LOCAL CHANGES IN THE HUMAN ELECTROENCEPHALOGRAM ASSOCIATED WITH SERIAL VISUAL IMAGES

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In an electrophysiological study of successive visual images, the moment of their origin and the period of their development is compared with the electrical changes either in the retina (electroretinogram — ERG) or in the brain (electroencephalogram — EEG). In 1934, Adrian and Matthews [2] first expressed the opinion that successive optic images delay the appearance of the α-rhythm. Similar correlations were established by Jasper and Cruikshank [5] in 1937. L. T. Zagorul'ko and coworkers [1] simultaneously studied the processes occurring in the retina and in the cerebral cortex during the consecutive stimuli. At the same time they also recorded the cutaneous galvanic reaction. A depression of the α-rhythm was noted in the EEG, corresponding to the consecutive image. The authors did not observe a complete correspondence in the course of the processes studied. The work of Bartley [4] holds special interest. The author selected a light flash of the proper intensity and duration to cause the subjective feeling of two flashes in the human, i.e., yield a vivid consecutive image. The effect of this flash on the eye of the rabbit was recorded in the ERG as two serially arising δ-waves, and two consecutive groups of impulses were recorded in the optic nerve.

Thus, the phenomenon in question begins in the retina: the second δ-wave causes a second group of impulses in the optic nerve. Depression of the α-rhythm during successive visual images is apparently an electrographic expression of the arrival of impulses in the cortex. It could be postulated that, under certain conditions, local changes would also be recorded in the EEG of the generated potentials type.

EXPERIMENTAL METHOD

The experiment was performed on 20 healthy adult human beings, in a darkened, screened chamber. The deflector of the photostimulator was placed in front of the open eyes of the subject, at a distance of 50-70 cm from the face. Single light stimuli of varying intensity and duration were generated from "Kaiser" and FFS-1 photostimulators. The EEG was recorded in bipolar fashion, according to the schema presented in Fig. 1. EEG tracings were taken from the occipital, parietal, and central regions. One sagittal electrode was placed over the occipital prominence (Sp), the other, in the region of the vertex (Sa). This placement of the electrodes made it possible to record both the local response to light in the occipital regions and the nonspecific response in the parietal-parasagittal areas. The intensity and duration of the light stimulus was selected so as to yield the most vivid serial visual images. The moment that the image appeared was noted either by the word, "est' ", or by pressing a button which put a mark on the curve. Multiple repetition of the word, "est' "[here], or multiple depression of the button, did not cause changes in the EEG. When there were several consecutive visual images, the most vivid one was noted.

EXPERIMENTAL RESULTS

According to the verbal response of the subject, the consecutive visual image corresponded in form to the screen of the photostimulator (round or square). It appeared after varying intervals in the different people, and, in the majority of cases, was perceived as being light blue or light violet in color.

Consecutive visual images caused changes in the general character of the EEG, manifested, as a rule, by the depression of the α-rhythm; this depression arose with the appearance of the image, and ceased with its disappearance. The depression was most clearly seen, and retained for the longest time, in the occipital regions. Local changes, namely generated potentials in the EEG at the time of appearance of the consecutive visual image, were observed only in the parieto-parasagittal regions, when recorded with a sagittal electrode located in the area of the vertex (Sa). We designated such local changes as " the local response associated with a consecutive visual image." There were no changes in the occipital regions other that the α-rhythm depression already noted.

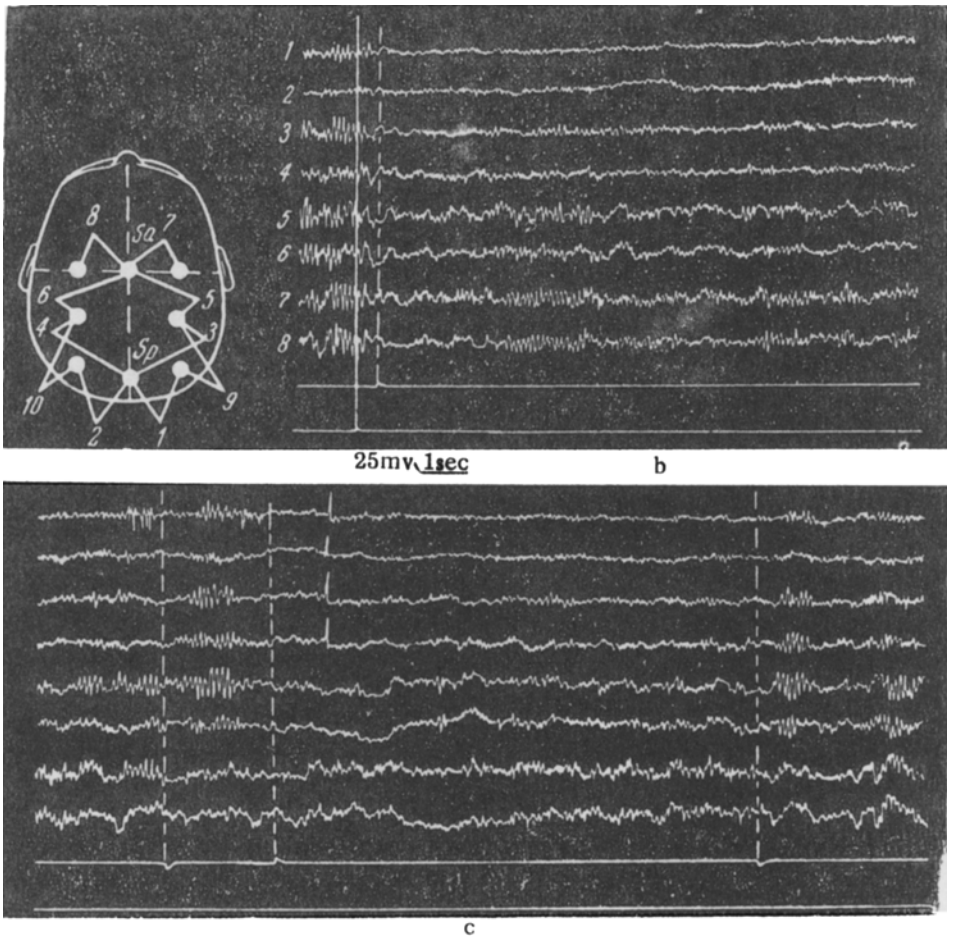

Fig. 1. General and local changes in the EEG associated with consecutive visual images (1-8). Curve c is a direct continuation of curve b; recordings were taken from the areas indicated in schema a. Lower line – photostimulation marking; second line from the bottom – subject's marking of the moment of appearance (above) and disappearance (below) of the consecutive visual image.

The curve in Fig. 1 serves as an example of the general and local changes. In the setting of the background α-rhythm, clearly manifested in all regions, a light flash was administered. A nonspecific response to the light arose, most clearly seen in the parietal areas (Fig. 1, 5, 6). After 1/3 of a second the subject noted the appearance of the serial visual image, in the form of a light blue disk (shown on the curve as an elevation in the second line from the bottom). After 14 seconds the serial image disappeared (the marking is directed downward on the curve). After approximately 2 seconds the second serial image arose, less vivid than the first. The second image lasted about 9 seconds.

The following changes were noted in the EEG. At the moment the first serial image appeared a depression of the α-rhythm began in all regions. In the occipital areas (Fig. 1, 1, 2, and 3, 4) the depression of the α-rhythm was observed until disappearance of the image. In the parietal and central regions (see Fig. 1, 5, 6, and 7, 8) the initial

rhythm was restored after 2 1/2 seconds, but the original amplitude was not attained. In the dark interval – between disappearance of the first, and appearance of the second, image – the α-rhythm arose in the occipital areas and the rhythm in the parietal regions increased in amplitude. After the disappearance of the consecutive images,

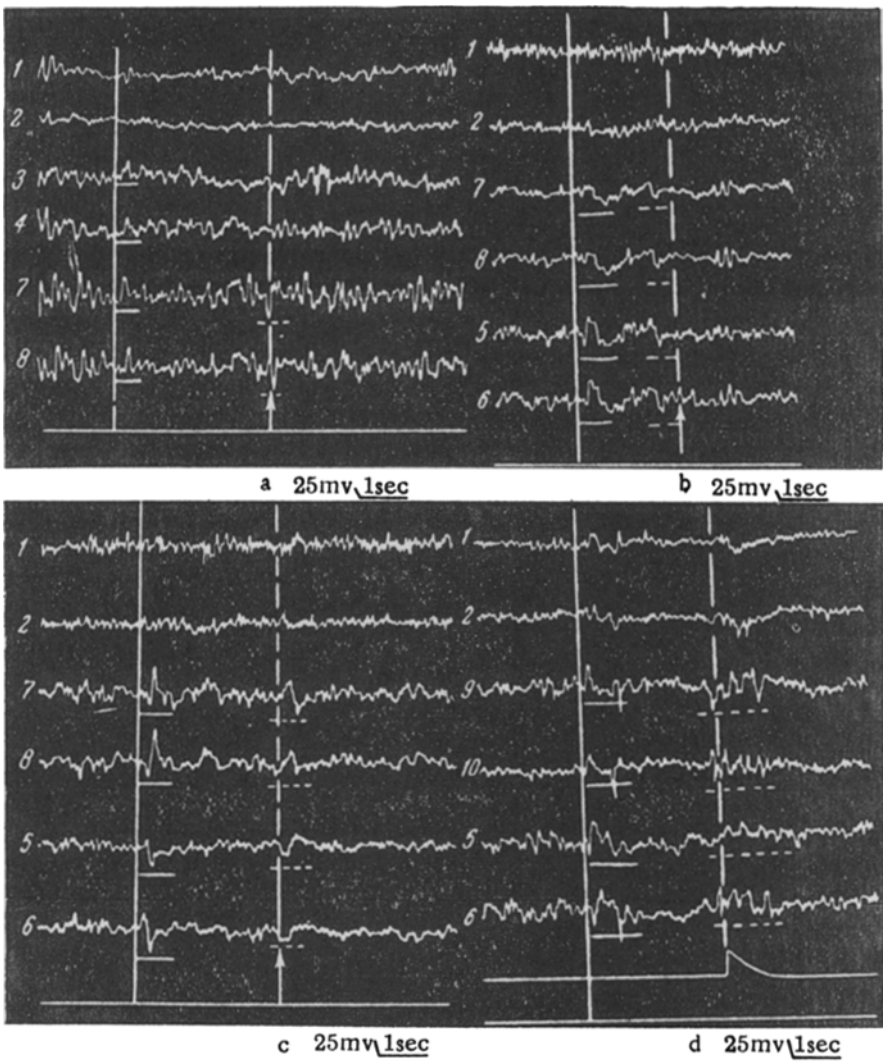

Fig. 2. Various forms of the local response to a serial visual image. Leads correspond to the schema illustrated in Fig. 1a. An arrow indicates the subject's exclamation at the moment of the image's appearance. The nonspecific response to light is underlined with a continuous line, the local response to the serial visual image – with a dotted line.

complete restoration of the original rhythm was observed. In addition to these general changes at the moment of appearance of the first serial image, a local response associated with the consecutive image arose in the parietal regions following a nonspecific reaction to the light flash. This local response took the form of a slow wave, and was also seen in posteriorly lying, neighboring regions. When the image disappeared and the second, less vivid, one appeared, local changes were not noted. In each of the individuals undergoing the investigation the local response to the serial image was seen in approximately two thirds of the total number of presented stimuli. The response was always localized in the region where the non-specific reaction arose when recording was made with the sagittal electrode, located in the vertex. Sometimes it disseminated to the neighboring, posteriorly lying area, especially when the stimulus was of great intensity and the serial images were correspondingly more vivid. The form of the

local response to the serial image varied from subject to subject, and often even from image to image in the same subject.

The varying forms of the local response to the serial image are presented in Fig. 2.

In response to the light flash there arose a nonspecific reaction, in the form of a rapid oscillation, recorded in the posterior parietal and central regions (Fig. 2a, 3, 4 and 7, 8). Appearance of the serial visual image, in the form of a light violet disk, was noted by the subject after approximately 1 1/2 seconds. A local response also arose in the central areas (see Fig. 2a, 7, 8) in the form of a rapid oscillation, but it was of opposite sign to the nonspecific response to the light. On the next curve (Fig. 2b) a nonspecific response to the light, in the form of a slow wave,

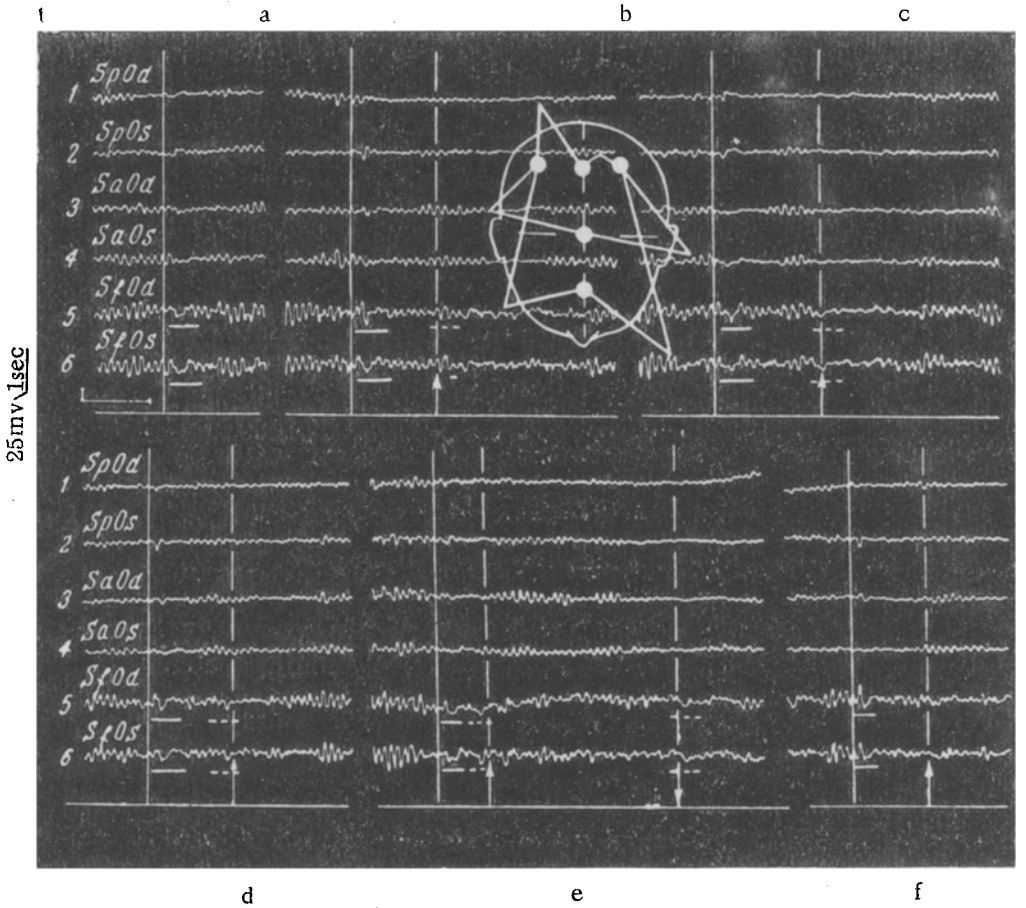

Fig. 3. Development of the local response associated with a serial visual image when the intensity of the light stimulus is progressively increased. Arrows indicate subject's exclamation at the moment the image appears. The nonspecific response to light is underlined with a continuous line, the local response associated with the serial visual image, with a dotted line.

was also recorded in the parietal and central areas (see Fig. 2b, 5, 6, and 7, 8). After approximately 1 second the appearance of the serial image was noted, again in the form of a light violet disk; in the regions where the nonspecific response to light appeared, a local response was recorded, similar in form to the nonspecific one. EEG tracings of the same individual are presented in Fig. 2c. A nonspecific response to light, in the form of a rapid oscillation, was observed in these areas. The serial image was noted after approximately 1 1/2 seconds, at which time a local response arose in tracings from those leads, seen as a slow wave.

In the next curve (Fig. 2d) a nonspecific response to the light flash is recorded, this time in the form of a rapid oscillation with a subsequent group of rhythmic fluctuations, most clearly manifested in the occipito-parietal regions (see Fig. 2d, 9, 10 and 5, 6). The serial image was noted after approximately 1 1/2 seconds, and, simultaneously, a group of rhythmic fluctuations appeared in the EEG recorded from the occipito-parietal areas.

A local response to the serial image arose only with certain stimulation intensity, and was observed irregularly. When there were frequent confrontations with the stimulus it sometimes completely disappeared, although the serial image was sufficiently bright as before.

The local response to the serial image in the same individual, with elevation of the intensity of the light stimulus, is recorded in Fig. 3. Fig. 3a shows the EEG with a weak light stimulus, which does not give rise to a serial image. A nonspecific response arises from the light flash, in the form of a slow wave in leads 5-6. Further (Fig.3b), with a light stimulus of greater intensity the nonspecific response is more apparent. After approximately 1 second a weak serial image is noted, in the form of a light violet disk; at the same time, a vague local response appears in leads 5-6, with subsequent depression of the original activity, and in leads 1 - 2 and 3- 4 depression of the α-rhythm is observed. With even greater intensity of the light stimulus (Fig. 3c) a local response to light arises in leads 1-2, and a nonspecific response to light in leads 5-6. After 1 1/2 seconds a serial image is noted, still faint but brighter than before. At this time a rather clear local response is seen in leads 5-6 and a simultaneous depression of the original rhythm in all regions.

With a bright flash of light (Fig. 3d) a clear local response to light arises in the occipital regions, along with a nonspecific response in leads 5-6. A bright serial image is observed after 1 second. Associated with this a clear local response appears in leads 5-6, with subsequent depression of the original rhythm. After several exposures to a light flash of the same intensity the following changes are observed (Fig.3e): the serial image arises after a smaller latent period (2/3 of a second); the local response associated with the serial image is manifested as clearly as before; the α-rhythm is depressed during the light flash and arises with the appearance of the serial image. When the serial image disappears a less distinct local response is noted in leads 5-6, and depression of the α-rhythm is seen in leads 1-2 and 3-4. With continued presentations of the stimulus the local changes associated with the serial image disappear. As can be seen in Fig. 3f, in response to a light flash of great intensity there is observed a vague nonspecific reaction in leads 5-6 and depression of the α-rhythm in leads 1-2 and 3-4. With appearance of the serial image no local changes are noted, but the α-rhythm appears in leads 1-2 and 3-4.

The character of the local response associated with the serial visual image, and the region of its development, suggests that this response is analogous to the nonspecific response of Banco [3].

SUMMARY

At the moment when a successive optic image appears the EEG gives a local response. This manifests itself in the occipital-parasagittal regions, when one of the leads is placed on the vertex. The response varies by its form from one subject to another and from one image to another in one and the same subject. With multiple stimulation the response may disappear. The above features of the local response in a successive optic image give reason to assume it to be analogous to the non-specific response of Banco [3].

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