PHOTOSENSITIVITY OF CENTRAL AND PERIPHERAL PARTS OF THE RETINA DURING EXPOSURE TO NOISE

I.N. Dantsig and A. V. Diev

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Photosensitivity of the retina is one of the most labile parameters of visual function relative to various factors including noise. Data in the literature on the action of noise on photosensitivity of the eye are few in number and contradictory in nature. Some workers [6, 7] observed an increase in photosensitivity during exposure to an acoustic stimulus, others [1, 3, 5, 11] found a decrease, while a third group [2, 10, 12] observed both types of response.

The absence of unanimity on the character and direction of changes in photosensitivity during exposure to noise was the motivation for the present investigation.

EXPERIMENTAL METHOD

Experiments were carried out in a specially equipped room on 31 male subjects aged 20-25 years with visual acuity of 1.0 without correction, during the first half of the day. Photosensitivity was studied by means of the mass-produced ADM adaptometer, brightness of the preliminary adaptation sphere was 795 cd/m^2 and brightness of the test object about 0.0028 cd/m^2. As parameter of photosensitivity of the peripheral portions of the retina, the time threshold of dark adaptation (TTDA) was determined by the 3-minute adaptometry method. Photosensitivity of the central part of the retina [8] was estimated as the visual acuity recovery time (VART), i.e., the time required for distinguishing a sign on a table corresponding to visual acuity of 0.5. The duration of each experiment was 3 h. After 45 min of adaptation of the subject to the conditions of illumination in the room, background levels of the test parameters were recorded. The subjects were then exposed to noise for 1 h. Values of TTDA and VART were measured every 15 min during exposure and for 1 h after exposure to sound. The acoustic stimulus, in the form of monotonous noise, was applied through TDS-3 earphones from a white noise generator (type 1402, from Brüel and Kjaer, Denmark), with an intensity of 95 dBA. Tests on the same subject were repeated not more often than at intervals of 2 days, 3 or 4 times with each subject. The number of observations in the group with exposure to noise was 122 and in the control group 95.

EXPERIMENTAL RESULTS

The first evaluation of the results removed all doubt that the character of the response of the different subjects to noise varied quantitatively. Detailed analysis of the results showed that all the subjects could be divided into four groups depending on the mutual relationship between changes in the two parameters studied: TTDA and VART. Group 1 included 4 subjects (15 investigations with exposure to noise and 10 without it), group 2 consisted of 7 subjects (28 and 19 tests, respectively), group 3 of 11 (42 and 37), and group 4 of 9 subjects (37 and 29 tests). The serial number of the group corresponds to the conventional description of the type of response. The results are illustrated in Fig. 1.

The first type of response was characterized by a smooth increase in the two parameters throughout the period of exposure with a maximum toward the 60th minute (TTDA was increased by 38%, $P < 0.05$; VART by 27%, $P < 0.05$). A further increase in TTDA (by 72.9% above the initial level) and a stepwise fall in VART were observed 15 min after the end of exposure. Both parameters still remained higher than initially 1 h after the end of exposure to noise.

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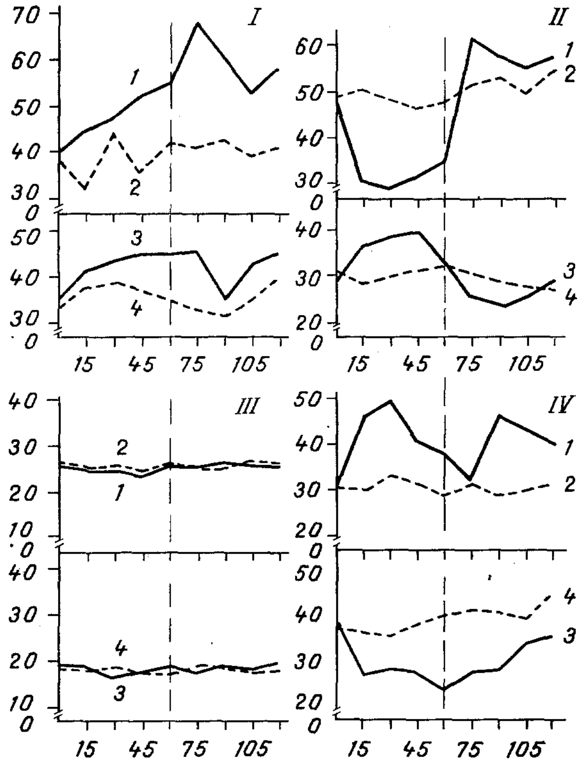

Fig. 1. Dynamics of TTDA and VART during exposure to noise. I, II, III, IV) types of response. 1) TTDA with exposure to noise, 2) TTDA without exposure to noise, 3) VART with exposure to noise, 4) VART without exposure to noise.

The second type of response was characterized by an opposite trend of the functions tested: a fall in TTDA, most marked by the 30th minute of exposure (by 58%; $P < 0.001$), and an increase in VART, maximal by the 45th minute of exposure (by 36%, $P < 0.05$). TTDA rose above its initial level 1 h after the end of exposure, whereas VART fell to its initial level.

A characteristic feature of the third type of response was the absence of significant changes in the two parameters both during exposure to noise and after its end. This type of response, incidentally, was observed against the background of low initial levels of TTDA and VART.

The fourth type of response was distinguished by an increase in TTDA, maximal toward the 30th minute of exposure (by 69%, $P < 0.001$), and by a decrease in TTDA, most marked toward the end of exposure (by 48%, $P < 0.05$). In the after period TTDA remained higher than initially. Meanwhile a gradual and steady recovery of VART was observed during the hour after the end of exposure to noise.

Comparison of the initial levels of TTDA and VART before the beginning of exposure with the corresponding values in the control revealed no significant differences in any of the four groups. Meanwhile, when the dynamics of TTDA and VART during exposure to noise was compared with the control values, significant differences were found in groups 1, 2, and 4 at all stages of exposure to noise, and as a rule they did not disappear in the period after exposure. The exception was group 3, in which there were no significant differences either from the initial values or from the control.

The results are in agreement with data in the literature [10, 12]. Under the influence of noise photosensitivity of the human eye has been shown either to decrease or to increase (responses of the 1st, 2nd, and 4th types). At the same time, it has been observed [10] that in some cases the effect of exposure was either indeterminate in character or absent altogether, and this also agrees with our own data (response of type 3). Dependence of the initial level of photosensitivity and the subsequent type of response to noise also was established in [10]. We also observed a decrease in photosensitivity of the peripheral part of the retina (TTDA) when its initial level was high, and an increase when its initial level was low (responses of types 2 and 4). The same dependence also was observed in relation to the center of the retina (for VART). It is to the point that the initial levels of TTDA and VART in group 1 were intermediate in position in relation to initial levels for groups 2 and 4, whereas for group 3 low initial levels relative to the remaining groups were characteristic. The results obtained in groups 2 and 4 illustrate well the reciprocal relations between central and peripheral vision, when a decrease in sensitivity of the rods evokes a decrease in sensitivity of the cones, and vice versa, and this also has been observed in the literature [10, 11]. Most workers consider [4, 6, 10-12] that the response of the visual system to an acoustic stimulus is largely determined by relations between excitation and inhibition processes in the corresponding neural centers. An indifferent stimulus can therefore play the role of inhibitory agent, and can stimulate excitation or enhance it, and this ultimately is reflected in the sensitivity of the eye to light [12].

Consequently, the response of the visual system to noise stimulation is independent of the individual characteristics of the particular subject [10], and manifestation of one or other type of response is stochastic in character. However, high stability of our results was observed during repeated investigations on nearly every subject. A change in the type of response to noise stimulation was found in only two cases (1.6% of the total number of investigations); in these cases, moreover, initial levels of TTDA and VART also were changed.

It can thus be concluded from these results that the character of the visual response to noise depends on the individual features of the particular subject, and this is not in agreement with data in the literature [2, 10, 12]. This contradiction may perhaps be based on the difference in the time of exposure to the acoustic stimulus. At the first moment of exposure to noise the test system responds in accordance with the momentary state of the CNS, after which there is gradual adaptation of the system relative to the stimulus, which depends on the individual properties of the CNS and is a manifestation of mechanisms of adaptation [9]. During temporary exposure for a few seconds [10] or minutes [2, 12] of the same subject, responses of different types may thus be observed to noise, and the frequency with which each type appears is stochastic in character. During prolonged exposure for 1 h, on the other hand, the type of response to noise is individual in character. However, if the subject is in an inadequate state, due to exposure to extremal factors, a response that is atypical for the given subject may develop.

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