PECULIARITIES OF CERTAIN QUANTITATIVE CHARACTERISTICS OF THE VESTIBULAR ANALYZER IN RABBITS

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The problem of the physiological range of the values of adequate stimuli of the vestibular analyzer cannot be considered as conclusively solved. In investigations where the ability to maintain a logarithmic dependence between the duration of postnystagmus and the magnitude of the adequate stimuli was taken as a measure of "physiological character," very close values of threshold stimuli for people and animals were found [7-10]. Along with this an appreciable number of experimental works have been carried out and are continuing to be carried out with the use of stimuli three-fold and more exceeding the limits of the logarithmic dependence [1, 3, 4, 6, 11]. Finally, certain authors completely deny the existence of any proportional relation between angular acceleration and the duration of nystagmus [16, 17].

In this study we investigated two basic indexes of the nystagmic reaction—duration and number of postnystagmic movements upon changing the magnitude of the adequate stimulus in a wide range.

METHOD

The experiments were carried out on chinchilla rabbits of both sexes, weighing on the average 2 kg. In the experiment we used a detachable stall for rotating the animals on a VU-2 device [2]. Before starting the experiment the extremities and trunk of the rabbit were strapped to the stall, and the head was firmly fixed by means of a bolster in the center of rotation with the longitudinal axis of the head arranged in a horizontal plane.

Rotation was carried out in a sound-proof room in the dark, always in a clockwise direction. The magnitude of acceleration (5 deg/sec^2), duration of uniform rotation (1 min), time of stopping (0.15 sec) and the intervals between two rotations (1 min) remained unchanged in all experiments. Postnystagmus arising in the animals after sudden cessation of uniform rotation (stop-stimulus) was recorded on an ink-writing "Kaiser" electroencephalograph at a time constant of 1.0. For tapping the corneoretinal potential we used needle electrodes which were inserted into the skin of the inner and outer canthi of the eye.

For the magnitude of the stop-stimulus we took the value of the angular velocity of uniform rotation [5, 9, 10, 12]. The minimal rotational velocity was 10 deg/sec, the maximal was 180 deg/sec. The velocity of two consecutive rotations differed by 10 deg/sec, so that during one experiment the animal experienced the effect of 18 stop-stimuli increasing in magnitude. Each of the six rabbits participated in six experiments, the intervals between which were from 2 to 6 days. Thus, there were 36 experimental points for each stop-stimulus.

After statistical analysis of the data we obtained experimental curves which enabled us to compare the intensity of the reaction (duration of postnystagmus, number of nystagmic movements) with the magnitude of the stimulus (angular velocity), the mathematical analysis of which was carried out by the least-squares method [14] on the "Ural-2" electronic computer.

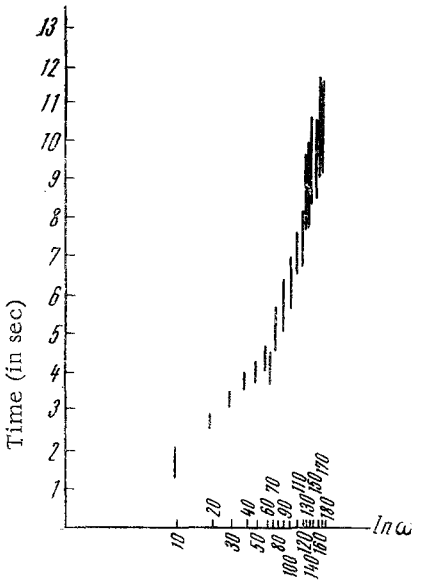

Fig. 1. Duration of nystagmus vs. magnitude of stimulus. Along axis of abscissa are natural logarithms of the angular velocity of uniform rotation.

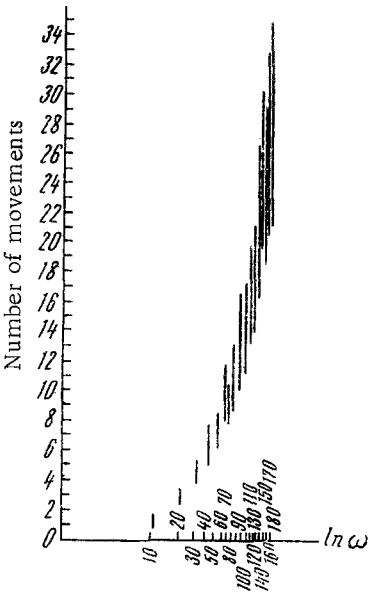

Fig. 2. Number of nystagmic movements vs. magnitude of stimulus. Along axis of abscissa are natural logarithms of the angular velocity of uniform rotation.

RESULTS

The experimental curves plotted in a semilogarithmic scale (Figs. 1, 2) are not rectilinear and, consequently, they cannot be expressed as a logarithmic function. However, the mathematical analysis showed that the section of the curve of nystagmic duration in the 10-60 deg/sec subrange of stimuli is best approximated precisely by a logarithmic function. The curve of a number of nystagmic movements, which owing to the great dispersion of the data is a less indicative characteristic of the nystagmic reaction, can be approximated in the 10-60 deg/sec subrange of stimuli both by a linear and by a logarithmic function. In the 70-180 deg/sec subrange of stimuli a linear approximation of both curves is possible.

The hypothesis of the existence of a linear dependence in the entire range of stimuli used was not confirmed for both curves (check by the F criterion at a 0.05 significance level). More definite conclusions about the functional dependence between the magnitude of the stimulus of the vestibular analyzer and the response of nystagmic reaction require further experiments.

Thus, we can consider as established that in the 60-70 deg/sec region of stimuli there occurs a change in the character of the curves (in any case, of the curve of the duration of nystagmus). But a stimulus of the order of 70 deg/sec is equivalent to the resting activity of the cristae of the semicircular canal [13]. Upon cessation of uniform rotation the receptors of the cristae of both semicircular canals are stimulated, the frequency of the impulses from the receptors of the cristae increasing in comparison with the resting frequency in the labyrinth with an ampulofugal flow [10, 12]. Upon return of the cupula to a position of equilibrium, the frequency of impulses from the cristae of the semicircular canal with an ampulopetal flow of endolymph gradually drops to the resting frequency and increases in the opposite canal. The time of establishing equilibrium impulse propagation apparently determines the duration of the nystagmic reaction. Stimuli of the order of 70 deg/sec and higher at the initial moment completely eliminate impulse propagation from the receptors of the cristae of the semicircular canal with an ampulofugal flow of the endolymph, which apparently leads to a certain prolongation of the nystagmic reaction in comparison with the time determinable by the logarithmic dependence.

An increase in the fluctuations of the reaction in the 120-180 deg/sec subrange of stimuli can be a measure of the "nonphysiological character" of the stimuli. For such a solution of the problem we must set up an experiment with the use of a large number of animals and without repeated experiments. It is interesting to note that the 10-120 deg/sec region of stimuli, with a moderate dispersion, approximately coincides with the range where the logarithmic dependence of the frequency of the impulses in the vestibular nerve on the magnitude of the stimulus is retained [15].

LITERATURE CITED

1. I. P. Baichenko, Fiziol. zh. SSSR, 23, No. 2, (1937), p. 211.
2. Yu. G. Grigor'ev and B. B. Bokhov, Vestn. otorinolar., 6, (1961), p. 85.
3. N. N. Lozanov, Physiological Components of the Vestibular Reaction. Clinico-Physiological Investigation [in Russian], Ufa, (1938).
4. G. A. Obraztsova, Formation of the Vestibular Function in Ontogeny [in Russian], Moscow-Leningrad, (1961).
5. V. S. Olisov, Thershold Investigation of the Vestibular Analyzer by Means of Slow Rotation. Candidate's dissertation. Leningrad, (1952).
6. A. I. Yarotskii, Fiziol. zh. SSSR, 27, No. 3, (1939), p. 351.
7. G. Aschan, Acta oto-laryng. (Stockh.), Suppl. 116, (1954), p. 24.
8. G. Aschan and J. Stahle, Ibid., 46, (1956), p. 91.
9. A. A. Van Egmond, J. J. Groen, and L. B. W. Jongkees, J. Laryng., 62, (1948), p. 63.
10. Idem, J. Physiol. (Lond.), 110, (1949), p. 1.
11. L. E. Floberg, Acta oto-laryng. (Stockh.), Suppl. 106, (1953), p. 23.
12. J. J. Groen, O. Lowenstein, and A. J. H. Vendri, J. Physiol. (Lond.), 117, (1952), p. 329.
13. J. J. Groen, Acta oto-laryng. (Stockh.), Suppl. 159, (1961), p. 42.
14. A. Khal'd, Mathematical Statistics with Technical Applications [in Russian], Moscow, (1956).
15. A. Ledoux, Confin. neurol. (Basel), 20, (1960), p. 196.
16. R. Mittermaier, Dtsch. med. Wschr., Bd. 85, (1960), p. 842.
17. G. Rossberg, Klin. Wschr., Bd. 34, (1956), p. 822.

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