THE ROLE OF ECOLOGICAL FACTORS IN THE REGULATION OF THE TONE OF THE CEREBRAL HEMISPHERES

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P. S. Kupalov [5, 8, 9] and his co-workers [4, 7, 11], and other investigators [1, 3, 16] have shown the relationship betwenn the general excitability of the cerebral cortex of experimental animals and the intensity of environmental stimuli and impulses continually flowing in from the viscera and proprioceptors [12, 14]. It has been found that the tone of the cerebral cortex is brought about by a special mechanism which takes the form of a conditioned reflex.

The functional significance of the higher centres of the brain, chiefly the cortex, increases in proportion to the phylogenetic development of vertebrates. It would appear that the general tone of the higher centres and the mechanisms for its regulation are developed gradually.

Utilizing work on the comparative physiological aspect [2] we have set out to determine at what developmental stage tone in the central nervous system starts to develop, and to study the mechanism of its regulation in relation to the ecological and biological significance of stimuli continually reaching the organism.

EXPERIMENTAL METHOD

The experiments were carried out on seven cats which were kept the whole time in the animal house under various conditions of illumination.

In all of them the cardiac and respiratory components of a conditioned defensive reaction were developed in response to a sound of 1000 cycles, 60 db. This isolated conditioned stimulus acted for six sec, and the unconditioned electrical re-inforcement, somewhat above threshold, was applied to the animals foot for one sec. During the experiment the conditioned stimulus was used six times, and the differential stimulus (a 500 cycle note at an intensity of 60db) was used twice. Respiratory movements and the ECG were recorded by means of a 4-channel ink-writing oscillograph.

EXPERIMENTAL RESULTS

Experiments on cats kept in the animal house under normal illumination. Cardiac and respiratory reflexes in five cats of this group were developed in the experimental enclosure which was illuminated with a 40w electric lamp Conditioned reflex were formed by the 2-3rd day of the experiment, and as a rule were quite stable. Under the conditions of illumination of the experimental enclosure conditioned reflex activity was shown on 80-100% of the occasions by the appearance of respiratory or cardiac components of the conditioned defensive reaction (Fig. 1a). In all the experimental cats the cardiac conditioned reflex responses took the form of a drop of 15-30 beats per min in the heart rate. The respiratory component of the conditioned reflex defensive reaction was shown by increased respiratory movements and by a marked reduction in their amplitude.

After conditioned reflex responses had been established in all the animals of this group, and when a certain level had been reached, the experimental enclosure was darkened. For one week after the start of the experiments,

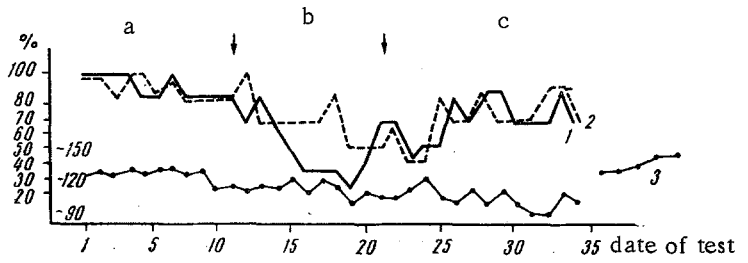

Fig. 1. Change of conditioned reflex activity in a cat living in the animal house under normal illumination. a) Background-experimental enclosure illuminated; b) Enclosure darkened; c) Enclosure illuminated; 1) percentage appearance of cardiac conditioned reflex; 2) respiratory conditioned reflex; 3) heart rate.

under the new experimental conditions the frequency of appearance of the cardiac and respiratory components of the reflexes was gradually reduced, falling to 50-70% and 30-60% for the respiratory and cardiac components respectively (Fig. 1b). The new level of the conditioned reflex activity was maintained for the whole time that the experiments were carried out in the darkened enclosure.

When a changeover was made to carrying out the experiments once more in an illuminated enclosure the conditioned-reflex activity level gradually returned to the original values; for 1-1½ weeks the frequency of appearance of the cardiac and respiratory reflexes increased greatly, and became the same as at the start of the experiment (Fig. 1c).

The experiments on cats living for a long time in an animal house at a low level of illumination. The cardiac and respiratory components of the conditioned defensive reflex were developed in an experimental enclosure illuminated by a 40w lamp. When the animals were transferred to a room with normal illumination the conditioned reflex activity showed 50-90% and 60-80% appearance of the respiratory and cardiac components respectively (Fig. 2a).

Darkening of the room in which the animals were kept in the animal house, or carrying out experiments in a darkened experimental enclosure was carried out after quite stable conditioned reflex activity had been established.

When the experiments were carried out in a darkened room, for the first 6-7 experiments the conditioned reflex changes in the cardiac and respiratory activities were very slight. Not until one week after the cats had been placed in a darkened room in the animal house and the experiments had been carried out in the darkened room did the percentage occurrences of conditioned reflexes begin to increase gradually. The number of positive responses increased from 60-80 from 80-100%. The percentage positive responses in the respiratory conditioned reaction rose to 80-100 on the 3-4th day after the changeover to the new experimental conditions (Fig. 2b).

The new level of conditioned reflex activity which had been established was maintained for the whole time that the experiments were carried out in the darkened room. After one month the experiments were carried out in an illuminated experimental enclosure, while in the animal house the cats continued to live in a darkened room. For the first five days of the experiment the percentage manifestation of cardiac and respiratory conditioned reflexes remained at the same level as when the experiments were carried out in a darkened enclosure; next the conditioned reflex activity changed so that it began to differ both from the original state of affairs and from the activity observed when the experiments were carried out in a darkened experimental enclosure (Fig. 2c). Illumination from an electric lamp was supplied for two months after the animals had been placed in the animal house where they normally lived. The change of living conditions in the animal house was associated with a change in their conditioned reflex activity; the percentage positive responses of the conditioned cardiac and respiratory reactions returned almost to the level observed at the very start of the experiment when the animals lived in the light, and when the experiments were carried out in an illuminated enclosure; the return of the cardiac and respiratory conditioned reflexes to their previous level took place gradually.

According to the change in the illumination of the experimental enclosure the differential inhibition underwent various changes. In the period when the experiments were carried out in the darkened enclosure there was a disinhibition of the respiratory and cardiac differential reflexes, particularly in the latter. When the experiments were carried out in an illuminated enclosure differential inhibition was restored.

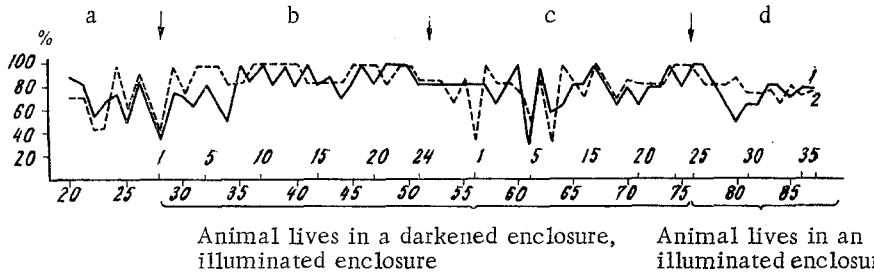

Fig. 2. Change in the conditioned reflex activity of a cat which had lived for a long time in a darkened animal house. a) Base-line condition, enclosure illuminated; b) Enclosure darkened; c) Enclosure illuminated; d) Enclosure illuminated, animal transferred to illuminated living quarters. Remaining indications as in Fig. 1.

In all the animals, independently of the time for which their normal living space was illuminated, the heart and respiration rates did not change as a result of darkening the experimental enclosure.

These results showed that increasing or reducing the illumination of the experimental enclosure causes a marked change in the functional condition of the higher cerebral centres, so that a new level of activity was established corresponding to the new circumstances, not immediately, but gradually over a definite period of time. Our results agree with those of many other workers [4-6, 10. 13, 15, 16], who found a definite change in the levels of the conditioned reflexes during a change from one set of circumstances to another; for example from experiments in silence to a noisy background, or from experiments with a normal illumination to those in which the room was brightly lit. In the case of such a transition these authors observed a gradual establishment of a new level of conditioned and unconditioned reflexes corresponding to the new experimental conditions.

In making an analysis of the changes we observed in the values of the conditioned reflexes of experimental animals living for a long time under various conditions of illumination we noticed essential differences in the functional condition of the higher centres of the central nervous system. In cats living for a long time in darkness in the animal house we were struck by the considerable increase in the percentage appearance of the cardiac and respiratory conditioned reflexes which occurred when the experiments were carried out in a darkened experimental enclosure, whereas in experiments made under corresponding conditions on cats living in an illuminated room in the animal house, the percentage fell. Apparently these differences of the conditioned reflex activity depending upon whether the experiments were carried out in a darkened experimental enclosure on cats living in the light or in the dark are determined by ecological factors, because the cat is specialized to being awake in the night, hunting, etc. The prolonged dark adaptation is a biologically adequate circumstance, so that for them conditioned reflex activity in a darkened experimental enclosure was not reduced, but increased considerably, an effect to be attributed to their increased attentiveness to various rustling or other small sounds. The disinhibition of the differential inhibition developing at this time is also evidence of some reduction in the inhibitory process. Such differences in the re-organization of the tone of the higher nervous centres is associated with the ecology of the domestic cat, which being biologically a night hunter is adapted to a considerable degree to a day life. According to the conditions under which the animals are kept, in their behavioral reactions the mechanisms of adaption to either a night or a day life will be the more pronounced.

In the results which we have reported we must note the gradual formation of conditioned-reflex tonic reactions
b by the higher nervous centres; an important part is played by environmental factors in the regulation of the tone of these centres.

SUMMARY

Our intention was to determine the stages of formation of higher nervous tone, and to study the mechanism and its regulation in relation to the ecological and biological significance of continuously applied stimuli; the results were interpreted from the standpoint of comparative physiology.

The experiments were carried out on cats kept under varying lighting conditions. The results showed that the conditioned reflex tonic reactions of the higher nervous centres were formed gradually, and that environmental conditions played an important part in regulating higher nervous tone.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.
