EVOKED POTENTIALS AND EEG DESYNCHRONIZATION TO LIGHT STIMULI DURING ONTOGENESIS IN MONKEYS

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In our previous work [4] we described the formation of electrical activity of the cerebral cortex of monkeys during postnatal development.

The present report is devoted to a study of electrical responses in the area of the visual analyzer of the cerebral cortex to single and continuous light stimuli in the same animals.

METHOD

The procedure of the experiments was described earlier [4]. We investigated 20 baboons, 31 rhesus monkeys, and 20 green monkeys. Among them 9 were neonates, 16 infants, 23 youngsters, 11 adults, and 12 elders. The adult animals were studied once a month; the neonates daily during the first weeks, every ten days up to four months of age, and further, once a month. To this we should add that the light stimuli were produced from a photostimulator of Kaiser's system in the form of individual flashes at different intervals or by general lighting. The EEG's of the right hemisphere at the fronto-occipital lead are given on all figures.

RESULTS

In the experiment we used one-day-old infants. It turned out that at this time in all the species of monkeys we examined (rhesus monkeys, baboons, and green monkeys) individual light flashes evoked distinct responses in the occipital area of the cerebral cortex. The responses had positive and negative phases and their amplitude exceeded their level of the initial activity at this age (Fig. 1, a and 2, a, b, and c). The potentials evoked during a train of light flashes at 1 sec intervals arose in response to each impulse, but the parameters of subsequent responses (latent period, duration of phases, their amplitude), as is apparent from a comparative evaluation, underwent diverse changes (see Fig. 1, a, d). The evoked responses were not analyzed in detail since they were recorded on an ink-writing instrument.

With a more frequent sequence of light flashes (2, 3, and 4 per sec) there were even more profound changes in voltage and duration of the response phases to the next flash, which led to the occurrence of a characteristic pattern of assimilation of the rhythm, (see Fig. 1, b, c, e, f).

In contrast to the rhesus monkeys and the baboons, the evoked potentials of the green-monkey infants during the first days of life had a more complex character, the phase duration was shorter, and their amplitude was higher. With light flashes at 1 second intervals the changes in the character of responses were less evident than for the rhesus monkeys and baboons (see Fig. 2, a, b). With more frequent flashes (2, 3, and 4 per sec) there were more substantial changes in the parameters of the subsequent responses (see Fig. 2, c, e).

Later during the first and second months of life we recorded distinct responses to light stimuli both in rhesus monkeys and baboons and in the green monkeys (Fig. 1, g and 2, e). The parameters of the responses revealed diverse

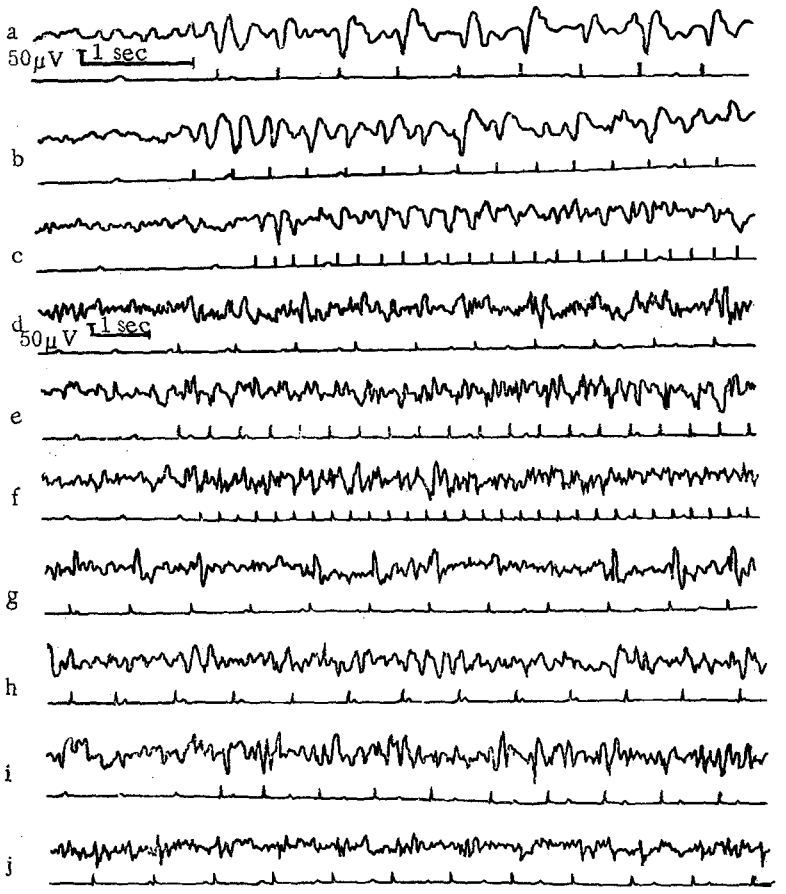

Fig. 1. Evoked potentials to light flashes for rhesus monkeys and baboons at various stages. Responses to light flashes in four-day-old rhesus monkey (No. 4277) at a frequency of: a) 2 per sec; b) 4 per sec; c) 5 per sec; evoked potentials of two-day-old rhesus monkey (No. 4272) to light flashes with a frequency of: d) 1 per sec; e) 2 per sec; f) 3 per sec; g) responses to light flashes with a frequency of 1 per sec for rhesus monkey (No. 4272) at one month of age: h) same for four-month-old baboon (No. 4232); i) same for nine-month-old baboon (No. 3945); j) same for three-year-old rhesus monkey (No. 2556).

changes. The repetition of single flashes at 1 sec intervals during this age period also evoked more substantial changes of the primary responses in the rhesus monkeys and baboons than in the green monkeys.

Beginning with the third-fourth month of life we noted a dependence of the response to individual light flashes on the character of the background EEG. In the presence of a relatively low initial activity in response to each flash there occurred a distinct evoked potential which in a number of cases for the green monkeys had a multiphasic character (Fig. 2, f, h). If the background activity was represented by diverse fluctuations of a rather high amplitude, then the evoked responses to the light were absent or they were difficult to elicit among the fluctuations of the background (Fig. 1, h and 2, g).

At age six-eight months, when the amplitude and the regularity of the basic activity reached a maximum (at periods of evident synchronized activity), evoked responses to light stimuli were not demonstrated in most cases.

By the end of the first year of life the evoked potentials to individual flashes of light again were elicited rather distinctly, but their character was even more changed during repetition of flashes at 1 sec intervals than in the first half year (see Fig. 1, i).

In mature monkeys, after stabilization of the background EEG, in a number of cases responses of a multiphasic

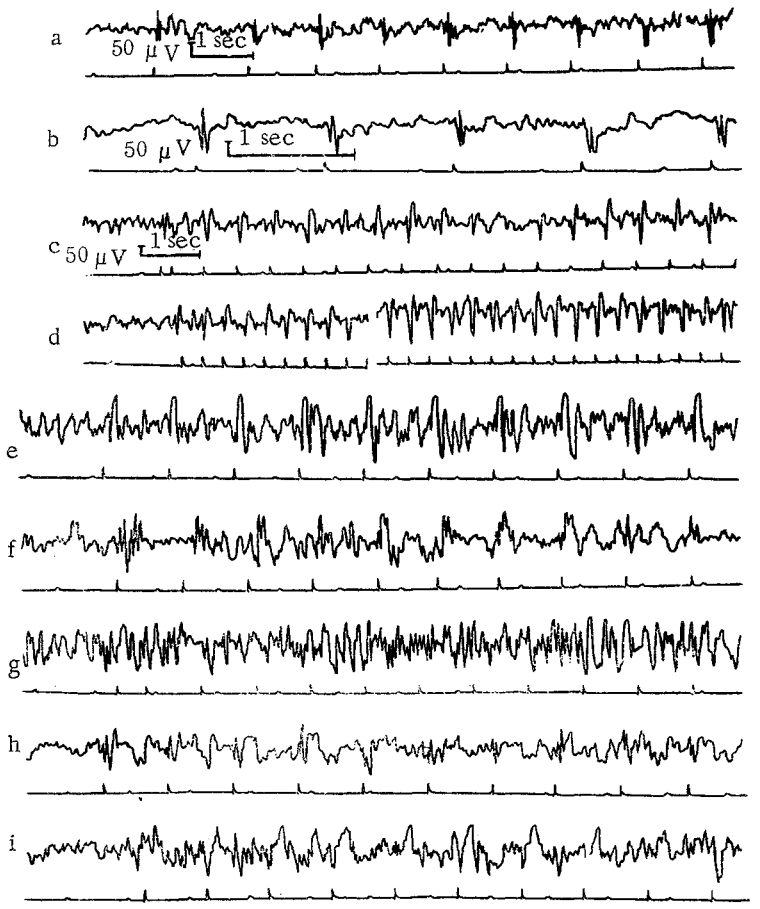

Fig. 2. Evoked responses to light flashes in green monkeys at various ages. Responses in two-day-old green monkey (No. 4276) to light flashes with a frequency of: a and b) 1 per sec; c) 2 per sec; d) 3 per sec; e) responses to light flashes with a frequency of 1 per sec in green monkey (No. 4276) at one month of age, f) same at three months of age; g) same at three months of age for another green monkey (No. 4270); h) same for green monkey (No. 4233) at five months; i) same for year-old green monkeys (No. 3936).

character appeared with after-discharges (Fig. 1, j), but their amplitude was appreciably lower than that for the infants. In aged monkeys (19-21 years old) which were in a resting but alert state, it was not possible to record evoked potentials to light stimuli.

During the first days of life for the species of monkeys we investigated, a "continuous" light led to an increase in the background activity, which was demonstrated in the appearance of groups of oscillations of different duration and in an increase of the amplitude of the background oscillations (Fig. 3, a, d, e). Beginning with the second month of life the effect of continuous light was accompanied by desynchronization of the electrical activity of the cerebral cortex at the fronto-occipital lead (Fig. 3, b, c, f, g).

The described results of the experiments show that for monkeys evoked potentials to light stimuli are recorded from the first days of life with a lead from the skull surface. In contrast to such potentials in human neonates [5, 7], kittens [8, 9] and rabbits [3, 10] these potentials had both positive and negative phases. Apparently this is associated with a greater functional maturity of the visual analyzer system in these animals at the time of birth. Such a notion agrees with the data characterizing the possibility of elaborating in newborn monkeys conditioned reflexes not only to light and darkness but also to the shape of geometric figures [11].

The difficulties in eliciting evoked responses during periods of high and frequently synchronized background

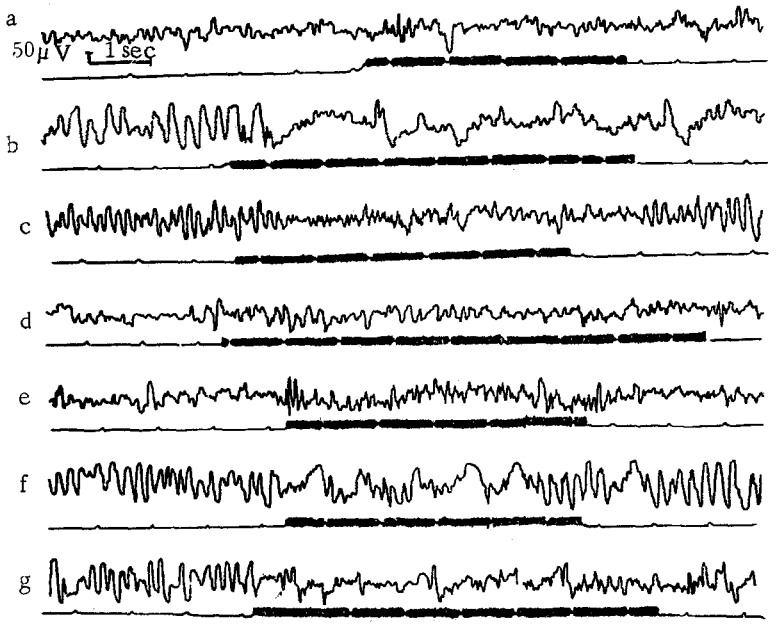

Fig. 3. Response to "continuous" light in monkeys at different ages. a) Seven-day-old rhesus monkey (No. 4277); b) baboon (No. 4233) at age one month, fifteen days; c) five-month-old baboon (No. 4232); d) green monkey (No. 4270) at eighth day of life; e) twenty-six-day-old green monkey (No. 4270); f) green monkey (No. 4229) at age one month sixteen days; g) two-month-old green monkey (No. 4224).

activity, beginning with the three-four months of life, are possibly associated with a certain stage of formation of the cortico-subcortical interrelationships, when the subcortical influences, expressed in synchronization of the fluctuations of the biopotentials and, apparently, having an inhibiting effect on the cerebral cortex, predominate.

The transformations of distinct evoked responses during repetition of light flashes to a pattern of rhythm adoption were traced in monkeys which were in a state of alertness during the first days of life. This observation indicates that the reaction of adopting rhythms of light flashes is not a consequence of changes in the frequency of the background activity following the fluctuations of the rhythm of the flashes [1, 6], but the phenomena of transformation of the evoked potentials underlie this event. Our data confirm the notion of the reaction of the adoption of rhythms in the EEG as a phenomenon directly associated with the evoked potential [2].

The differences in the stages of the formation of evoked responses in the cerebral cortex and the phenomena of desynchronization to light stimuli attest to the participation of different mechanisms in accomplishing the reactions.

As is known, recently the phenomena of desynchronization or activation of the EEG have been related to the function of the reticular formation of the brain stem. On the basis of our data, the effect of the reticular formation on the cerebral cortex, manifested as activation of the EEG, is formed at a definite stage of ontogenesis—at two months of age for monkeys.

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