DIFFERENTIATION OF SOUND RHYTHMIC STIMULI DURING FREE MOVEMENT OF THE ANIMAL

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The school of I. P. Pavlov has established that differentiation of conditioning stimuli is possible on the basis of two mechanisms – internal inhibition [5] and the excitation process concentration [4, 7]. Both of these mechanisms were discovered by secretory and electrodefensive methods. It was shown, that in these cases differentiation of a major part of the conditioning stimuli was accomplished by the animal without difficulty.

Differentiation of conditioning stimuli under conditions of free movement of the animal was learned later. It was shown by the experiments of P. S. Kupalov [3, 4], begun in 1942, and M. I. Emchenko [1], that the formation of inhibited differentiation of the frequency of the ticks of a metronome is possible. E. S. Tolmasskaya [6] established, that the differentiation of two tones on the basis of the excitation process concentration, when one sound was a signal to food on one end of the table, and another sound – on the other, was shown to be an insurmountable problem for dogs.

On the basis of these works one can propose that the difficulty in the differentiation in the latter case was caused by the necessity of the formation of two distinct motor conditioned reflexes on the basis of one and the same unconditioned stimulus.

While studying the higher nervous activities of dogs with the aid of the method of situational conditioned reflexes [2], we also met with difficulty in the differentiation of sound stimuli when one metronome frequency (60 beats per minute) was reinforced with food on one table, and another frequency (120 beats per minute) – on another table. In this report an attempt is made to approach the analysis of this phenomenon.

EXPERIMENTAL METHODS

The experiments were conducted in a large room where the conditioned reflexed feeding-motor-activity was formed. The basic elements of this activity consisted of the following. The animal stood on a rug in a fixed place in the room; following this we turned on the sound conditioning stimulus – sound of different frequencies being emitted from an electrometronome. At the start a motor conditioned reflex was formed at one frequency (60 or 120 beats per minute) in the form of the dogs gaiting and jumping on one table. After this reflex was strengthened, we shifted towards the formation of a conditioned reflex to another frequency (120 or 60 beats per minute) with gaiting towards another table. Electrical contacts located on the rug and tables and combined with the feeding system, made it possible to record on a hymograph the latent period and the elapse rate of the motor response. The investigation was carried out on three dogs.

RESULTS

In all the dogs the differentiation of frequencies of 60 and 120 beats per minute occurred with great difficulty. Often the animals, after application of two-three conditioning stimuli began to whine, bark and retire to

TABLE 1

Record of an Experiment from May 22, 1959 (the dog Una)

Number of applications	Number of beats per minute (conditioning stimulus by the metronome)	Character of conditioned response	Response; + correct, - wrong
150	60	Ran to left table	—
151	60	» » right » . . .	+
123	120	» » left »	+
124	120	» » » »	+
152	60	» » » »	—
153	60	» » » »	—
125	120	» » right »	—
154	60	» » left »	—

TABLE 2

Record of an Experiment, June 16, 1959 (the dog Una)

Number of applications	Number of beats per min (conditioning stimulus by the metronome)	Latent period (in seconds)	Gaiting time (in seconds)	Character of the conditioned response	Response: + correct, —wrong.
27	30	1.0	1.7	listens, runs	+
28	30	0.5	3.8	moved off rug, stopped, moved further	+
27	240	0.7	1.6	listens, runs	+
28	240	0.7	1.7	listens, runs	+
29	30	0.9	4.0	listens, goes, stops, resumes movement	+
29	240	0.5	2.3	listens, runs	+
30	30	1.4	1.9	listens, runs	+
30		0.6	1.6	listens, runs	+

the door. In connection with this in some cases the experiment had to be discontinued. In spite of the great number of times the conditioned stimuli were applied (more than 100 times), a stable differentiation was not achieved. The percentage of errors made by all the dogs was great (50-70). For an illustration of what has been stated we cite a record of an experiment (Table 1).

As is evident from the record of an experiment, a differentiation of frequencies of 120 and 60 beat per minute is absent. This fact was unexpected and difficult for us to understand. The point is, that the formation of motor conditioned reflexes, when tone was reinforced with food on one table, and with the metronome at 120 beats per minute – on the other, proceeded easily in our investigations. Under such conditions V. V. Yakovlevoy succeeded in forming in one dog four motor conditioned reflexes on one table and four – on the other. For conditioning signals they used such stimuli as tone, a metronome, ringing, etc. On the other hand, it is well known that the formation of inhibited differentiations at metronome frequencies of 60-120 beats per minute under room conditions, as a rule, does not cause difficulty. All of these aspects give us a basis to assume that the cause of the difficulty of differentiation of frequencies of 60-120 beats per minute in the given conditions must be looked for in the structure of the sound stimuli and in the peculiarities of formation of motor conditioned reflexes to different tables. The graphic record of the motor responses on the kymograph enabled us to analyze the facts obtained.

An analysis of the kymograph showed that the latent period of motor conditioned responses (i.e., the time from the moment of inclusion of the conditioning stimulus to the beginning of the motor act) fluctuated within 0.1-0.5 seconds. The rate of gaiting equalled on the average 2 m/sec. Consequently, to calculate the true re-

TABLE 3

Record of an Experiment, August 12, 1959 (the dog Una)

Number of beats per minute (conditioning stimulus by the metronome)	Latent period (in seconds)	Gaiting time (in seconds)	Character of conditioned response		Response: + correct, - wrong
120	0.8	1.0	Listened,	ran	+
60	0.7	1.3	»	»	+
120	0.7	1.6	»	»	+
120	0.9	0.9	»	»	+
60	0.7	1.3	»	»	+
60	0.7	1.7	»	»	+

sponse of the animal at frequencies of 120 and 60 beats per min was hardly possible since the time interval between the sound at a frequency of 60 beat per min equalled 1 sec and at a frequency of 120 beats per min - 0.5 sec, i.e., it was longer than the maximal quantity of the latent period of the motor response.

In connection with this, at these frequencies the process of distinction of the conditioning stimuli must actually occur after the motor response begins to be fulfilled, i.e., when the animal runs to the table.

The following fact serves as an example. In the operation of the metronome at 60 beats per min the animal begins movement immediately after the first sound, but after gaiting 1-2 m. stops, listens and after this subsequently resumes movement. The stopping of the animal 1-2 m from the rug was not fortuitous. In turning the metronome to 120 beat per min the interval between separate sounds equals 0.5 sec, and with the metronome at 60 beats per min -1 sec. Consequently, in order to recognize the given frequencies, it is necessary that the time be at least not less than 1 sec. After this time interval the animals would be in motion for 0.9 or 0.5 sec. If we take into account that the gaiting rate equals 2 m/sec, in the first case the animal stops at a distance of 1.8 m from the rug, and in the second case, 1 m.

Thus, the basic difficulty in the differentiation of frequencies 120 and 60 beats per min is the fact that from the moment the sound is turned on to that moment when this sound acquires a fixed rhythmic pattern, so much time passes that there is enough time to begin the motor conditioned response. This response is displayed thanks to the fact that at the first stages of formation of the conditioned reflex the first sound acquires significance as a feeding signal.

In using the given frequencies the first long duration sound retains its signal significance; this makes the differentiation process difficult.

If our reasoning is correct then it is to be expected that the use of such frequencies, in which the time intervals between the sounds approach the minimal quantity of the latent period of the motor conditioned response, must considerably facilitate differentiation of conditioning stimuli. After unsuccessful attempts to form a differentiation to frequencies of 120 and 60 beats per min it was decided to use frequencies of 240 and 30 beats per min. The choice of the frequency 240 beat per min was due to the fact that in this case the interval between sounds equals 0.25 sec, i.e., it approaches the minimal quantity of the latent period of the motor response. This creates the prerequisite that the process of sound distinction happen at that moment when the animal is still in position, since two sounds and the pauses between them at a frequency of 240 beats per min can still be perceived by the animal up to the beginning of the motor response.

Indeed, the use of these frequencies at once facilitated the process of differentiation, and after several days the distinction of the frequencies 240 and 30 beats per min became literally absolute. We cite the record of an experiment (Table 2).

With the introduction of the 240 and 30 beats per min frequencies the character of the conditioned reflex response changed. At the operation of the conditioning stimulus the animal still did not run immediately after the first sound, but first listened and only then rushed to the table. A lengthening of the latent periods of the motor response occurred. So, in one dog the latent period of the response to a frequency of 240 beats per minute in-

creased on the average to 0.6 sec, and to a frequency of 30 beats per min – to 0.9 sec. In another dog the latent periods correspondingly increased to 0.6 and 1.4 sec. Such a change in the time characteristic indicates that at the operation of the metronome at 30 beats per min the animal runs at the interval (one sound follows another after 2 sec), while at a metronome frequency of 240 beats per min at several sounds and intervals between them (one sound follows another after 0.25 sec). This gives us a basis to consider that the first sound lost its signal significance while the rhythm acquired it and the distinction of the rhythm ensued.

As soon as this occurred, differentiation became stable. After differentiation of the frequencies 240 and 30 beats per min was accomplished, the distinction of the frequencies 60 and 120 beats per min became possible. This is evidence of the fact that the distinction of the latter frequencies by these animals was fully possible, however because of the reasons stated above the process of learning was difficult. We cite the record of an experiment (Table 3).

The basic reason, making the differentiation of the frequencies 120 and 60 beats per min difficult, was that at these frequencies the motor conditioned response was displayed before the process of distinction of these stimuli was completed. The question arises, how then should we understand the difficulty in the formation of differentiation of tones in the experiments of E. S. Tolmasskaya. It is impossible for us to answer that question with complete certainty, since all the details of the investigation are unknown to us. One can only assume that such conditions were created in her experiments, that at the first moment the sound conditioning stimulus retained its signal significance over a long period of time.

Thus, for achieving a stable differentiation on the basis of the excitation process concentration under conditions of free movement of the animal, it is necessary that the nervous process, provoking the distinction of the conditioning stimuli, should be formed during the latent period of motor conditioned response.

SUMMARY

In conditions of free movement of animals (3 experimental dogs), it was impossible to achieve stable differentiation of the metronome frequencies – 120 and 60 beats per minute – on the basis of the excitation process concentration. To elaborate stable differentiation in the given experimental conditions, the nervous process provoking differentiation of conditioned stimuli should be formed in the latent period of conditioned reaction.

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