THE RETINAL RESPONSE IN RELATION TO AN UNCONDITIONED AND TO A CONDITIONED STIMULUS

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P. G. Snyakin and others [3] have shown that the number of active retinal receptors (the degree of their mobilization) varies in relationship to a number of external factors, which include the level of daylight illumination, time of day, etc. This fact was the basis for the concept of functional mobility.

This concept embodies the idea that the retinal receptor apparatus, like that of any other organ or tissue, is able to alter the number of active elements according to the demands of the prevailing conditions. This ability is of great physiological significance.

The association between the mobilization of the receptors and the variation of light intensity brings about optimal conditions for retinal action, and therefore is adaptive in nature. Further, this correspondence entails a differentiation by the visual analyzer of adequate stimuli of different strengths. Therefore a study of the response of the retina to the action of different strengths of adequate stimulation may enable us to evaluate quantitatively the adaptive and analytic functions of the visual analyzer.

The results obtained by P. G. Snyakin and others [4] in their studies of the functional mobility of the retina in human subjects suffering from various diseases of the central nervous system indicate that the criterion of correspondence may also be useful clinically for diagnosis.

To establish such a criterion we have to investigate quantitatively the characteristic response of the retina in response to conditioned and unconditioned stimuli of various strengths, and so establish this kind of criterion. To do so, in the present investigation we set ourselves the following aims.

1. To find whether perimetry can be used to determine the response of the retina to the action of adequate stimuli of different strengths.

As P. G. Snyakin [3] showed, the area of the light-sensitive retina as determined perimetrically indicates the degree of mobilization of the receptors. On this basis, perimetry was proposed as a method of evaluating the functional retinal mobility. The method appears promising practically because of the widespread use of perimeters in clinical practice. It is therefore of interest to find whether perimetry gives a sufficiently accurate picture of the mobilization of the receptors to make it applicable as a method of determining the response of the retina to the action of the stimuli of values selected by us.

2. To consider the possibility of establishing a quantitative relationship between the intensity of the light stimulus (unconditioned) and the degree of mobilization of the retinal receptors. Such a dependence would enable an accurate assessment to be made of the analytic and adaptive functions of the retina under various conditions of illumination.

3. To study the quantitative characteristics of the retina in response to the action of conditioned stimuli of various strengths.

L. M. Kurilova [2] and N. V. Galuzo [1] and others have developed a method of investigating the conditioned-reflex changes in the level of mobilization of the retinal receptors. However, there is no published information concerning the correspondence between such a shift and the actual value of the conditioned stimulus.

An investigation into such a correspondence could reveal a number of facts concerning the cortical mechanism governing the reflex setting of the retina as influenced by external stimuli of various strengths.

METHOD

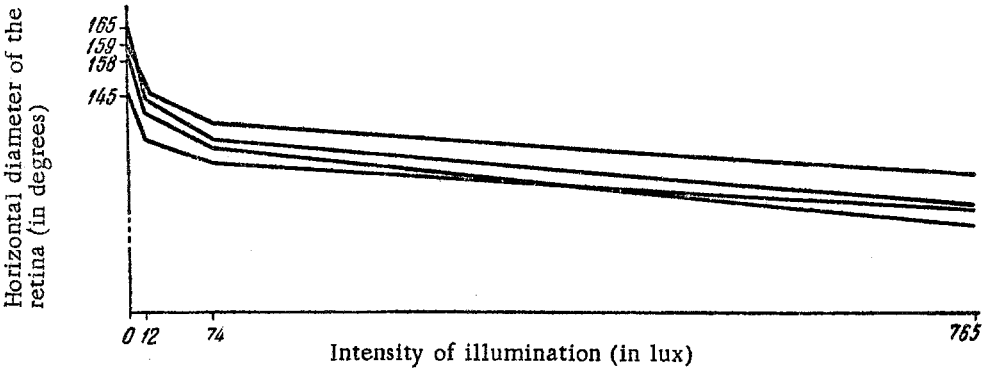
Experiments were carried out on healthy human subjects aged 18 to 23 years.

To determine the boundary of the light sensitive boundary of the retina, we used a projection perimeter. The boundaries of the horizontal meridian only were registered, because its value undergoes greatest alteration during adaptation. The studies were made monocularly in a darkened room. As a result of dark adaptation for 35-40 min, the maximum values of the boundaries of the light sensitive area of the retina were determined. In our experiments, these values represent the so-called initial level of mobilization of the rods.

As unconditioned stimuli we used illumination of the experimental room for 30 sec produced by incandescent lamps of 25, 96, and 500 w, giving illuminations of 12, 74, and 765 lux on the surface of the table used.

The conditioned stimuli were sounds of different frequencies obtained from an audio-oscillator. The orienting reaction of the retina to the sound stimulus was extinguished after several repetitions.

Each conditioned stimulus was reinforced by an accurately defined unconditioned stimulus, as follows: a sound stimulus of 200 cycles was reinforced by a light of 4 lux; a sound stimulus of 1000 cycles by a light of 21,5 lux, and a 1500 cycle stimulus by illumination of 295 lux.



Relationship between the value of the horizontal diameter of the retina (level of mobilization of the receptors) and the intensity of illumination; curves for four subjects.

In this way we obtained a group of unconditioned and a group of conditioned stimuli having different strengths and providing a graded retinal stimulation.

The interval between the stimuli was 3-7 minutes; it was adequate for the light sensitivity of the retina to recover to its original value.

RESULTS

In 74 studies made on four young people it was shown that light stimuli of different intensities induce a reduction of the light sensitive area which depends upon the intensity as follows: a weak stimulus of 12 lux caused a reduction of 17°, a moderate stimulus of 74 lux gave a reduction of 29°, and the strongest stimulus of 765 lux gave a reduction of 41°.

Because the constriction of the field represents a reduction in the level of mobilization of the receptors, it must be supposed that this biologically important phenomenon of the retina being able to react adequately may be revealed by the simple and generally available method of perimetry. This greatly extends the possibilities of studying the properties of the retina of interest to us.

The diagram shows the quantitative relationships. First of all we must note the marked resemblance between the four curves. Their corresponding portions are almost parallel. The general shape of the curves and their characteristic slope towards the ordinate and their tendency to flatten out as they depart from it suggest an exponential function. It is known that such a function is typical for the course of changes in the level of mobilization of the receptors during adaptation of the visual system to light [4].

In order to study the role of cortical function in regulating retinal activity we studied the action of various conditioned stimuli, and altogether we carried out 173 observations on four subjects.

In each we developed three groups of conditioned reflexes representing different quantitative indices.

The conditioned reflexes of the first group developed in response to sound of 200 cycles and reinforced by illumination of 4 lux gave a retinal response of 2-5°; conditioned reflexes of the second group developed in response to sound of 1,000 cycles and reinforced with illumination of 21.5 lux gave a response of 5-10°; finally reflexes of the third group elaborated in response to a signal of 1,500 cycles reinforced by light of 295 lux determined the reaction at 10-15°.

Consequently, there was a certain correspondence between the value of the conditioned stimulus and of the retinal response as determined perimetrically.

These facts indicate the undoubted role of the cortex in determining the setting of the retina and so controlling its response to external stimuli of different strengths. Also, they signify that cortical action can be investigated not only by means of the generally accepted methods of motor, secretory, etc. conditioned reflexes, but also in terms of the degree of correspondence between the extent of the retinal response and the value of a conditioned stimulus.

SUMMARY

A study was made of the retinal response to unconditioned and conditioned stimuli of different strengths. The alteration in the degree of mobilization of the receptors (number of active receptors) served as an index of this reaction. It was shown that perimetry could be used to relate the value of the unconditioned and conditioned stimuli to the retinal response. It therefore becomes possible to study the analytical and adaptive function of the visual analyzer in terms of this relationship.

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