

PHYSIOLOGY

REFLEX EFFECTS ON THE HEART FROM THE PROPRIOCEPTORS ALTERATION OF CONDITIONED REFLEXES FORMED ON A BASIS OF UNCONDITIONED REFLEX EFFECTS ON THE HEART FROM THE PROPRIOCEPTORS

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(Received June 5, 1956. Presented by Academician K. M. Bykov)

In earlier articles [5, 6], we presented data concerning the speed of the formation, elimination and restoration of positive conditioned reflexes, the development of which was based on unconditioned reflex effects on the heart from the proprioceptors, and on the development of a differentiation. This article will present the results obtained by changing the signal meaning of the conditioned stimuli. This series of experiments was conducted on five dogs.

We should mention that certain peculiarities in the reactions of two dogs, Jack and Treasure, to conditioned stimuli and to an unconditioned stimulus developed before these experiments were conducted. After many uses of the differentiation stimulus, the negative conditioned stimulus, a metronome of 60 beats per minute (M60) caused no change in heart activity. The positive conditioned stimulus, a metronome of 120 beats per minute (M120), after being combined many times with a static physical load, caused no change in heart activity either. There was a fourth phase observed in the reaction of the animals to both the unconditioned stimulus and to the unconditioned and conditioned stimuli combined. At this time, the stimuli M120 and M60, as well as the static load, seemed to have no effect on heart activity. The question was — was the heart activity of the animals really unaffected by these stimuli?

The experiments with the alteration of the conditioned reflexes answered this question. Considerable changes occurred in heart activity during reinforcement of the differentiation stimulus by the unconditioned; they were expressed by changes in all elements of the electrocardiogram. The negative T wave became isoelectric or positive (most pronounced in the dog Treasure), the number of heart contractions increased considerably, and respiratory arrhythmia disappeared (most pronounced in the dog Jack).

The alteration of the conditioned reflexes was virtually perfected during Experiment I after 4 combinations in Treasure and after 3 in Jack. On the following day, M60 used alone in the beginning of the experiment caused the same changes observed when it was combined with the unconditioned stimulus. M120, which had been used twice without reinforcement the preceding day, caused no evident change in heart activity, just as before the alteration of the conditioned reflexes. We continued to reinforce the altered conditioned reflexes for 3 more days in Treasure and for 2 more in Jack. At this time, the earlier differentiation stimulus, M60, reproduced the changes which it caused during its first combinations with the unconditioned stimulus.

The changes which occurred in the alteration process became permanent and were observed without the use of the stimuli beginning with the second day of conditioned reflex signal meaning alteration in Jack and with the third day in Treasure. Moreover, the unconditioned stimulus caused no change in heart activity, which remained disturbed to the same extent as before. The new positive stimulus (formerly the differentiation) intensified these changes. For example, in the dog Jack, only the rhythm of the heart activity changed when M60 was combined with the static load, while the use of M60 alone caused not only a more pronounced rhythm acceleration, but also,

In separate instances, caused the negative T wave of the electrocardiogram to be transformed into a positive wave. The former positive stimulus, which ceased to be reinforced when conditioned reflex alteration began, normalized the heart activity. The above is illustrated in the graphs of Jack's heart activity rhythm (Fig. 1) and in the electrocardiograms of Treasure (Fig. 2). After conditioned reflex alteration began, Treasure's outward behavior was about the same, but Jack showed a general motor restlessness, pulling away from the bench and gnawing at the straps.

Since the changes in the heart activity of these animals became stable 2-3 days after conditioned reflex alteration was begun, further action of the stimuli was stopped. The dogs were allowed to rest, during which time we made periodic electrocardiographic observations until the original indices of heart activity were restored. The animals were placed on the benches for 15-20 minutes, and electrocardiograms in the 3 standard leads were recorded. The observations were not conducted in the conditioned reflex chamber, in which the alteration of the stimulus signal meaning had been done, but in an ordinary laboratory room. Here, for the first few days, we noted changes in the animals' heart activity identical to those observed in the conditioned reflex chamber.

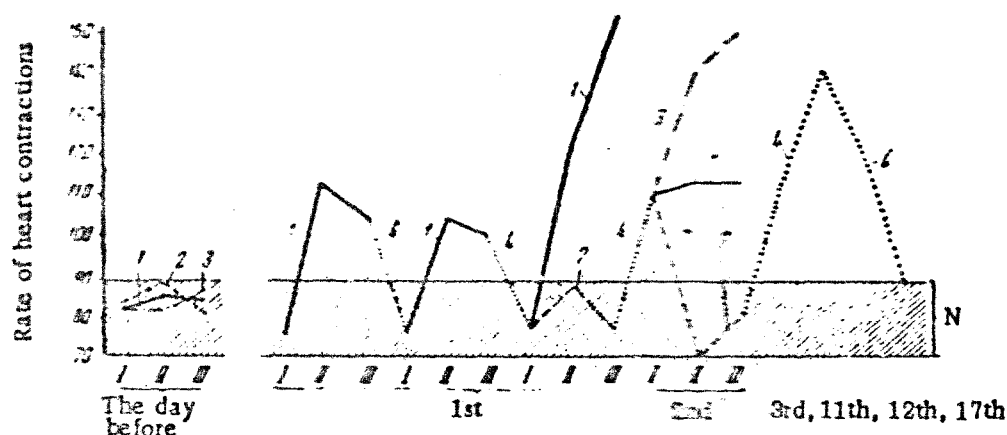


Fig. 1. Dynamics of the changes in the heart activity rhythm of the dog Jack during conditioned reflex alteration.

I) Background; II) during the action of the stimuli; III) after the action of the stimuli; on the 1st, 2nd, 3rd, 11th, 12th and 17th days after alteration began; 1) M60 combined with unconditioned stimulus, but static load alone on the day before alteration and on the 2nd day afterward; 2) M120; 3) M60; 4) undetected rhythm changes; N—normal range of rhythm.

Periodic electrocardiographic study of the animals showed heart activity approximated the original level in the dog Treasure 14 days after alteration began (Fig. 2, see Fig. 3, electrocardiographic forms I, II, III of this dog before the conditioned reflex experiments), and, in the dog Jack, heart activity became normalized 17 days after the beginning of conditioned reflex alteration (Fig. 1).

After the electrocardiogram indices had returned to the original level, which was observed in conditions of an ordinary laboratory room, the dogs were not used again experimentally for more than three months: Treasure was used after 95 days, Jack after 96. Then observations on them were continued. When Jack was first used in the chamber after the recess, his electrocardiogram showed no change from the original (normal) both without the use of the stimuli (3 experiments) and with their use (4 experiments). However, when Treasure was used in the conditioned reflex chamber, changes appeared in the electrocardiogram which were analogous to those caused by the alteration of the conditioned stimuli signal meanings: there was some increase in the number of heart contractions as compared with the original background, but the principal change was a disturbance in the end section of the electrocardiogram; a positive T wave was observed instead of the negative normally observed.

These electrocardiographic changes were observed in the conditioned reflex chamber without the use of stimuli (4 experiments). As before the recess, M60 intensified heart activity disturbance in this dog, while M120

almost completely normalized it (5 experiments). Moreover, the electrocardiogram recorded of Treasure during this period in the laboratory room, where the electrocardiographic observations were conducted, immediately after the conditioned reflex alteration was hardly distinguishable from the normal. This led to the proposal that changes in heart activity caused by the conditioned reflex alteration were due to the whole complex of experimental conditions as well as to the specific use of the stimuli.

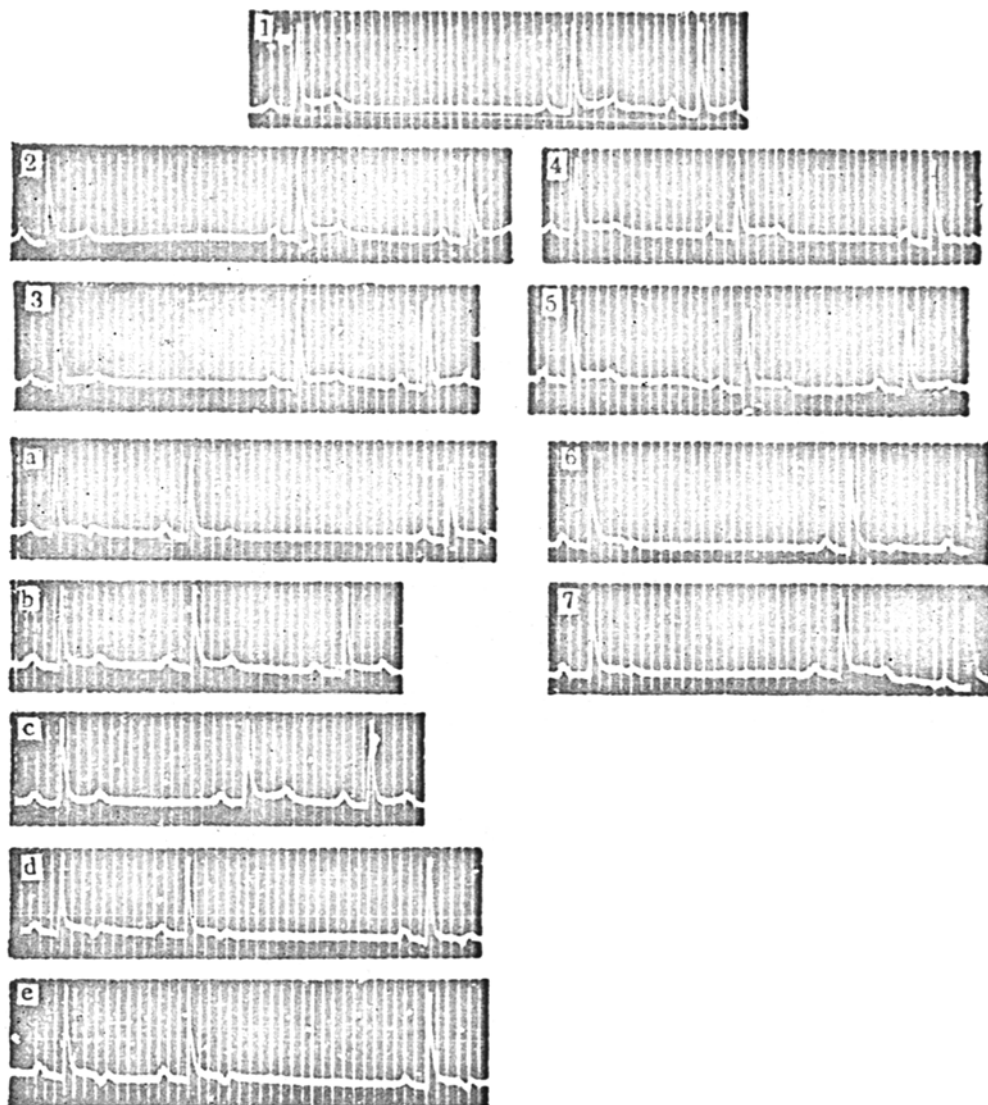


Fig. 2. Electrocardiograms showing the changes in the heart activity of the dog Treasure caused by the conditioned reflex alteration (the II leads).

1-7) On the 4th day after alteration began; 1) background; 2) during the action of the unconditioned stimulus; 3) after the action of the unconditioned stimulus; 4) during the action of M60; 5) after the action of M60; 6) during the action of M120; 7) after the action of M120; on the 10th (a), 11th (b), 12th (c), 14th (d) and 17th (e) days after the beginning of conditioned reflex alteration.

Specific experiments were conducted to prove this proposal: electrocardiograms of the animal were first recorded in the conditioned reflex chamber and then, 15-20 minutes later, in the laboratory room, and then the process was repeated inversely. Figure 3 shows the electrocardiograms obtained from Treasure in two such experiments; they show that the setting in which the signal meaning of the stimuli had been altered (the conditioned

reflex chamber) seemed to have become a "pathologic stimulus", while the removal of the animal from these surroundings caused the electrocardiographic indices to approximate the original and heart activity to be normalized.

When the dog Treasure was placed systematically over a period of a month in the conditioned reflex chamber for 30-40 minutes a day (22 experiments), the electrocardiograms recorded during this time showed the gradual return to normal of the heart activity, but slight electrocardiographic changes were observed periodically even after this. Electrocardiograms recorded from the dog Jack in the laboratory room and in the conditioned reflex chamber during the same experiment were indistinguishable from each other.

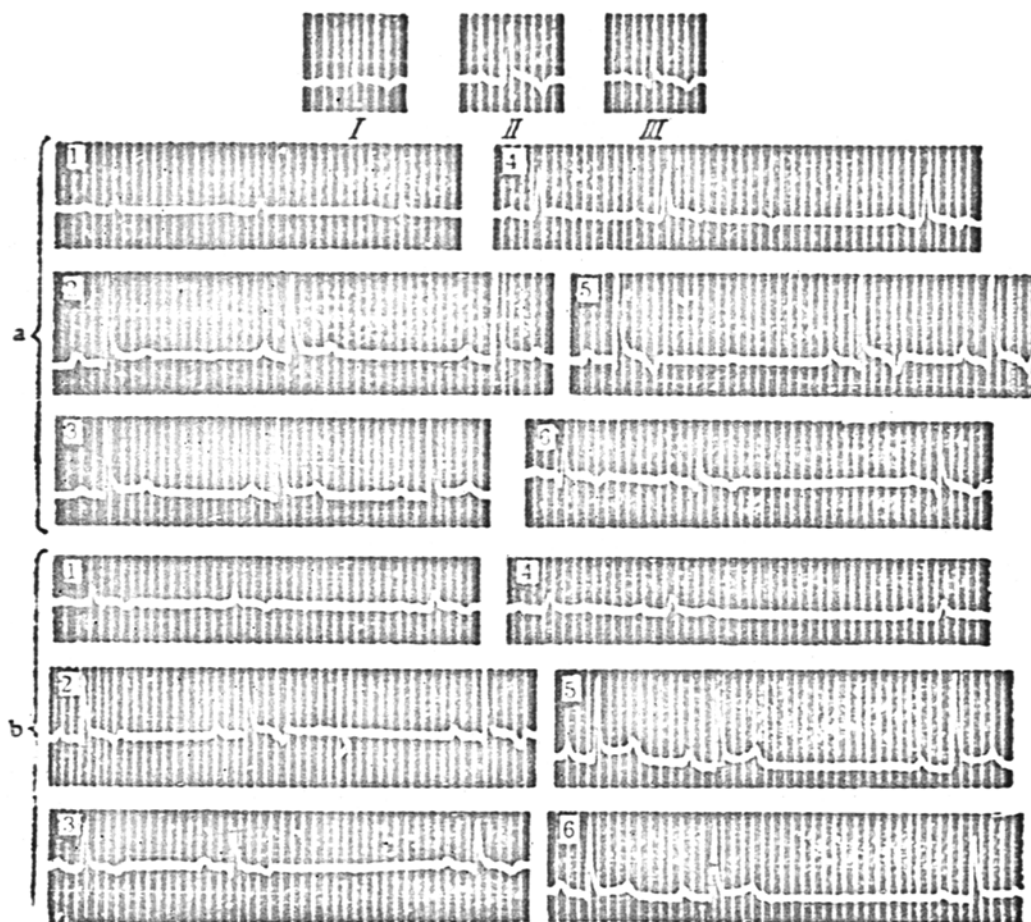


Fig. 3. Electrocardiograms recorded from the dog Treasure in different rooms. I, II and III) form of the electrocardiogram in leads from the extremities before the formation of the conditioned reflexes was begun; 1, 2, 3 (a) electrocardiograms in the conditioned reflex chamber, in order — leads I, II and III; 4, 5, 6 (a) the same in the laboratory room 15 minutes later; 1, 2, 3 (b) electrocardiograms in the laboratory room, leads I, II and III; 4, 5, 6 (b) the same 15 minutes later in the conditioned reflex chamber.

Therefore, in the fourth phase of training to the static load, the alteration of the proprioceptive conditioned reflexes on the heart was quickly accomplished. Three to four combinations of the differentiation stimulus with the unconditioned stimulus sufficed. However, higher nervous activity in the animals was disrupted due to the alteration of the proprioceptive conditioned reflexes. This neurotic condition was expressed in heart activity disturbances which differed as to character and duration depending on the dog. This would seem to be primarily connected with the experimental conditions and with the type of higher nervous activity in the animals, as well as with their age. When the signal meaning of the stimuli was altered, only a persistent change in the rate of

the heart contractions occurred in the young dog, Jack (aged about 3 years). Only 17 days after alteration of the signal meaning of the stimuli was begun did the heart rhythm return to normal and the animal finally emerge from the neurotic condition. In the old dog, Treasure (about 9 years old), the neurotic condition was characterized by a distorted form of stimulation stoppage in the ventricular myocardium or by a disturbance of the restoration processes in the cardiac muscle (1, 2, 3, 4 and others), as well as by change in the heart activity rate. When this animal was removed from the setting in which the conditioned reflexes had been altered, heart activity was normalized; the entire complex of experimental conditions had become a "pathologic" stimulus which could cause a neurotic condition even 5 months after the beginning of stimuli signal meaning alteration.

One must again emphasize that although the use of the new positive stimulus (formerly the differentiation) aggravated the heart activity disturbances throughout the neurotic period, the use of the former positive stimulus (now the differentiation) actually caused a temporary, almost complete restoration of heart activity to the original indices. Here the action of the unconditioned stimulus had almost no effect on the altered operation of the heart. This indicates that, in such conditions, the influences on the heart which are realized through the cerebral cortex are expressed to a greater degree.

The question of whether collapse of the animal's higher nervous activity is unavoidable under the conditions described needs further study. We propose that, in the majority of animals, it is unavoidable in such experimental conditions. The reason for this seems to be the "petrification" of the previously developed stereotype.

The factual material obtained in the experiments described above shows the complexity of explaining the reasons for functional disturbances of heart activity. Actually, considerable disturbances in cardiac activity can be caused by factors which are seemingly usual and without effect on this activity, but which become "pathologic" stimuli when their signal meaning is changed, as well as by those factors which are known to change heart activity without fail. It is possible, therefore, that the environmental factors which have acquired a new signal meaning but which previously seemed to have no effect on the given activity could be regarded as usual and habitual and not considered in the search for the reasons underlying the functional disturbance of the body. They may escape attention, although a detailed study of changes in the meaning of the environmental factors usually affecting the body could help disclose a "pathologic" stimulus among them.

SUMMARY

Alterations of conditioned reflexes which we studied takes place in dogs after 3-4 combinations. In the neurosis which appears, the stimulus, which was formerly differential, enhances the disorder of the heart activity while the one that was formerly positive normalizes it.

Neurosis is maintained only for 14-17 days if the animals are removed from the room where experiments of alteration of reflexes were conducted. One 3-year-old dog completely recovered from neurosis in a fortnight.

The environment in which alteration of reflexes took place maintained disturbances of the heart activity for 5 months in a 9 year old dog, without administration of additional stimulation.

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