EFFECT OF LIGHT DEPRIVATION ON FORMATION OF THE METABOLIC REACTION OF THE RETINAL GANGLION CELLS

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The role of sensory stimulation in the development and function of nerve tissue was studied with special respect to the retinal ganglion cells of BALB mice and CBA × C57BL hybrids. The dry weight of the cells at different stages of stimulation by flashes was determined interferometrically. Changes in the protein content in mice aged 2 months grown under ordinary conditions of illumination followed a clearly defined curve. In mice born and reared up to the age of two months in darkness the metabolic response was changed and the dry weight of the cells was lowered. No morphological differences were found in the retina. The need for photic stimulation for the manifestation of congenital patterns of metabolism of the retinal ganglion cells is discussed.

The visual system provides a convenient object in which to study the role of sensory stimulation in the development and function of nervous tissue. Light deprivation is known to induce physiological, biochemical, and morphological changes in various components of the visual system [8, 12, 14, 15, 19]. The sensitivity of the visual system to absence of light is at its highest in young animals. The upper age limit of sensitivity is 4-8 weeks, and more prolonged hypofunction may lead to irreversible disturbances of vision [10].

The retinal ganglion cells respond to stimulation by flashes with fluctuations in their protein mass due to variation in the intensity of protein synthesis [1, 2]. The kinetics of the fluctuations in response to the same procedure varies during individual development and may be modified in the course of a frequently repeated functional load [2, 4]. Changes in the protein content of the ganglion cells are thus probably adaptive in character. It can accordingly be expected that a change in the working conditions of the organ leads to changes in the protein metabolism of the nerve cells.

The object of this investigation was to examine the effect of prolonged absence of adequate stimulation (light) on the kinetics of changes in the dry weight of the ganglion cells during stimulation of the retina by flashes.

EXPERIMENTAL

Experiments were carried out on 119 male mice with pigments (CBA × C57BL hybrids) and nonpigmented (BALB) retina. The animals of the first (experimental) group consisted of newborn BALB and hybrid mice which had been kept in a dark cabinet since birth. The second (control) group consisted of mice grown in ordinary illumination. At the age of 2 months all the animals were exposed to flashes (frequency 2 Hz, intensity about 100 lx). The eyes were fixed in darkness and at intervals of 5-10 min during illumination for 2 h. The fixative consisted of a mixture of formalin, alcohol, and acetic acid (9 : 3 : 1). At each time 150-300 cells from 2-4 animals were investigated in each group. To rule out the possibility of error in the measurements because of unequal thickness of the sections, as a first step the thickness of

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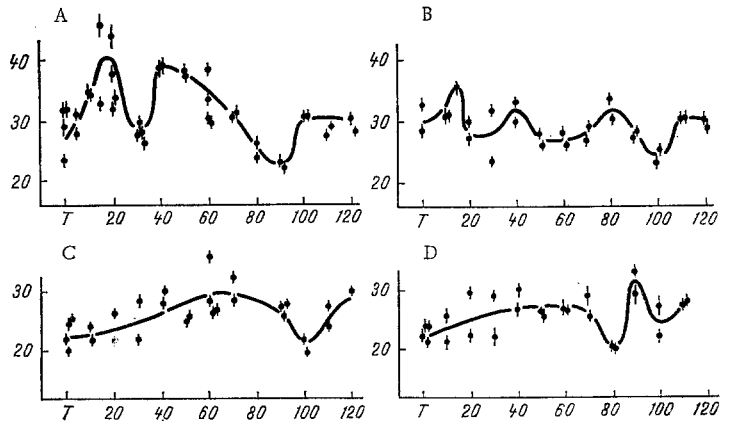

Fig. 1. Kinetics of changes in dry weight of ganglion cells during stimulation of mouse retina by flashes. Abscissa – duration of photic stimulation (in min); ordinate – dry weight in conventional units. DA) State of dark adaptation; each point represents arithmetic mean value of dry weight of ganglion cells of one animal- vertical lines represent standard errors of arithmetic means; A) control hybrid mice; B) control BALB mice; C) experimental hybrid mice; D) experimental BALB mice.

each section was estimated. When this had been done the dry weight of the ganglion cells was determined. The thickness of the sections and the dry weight were measured by interference microscopy.

EXPERIMENTAL RESULTS

The results of the measurements are summarized in Fig. 1. In the control animals, aged 2 months, during the first 15-20 min of photic stimulation there was an increase in the dry weight of the ganglion cells. In the next 10-15 min the protein content in the neuron fell to its initial level. During stimulation for 2 h, two or three cycles of rapid changes in the protein mass were observed (Fig. 1A, B). This type of metabolic response corresponded to the normal pattern of metabolic response of the cell to photic stimulation and it is reproduced in different experiments [3, 4].

The kinetics of the changes in dry weight of the ganglion cells was different in the mice growing up in darkness. The rate of increase in the protein mass was much smaller and it took place gradually over a period of 60-70 min. All these factors led to a much smoother kinetic curve. A more rapid rate of change in dry weight by comparison with the control was observed only after stimulation for 2 h. The dry weight of the retinal ganglion cells of mice grown in darkness also was reduced by almost 20% when compared with the state of dark adaptation Fig. 1C, D).

No morphological differences were found in the retina and, in particular, in the ganglionic layer between the two groups of animals. Some authors found no morphological changes in the ganglion cells of animals grown in darkness [6, 16]. Hypofunction was mainly reflected in the degree of myelinization of the optic nerve fibers and their density and relative distribution by thickness [7, 18]. However, light deprivation did not affect the rate of axoplasmatic protein transport in the ganglion cells [11]. On the other hand, the modification and delayed appearance of evoked potentials in the electroretinogram and the biochemical abnormalities in the retinal cells (decrease in RNA and protein content, reduced activity of acetilcholinesterase and other enzymes) are evidence of delay in the functional development of this part of the visual system [5, 9, 12, 13, 15-17].

During normal development, in the prefunctional period before any nervous connections have formed, stimulation of the retina by flashes does not induce significant changes in the dry weight of the ganglion cells [3, 4]. Fluctuations in protein are observed for the first time when the animal acquires vision, regardless of whether or not the animal is kept under ordinary conditions of illumination or in darkness. They are evidently inborn [4].

Comparison of the facts described above with results obtained in the present investigation suggests that changes in the metabolic response of the ganglion cells to adequate stimulation is the result of functional immaturity of the visual system. Natural functional stimulation is essential for manifestation of the inborn peculiarities of ganglion cell metabolism.

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