THE ROLE OF BARORECEPTIVE SYSTEMS IN THE NASAL CAVITY OF BIRDS IN REGULATION OF RESPIRATION

COMMUNICATION II

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Our investigations into the effect of the baroreceptor olfactory system on respiration have beem aimed at discovering role of this function in regulation of respiration at various stages of phylogenesis and its dependence on the animal's environment.

The first communication [1] described the role of olfactory nerve baroreceptors in the regulation of respiration in frog and the place occupied by this system among other baroreceptor systems situated along the respiratory passages. It seemed particularly interesting to study the baroreceptor system in the mucosa of the upper respiratory passages in birds who experience the effect of large currents of air exerting considerable pressure on the mucosa of the nasal activity. No references to this question could be found in available literature. Yet marked pressure on the receptor endings of nerves innervating the intranasal mucosa by air currents during flight must during the process of phylogenesis, have led to the appearance in birds of special mechanisms concerned with adaptation of the intranasal different system to receiving strong baroreceptor stimuli.

The present work is concerned with the study of the role of olfactory nerve baroreceptors in the regulation of respiration in birds as well as of compensatory, adaptational mechanisms in the central nervous system.

EXPERIMENTAL METHODS

A total of 30 experiments was performed on 21 pigeons. The weight of the birds varied from 525 to 670 g. Respiratory movements were recorded by a modification of N. G. Goleva's method [2] using a rubber cuff placed around the chest and abdomen of the pigeon and connected to a Marey's tambour. The cuff was slightly inflated with air before the experiment. Stimulation of the intranasal mucosa baroreceptors was achieved by rhythmic introduction of a stream of air into the mask placed over the bird's beak. The pressure and rhythm of this air stream was recorded on a kymograph. All the experiments were carried out on tracheotomized pigeons with transected esophagus in order to exclude mechanical stimulation of the upper portions of the gastro-intestinal tract by the applied air stream.

Olfactory afferents were excluded by means of extirpation of the olfactory lobes and the trigeminal afferents were excluded by painting the intranasal mucosa with a 2% solution of cocaine. In order to demonstrate the relationship between the cerebral cortex and the subcortical formations of the intranasal baroreceptor system either the cerebral hemispheres were removed or the cerebral cortex was stimulated by application to it of 0.1% solution of strychnine.

EXPERIMENTAL RESULTS

Initial respiratory rate in pigeons was from 45 to 60 per minute, the amplitude of the movements being from 4 to 10 mm. Following tracheotomy the rate of respiratory movements dropped to 24-40 per minute and the amplitude fell to from 1 to 7 mm. The form of the movements was unchanged but the general background of the respiratory trace became considerably more even.

In most cases there was no respiratory reaction to application of a stream of air to the nasal passages of tracheotomized birds even when this was done under high pressure (up to 180 mm water). Only in 6 cases was a respiratory reaction observed; it consisted of a slight increase in the rate of undulation of the background respiratory trace without change in the amplitude of the respiratory movements (Figs. 1 and 2).

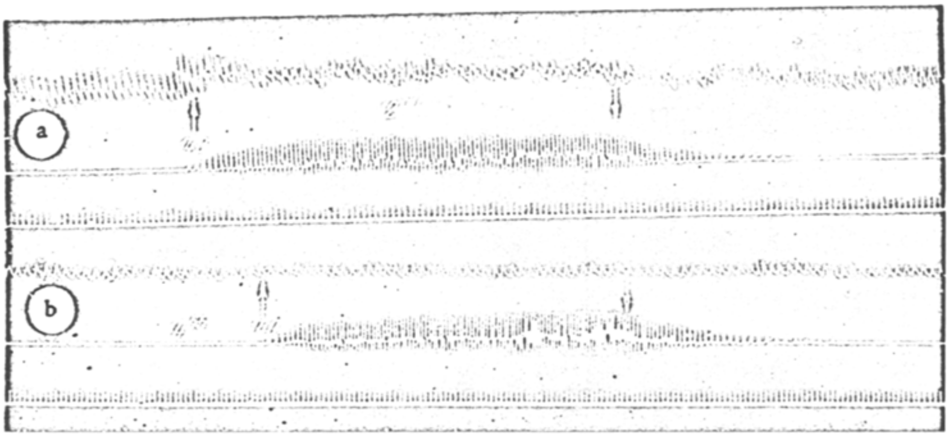

Fig. 1. Effect of tracheotomy on the character of respiration and on respiratory reaction in pigeon.
a) Initial respiration; b) respiration and absence of respiratory reaction to insufflation of air following tracheotomy (↑ beginning, ↓ cessation of insufflation). Records from above down: pneumogram, record of air insufflation; time marker (1 second).

Extirpation of the olfactory bulbs had little effect on respiration. In most experiments the respiratory movements showed some increase in rate (from 30 to 33-36 per minute) and increase in their amplitude (from 4-7 to 6-10 mm).

Most birds showed absence of respiratory reaction to insufflation of air into the nasal passages following removal of the olfactory lobes.

The experiments revealed that under normal conditions in the case of birds, unlike that of frogs, baroreceptor stimulation of the intranasal mucosa caused almost no changes in respiration even when high pressures were used. This can be explained by the hypothesis that the environment, i.e., almost constant influence of strong air currents on the nasal baroreceptor system during flight caused the appearance, in the process of phylogenesis in pigeons, of some compensatory mechanisms adapting the activity of this system to various conditions of existence. In order to discover these adaptive mechanisms the pigeons were subjected to removal of various parts of the central nervous system, including extirpation of the cerebral hemispheres.

Removal of the cerebral hemispheres in pigeons, performed in 9 experiments, caused an increase in respiratory rate in 6. Changes in the amplitude of respirations were not characteristic: in 4 experiments there was a decrease in amplitude, in 4 an increase and in one it remained unaltered. It must be noted that there was a change in the form of respiratory movements as well, as they were stepped up

It is significant that following extirpation of the cerebral hemispheres in pigeons there was an increase in the respiratory reaction to rhythmic stimulation (even under small pressure — 30-60 mm water) of the intranasal baroreceptors. These reactions were expressed in reduction of the rate and amplitude of respiratory movements; this phenomenon was so marked in a number of experiments that apnea occurred either in expiration or in inspiration and persisted throughout the period of stimulation (Figs. 2 and 3).

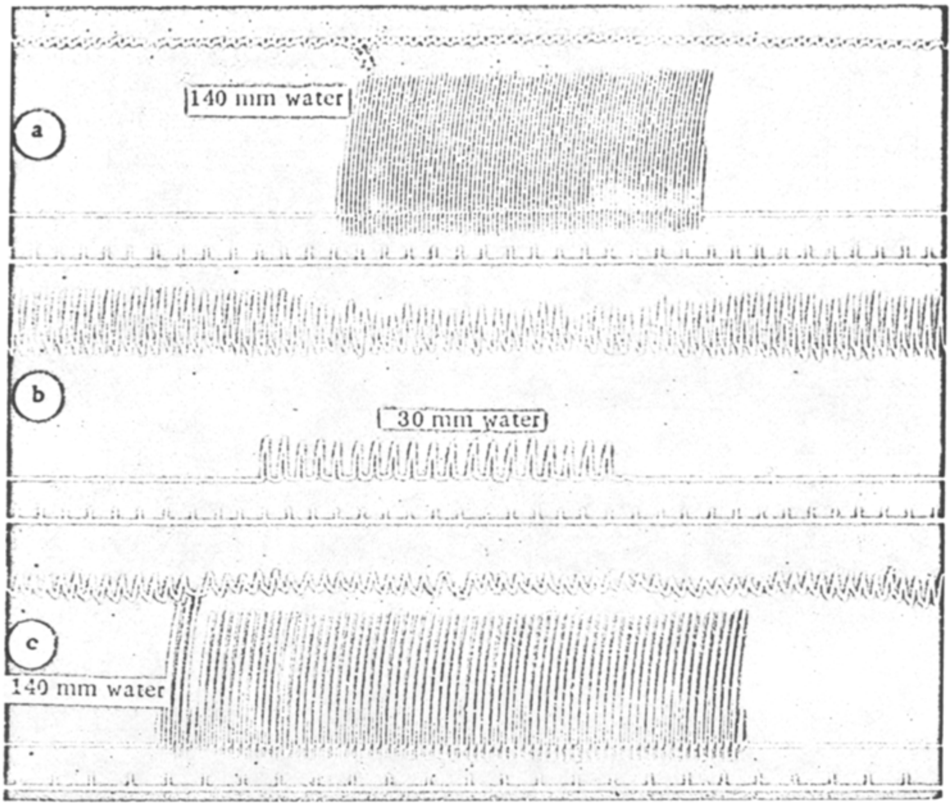

Fig. 2. Effect of extirpation of the cerebral hemispheres and subsequent removal of olfactory lobes on respiration and respiratory reaction in pigeon.
a) Respiration and respiratory reaction to insufflation of air after tracheotomy; b) respiration and respiratory reaction after extirpation of cerebral hemispheres; c) the same after removal of olfactory lobes. Records from above down: pneumogram, record of air insufflation; time marker (5 seconds).

These experiments revealed clearly the role of the cerebral hemispheres in the regulatory mechanism adapting respiration to various afferent impulses from the intranasal baroreceptor system. These data find confirmation also in experiments with stimulation of the cerebral cortex by strychnine (piece of filter paper 4 x 4 mm^2 moistened with 0.1% solution of strychnine); in these experiments even strong baroreceptive stimulation of the intranasal mucosa (above 180 mm H_2O) produced no respiratory reaction. The inhibitory and corrective influence of the cerebral hemispheres on the subcortical parts of the respiratory center has thus been established.

Removal of the olfactory lobes in birds deprived of their cerebral hemispheres (6 experiments) caused reduction of frequency and amplitude of respiratory movements. Respiratory reaction in response to rhythmic stimulation by an air stream was absent in the majority of experiments or only appeared in the form of a slight reduction in the amplitude of respiratory movements without a change in rate.

The removal of the olfactory baroreceptor system thus abolished or reduced the excitability of the intranasal mucosa with respect to stimuli produced by air pressure. It can be concluded on the basis of the data presented that the olfactory nerve baroreceptors in birds from part of an afferent baroreceptor system of the upper respiratory tract which exerts an influence on the respiratory center. The reactivity of the whole system is related to the conditions of the animal's environment. The highest reactivity was encountered in land or amphibious animals (frogs, lizards, rabbits, dogs). Under such conditions of environment even small fluctuations

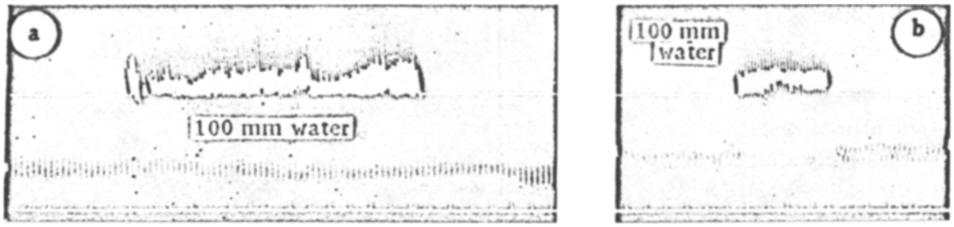

Fig. 3. Effect of extirpation of cerebral hemispheres on the respiratory reaction in pigeon.
a) Prior to extirpation of cerebral hemispheres; b) after removal of cerebral hemispheres. Records from above down: record of air insufflation, pneumogram, time marker (5 seconds).

in air pressure within the nasal cavity signal considerable changes in the environment [4]. The quite different conditions of existence in the case of birds lead to development of a regulatory apparatus which suppresses the effect of large fluctuations of air pressure on the intranasal mucosa. Such a regulatory influence is exerted by the cerebral hemispheres which, according to our data, lower the excitability of the whole afferent baroreceptor system of the nasal cavity of birds during flight.

SUMMARY

The author demonstrated the existence of afferent baroreceptive olfactory-respiratory system in birds.

The function of this system in normal conditions is depressed by the cerebral cortex and is manifested only after the removal of the latter.

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* Original Russian pagination. See C. B. Translation.
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