INFLUENCE OF SOUND ON THE MOTOR ACTIVITY OF CHICK EMBRYOS

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The work of L. A. Orbeli [3, 4] showed that the maturing afferent systems play an important role in in the development of the motor coordination of the organism. However, the information in the literature on the effect of acoustic stimulation on the motor activity of animals in general and of chick embryos in particular, is extremely limited. There are reports [6] that the motor reaction to sound does not appear in chick embryos until after the 19th or 20th day of incubation. This is the time of morphological differentiation of the organ of hearing [5, 7]. According to other observations [1], conditioned reflexes to acoustic stimulation may be formed from the 14th-15th day of development. The effect of sound at still earlier stages on development of chick embryos remains unknown.

The object of the present investigation was to study the effect of sound on the motor activity of chick embryos from the 5th until the 18th day of incubation.

EXPERIMENTAL METHOD

Experiments were carried out on White Leghorn chick embryos. The egg was opened on the side of the air chamber, the membranes over the embryo were incised, and the egg was then placed in a soundproof chamber with a temperature of 38°, containing the source of sound. Observations of the embryos in the egg were carried out until the 12th day of incubation. The embryos were later placed in a special vessel with warm physiological saline, also kept in a soundproof chamber. The connection was preserved between the embryo and the allantois remaining in the egg, which was fixed to the wall of the vessel. The action of a sound of frequency 1000 cps and intensity of the order of 95 dB, produced by a type ZG-10 generator, was studied in the experiments. An intermittent sound was used: the stimulus was switched on for 5 sec every 25 sec with a frequency of 2 signals/sec. The motor activity was recorded on a loop oscillograph by converting the mechanical movements into electrical as in the method of A. V. Voino-Yasnetskii and Yu. E. Moskalenko [2]. The experiment lasted 30 min. During the first 10 min movements in normal conditions were recorded, during the second 10 min — movements during the action of sound, and during the last 10 min — again in the absence of the acoustic stimulus.

In the analysis of the data, the combined activity of the spontaneous movements in normal conditions and under the influence of sound was determined and qualitative variations in the character of the spontaneous movements were also scrutinized. The data were analyzed by statical methods. Altogether 115 embryos were investigated.

EXPERIMENTAL RESULTS

In normal conditions the spontaneous motor activity of chick embryos appears on the 4th day in the form of occasional dorso-ventral and lateral movements of the head. On the 5th day, these are joined by lateral flexions of the trunk. If these movements are recorded graphically, they can be seen on the film as mono- or biphasic peaks. The duration of each movement is 1.5-2 sec and the intervals between them vary from 40 to 100 sec. In some of the embryos investigated in these experiments single movements were aggregated into small groups; the movements of the group followed one another at intervals of 1-5 sec (Fig. 1, 1a).

At this age the influence of sound on the motor activity of the embryo could be detected. In 50% of embryos, for instance, in response to acoustic stimulation the number of movements in the groups increased (Fig. 1, 1b). Dur- the action of the sound the total duration of the spontaneous movement also varied. For example, in one of the experiments (Fig. 2a) the embryo spent 48 sec of the first 10 min in movement, but during application of the sound the time spent was 58 sec. After switching off the sound the total duration of the spontaneous movements reverted to the original (46 sec). An increase in motor activity was found in 34% of embryos; conversely, in 55% of embryos

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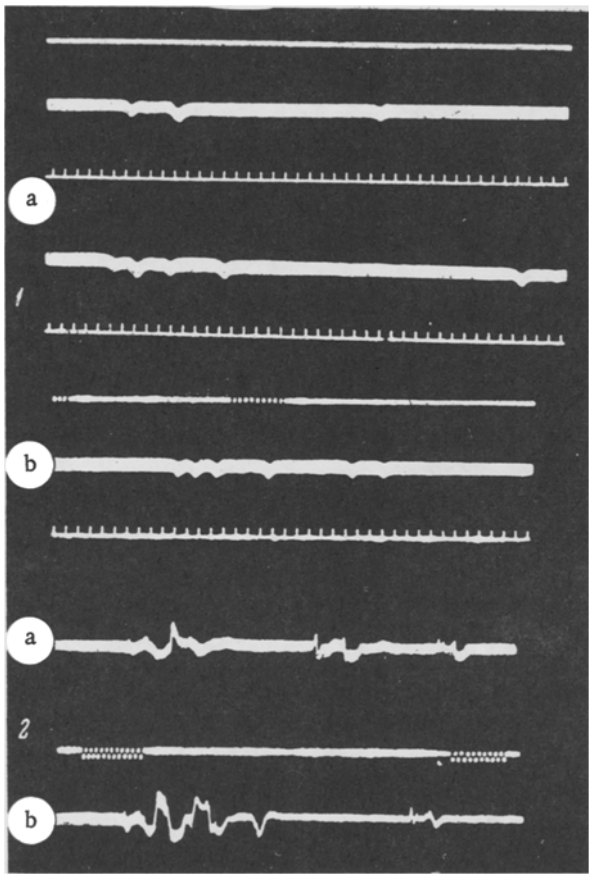

Fig. 1. Spontaneous movements of a chick embryo on the 5th (1) and 6th (2) days of incubation in normal conditions (a) and during the action of sound (b). Top — marker of acoustic stimulation; bottom—time marker.

Number of Embryos (in %) Showing Changes in Total Motor Activity under the Influence of Sound

Age (in days)	Strengthening of activity	Weakening of activity	Activity unchanged
5	34	55	11
6	40	47	13
7	45	55	—
8	42	58	—
10	40	60	—
14	34	66	—
16	15	85	—
17	—	100	—
18	34	66	—

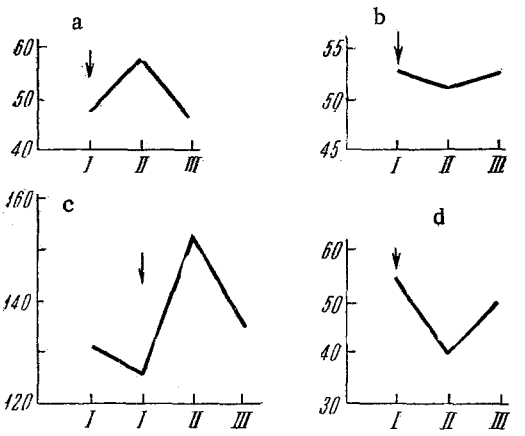

Fig. 2. Changes in the total duration of spontaneous movements of a chick embryo during the action of sound on the 5th (a and b) and 8th (c and d) days of incubation. Along the axis of ordinates — motor activity (in sec); along the axis of abscissas: I — in normal conditions; II — during the action of sound; III — after the action of sound. The arrow indicates the beginning of the action of sound.

activity was reduced (Fig. 2b; the table); The total duration of the movements during application of the sound on the 5th day was 38.6±5.3sec, and in the absence of sound 40.5±4.7 sec.

On the 6th day of incubation in normal conditions a further increase in the frequency of the movements and in their aggregation into groups took place, so that short continuous movements were formed (Fig. 1, 2a). In 40% of embryos during the action of sound the groups became longer; one such case is illustrated in Fig. 1, 2b. In other embryos, however, the character of the movements was unchanged. The total duration of the movements during the action of sound was also increased in 40% of embryos, whereas in 60% it either remained unchanged or was reduced (see the table).

On the 7th-10th day of incubation the movements of the chick embryos in normal conditions became more complex. After the 7th day, movements of the limbs began to be combined with the dorso-ventral and lateral flexions of the head and trunk. Slow and fast components, in the form of pointed waves, were clearly seen during the graphic recording of these movements of generalized character. The duration of the continuous movements increased. On the 8th day they lasted 17-25 sec, and on the 10th day 30-40 sec. The periods of movement of the embryo were clearly separated by the periods of rest.

No changes in the character of the spontanteous movements would be detected during the action of sound on the chick embryos of this age. As in normal conditions, complex generalized movements were observed, clearly separated by periods of rest. The duration of the individual continuous movements varied on the 8th day from 15 to 38 sec, and on the 10th day from 30-50 sec. As on all the preceding days of incubation, the action of sound on

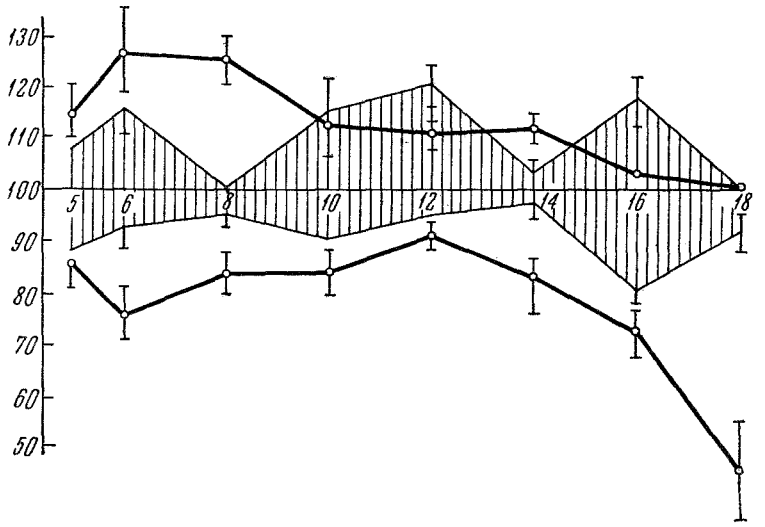

Fig. 3. Variations in the total duration of spontaneous movements in normal conditions and during the action of sound. The total duration of the movements in the first 10 min in normal conditions is taken as 100. Along the axis of ordinates — change (in %) in motor activity during the second 10 min in normal conditions (shaded area) and during the action of sound; along the axis of abscissas — days of incubation.

the spontaneous movements was not always the same. On the 8th day weakening of the motor activity was observed in 58% of embryos and an increase in its intensity in 42%. A similar ratio between intensifying and inhibitory influences was also found on the 10th day (see the table).

The activating action of sound may be demonstrated by the following example. In an 8-day embryo the total duration of the movements during the first 10 min was 138 sec, during the second 10 min — 130 sec, and druing the third 10 min — 125 sec. Prolonged observations on the background motor activity thus revealed a slight decrease in its intensity. During the action of sound, however, the duration of motor activity increased to 152 sec, and immediately after the sound was switched off it fell again to 135 sec (Fig. 2c). Meanwhile, in other embryos the action of sound was opposite, for the motor activity diminished (Fig. 2d). The total motor activity during the action of sound on the 8th day was 103.0±22.4 sec, and on the 10th day 190.2±29.3 sec. In normal conditions, however, it was 77.4±16.8 and 201.0±24.6 sec respectively.

After the 12th day in normal conditions new changes began to appear in the character of the spontaneous movements of the chick embryos. The motor activity of the embryos increased, and the distinct pattern of alternation of periods of movement and rest disappeared. The movements became less compact and in the intervals between the lung movements, irregular, short or single movements began to appear. The relative importance of the fast component increased. These changes also continued on the subsequent days (14th-18th days). Meanwhile, the total duration of the movements also changes. On the 14th day it was 316.7±29.2 sec, but by the 16th day showed a considerable decrease — to 236.0±35.0 sec. No qualitative changes could be found in the course of the spontaneous movements during the action of sound, for in normal conditions at this period the character of the movements was extremely variable.

As on the preceding days of development at this age sound could either stimulate or inhibit the motor activity, but at this period (from the 14th to the 18th day) the inhibitory action was predominant and was found in 66-100% of embryos (see the table).

The total motor activity during the action of sound on the 14th day was 308.0±27.8 sec, and on the 16th day 185.0±42.0 sec.

It was thus found that under the influence of sound the motor activity could be either stimulated or inhibited. Analysis of the influence of sound on chick embryos is made difficult by the fact that in normal conditions variations in the duration of the spontaneous activity are also observed, for in some cases it is stronger and in other, weaker. On some days of incubation these variations are of considerable extent. However, as is clear from Fig. 3,

the limits of these variations were modified by the action of sound. In the first half of incubation they were widened and exceeded the limits of the normal variations. In the subsequent periods (10th-12th day) the difference was less marked, and starting from the 14th day, both the upper and lower limits of the variations of total motor activity were distinctly lowered. Hence, as is clear from Fig. 3, despite the marked lability of the motor activity in normal conditions, the changes during the action of sound were considerable, and on some days of incubation they attained a high degree of significance.

The results obtained may be summarized as follows. The observations show that during the action of sound changes occur in the motor activity of the chick embryos as early as on the 5th day. During the first day of incubation the action of the acoustic stimulus produced both inhibition and stimulation, but after the 14th day of development the inhibitory action of the sound began to predominate. During the action of sound at this period the total duration of the spontaneous movements was shortened and the period of rest lengthened. This suggests that the embryos are not indifferent to the action of sound in the early stages of their development. At present, however, it is impossible to say exactly by what means this reaction to sound takes place. In the later periods of incubation, starting with the 14th day, it may be postulated that the specific acoustic pathways participate in the reaction, because by this time the first cells have appeared in the organ of Corti. The lagaena — the organ which in birds evidently also performs an acoustic function — matures somewhat earlier. In the first half of embryonic development, however, the influence of sound is probably nonspecific in character, and the acoustic stimulus may act on the skin, the muscles, or directly on the neural elements of the spinal cord. Further investigation in this direction will help to clarify the phenomena described.

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