


ROLE OF THE SENSORY INNERVATION OF THE EXTRAOCULAR MUSCLES
IN HABITUATION OF VESTIBULO-OCULOMOTOR RESPONSES

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The role of the sensory innervation of the extraocular muscles in extinction of reflex nystagmus induced by periodic rotation with standard angular acceleration was studied in experiments on rabbits. Limitation or complete abolition of the motor activity of the extraocular muscles and also passive forced movements of the eyes were used. Comparison of results obtained with intact animals and animals with abolition of motor activity of the extraocular muscles showed no difference between them. In both cases the dynamics of extinction of nystagmus was the same. On the other hand, repeated forced movements of the eyes had no effect on reflex nystagmus of the eyes. It is concluded from the results that the proprioceptive efferent innervation of the extraocular muscles plays no part in habituation of vestibulo-oculomotor responses.

The problem of habituation of vestibular responses to periodically repeated stimulation of the receptors of the labyrinth has recently been intensively studied. The stimulus to this research has been the development of astronautics, requiring the solution of many practical and theoretical problems in labyrinthology. In most investigations habituation in the vestibular system has been studied in relation to reflex nystagmus of the eyes induced by adequate or inadequate stimulation of the semicircular canals. Extinction of nystagmus under these circumstances has been interpreted as a manifestation of central plastic learning processes [16]. However, can eye movements themselves introduce complications into the explanation of vestibular habituation as a central process triggered by vestibular afferentation? To what extent can eye movements themselves participate (through proprioceptive feedback) in those plastic changes in the CNS which lie at the basis of extinction of the vestibulo-oculomotor reflex? There is good reason to pose the question in this way: morphological and electrophysiological investigations have conclusively shown that the extraocular muscles contain sensory elements which respond to a change in muscle length [3, 9, 20]. Stretching the extraocular muscles or stimulation of the motor nerves of these muscles changes the activity of neurons of the brain-stem reticular formation and vestibular nuclei [10, 11, 19], i.e., of brain structures which have a dominant role in the development of extinction of vestibular nystagmus [7, 14].
To examine this problem the following methods were used: passive forced stretching of the extraocular muscles and limitation or complete abolition of the motor activity of these muscles.

EXPERIMENTAL METHOD

Experiments were carried out on 32 adult waking rabbits of both sexes weighing 3-3.5 kg. Nystagmus of the eyes was induced by stimulation of the horizontal semicircular canals by unidirectional negative angular accelerations of 40 deg/sec², by the method described previously [1]. Methods of deriving, recording, and processing the electronystagmogram were also described in [1].

Forced movements of the eyes were carried out by means of a specially constructed device (Fig. 1). A crank and connecting rod mechanism 1, consisting of two pulleys, the axes of which were located on opposite sides of the center of rotation at a distance of 4 mm, was fixed to the shaft of a DSD60-P1 electric motor. Each pulley was loosely connected to a follower 2, consisting of a thin metal rod 14 cm long. To make the motion of the two rods linear, they run in guiding channels 3. During rotation of the whole crank and rod mechanism, because of displacement of the axes of the pulleys the two followers are made to move alternately forward and backward over a length of 8 mm. The two followers had small holes at their ends through which they were sutured to the previously anesthetized surface of the eyes, so that when the motor was started forced movements of both eyes took place in the horizontal direction.

Several methods were used to immobilize the eyes: in some experiments (8 rabbits) the apparatus described above was used, for when switched off it possesses considerable inertia, much greater than the effort developed by the extraocular muscles during contraction, so that reliable fixation of the eyes in one position was ensured. In some experiments (7 rabbits), after preliminary anesthesia with 1% amethocaine solution, 6-8 sutures were applied to the edge of the sclera and the eyes were attached to the periosteum around the orbit. Finally, to produce complete immobilization of the eyes, the animals were curarized with D-tubocurarine chloride (8 rabbits). In these experiments, air from the artificial respiration apparatus was supplied to the immobilized animals on the rotating platform by means of an air collector.