ENHANCED RETINAL RESPONSES WITHOUT SIGNS OF OPTIC NERVE INVOLVEMENT

by

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ABSTRACT

Seven patients with low visual acuity displaying enhanced positive waves in retinal responses of normal shape and reduced or extinct visual evoked potentials were presented. None of these cases exhibited any sign of optic nerve affection and visual field defects nor any localizing neurological deficits. Conclusions drawn in an earlier report from similar electrophysiological findings but obtained in cases with optic nerve atrophy were applied here. On the basis of these findings, it is hypothesized that the enhanced ERG represents the result of an abolition of a physiological rivalry between the increasing retinal sensitivity in the dark and an inhibitory cerebral influence upon retinal activity exerted via efferent fibers in the optic nerve. The possible origins of this assumed negative feedback mechanism are discussed, though neither experimental facts nor speculation did provide a reasonable clue. An answer may be given by observing the patients during the following years and possibly by animal experiments.

INTRODUCTION

In a previous paper (FEINSOD, ROWE & AUERBACH, 1971) we reported on 69 cases with optic nerve affections due to various causes. The electrophysiological recordings carried out in these patients were characterzed both by reduced or

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absent visual evoked potentials of the striate cortex (VEP) and by changes in the retinal responses. It was found that the electroretinogram (ERG) was enhanced in 42% of the cases and subnormal in 55%. The criterion to decide upon the a- and b-waves of the ERG as being enhanced or reduced was established by an evaluation of the distribution of the values of the respective amplitudes in a great number of ERGs from persons with normal visual systems.

In this paper the cases of seven patients with low visual acuity in both eyes and no clinical signs of optic nerve involvement will be presented.

METHODS

The ERGs were produced by single stimuli. They were recorded from both eyes at the steady state of light adaptation. After its discontinuation, the recovery of the ERGs was followed in the dark whenever possible for 30 minutes. The averaged VEP was recorded after monocular stimulation from either eye and binocular stimulation. The methods of examination were identical to those described in the previous report (FEINSOD et al., 1971).

Color vision was tested by means of the Ishihara plates and the Farnsworth panel D-15 test.

RESULTS

Common to all cases reported here is the absence of ophthalmoscopical signs of optic nerve affection, of visual field defects and of localizing neurological deficits. The fundi were normal, except in two patients with foveal degeneration. The electrophysiological recordings always ahowed a small or extinct VEP and an enhancement of the b-waves of the ERGs of both eyes which were of normal pattern. Their recovery followed an independent course for each eye during dark adaptation, i.e. the amplitudes of the b-waves of the ERGs of both eyes were not equal during the whole course of dark adaptation, except perhaps during the first minute or so. This was found even when they eventually attained equality at the end of the recovery. However, the amplitudes of the negative potentials were with one exception within the normal range. In addition, the ERG recorded at the steady state of light adaptation was normal. If note specially mentioned, the physical and neurological examinations did not present any abnormal findings. Color vision was normal except in one case.

Case Reports

Patient 1 (H. N.): A 15-year-old boy was sent to us with a history of low visual acuity. It had deteriorated over several years and could not be corrected. This process came to an end six years ago leaving him with an acuity of 5/60. Color vision was deuteranopic. Fundoscopy carried out during the last six years revealed bilateral foveal degeneration but otherwise normal fundi.

The ERGs in both eyes recovered much faster than normal during dark adaptation; they reached already five minutes after the cessation of light adaptation supernormal positive waves of more than 700 μV in the right eye and about 650 μV in the left eye. During the further course of dark adaptation they

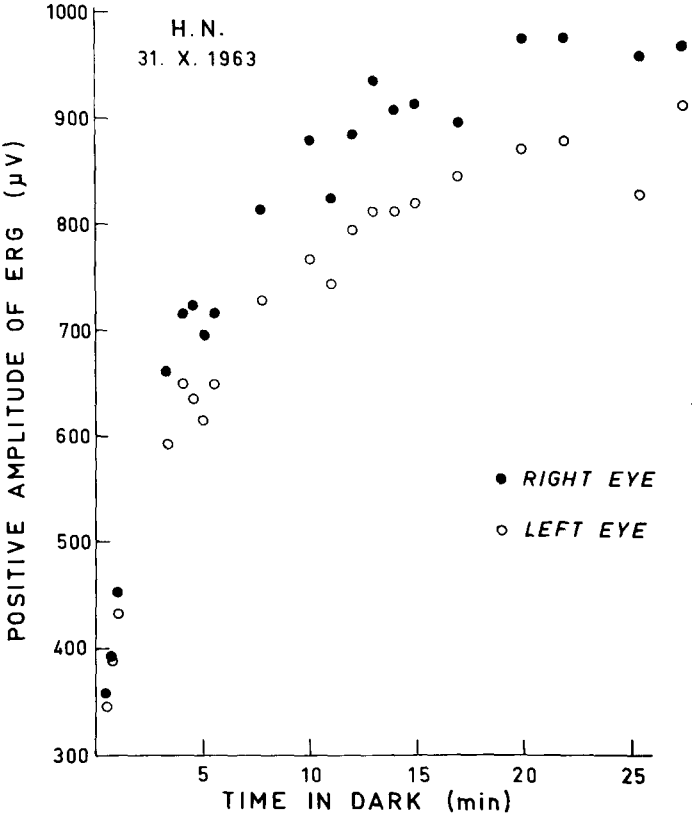

Fig. 1 The recovery of the b-wave of the ERG in the dark from a 5-minute light adaptation (patient 1).

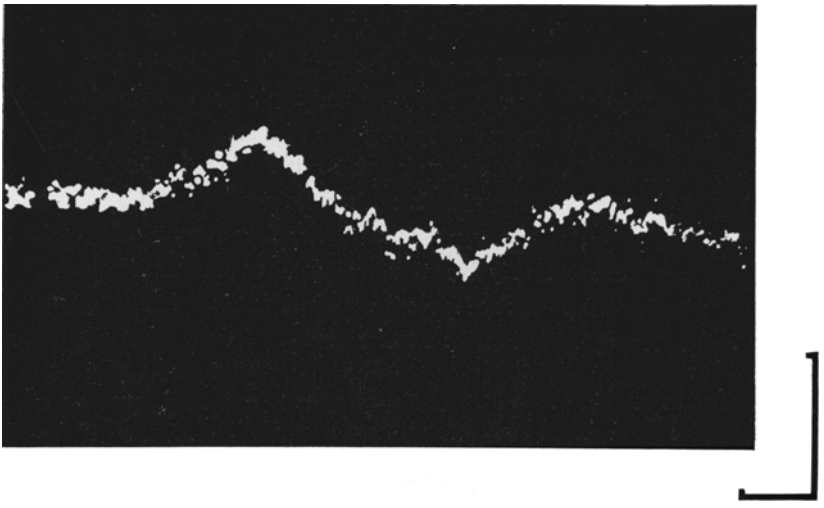

Fig. 2 The averaged VEP to binocular stimulations.
Calibrations: 10 μV; 25 msec. (patient 1).

increased steadily and reached after 30 minutes, when the steady state was almost attained, very large amplitudes of about 970 μV in the right eye and 900 μV in the left eye (Fig. 1). On the other hand, the values of the a-waves were at that time well in the normal range, i.e. around 170 μV in the ERGs of both eyes.

The VEP elicited by monocular and binocular stimulations displayed very subnormal amplitudes with lengthened latencies (Fig. 2).

Repeated electrophysiological examinations during the last six years did not exhibit any changes of the condition.

Patient 2 (W. N.): A 16-year-old boy was referred to us because of low vision in both eyes. His visual acuity was 6/20. The fundi displayed perhaps a slight constriction of the retinal blood vessels.

The ERGs of both eyes recovered within 20 minutes in the dark to values beyond the normal range. The b-wave of the right ERG attained amplitudes of 630 μV, that of the left ERG of 600 μV while the a-wave had amplitudes of less than 200 μV in the ERGs of both eyes.

The VEPs displayed very low amplitudes and lengthened latency.

Patient 3 (Y. E.): A seven-year-old girl with a visual acuity of 6/21 in the right eye and 6/15 in the left eye was sent to us from the low vision clinic. The fundi were normal. There was a slight divergent strabismus.

The recovery of the ERG could be followed only for ten minutes when it revealed enhanced b-waves of 750 μV in both eyes but a-waves of normal amplitudes (110 μV in the right ERG and 150 μV in the left ERG). The VEP displayed low amplitudes but normal latency.

Patient 4 (T. H.): This ten-year-old girl complained about disturbed night vision and very low visual acuity. She was able to count fingers only at a distance of one meter with her right eye and at two and a half meters with her left eye. The fundi were normal.

Owing to lack of co-operation only a few undisturbed ERGs could be recorded which were enhanced in both eyes. In the right eye the b-wave recovered within five minutes to 600 μV and increased still further to 650 μV during the following twelve minutes. The b-wave of the left ERG was of around 730 μV after 17 minutes in the dark. Also the a-waves were large. While the a-wave in the right ERG with 200 μV was close to the upper normal limit, that of the left ERG was enhanced and attained an amplitude of 250 μV. The VEP was practically extinct.

Patient 5 (G. E.): A seven-year-old boy suffered from low vision and convergent strabismus. His visual acuity was 5/36 in both eyes. The fundi were normal.

Since the patient did not co-operate the standard light adaptation could not be carried out, and only a few ERGs could be recorded during the first two minutes in the dark after the room light was switched off. The b-wave was already at that time enhanced in the left ERG to 670 μV while it was large but still at the upper normal limit in the right ERG (540 μV). On the other hand, the a-waves were within the normal range in both ERGs (140 μV in the right ERG and 170 μV in the left ERG). Beyond doubt, if the examination could have continued, the responses would have increased still further. The VEPs were very abnormal and obscured by reflectory eye movements. The amplitudes of the faster waves were very low.

Patient 6 (E. A.): A girl of 18 years of age had suffered, according to her parents, from a prolonged and severe febrile disease in her infancy. Thereafter vision was reduced in both eyes. Her mental development was not normal.

On examination only light perception was found in the right eye while the visual acuity of the left eye was 6/36 and its visual field was complete. There was a marked convergent strabismus of the better eye which may be a residual of the disease in her infancy. The fundi were normal.

The b-waves of the ERG of both eyes recovered within the 30 minutes tested to supernormal values of around 700 μV.However, as the recovery curves illustrate, the steady state was not yet reached at that time in the dark (Fig. 3). The amplitudes of the a-waves attained values within the normal range (150 μV in the right ERG and 130 μV in the left ERG).

The VEP following stimulation of the right eye was nearly extinct while stimulation of the better left eye yielded a response of abnormal pattern and low amplitudes (Fig. 4).

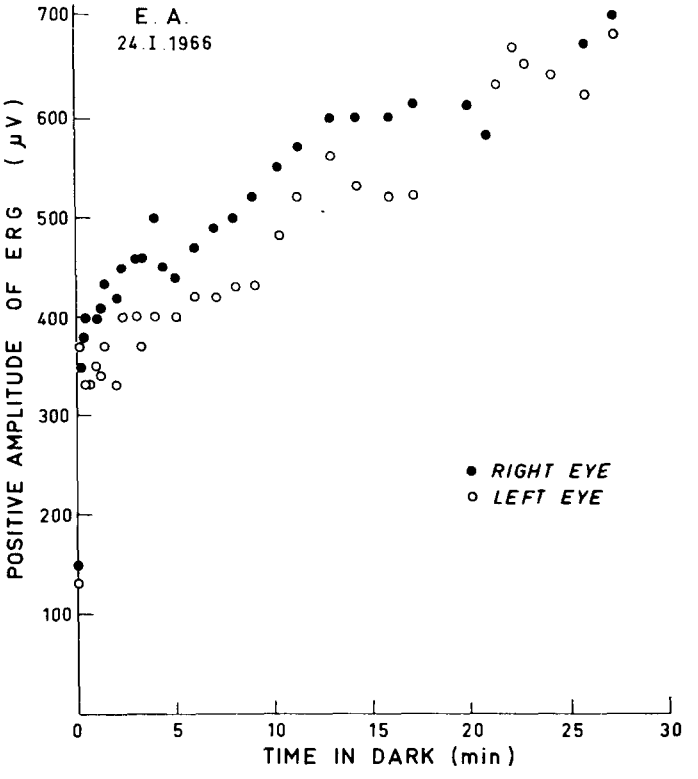

Fig. 3 The recovery of the b-wave of the ERG in the dark from a 5-minute light adaptation (patient 6).

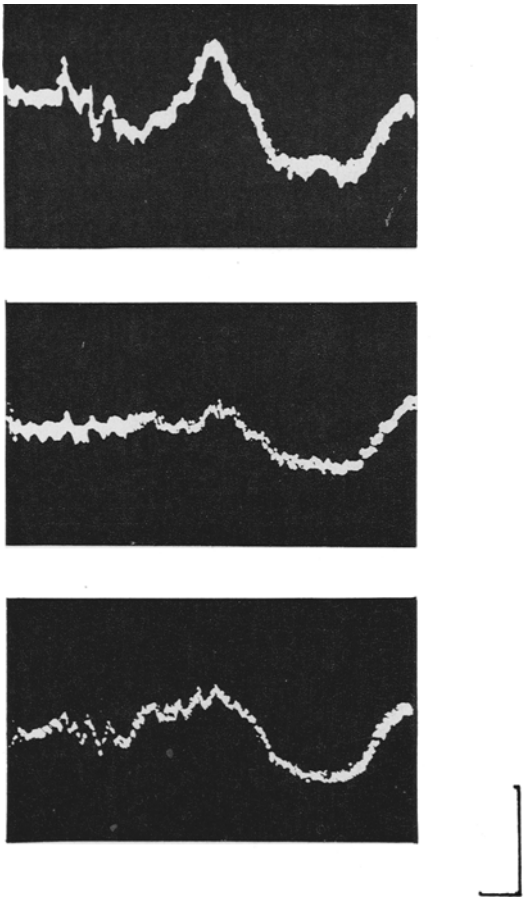

Fig. 4 The averaged VEP to binocular (upper trace) and monocular stimulations. The VEP following stimulation of the right eye (middle trace) and following stimulation of the left eye (lower trace).
Calibrations: 10 μV; 25 msec. (patient 6).

A re-examination twenty months later displayed similar findings.

Patient 7 (R. M.): Twenty-five years ago this 42-year-old man was hit on the head during an explosion. Ever since he suffered from low vision in both eyes (5/36 in the right eye and 5/60 in the left eye), grand mal seizures and speech

difficulties. There were no other neurological deficits. The fundi were normal and the visual fields seemed to be complete.

In the electrophysiological examinations the positive amplitudes of the ERG reached supernormal values of about 600 μV in the right eye and of almost 700 μV in the left eye (Fig. 5) while the a-waves attained the normal amplitudes of 150 μV in the right ERG and of 170 μV in the left ERG. The VEP displayed very low amplitudes and lengthened latency.

DISCUSSION

In the former study the electrophysiological findings were reported in patients with optic nerve lesions, which could be clinically diagnosed (FEINSOD et al., 1971). 42% of these patients exhibited enhanced b-waves of the ERG with generally normal a-waves and absent or reduced VEPs. This phenomenon was

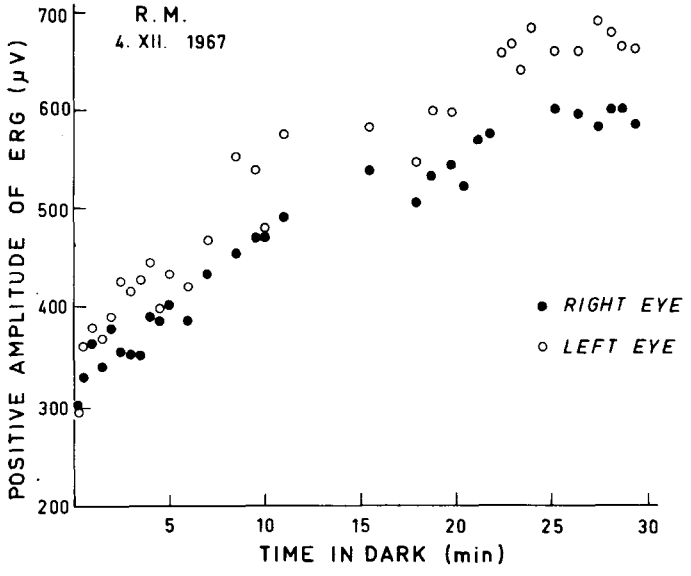

Fig. 5 The recovery of the b-wave of the ERG in the dark from a 5-minute light adaptation (patient 7).

attributed to an abolition of a rivalry assumed to exist in the intact visual system between the increasing retinal sensitivity in the dark and an inhibitory influence on retinal activity by a negative feedback mechanism via efferent (centrifugal) fibers, whose existence in the human optic nerve was demonstrated by several authors (WOLTER, 1965; WOLTER & KNOBLICH, 1965; HONRUBIA & ELLIOTT, 1968).

The group of patients presented here did not show any sign of optic nerve affection or any localizing neurological deficit, even not the three patients who were observed for extended periods of time. Likewise, there was no history or any findings suggesting causes other than connected with the neural mechanisms of the visual system for the enhancement of the retinal response, such as siderosis of the retina (KARPE, 1957), hyperventilation (ALPERN et al., 1955) or vascular disturbances (HENKES 1954). The ERG being of normal shape, i.e. containing all components, reflect normal retinal function. This points away from the defect being located in the first two neurons of the retina.

In the patients of the earlier report, the occurrence of an enhanced ERG was related to the eye whose optic nerve was affected no matter whether it occurred in one eye or in both eyes. In the present group in which the optic nerve did not appear to be affected, it occurred always bilaterally, even when when the visual acuity differed markedly in both eyes.

A reduced or extinct VEP, in the absence of an affection of the optic nerve, may result either from a disturbance in the afferent propagation of visual impulses or from an involvement of the striate cortex. However, these affections usually cause visual field defects and none of the patients examined displayed this symptom.

Patients whose clinical manifestations consisted in blindness or decreased visual acuity without visual field defects and optic nerve atrophy were described by WALSH (1957). Their symptoms were attributed either to anoxic episodes at birth or later in life or to central inflammatory processes such as viral encephalitis.

The enhanced retinal response, obtained in patients with optic nerve involvement, especially the rapid recovery of the ERG during dark adaptation, was assumed to be due to the absence of an inhibitory central influence which controls retinal activity in the intact visual system (FEINSOD et al., 1971). Applying this hypothesis to the present group where an enhancement of the b-wave of the ERG was always found, it has to be assumed that the postulated rivalry between the efferent impulses and the retinal sensitivity was abolished despite

the absence of optic nerve involvement. Because the optic nerves were unlikely to be affected and because of the bilateral appearance of the enhancement of the ERG, the origin of this controlling influence on retinal activity in the intact visual system may be expected to be located at a level where the nervous connections from one eye join those from the other eye.

Several observations and experiments seem to support a hypothesis that these regions are responsible for the defects observed in the patients reported here. In man centrifugal fibers were traced histologically up to a region immediately adjacent to the lateral geniculate body (WOLTER & KNOBLICH, 1965). Although it is possible that they originate in the human cerebral cortex, the efferent fibers were described only in the cat to originate here; they were found to terminate in the lateral geniculate body and the superior colliculli among other structures (BERESFORD, 1961). Other experiments demonstrate in cats and monkeys descending effects on the activity of the lateral geniculate body following cortical stimulation (WIDÉN & AJMONE-MARSAN, 1961; HULL, 1968) and in cats and dogs degeneration of nerve fibers down to the optic tracts, chiasma and optic nerves after ablation of the visual cortex (HASCHKE, 1963; ERMOLAEVA, 1961). These authors consider the fibers to represent the centrifual pathways in the optic nerve.

However, provided that our theory of retinal rivalry (see above) is correct, against the above hypothesis speaks very strongly that necessarily both lateral geniculate bodies would have to be affected. If the lateral geniculate body of one side alone would be involved, a certain number of centrifugal fibers from the other lateral geniculate body should reach the eyes and exert here their inhibitory influence. The same argument applies probably to the visual cortex in both hemispheres.

There is other evidence which seems to point primarily to the anterior hypothalamus as the origin of the efferent fibers, and that the number of efferent fibers arising in the lateral geniculate body is not significant (SACKS & LINDENBERG, 1969). No evidence of an efferent fiber connection from the visual projection to the hypothalamus, however, has been established (BERESFORD, 1961).

Therefore, since a bilateral disturbance in the lateral geniculate bodies with their synaptic connections from both eyes appears extremely unlikely, the localization of the affection in the optic chiasma could not be excluded if there were any field defects present. In their absence in all cases presented, a localization of the affection in the chiasma is very unlikely.

We conclude that we cannot as yet adequately explain the underlying neural

mechanisms which cause the pathology in the cases reported here. An answer to that question may be given by continued observation of the patients and possibly by animal experiments.

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