CHANGES IN THE SITE OF APPEARANCE OF NONSPECIFIC RESPONSES IN THE HUMAN EEG IN NORMAL SUBJECTS AND IN PATIENTS WITH FOCAL DAMAGE

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With tactile, acoustic, or photic stimuli in human subjects a nonspecific potential may be recorded from the vertex [2, 5-7]; it disappears when the stimuli are presented at a short interval. Oswald [10] considers that this nonspecific effect is an artifact, but his opinion has been rejected by many authors [1, 3, 8, 9].

The nonspecific response was investigated in detail by Kats [2] working in V. S. Rusinov's laboratory. It was shown that the responses developed maximally in the parieto-central regions, but as the stimuli are repeated it spreads to other regions of the brain also. This spread occurs at the same time as the amplitude of the response increases. The fact that as the stimuli are repeated the region involved may alter gives reason to suppose that the nonspecific response is not strictly localized.

The present work is an investigation into the localization of the nonspecific response to light and sound.

EXPERIMENTAL METHOD

The EEG was recorded with a single-channel ink-writing electroencephalograph. We examined 29 healthy human subjects and 17 patients with focal lesions in the posterior part of the cerebral hemispheres.

EXPERIMENTAL RESULTS

The nonspecific response to light and to sound was recorded in the EEG of 22 of the 29 healthy subjects. According to the stimulus used and to the sequence of presentation we observed a change in the region in which the nonspecific effect appeared. In 19 subjects even when light and sound acted for the first time certain features were found in the spread of the nonspecific response to these stimuli. An example of the distribution is given in Fig. 1, a, which shows the nonspecific response to light and to sound in the same subject. The zones where the effect was maximum (central-parietal lead) coincide, but the nonspecific response to light appeared also in the posterior regions and the response to sound in the anterior lobes. With repeated stimulation this distribution of the nonspecific response became more definite. In 6 subjects when the light flashes were repeated we observed a spread of the nonspecific response to light to the posterior lobes. At the same time repetitive use of the sound stimulation led to no such spread of the nonspecific response. In 12 subjects to which light flashes were repeatedly presented the nonspecific response to light disappeared from the zone where the response had been maximum, whereas in the occipitoparietal region it was recorded more definitely, i.e. there was a shift of the nonspecific response to light towards the posterior lobes. An example of such a shift of the nonspecific response to light is shown in Fig. 1, b. The early responses to light were diffuse and nonspecific, the maximum amplitude occurring in the central regions (leads 5 and 6). With subsequent stimulation (7th flash) there was a shift of the nonspecific response to light towards the posterior lobes. As can be seen from the curve the nonspecific effect was recorded in the occipital and in the parietal regions, it was less well marked in the central region, and was absent from the posterior and frontal lobes. In the same subject the nonspecific response to sound was recorded in the central and frontocentral regions. The region of the nonspecific response did

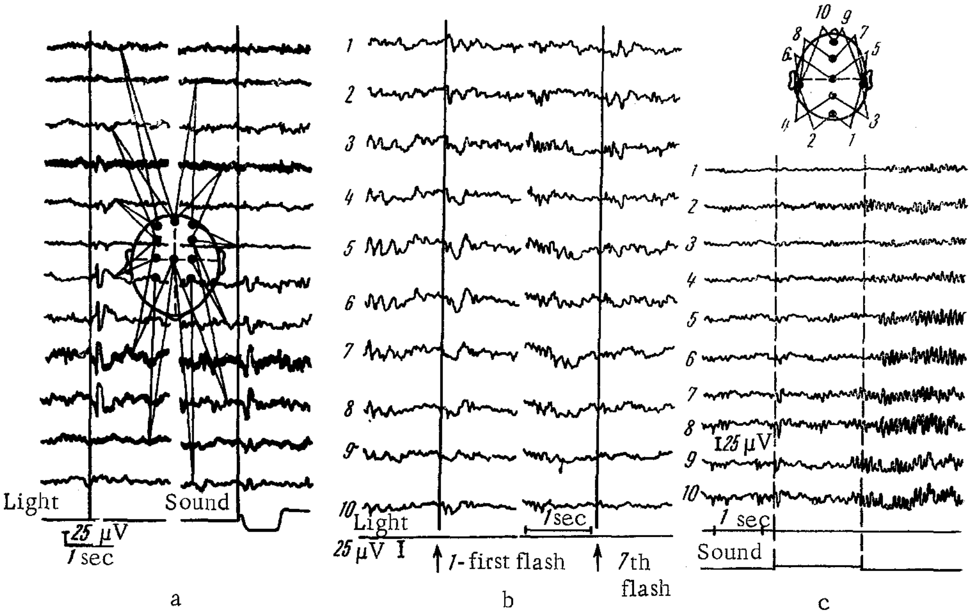

Fig. 1. Distribution among the different hemispheric regions of the nonspecific response to light and to sound in a single subject. Moment of application of the stimulus is indicated by a vertical line. a) Nonspecific response to light and to sound; b) displacement of the nonspecific effect to light into the posterior parts of the hemispheres; c) nonspecific response to sound (10th application). Here and in other drawings the numbers to the left of the curves indicate the number of the lead.

not shift when multiple stimuli were given. Fig. 1, c shows the nonspecific response to sound in the same subject at the 10th presentation. The response is maximum in the central and fronto-central regions. Consequently the shift of the nonspecific effect occurring on repetitive stimulation is related to an increase in the level of excitability in the posterior lobes under the influence of the light stimulus itself. This point of view receives confirmation from yet another fact which we have observed. If the sound acted by the effect being superimposed upon the rhythmical light stimulus,the nonspecific response to this sound could shift into the posterior regions, i.e. into the region into which the rhythmical light stimulation is directed. As an example consider some of the curves shown in Fig. 2. In response to the acoustic stimulation (Fig. 2, a) a nonspecific effect in the EEG took the form of a slow wave in the central region (7th-8th lead), and in the frontal lobes (9-10th leads). It was absent from the posterior regions. The same sound superimposed on a rhythmic light stimulation (Fig. 2, b) caused a response which took the form of a slow wave, but which was also recorded from the posterior regions (leads 3-4 and 5-6). Acoustic stimulation was applied to another subject at the start of the investigation and was superimposed on a rhythmic light signal flashing slowly once per second. The response to sound which took the form of a slow low-amplitude wave appeared diffusely in all the leads. After a few seconds during which the light stimulus was maintained the sound stimulus was given once more superimposed on light flashing twice per second (Fig. 2, d). In this case the response to sound also appeared in all regions, but the form changed: instead of a slow wave the response consisted of a rapid spike potential. Yet another sound stimulus was superimposed on light flashes at a frequency of 4 per second (Fig. 2, e) and it elicited a response in the form of a rapid oscillation which was best shown in the posterior lobes themselves (leads 3-4, 5-6, less response in leads 7-8). The acoustic stimulation presented a certain time after cessation of the light stimulus (Fig. 2, f) caused a response consisting of a slow low-amplitude wave in the centro-parietal regions (leads 5-6 and 7-8).

These results indicate that the region at which the nonspecific effect appears is determined by the condition of a particular part of the cortex, which condition in turn is determined by the nature of the stimulus acting.

Here it seemed worthwhile to investigate the nonspecific response in patients having focal cerebral damage, because the pathological process itself must create in the cortex a region of maintained excitation [4].

In many cases in these subjects we observed a characteristic distribution of the nonspecific effect in the different cerebral regions. In patients with an extracerebral tumor in the parieto-occipital region the nonspecific effect, if present, was recorded chiefly in the occipital regions, i.e. at the site of the damage. Here the nonspecific effect might be marked in response to sound and might be absent in response to light.

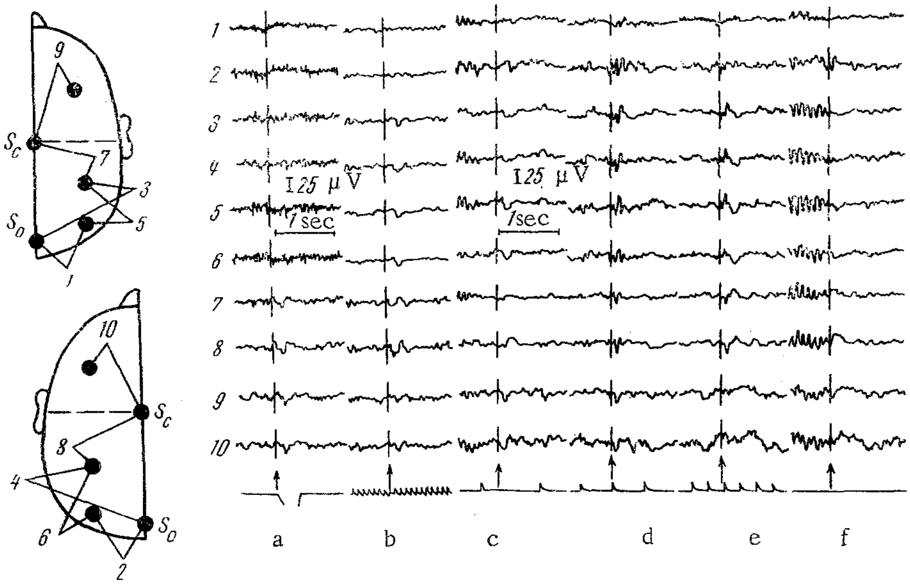

Fig. 2. Change in the form (d, e) and in the area (b) in which the nonspecific response to sound appears when it is superimposed on the effect of rhythmic light stimuli. Light stimulus markers (b, c, d, e) are shown on the bottom line. The time at which a sound signal was given (a, f) is indicated by an arrow and by a dotted vertical line.

Consider as an example the EEG of a patient having a bilateral extracerebral tumor of the parieto-occipital region (Fig. 3, a). The EEG of this patient shows a response to light and to sound whose amplitude was 2-3 times as great as that of the alpha-rhythm. The response was maximal in the occipital regions (leads 1-2 and 3-4); it was less marked in the anterior region (leads 9-10). With repeated stimulation the response was reduced and might disappear altogether from the frontal regions, while continuing to be recorded from the occipitoparietal regions.

In the case of a large cerebral tumor occupying the parieto-occipital region if there was a nonspecific response it was recorded in the central and medio-frontal regions, just as in healthy subjects. In many cases in which there was a small pathological focus in the parieto-occipital region we observed a nonspecific effect not only in the central regions of both hemispheres but also in the affected zone. As an example consider the nonspecific response in the EEG of a patient with a subcortical tumor of the left parieto-occipital region (Fig. 3, b). In response to a single light flash, in addition to the specific response to light in the occipital regions a nonspecific response was also recorded. It occurred in the anterior parts of the hemispheres. In addition the nonspecific response to light appeared in the posterior parts of the hemispheres when recordings were made at a large interelectrode distance (parieto-temporal leads). At the same time when potentials were led off locally from the occipital region this response was only on the left side, i.e. at the focus (lead 2). The nonspecific response to sound was recorded both from the anterior parts of the hemispheres as well as locally in the left occipital lobe. With repeated stimulation at small intervals the nonspecific effect disappeared more rapidly from the anterior parts of the hemispheres while it was preserved in the affected zone.

All these facts may be explained if we suppose that the impulses which evoke the nonspecific response enter the cortex diffusely, but that the response develops in the cortical region where the level of excitability is raised. It is true that in cases when repeated light flashes are presented a zone of enhanced excitability is established in the posterior regions of the hemispheres, and this effect is shown in the displacement of the nonspecific effect into this region. A pathological process acting on the parieto-temporal region in cases of an extracerebral or intracerebral tumor may establish a condition of enhanced excitability in the damaged area. Apparently the appearance of the nonspecific response in this region may be explained as developing in this way. The condition may be considered analogous to one of dominance, because a stimulus of any modality evokes a nonspecific response from just this cortical region.

The results obtained indicate that the zone in which the nonspecific effect appears is determined by the condition of excitability of the cortex in this area. The condition may be brought about either by afferent impulsation

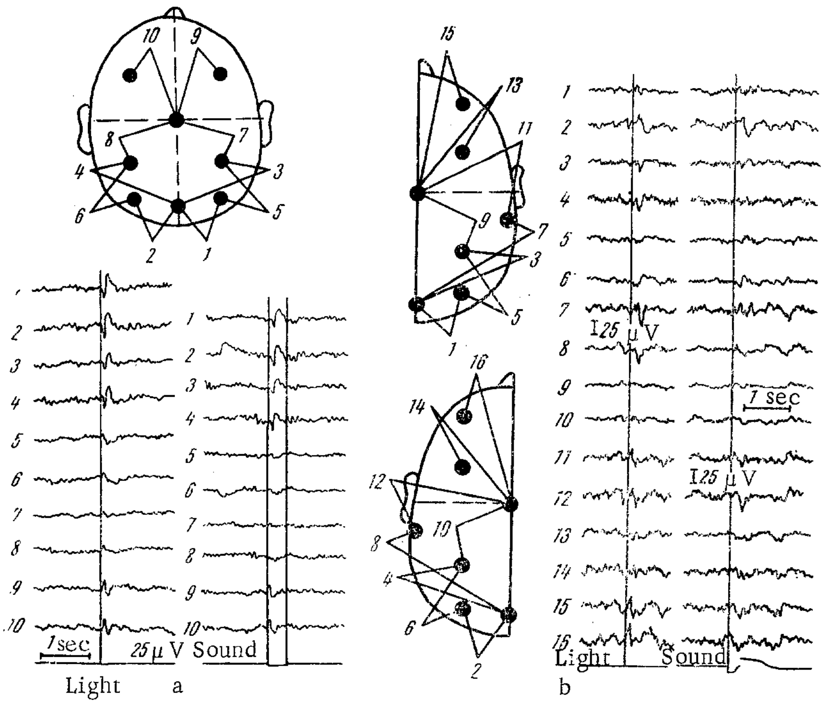

Fig. 3. Nonspecific response to light and to sound in the EEG of a patient with a bilateral extracerebral tumor in the occipito-parietal regions (a), and in the EEG of a patient with a subcortical tumor of the left occipital lobe (b). Stimulus shown on bottom line. Moment of application of the stimulus indicated by a vertical line.

or by a pathological process. The ultimate effect of diffuse impulses from the nonspecific system is determined in the cerebral cortex.

SUMMARY

The zone in which the nonspecific response was manifested in the human EEG changed according to the nature of the stimuli and their sequence. The nonspecific response had a different distribution according to the modality of the first stimulus. Repeated photic stimuli produced a shift in the nonspecific response in the direction of the primary projection field of that stimulus. Nonspecific responses to sound may be shifted towards the zone of increased excitation created by rhythmic photic stimulation. The shift is particularly well shown in certain focal cerebral lesions. Thus in an extracerebral tumor and in some forms of intracerebral tumor of the parieto-occipital area, apart from the central zones the nonspecific response both to light and to sound was recorded at the pathological focus itself.

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