SELECTIVITY OF VESTIBULAR HABITUATION TO THE DIRECTION OF REPEATED ANGULAR ACCELERATION

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Rotation experiments on guinea pigs have shown that habituation to repeated angular accelerations is selective relative to the duration of acceleration, and is not transmitted to acceleration in the opposite direction, during the first or any subsequent rotation.

Habituation to repeated vestibular stimuli (accelerations) is known to be selective as regards both the magnitude and direction of the stimulus [2]. Using extinction of the nystagmus response during repeated rotations as an index of habituation, Crampton [4] concluded that during the first two or three rotations habituation to accelerations in one direction is transmitted to accelerations in the opposite direction, and that during subsequent rotations no such transmission takes place. A possible reason for this contradictory conclusion may be that stimulation of the semicircular canals during the program of rotations was above the threshold for development of nystagmus in the periods of building up and slowing down of acceleration.

The object of the present investigation was to develop a program of rotation during which nystagmus would develop only during slowing. With such a program it would be possible to discover whether transmission of habituation to acceleration in one direction does or does not take place to acceleration in an opposite direction.

EXPERIMENTAL METHOD

Experiments were carried out on 36 male guinea pigs weighing 200-250 g, rotated on a VU-2 apparatus [1]. Before the beginning of the experiment the animals were fixed to the removable turntable so that the vertical axis of rotation passed through the middle of the line joining the two labyrinths, and the head occupied the natural position for the animals in space. Rotation was carried out in accordance with a complex program (Fig. 1): positive acceleration of 5 deg/sec^2 for 2 sec – a plateau with velocity of 10 deg/sec for 30 sec – positive acceleration of 5 deg/sec^2 for 2 sec – a plateau at a velocity of 20 deg/sec for 30 sec, and so on, up to a velocity of 60 deg/sec – a plateau of 30 sec – stopping in a period of 0.15 sec (the stop stimulus). The animals were rotated in accordance with this program to the right (first rotation) and to the left (second rotation). Next, 22 animals were subjected to 10 rotations to the right, the remaining animals kept throughout this time in a fixed state on the turntable, after which a test (the 13th) rotation to the left was given. The time interval between successive rotations was 30 sec. Nystagmus developing during rotations was recorded on a electroencephalograph (Kaiser) with time constant 1 sec by means of needle electrodes inserted into the skin of the anterior and posterior angles of the eye. Nystagmus was assessed from the number of oscillations, their duration, and their frequency.

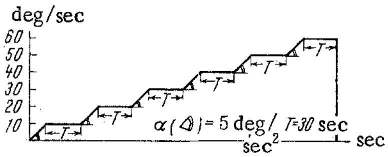

Fig. 1. Program of rotation of animals. Abscissa, time (in sec); ordinate, angular velocity of rotation (in deg/sec).

EXPERIMENTAL RESULTS

The experiments showed that during the period of building up of acceleration to the basic velocity of 60 deg/sec with angular accelera-

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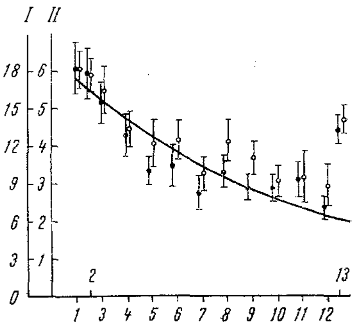

Fig. 2. Changes in number of oscillations and duration of nystagmus reaction during repeated rotations of guinea pigs (22 animals) in accordance with program with intermediate plateaus (stop stimulus 60 deg/sec). Abscissa, serial no. of rotation (second and thirteenth rotations to left, remainder to right); ordinate: I) number of oscillations (filled circles); II) duration of nystagmus (empty circles, in sec). Continuous line is curve approximating changes in characteristics of nystagmus during rotations of animals to the right.

tion of 5 deg/sec^2 and with intermediate plateaus at velocities of 10, 20, 30, 40, and 50 deg/sec, the animals developed only one or two oscillations of nystagmus, i.e., stimulation of the vestibular systems was threshold for development of nystagmus. Above-threshold stimulation took place when rotation stopped. The number of oscillations, and the duration and frequency of nystagmus recorded after stopping did not differ significantly during the first (to the right) and second (to the left) rotations (Fig. 2).

During the first rotation to the right, because of the mechanics and the arrangement of the semicircular canals in the skull [3], the cupula of the left semicircular canal is jerked in the ampullopetal direction, while the cupula of the right semicircular canal is jerked in the ampullofugal direction. The arrival of impulses from the ampullary receptors of the left canal in the vestibular nuclei of the left group is thereby increased, while that from receptors of the right canal in the nuclei of the right group is decreased. Because of the existence of commissural connections between the vestibular nuclei of both sides, exerting inhibitory effects, activity of neurons of the right nucleus is depressed still further [3]. As the cupulas return from their deflected positions under the action of their own elasticity into the initial equilibrium position, the flow of impulses from receptors of the left canal is reduced, while that from receptors of the right canal is increased up to the resting level. During the second rotation (to the left) changes in unit activity of the vestibular nuclei take place in the opposite direction. Since no differences were found between the nystagmus reactions during the first and second rotations, it follows that rotation to the right had no significant effect on the response to subsequent rotation to the left.

During repeated rotations to the right the number of oscillations and the duration of the nystagmus reaction decreased, after the 12th rotation they differed significantly from the values during the first rotation (Fig. 2). The decrease in the frequency of nystagmus was not significant. Test rotation to the left (the 13th rotation) showed that the number of oscillations and the duration of nystagmus decreased relative to the values obtained during the first rotation to the left (2nd rotation) by 20%. This decrease was not caused by the ten preceeding rotations to the right, for the same decrease in both indices of the nystagmus reaction was observed in the animals of a control group which were not rotated in the time interval between the first and second rotations to the left. The parameters of the nystagmus reaction from the first to the second rotation to the right were reduced by 10%. Slightly greater extinction of parameters (a decrease of 20%) from the first to the second rotation to the left can probably be explained by the decrease in general excitation of the animal. In fact, the time interval between the first and second rotations to the left was about 1 h, and during the whole of this time the animals were kept in darkness and fixed to the turntable.

Habituation to repeated angular accelerations is thus selective relative to the direction of acceleration, and is not transmitted to acceleration in the opposite direction either during the first or any subsequent rotation. The decrease in the response to repeated angular acceleration is probably the result, above all, of repeated excitation of neurons of the vestibular nuclei on the side ipsilateral to the direction of nystagmus [5].

LITERATURE CITED

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