POSTNATAL DEVELOPMENT OF INBORN RHYTHMIC MOVEMENTS OF RABBITS AFTER REMOVAL OF THE SUPERIOR CERVICAL SYMPATHETIC GANGLIA

L. N. Deryabin

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Bilateral extirpation of the superior cervical sympathetic ganglia in rabbits before the animals have acquired vision delays the inhibition of spontaneous limb movements. In young rabbits undergoing the operation after acquiring vision, spontaneous movements are strengthened and persist at a higher level for a long time—for two months or more.

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The object of this investigation was to continue the study of the role of adaptive and trophic systems in the development of the alternating and "jumping" rhythmic movements of the limbs occurring in rabbits during early postnatal ontogenesis.

Such an investigation is justified, first, by the need for a thorough study of all intracentral and intercentral relationships between nervous structures laid down during perfection or suppression of inborn coordinated motor activity in animals, and second, by Orbeli's statements [4, 5] on participation of the sympathetic nervous system in the suppression of old and organization of new coordinated acts. These statements were based on the study of coordination in adult animals.

As our investigations [1, 2] have shown, rhythmic movements of the hind limbs of rabbits lying on their back undergo a complex type of development during the imperfect two months after birth, during which regular changes take place in the rhythm of the movements, ending by their complete disappearance and inhibition. This process is therefore a particularly convenient model for study of the assigned problem.

EXPERIMENTAL METHOD

Bilateral extirpation of the superior cervical sympathetic ganglia was carried out on 43 rabbits at the ages of 5, 7, 10, 14, 21, 28, and 35 days under aseptic conditions. A mock operation was performed on 18 other rabbits, during which the ganglia were simply separated from surrounding tissues but not removed. A group of 10 rabbits underwent no operation. Every day for 10 min the spontaneous alternating and the simultaneous movements of the hind limbs of rabbits of all three groups were recorded for 10 min on a kymograph as described previously [1]. During analysis of the kymograms the total number of elementary limb movements (flexion—extension pairs) during the experiment and the number of movement complexes were counted; in the latter case the number of elementary movements included in the groups being taken into account.

EXPERIMENTAL RESULTS

Bilateral extirpation of the superior cervical sympathetic ganglia in rabbits of different ages caused regular changes in the dynamics of inborn rhythmic movements. The character of these changes depended on the age at which the ganglia were removed (Fig. 1).

In rabbits undergoing ganglionectomy before the acquisition of vision (at the ages of 6, 7, and 10 days) the movements diminished during postnatal ontogenesis as in the intact animals, but with a lower gradient. As a result of this, the activity of the ganglionectomized animals became greater than that of the control

Laboratory of Development of Nervous Activity of Animals in Ontogenesis, I. M. Sechenov Institute of Evolutionary Physiology and Biochemistry, Academy of Sciences of the USSR, Leningrad (Presented by Active Member of the Academy of Medical Sciences of the USSR D. A. Biryukov). Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 66, No. 10, pp. 3-7, October, 1968. Original article submitted July 17, 1967.

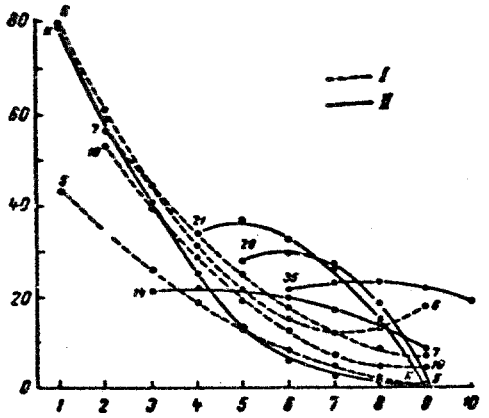

Fig. 1. Number of spontaneous limb movements in ganglionectomized and intact rabbits. Abscissa, age (in weeks), numbers above curves show age (in days) at time of ganglionectomy; ordinate, number of movements (flexion-extension pairs) in experiment on rabbits undergoing operation before (I) and after (II) the acquisition of vision. K) control.

animals of the same age. However, this difference in activity did not become significant until the 5th-6th week of life.

Removal of the superior cervical sympathetic ganglia after the acquisition of vision (14-35 days) also changed the dynamics of development of the movements in the rabbits, but in a different manner. In this case, after removal of the sympathetic ganglia, a definite increase in activity was observed during the first 1-3 weeks, compared with the level reached by the time of ganglionectomy. This was followed by a decrease in activity which followed a curve differing sharply from the corresponding curves in intact rabbits undergoing operation before the acquisition of vision.

The difference in character of the effects of ganglionectomy before and after acquisition of vision by the rabbits was not connected with the level of activity before the operation. For example, the initial activity in both groups of rabbits ganglionectomized at the age of 5 and 14 days was much lower than in the control animals, but the operation produced different results.

The operation of mock ganglionectomy, whether performed before or after the acquisition of vision by the rabbits, in every case caused slight slowing of the decrease in limb movements compared with that in intact rabbits. This means that the results of the true ganglionectomy performed after the acquisition of vision were caused, not by operation trauma, but by exclusion of the superior cervical sympathetic ganglia from the system of mechanisms as a result of whose activity the limb movements diminish during development. However, in relation to the results of ganglionectomy performed before the acquisition of vision, the mock operation experiments demonstrate the need for caution: at this period both true and mock operations produced approximately identical effects of an increase in motor activity. However, analysis of the dynamics of a more complex process, the change in numerical composition of various movement complexes, demonstrates that the superior cervical sympathetic ganglia participate in evolution of inborn rhythmic limb movements even before the acquisition of vision.

As was described previously [1, 2], in intact animals limb movements before acquisition of vision occur as movement complexes consisting of prolonged, continuous alternating movements and of rhythmically alternating groups of movements. Each complex may include from 1 to 5 or more groups. After the acquisition of vision, on the 16th day of development, the continuous forms of movement disappear, and later the prolonged interrupted forms disappear also. Soon after, from the 5th to the 7th-8th week after birth, complexes of 2-3 groups of movements disappear in turn, and finally single groups of movements disappear.

In the ganglionectomized animals, not only was the total number of complexes increased, but they persisted longer than under normal conditions, and complexes of movements characteristic of an earlier period of ontogenesis reappeared (Fig. 2).

The increase in the total number of complexes took place both on account of a slower decrease in their number than in the intact animals and because of an increase in the number of complexes compared with before the operation. Calculation of the total number of complexes of each form throughout the postoperative period of development revealed particularly clearly the relative importance of each form in producing the increase in total motor activity and its relationship to the time of operation (Fig. 3).

The number of complexes consisting of 1 or 2 groups of movements increased particularly sharply in rabbits undergoing the operation after acquisition of vision (by 3 or 4 times), but it was also clearly distinguishable in animals undergoing operation before acquisition of vision (by 1.5-2 times).

The reappearance of complexes of continuous prolonged movements and of complexes consisting of many groups (Fig. 2, b, d) after they had disappeared in some animals undergoing the operation and had not appeared after one week is noteworthy. No less important in the fact that prolonged complexes consisting of many groups and continous complexes persisted or reappeared at a stage of postnatal development when they were no longer present in intact animals (in Fig. 2, between the lines a and b).

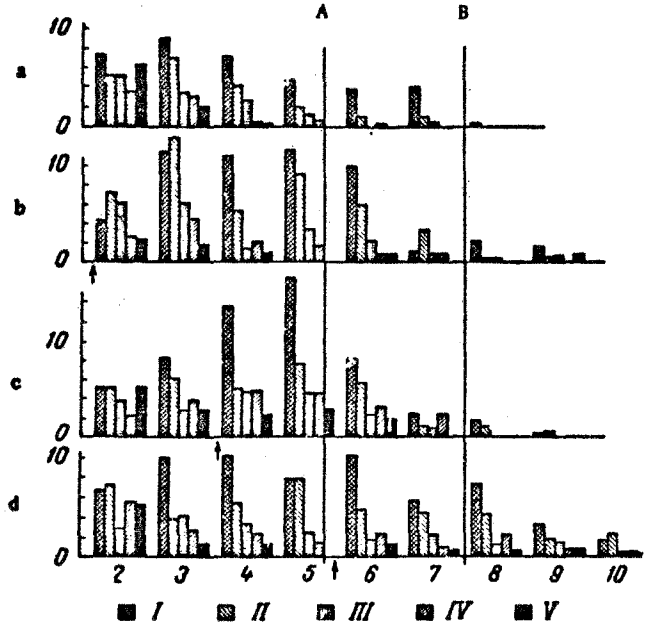

Fig. 2

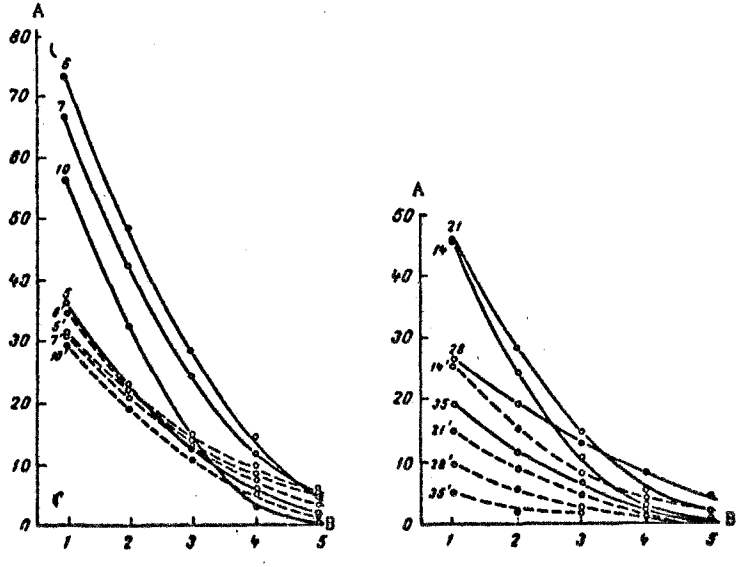

Fig. 3

Fig. 2. Number of different complexes of movements in postnatal ontogenesis of ganglionectomized and intact rabbits. Abscissa, age (in weeks); ordinate, number of complexes. I) single groups of movement; II, III) complexes of 2 and 3 groups; IV) of 4 and 5 groups; V) of 6 or more groups and prolonged continuous movements; a) intact, b-d) ganglionectomized rabbits. Time of operation denoted by arrow: b) 7th day, c) 21st day, d) 35th day. Remainder of explanation in text.

Fig. 3. Total number of different forms of movement complexes in intact rabbits and in rabbits ganglionectomized before (I) and after (II) acquisition of vision. A) number of complexes; B) forms of complexes (number of groups of movements in complex). Continuous lines indicate ganglionectomized animals, broken lines intact rabbits. Numbers near continuous lines show age at which ganglionectomy was performed. Numbers near broken lines: 5' control for animals undergoing operation at 5 days; 6' control for operation at 6 days, and so on. Remainder of explanation in text.

The whole process of development took place more slowly in the ganglionectomized animals. In intact animals at about the 50th day the limb movements which we studied were completely inhibited. In animals ganglionectomized even in the 9th-10th week, all forms of complexes were found, including those with many groups or with continuous movements (to the right of line B in Fig. 2).

The reappearance of movement complexes with many groups or with continuous movements, such as we found in chordotomized [1, 2] and cerebellectomized [3] rabbits, in intact animals after their disappearance in the first weeks of postnatal life indicates the removal or weakening of influences originating from the brain. In the absence of the cerebellum, the evolution of these limb movements and their complete inhibition are more difficult and require a longer time to take place. The same result is found after removal of the superior cervical sympathetic ganglia.

Desympathization of the brain does not abolish the recorganization and suppression of inborn coordination but merely delays them.

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