIMENTAL METHOD

The experiments were carried out on 36 adult cats, anesthetized with pentobarbital (30-40 mg/kg), during which ECAR was recorded in the parietal cortex in response to stimulation of forelimb nerves and various thalamic nuclei: the ventrobasal complex (VB), the pulvinar (Pul), and n. lateralis posterior (NLP). The methods of stimulation of the limb and nuclei and of recording responses in the cortex were described by the writers previously [2, 7]. The amplitudes of ECAR was subjected to statistical analysis of Student's test ($P < 0.05$) with averaging of 20 responses for the same animal at each point of the parietal cortex.

EXPERIMENTAL RESULTS

During stimulation of VB of the thalamus, a relay complex transmitting somatic signals, in the part which receives the most powerful afferentation from the forelimb, an ECAR of maximal amplitude was recorded in that part of the parietal cortex that borders on the corresponding somatic area (Fig. 1: 1, 2, top traces). When the recording electrode was removed from this projection zone the amplitude of ECAR decreased irrespective of whether responses were recorded in the lateral or the suprasylvian gyrus (Fig. 1: 3-8, top traces). In other words, during stimulation of VB the character of distribution of the responses was the same as during peripheral somatic stimulation (Fig. 1); the amplitudes of ECAR in the anterior and middle zones of the parietal cortex, moreover, differed statistically significantly from each other and from the amplitude of ECAR in the posterior zone, where the responses disappeared at the extreme periphery (Fig. 3A, a, b; F: 15-13, 9-5, 3-0).

Meanwhile stimulation of the thalamic associative nuclei chosen for investigation, more precisely, of those areas to which ascending visual specific pathways project [2], led to

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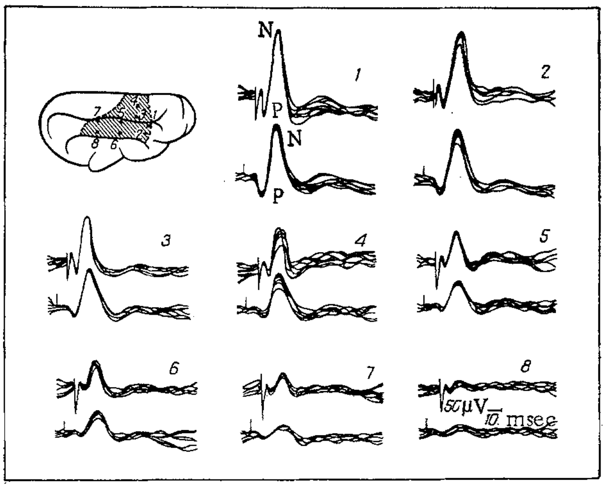

Fig. 1. Distribution of ECAR recorded at different points (1-8) on surface of parietal cortex during ipsilateral electrical stimulation of VB and nerves of contralateral forelimb (see points in zone of representation of these responses, shaded on diagram of cerebral hemisphere). Top traces) ECAR to stimulation of VB, bottom traces) ECAR to stimulation of forelimb. P) Positive, N) negative wave of ECAR.

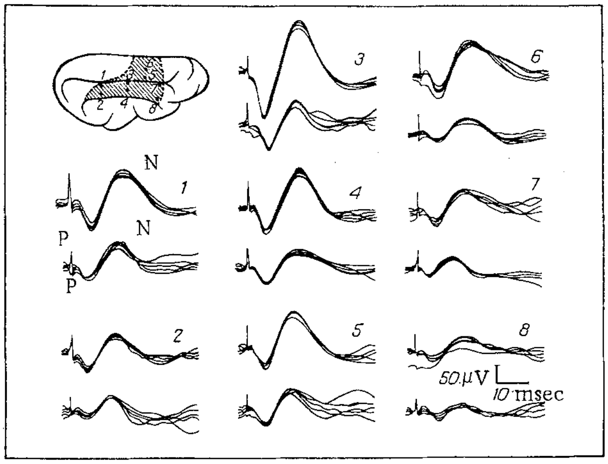

Fig. 2. Distribution of ECAR recorded at different points (1-8) on surface of parietal cortex during ipsilateral electrical stimulation of Pul and NLP. Top traces) ECAR to stimulation of Pul, bottom traces) ECAR to stimulation of NLP. Remainder of legend as to Fig. 1.

the appearance of an ECAR of maximal amplitude, not near the corresponding projection zone (Fig. 2: 1, 2), but in the part of the suprasylvian gyrus located in the middle part of the parietal cortex (Fig. 2: 3, 4). In more distal zones the amplitude of ECAR decreased (Fig. 2: 5-8). It was also found that the character of distribution of ECAR was similar during stimulation of Pul and NLP (Fig. 2): in both cases the amplitudes of responses in the anterior, middle, and posterior zones of the parietal cortex differed statistically significantly from one another (Fig. 3A, c, d).

The experimental results obtained during stimulation of the above-mentioned thalamic nuclei thus confirm the findings obtained previously during somatic [7] and visual [6] peripheral stimulation, that if the recording electrode is moved within the parietal cortex in the frontal plane the responses differ in their distributions, and the most intensive specific signals of a particular sensory modality reach different regions (Figs. 1-3). The similar character of distribution of ECAR to peripheral and thalamic stimuli within the bounds of a particular sensory system, moreover, suggests that the nuclei studied play an important role in the transmission of specific impulses from peripheral parts to the parietal cortex. This is in good agreement with data in the literature [3, 5, 8, 13] on projections of signals in the visual system. Analysis of these data showed that although the lateral geniculate body,

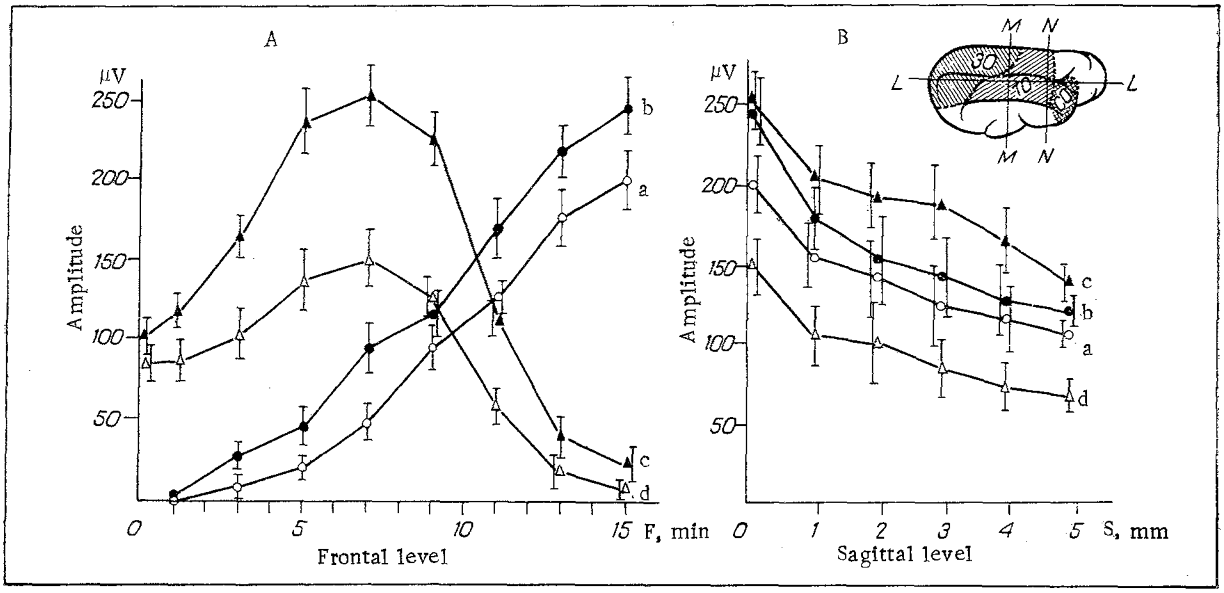

Fig. 3. Averaged graphs of distribution of amplitudes of ECAR (negative wave) within suprasylvian gyrus of parietal cortex during contralateral peripheral somatic stimulation (a) or ipsilateral stimulation of thalamic nuclei: VB (b), Pul (c), and NLP (d). Parietal region (PR), visual region (VR), and somatic region (SR) of representation of forelimb are distinguished on diagram of cerebral hemisphere. L-L) Sagittal level near lateral sulcus, M-M and N-N) frontal levels close to SR and middle part of PR respectively, i.e., levels passing through areas with most marked ECAR. Abscissa (in mm): A) length of PR from VR to SR in frontal plane (F), B) length of PR in sagittal plane (S) from lateral to suprasylvian sulcus; ordinate, amplitude of ECAR (in μV). A) Distribution of ECAR at points in different positions in frontal plane (along L-L); B) the same, at points in different positions in sagittal plane: a, b) along N-N; c, d) along M-M. N-N, M-M, and L-L denote F = 15, F = 7, and S = 0, respectively.

the thalamic relay nucleus for this particular system, activates the parietal cortex, the latter is more closely connected with the Pul-NLP complex, which serves, in our opinion, as an essential relay stage for specific visual signals to this region of the neocortex. When the character of transmission of signals in the somatic system is examined, attention must be paid to morphological data obtained previously [1, 7] and showing that fibers from VB reached the anterior zone of the parietal cortex, and through physiological data [7] showing the appearance or disappearance of ECAR here during stimulation or destruction of VB. The results of the present experiments provide new evidence of projections of VB, evidence both of the precise localization of the zone of representation of specific somatic impulses in the frontal plane of the parietal cortex during stimulation of the recipient zone of the forelimb and VB, as well as the similarity between this region and that discovered for specific signals during stimulation of the limb itself.

Another important feature of the distribution of ECAR in the parietal association region is that the responses we are examining are better expressed near the lateral sulcus than at other points located in the sagittal plane, including points near the suprasylvian sulcus. For instance, during stimulation of VB responses derived as the recording electrode was moved in the sagittal plane were greater near the lateral sulcus than elsewhere (see Fig. 1: 1 and 2, 3 and 4, 5 and 6, 7 and 8 — top traces; Fig. 3B, a). As regards ECAR evoked by peripheral somatic stimuli, in addition to data obtained previously on similarity between these responses at neighboring points of the parietal cortex [7], the same distribution of responses, with maximal amplitude at the same frontal level near the lateral sulcus and diminishing with increasing distance from it in the sagittal plane, as during stimulation of VB, was found in the present investigation (Fig. 2, bottom traces; Fig. 3B, b). During both types of stimulation, the most stable responses, with the least scatter, and detected in cases when at other points of this frontal level they could be absent, occurred near the lateral sulcus.

Responses of maximal amplitude also appeared consistently and regularly near the lateral sulcus to stimulation of Pul and NLP. During stimulation of Pul the amplitude of ECAR was greater here than at the center of the gyrus or at other points located more sagittally (Fig. 2: 1 and 2, 3 and 4, 5 and 6, 7 and 8 — top traces; Fig. 3B, b). The same effect also was found during stimulation of NLP, but with a smaller drop in the amplitude of ECAR near the sulcus and at other points of the parietal region (Fig. 2, bottom traces; Fig. 3B, d).

In all cases examined, statistically significant differences were thus observed in the amplitude of ECAR near the lateral sulcus and at different points of the parietal cortex, where the difference between responses recorded at neighboring points need not be significant (Fig. 3B).

Data obtained after total destruction of individual thalamic associative nuclei (involving neighboring structures to some extent), reported in the morphological literature [10], are evidence that more powerful projections of fibers exist from the above-mentioned nuclei, especially from NLP, to areas near the lateral and suprasylvian sulci than to central zones of the gyri of the same name. The physiological data obtained in the present investigation, which correlate with this information to some degree, at the same time suggest that, with the method of local stimulation of areas of associative nuclei that are recipients for visual signals, which we used, the most powerful stream of ascending specific signals is recorded near the lateral sulcus. Meanwhile, considering that the phenomenon we have described above is found both during peripheral stimulation and during stimulation of the thalamic nuclei, on the arrival of both somatic and visual signals in the cortex, the existence of a general principle of approach of the most intensive specific afferentation of different modalities to points near the lateral sulcus and a less intensive afferentation, and not all of the same value, to other areas of the parietal cortex, can be postulated.

It can thus be concluded from the results that in the parietal association region there is a definite topographic organization of specific impulses of different modalities, which have characteristic patterns of distribution in both the sagittal and the frontal plane; in the second case, moreover, the spread of these signals differs during stimulation of different sensory systems. This type of localization of specific signals in the parietal cortex differs significantly from the diffuse distribution of nonspecific impulses evoking LCAR in it [8, 9, 13], or from the topography of the specific afferentation which forms primary responses in the projection region and which, as we know, have a clearly defined focus of maximal activity and diminish in all directions from that focus.

Specific signals are thus characterized by a unique kind of distribution within the parietal cortex which, being the site of intensive convergence and integration of polysensory signals [4, 7, 11, 13], processes these signals unequally in its various parts, from which it can be deduced that these various parts are themselves involved to different degrees in the activity of brain systems.

LITERATURE CITED

1. O. S. Adrianov and A. G. Polyakova, Zh. Vyssh. Nerv. Deyat., No. 5, 1039 (1972).
2. B. Kh. Baziyan, Neirofiziologiya, No. 4, 355 (1978).
3. B. Kh. Baziyan and V. N. Bochorishvili, in: Thalamo-Strio-Cortical Interrelations [in Russian], Vol. 1, Moscow (1980), p. 49.
4. A. S. Batuev, Higher Integrative Systems of the Brain [in Russian], Leningrad (1981).
5. V. I. Maloletnev, Electrophysiological Characteristics of the Pulvinar of the Thalamus [in Russian], Tbilisi (1977).
6. T. V. Orlova, Zh. Vyssh. Nerv. Deyat., No. 5, 1088 (1971).
7. A. G. Polyakova, Functional Organization of the Association Cerebral Cortex [in Russian], Moscow (1977).
8. A. G. Polyakova, Neirofiziologiya, No. 6, 573 (1978).
9. P. Buser and K. E. Bignall, Int. Rev. Neurobiol., 10, 111 (1967).
10. A. M. Graybiel, Brain Res., 22, 131 (1970).
11. J. Hyvarinen, Brain Res., 206, 287 (1981).
12. E. G. Jones and T. P. S. Powell, J. Comp. Neurol., 143, 185 (1971).
13. R. F. Thompson, R. H. Johnson, and J. J. Hoopes, J. Neurophysiol., 26, 343 (1963).