The Mechanism of Dark Adaptation

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Many investigators have tried to explain the phenomena of human dark adaptation solely on the basis of photochemical theories. All their attempts have failed. In the first place, there is no doubt but that the increase of the concentration of photopigments during dark adaptation is insufficient for a complete explanation of the phenomena; in the second place psycho-physical and electro-physiological evidence have made it clear that apart from a "photochemical" mechanism, "neural" mechanisms are active during dark adaptation.

The present paper has as its purpose an experimental evaluation of the relative importance of the various components of dark adaptation. On theoretical and experimental grounds the following list of mechanisms of dark adaptation is suggested:

f1-component. This is the photochemical component discussed above.

f2-component. The neural receptor component. In the dark adapted eye a certain amount of decomposition of visual pigment causes the receptor to answer with a spike response whereas the same amount of decomposition does not have this effect in the light adapted eye.

D-component. The spatial integration component. In the dark adapted eye the diameter (D) of the retinal area within which complete integration occurs is larger than in the light adapted eye.

T-component. The temporal integration component. In the dark adapted eye the duration within which complete integration occurs is larger than in the light adapted eye. In the experiments which will be studied in the present paper this component was eliminated by the use of light flashes of very short duration.

k-component. The coincidence component. Bouman and v. d. Velden have shown that for the fully dark adapted eye two "coincident" quanta (i.e., two quanta incident within a critical retinal area with diameter D and within a critical duration T) are sufficient to elicit a visual response. Bouman and ten Doesschate have shown that for the light adapted eye this number $k > 2$. The resulting adaptational effect is called coincidence or k-component.

Subsequently it is shown that some of the components mentioned above can be separated experimentally by studying the behaviour of dark adaptation as a function of the diameter (d) of the test field. Such experiments can thus be made for the centre of the retina (exclusively foveal cones) and for the

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retinal periphery (rods and cones) and further for both red light (that predominantly stimulates the cones) and green light (that stimulates both rods and cones). The results of such experimental analyses are described.

Analysis of the experimental data yields the following, rather schematic survey of the process of dark adaptation:

Mechanism

Foveal adaptation f_1 at least a factor 5

perhaps f_2 but if so not more than a factor 20

Peripheral adaptation

in phase I f_x at least a factor 5

perhaps f_2 but if so not more than a factor 20

D approximately a factor 1.5 in phase II k-component by a factor 6 to 8

An extensive paper on the same subject has been published in "Vision Research". 1962 Vol. 1, pp. 386–403.

Discussion

Roelofs asked whether in determining the foveal adaptation the experiments were made only with red or also with green light and whether if the latter was the case, the red and green lights produced any difference whatsoever in the results.

ten Doesschate: The form of the foveal curves was identical for red and green.

Jonkers: On the basis of our present knowledge of the anatomy and the physiology of the retina, what physiological factors must be taken into consideration in respect to the mathematical factors cited?

ten Doesschate: The f_2 -component refers to the single receptor and may be regarded as a "facilitation". The D-

T- and k-components are connected with a change that seems to take place in the synapses. This change brings about an increase in efficiency of the "switching arrangement" in the course of dark adaptation.