FUNCTIONAL MATURATION OF THE VISUAL CORTEX
DURING PRENATAL DEVELOPMENT OF THE CAT

E. V. Maksimova and L. N. Maksimova

The development of the perceptual function of the visual cortex at different stages of postnatal development has been studied in detail in animals of different species both by the evoked potentials method [1-3, 8, 10, 11, 15], and in relation to the character of unit activity [4, 8, 9]. Evoked potentials (EP) to light can be found for the first time in the cortex of rabbits on the 5th day, and of cats on the 2nd-3rd day after birth. In response to electrical stimulation of the optic nerve, evoked electrical responses are found in the occipital cortex during the first few hours after birth. These findings show that the initial stages of formation of the electrical responses of the visual cortex take place during intrauterine development. However, the initial period of formation and development of the perceptual function of the visual cortex remains virtually unstudied. The only exception is the work of Persson and Stenberg [13] on lamb fetuses. They found that EP to stimulation of the optic nerve appear in the occipital cortex at the end of the first half of intrauterine life.

It was accordingly decided to investigate the development of the visual cortex in the early stages of prenatal development in cats and to compare the basic characteristics of functional maturation of the visual cortex with that of the sensomotor cortex, the development of which during the same period of ontogeny was studied by the writers previously [6, 7]. Characteristics of electrical responses arising in the cortex of the contralateral hemisphere in cat fetuses and newborn kittens in response to stimulation of the optic nerve were investigated.

EXPERIMENTAL

Experiments were carried out on 80 cat fetuses during the second half of intrauterine development (weighing from 13 to 100 g) and on kittens during the first week of life. The pregnant cat, anesthetized with pentobarbital sodium (30 mg/kg), was fixed in a special frame. In some experiments, after immobilization with flaxedil (4 mg/kg), the cat was artificially ventilated. Caesarian section was then performed and the fetus was carefully removed and placed in a bath held immediately beneath the uterus. The precautionary measures necessary to maintain the intact placental circulation and to prevent cooling of the fetus were described previously [5, 6]. To dissect the optic nerve partial enucleation was performed, after which all the oculomotor muscles were removed with great care. The optic nerve was stimulated either by needle electrodes introduced into the nerve through the eyeball or (in most experiments) by bipolar silver electrodes, bent at an angle so that they could be introduced under the nerve. Square pulses of varied intensity and from 0.1 to 1 msec in duration were used for stimulation. EP were recorded from the exposed surface of the cortex by a monopolar wick or silver ball electrode. The reference electrode was fixed to the muscles of the neck. The potentials recorded were led to the input of an ac amplifier with time constant of 1 sec through a cathode follower and were photographed from the screen of a cathode-ray oscilloscope. The UEFI-2 apparatus for electrophysiological research was used.

RESULTS

The smallest fetus in whose cortex an electrical response to stimulation of the optic nerve could be recorded weighed 36 g. At the stage corresponding to the beginning of the second half of intrauterine life, the brain of the fetuses weighed a little more than 1 g and in appearance it resembled cerebral vesicles. The first EP had the form of slow positive-negative waves of low amplitude. They appeared after a long latent
Fig. 1. Change in configuration of EP arising in primary visual projection area of cat fetuses at various stages of prenatal development. Recordings from fetuses of different age groups. A) Weight from 50 to 65 g, B) from 70 to 85 g, C) from 80 to 100 g, D) from kittens during the first 5 days after birth. Time marker 50 msec, calibration 500 μV.

period (LP) and were extremely unstable. They could be recorded in the occipital cortex only during very infrequent application of stimuli to the optic nerve.

In fetuses at rather later stages of development (weighing 50–60 g) the evoked electrical responses to optic nerve stimulation became more stable and the amplitude of their components rose sharply. During this period the electrical response of the cortex began with a positive wave of potential, against the background of which a high-amplitude negative wave, accompanied by a second positive wave, developed. Examples of EP recorded in the specific projection zone of the cortex during this period of prenatal development are given in Fig. 1A.

About 10 to 12 days before the end of intrauterine development (in fetuses weighing over 70 g), when small depressions appeared on the surface of the hemispheres at the site of the future fissures, the configuration of EP in the striate area of the cortex became more complex on account of the appearance of an additional short-latency negative wave of low amplitude. The evoked responses acquired the appearance of complex multicomponent potentials, starting with a small positive wave, against the background of which two negative waves appeared (Fig. 1B). The amplitude of the first short-latency wave (N₁) was as a rule small, but the amplitude of the second negative wave (N₂) reached 500–700 μV. The amplitudes of components N₁ and N₂ of EP and of the positive wave separating them were very variable at this period. The configuration of EP differed not only in fetuses of the same litter, but also essentially in the course of an experiment on the same fetus, using a stimulus of unchanged intensity and duration.

During the last week of intrauterine development (weight of the fetuses over 80 g) the fissures on the surface of the hemispheres became more distinct. EP in the middle and caudal parts of the lateral gyrus consisted mainly of two negative waves N₁ and N₂ (Fig. 1C). The initial positive wave of EP during this period was sharply reduced in amplitude and frequently could not be seen at all. Differences in the amplitude of components N₁ and N₂ of EP were less marked, but as a rule the amplitude of N₁ was smaller than that of N₂. This configuration of EP to stimulation of the optic nerve persisted in the striate area of the cortex in kittens during the first week after birth (Fig. 1D).

When the dependence of the amplitude and temporal characteristics of the various phases of the integral response of the visual cortex on the intensity and duration of the stimulus was studied, differences in the threshold intensity of the stimulus for the different components of EP could not always be detected. However, in most cases in fetuses in the early stages of development the initial positive wave to a stimulus of threshold strength was more clearly defined, but its latent period was virtually unchanged by an increase in stimulus.