EFFECT OF DEFECTIVE VISION ON VISUAL EVOKED POTENTIAL

Thesis submitted in partial fulfilment of the requirement of the M.D. Degree in Ophthalmology

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1990

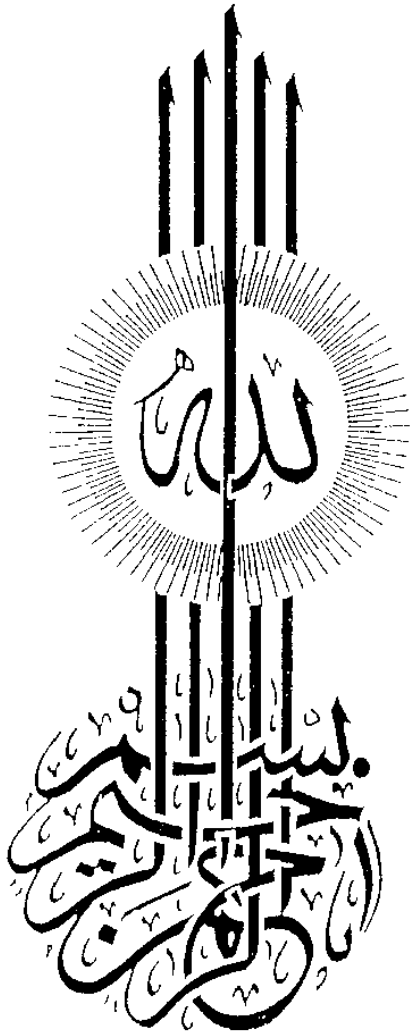
Acknowledgement

It is indeed my utmost pleasure to thank my most honoured supervisor, Professor Doctor Mohamed Fathy El Mekawy who has closely supervised every work detail with kindness and devotion.

I am also greatly indebted to Professor Doctor Youssef Abu Zeid for his valuable advice and guidance throughout this work.

I whish to express my thanks and respect to Professor Doctor Magdoline El Gammal for her able guidance and moral support.

Thanks are also due to all members of the Ophthalmic Department specially due to Doctor. Hoda Saber Naaim and Doctor Fatma El Hennawy and specially due to Doctor Magd Zakaria from the Neurology department for their help during the practical work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INTRODUCTION

ELECTRICAL ACTIVITY OF SINGLE CELLS OF THE RETINA AND VISUAL PATHWAY

A. *Responses from Rods and Cones :*

Bleaching process of visual pigment due to light produces what is called the early receptor potential which is a very rapid component that can be seen at the very beginning of the E.R.G. before the "a" wave.

Responses have also been detected from inner segments of the receptors which resemble the PIII component of electroretirogram. These electrical changes are different from nerve spikes which can not be detected in the receptor layer of retina. That is why it is suggested that the P_{III} component reflects the conduction of the visual signal itself (Brindley 1970).

B. *Responses from Horizontal and bipolar cells :*

Intracellular recording technique have revealed the presence of relatively low slow potentials in the inner nuclear layer. These slow potential (S potentials) vary in size with the strength of the stimulus and are of 2 kinds "L" type which is not colour sensitive and appears to be produced by horizontal cells and "C" type which responds in a different manner to different coloured stimuli and is produced either by horizontal cells or bipolar cells (MacNical and Svaenichen 1958). It is likely that those slow potentials also contribute to the electrogram.

C. *Responses from Ganglion Cells and Nerve Fibres :*

When the visual signal reaches the ganglion cell layer it appears to be recorded in the form of nerve cell spikes.

Each nerve fibre can thus convey information in terms of frequency of nerve spikes, and in this way the whole sensation of vision is conveyed to the lateral geniculate body and occipital cortex. The optic nerve shows continuous activity even in the dark. Several different classes of nerve fibre have been defined depending on their response to light to on, off or on and off nerve fibres (Hartline, 1958).

Receptive Fields :

It is known that the number of receptors far exceeds ganglion cells hence there must be some convergence of nervous pathways on the ganglion cells. The area of retina which can be shown to influence a given ganglion cell and associated nerve fibre is called the receptive field of the ganglion cell. The concept of the receptive field of individual neurons is crucial for appreciating why spatial contrast (i.e. Pattern) is so important for V.E.P. studies. Signals from photoreceptors of a portion of illuminated retina converge into 2 separate pools of a neuron (ganglion cell). Because of the geometry of the receptive field these pools are called the center and the surround. The ganglion cell response recorded from the appropriate single fiber of the optic nerve or tract is a departure (decrease or increase) from the mean firing rate (i.e. the neuronal response is a modulation around some steady level of number of spikes per unit time).

When both center and surround are illuminated that modulated response decrease compared to the illumination of the center alone. As a consequence of antagonistic organization, the size of center relative to the surround establish the spatial selectivity of individual neurons (ganglion cells). For example if a neuron is stimulated by a small spot of light the response of the neuron will 1st grow as the size of the spot becomes larger than the diameter of the receptive field center. This is due to the surround antagonism. Owing to the antagonistic organization of separate pools for center and surround portion of the receptive field of bipolar neurons and ganglion cells the retinal out put dose - not simply represent the illumination of a retinal patch. Instead the response of bipolar and ganglion cells is determined by spatial contrast (i.e. difference of illumination between neighbouring retinal areas), rather than by the sum of their separate illumination. The distinction between center and surround and hence their interaction is sharper in foveal ganglion cells.

The more sharply defined is each mechanism the more selective is each neuron for stimulus size. For example bipolar cells of the retina are less selective for stimulus size than ganglion cells which in turn are less selective than cortical neurons. (retinal and lateral geniculate body nucleus are radially symmetrical i.e. show little or no orientation selectivity unlike neurons of cortex).

Individual ganglion cells differ in the size of their receptive field (i.e. their spatial selectivity). In general the closer the neuron is to the anatomical fovea the smaller its receptive field. The population of parafoveal located ganglion cells has larger receptive field centers than the foveal population of ganglion cells. It is estimated that the central size of the human foveal ganglion cells is smaller than 20'. An understanding of these physiological principles is necessary to appreciate the importance of pattern element size of the V.E.P. stimulus.

D. Responses from Visual Cortex and Lateral Geniculate Body :

The response of the cells in the lateral geniculate body are very similar to those of the ganglion cells of the retina. The receptive fields are circular with concentrically arranged mutually antagonistic regions as in the retina and these appears to be little recording or discarding information at this stage. In the striate cortex the receptive field have been divided into four kinds : a. Circular concentric, b. Simple, c. Complex and, d. Hypercomplex cells (Hubel and Wiesel, 1962, 1968).

a. Cells with concentric circular receptive fields are similar to geniculate cells (not clear either they are true cortical cells or just geniculate fibres the other three types of cortical unit are definitely cortical cells).

b. The simple type differ from retinal ganglion cells and geniculate cells in that their receptive field tend to lie side by side rather than concentrically.

c. Complex cells have been shown to be particularly sensitive to bright lines, dark lines or boundaries over a relatively wide receptive field and they do not respond to circles or inappropriately orientated lines and boundaries.

d. The hypercomplex cells also respond only if lines or boundaries which are suitably oriented, but they only respond if the lines or boundaries actually terminates in the receptive field.

This hierarchy of the cortical cells has been shown to be arranged in horizontal layers. Thus layers V and VI contain mostly complex and hypercomplex cells as well as layer II and III. Simple cells are found in abundance in layer IV and deep in layer III (Hubel and Wiesel, 1967).

It was found that along a track perpendicular to the surface of the brain all cells have the same receptive field orientation, although such a column will include all different types of cortical cells. Another type of column is also seen in which cells are arranged or grouped according to eye preference.

REVIEW OF LITERATURE

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Historical Review :

In 1934 Adrain and Matthews were the first to notice the electrical response to repeated flashes of light which can be detected by using scalp electrodes sited in the occipital region and called it visually evoked response (V.E.R.). Owing to the small size of the response ranging from 5-10 µv in amplitude in comparison to 300 - 500 µv for the E.R.G.. Only many years later after the discovery of amplifiers and modern electronics, that it was further elucidated.

In the late 1950s, and early 1960s several descriptions of normal wave form of the visually evoked response appeared. Although there were similarities between all these recordings it became apparent that considerable variation in this wave - form exist depending on the stimulus parameters and on the particular subject being tested. Fig (1) shows the schematic representation of the visually evoked response according to Ciganek (1961), who was the first to describe satisfactory visually evoked response. In (1964) he recorded early waves of evoked responses. They consist of seven waves of positive and negative alternative polarity with average latency of 40, 53, 75, 95, 115, 130, 190 m sec. Ciganek called them wave I, II, III, IV, V, VI, VII he also named the rhythmic oscillations which follows "after discharge phase".

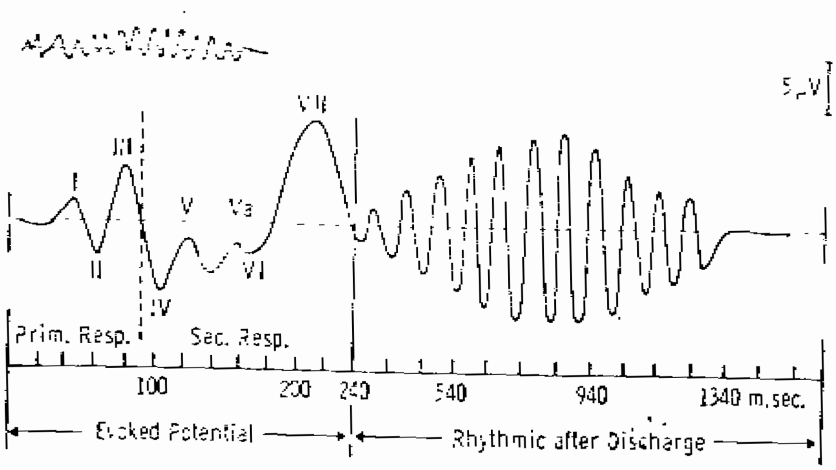

Fig (1) Diagramatic representation of the wave form of the visually evoked response as summarised by Ciganek (Quoted from Ophthalmic electro diagnosis, edited by Nr Galaway PP 29 W.B. Saunders company Ltd. London 1975).

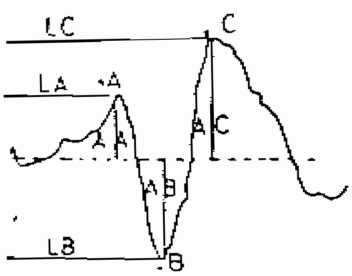

Fig (2) Showing the V.E.R. waves discribed by Koral
AA = A- wave amplitude   AB = B wave amplitude
AC = C- wave amplitude   LA = Latency of A wave
LB = Latency of B wave   LC = Latency of C wave
(Quoted from Ocular electrophysiology, edited by J. Babel, N Staangos, S Koral and M. Spiritus, pp 103 Gearg Thieme Publishers, Stuttgart 1977).

The early phase I, II & III represents the specific part of the visual cortex response and the 2nd phase belongs to an unspecific diffuse organized system.

Koral (1974) using a new method was able to distinguish the following waves (Fig 2). "A" wave (with average latency of 53.9 m sec) is positive and often split into A_1 and A_2. This wave is preceded by an early negative polarized wave of low amplitude and latency (average 40 m sec) which corresponds to Ciganek's wave I. The "B" wave (with average latency of 81.8 m sec) is the second wave and the most constant component, it is negatively polarized and includes Ciganek's wave III and the "C" wave (with average 110 m sec) is of positive polarity and corresponds to Ciganek's wave IV and this wave increases in amplitude in dark adaptation.

It was soon realized that the visually evoked response is predominantly foveal thus the amplitude of the response increases with increasing stimulus size until it subtends an angle of 12°. The response is also affected by different factors as subject attention, frequency of stimulus flashes and by the preadapting stimulus (May, et al 1974).

It was of great interest to the clinicians to realize that the visually evoked response is predominantly foveal and that the wave form of the V.E.P. would tend itself to analysis in similar manner to the analysis that have been applied to electroretinogram. Along the years other types of stimuli were used to elicit V.E.P. as pattern onset - offset, sinusoidal gratings, pattern checkerboard with transient and steady state mode of stimulation. These types lead to different forms of V.E.P. which were thought to be different modalities that may be convoyed along separate neurons in the visual system (Campbell and Maffi 1970, Regan 1972). A new achievement was the use of pattern reversal stimuli used by Van der Tweel and Spekreijse (1966) many varieties of patterns have been tested but the most useful and accurate is the checkerboard as it has larger response than flash and light energy required to produce V.E.P. is less.

V.E.P. to pattern reversal have now become a standard method of investigating the visual system in adults (Halliday et al., 1972, 1974. Sokoland Bloom 1973, Asselman et al., 1975, Sokol and Shatterian 1976).