

TEMPORARY CONNECTIONS OF THE RESPIRATORY SYSTEM OF CATS DEPRIVED OF THE CEREBRAL CORTEX

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(Received April 7, 1955. Submitted by Active Member of the Academy
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A number of investigators [1,2,4,5 and others] have shown that conditioned motor reflexes can be established in animals deprived of the cerebral cortex.

Work carried out in the laboratory supervised by K.M. Bykov (A.L. Komendantova, K.A. Dryagin, V.G. Prokopenko; 1) has established that, after removal of the premotor area of the cerebral cortex, conditioned reflex action of the internal organs can be established. However, the temporary connections established under these conditions differ from those in normal animals. The question of the possible establishment of such connections in animals deprived of the cortex of the brain has not been resolved as yet.

We studied the possibility of conditioned reflex changes in the respiration of cats completely deprived of the cerebral cortex.

The experiments were carried out on two decorticated cats*; sound (electric bell, metronome) and light (200 w electric lamp) stimuli were used as conditioned stimuli. Ammonia, which, as is known, interrupts breathing during inspiration, was used as the unconditioned stimulus. Respiration was recorded with a pneumograph.

In one day of experimentation, 10-15 associations were applied; each association consisted of a conditioned and unconditioned stimulus — a little bottle of ammonia which was brought up to the cat's nose (without touching it) 4-6 seconds after switching on the conditioned stimulus. The actions of the conditioned and unconditioned stimuli were ended simultaneously. The intervals between separate associations were 4-5 minutes.

Experiments on the cat, "Blackie", were begun three months after extirpation of the brain cortex. The first signs of the formation of a temporary connection with the bell were found after 71 associations. The conditioned reflex manifested itself in a brief interruption of respiration during inspiration (Fig. 1), a phenomenon which had only been observed during the action of ammonia (unconditioned stimulus). Almost simultaneously with the conditioned respiratory reflex, a conditioned general motor reaction, almost always observed during the action of ammonia, often appeared also. This general motor reaction also became conditioned and combined with the conditioned respiratory reflex after 125 associations. After 140 associations, the temporary connection which had been developed began to appear regularly and after 213 associations, the positive conditioned reflex was observed in 92% (in some experiments, 100%) of the cases when the conditioned stimuli were used.

The experiments on the cat, "Mercury", were begun 18 months after extirpation of the cortex of the cerebral hemispheres. A temporary association with the light of a 200 w electric lamp (at a distance of 1-1.5 m

*Macroscopic investigation of the brain of one of the cats (Blackie) showed that the brain cortex had been completely extirpated.

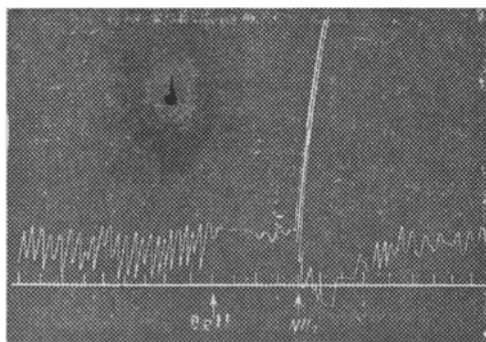


Fig. 1. Change in the respiration of the cat, "Blackie", on use of a conditioned stimulus (bell).
Lower line — designation of time (2 seconds).
The general motor reflex of the animal, arising on application of the unconditioned stimulus (ammonia), is reflected on the pneumogram.

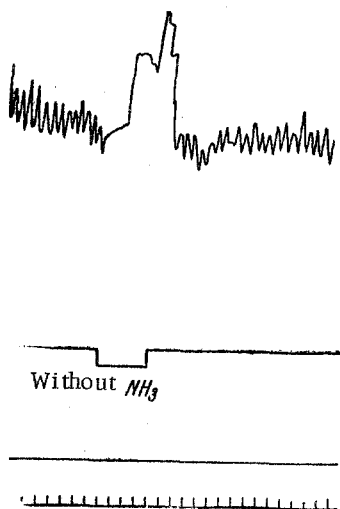


Fig. 2. Change in the respiration of the cat, "Mercury", on use of the conditioned (light) stimulus.
Curves (top to bottom): pneumogram, application of stimulation, null line, designation of time (2 seconds). The general motor reaction of the animal, arising at the end of the application of the conditioned stimulus, is indicated on the pneumogram.

(M_{120}) and an unreinforced stimulus — the sound of a bell. The stimuli (the bell and metronome) were used in the ratio of 1:2.

At first the cat developed a positive reaction to the bell (a temporary connection for this stimulus had been developed earlier in the cat), and a negative one for the metronome. However, after some time a negative reaction to the bell began to appear, and the metronome began to acquire a distinctly positive meaning. The first positive reaction to the metronome appeared after 59 applications of it in association with ammonia (Fig. 3).

from the animal's head) was developed. The first signs of the establishment of a temporary connection were discovered after 100 associations, when respiration stopped for 2-3 seconds after the light signal alone. Beginning with the 144th association, the general motor reflex allied itself with this conditioned reflex (Fig. 2). Thus, in this cat also, conditioned reflexes in the form of inhibition of respiration were observed.

However, in some cases the reflex of only the respiratory system was apparent, in other cases, only the general motor reflex.

After 380 associations, a temporary connection was observed in 93% of the cases in which the conditioned stimulus was used.

The temporary connections which had been developed in decorticated cats for both the bell and the light could undergo extinction. The temporary connection which had been developed for the conditioned light stimulus was completely extinct after 20 applications of the conditioned stimulus without reinforcement; the reaction to sound stimulus was extinct after 13 applications.

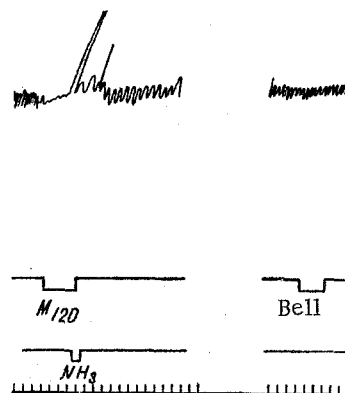


Fig. 3. Change in the respiration of the cat, "Blackie", on use of the positive conditioned stimulus (M_{120}).
Curves (top to bottom): pneumogram, application of conditioned stimulus, application of unconditioned stimulus, designation of time (2 seconds).

We attempted to develop in the cat, "Blackie", a differentiation of a reinforced stimulus — the sound of metronome beats with a rhythm of 120 per minute

Although the positive signal was used 270 times and the negative, 127 times in the above series of experiments, the differentiation developed was unstable and was demonstrated irregularly. Thus, a problem which is quite elementary for a normal animal proved to be difficult for the animal deprived of its cerebral cortex.

Nevertheless, we tried to develop differentiation between more similar conditioned stimuli in this cat: a metronome with a rhythm of 120 beats per minute as a positive differentiation stimulus, and a metronome with a rhythm of 60 beats per minute (M_{60}) as a negative differentiation stimulus. During the first days of experimentation, a regular demonstration of a positive reaction was observed for M_{120} and M_{60} as well. But on the fourth day of work, definite signs of differentiation were already observed.

However, in the days following, the differentiation became incomplete, and after 14 days not only the differentiation disappeared, but the response to the conditioned stimuli also. In some cases, a very strong reaction to the conditioned stimuli was observed in the animal during this period of the work.

All of this was somewhat reminiscent of the picture of the neurotic state of normal animals, arising sometimes on extremely difficult differentiation. It seems to us that the facts, obtained in experiments on decorticated cats who developed a condition similar to the neurotic when comparatively far-removed differentiation stimuli were employed, deserve attention.

The work described certainly does not pretend to illuminate the problem completely. These are merely the first steps toward studying the reflexes which are connected with the activity of the viscera of animals deprived of the cortex of the cerebral hemispheres.

LITERATURE CITED

- [1] N.Yu. Belenkov, Bull. Exptl. Biol. Med., No. 2, pp 100-103, No. 3, pp 182-185 (1950).
- [2] K.M. Bykov, The Brain Cortex and the Viscera, Moscow (1944).
- [3] G.P. Zeleny, Med. Biol. J. USSR, Issue 1-2, pp 3-18 (1930).
- [4] M.A. Pankratov, Bull. Inst. Recherches Biol. Perm, Vol. 21, Issue 1-2, pp 3-18 (1938).
- [5] S.S. Poltyrev, in: Collected Works of the Leningrad Veterinary Institute, pp 30-36, Moscow-Leningrad (1933).