INCREASING THE WORKING CAPACITY OF THE CORTICAL CELLS BY THE USE OF CONDITIONED STIMULI OF DIFFERENT DURATIONS

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The possibility of increasing the working capacity of the cortical cells is a matter of great theoretical and practical interest. The work of P. S. Kupalov and his school [1-4] showed that the working capacity of the cortical cells is dependent on general stimuli – on the experimental environment and on the quantitative and qualitative properties of the unconditioned reinforcement.

In our previous researches [7] we showed that during the prolonged application of stimuli of short duration the magnitude of the secretion falls, indicating a reduction in the working capacity of the cortical cells.

We describe below the results of a study of the working capacity of the cortical cells during the systematic alternation of stimuli of different durations.

EXPERIMENTAL METHOD

Experiments were carried out on 4 dogs aged 6-8 years with a strong type of nervous system. The dogs had stable positive conditioned reflexes to a bell, a light (40 W), and a metronome giving 120 beats per minute (and differentiation to this metronome), applied during the experiment as a stereotype. The unconditioned stimulus was powdered meat and biscuit. The saliva was recorded drop by drop for a period of 5 seconds throughout the experiment. The experiments were performed at the same time of day. In all 7 series of experiments were conducted, and in each series stimuli of the same duration were used. For example, in the first, third, fifth, and seventh series the positive stimulus acted for 30 seconds, and in the second, fourth, and sixth series, for 2 seconds, followed by a pause of 28 seconds before food was given. Each series of experiments lasted for 10 to 40 days. The series alternated regularly with each other.

EXPERIMENTAL RESULTS

At the beginning of the experiments we established a control background level of the conditioned reflexes in response to application of the stimulus for 30 seconds. The mean magnitude of the conditioned secretion in the control experiment was 60 in the dog Druzhok, 62 in Pirat, 49 in Kosman, and 42 drops of saliva in Dzhul'bars.

Against this background of the conditioned-reflex activity we began applying all the stimuli for 2 seconds instead of 30 seconds as before, and following this by a pause of 28 seconds. When stimuli of short duration were applied, for the first 2-3 days a decrease in the conditioned secretion was observed, and its course was modified so that the rates of secretion in the first and second halves of the pause were equalized.

It can be seen from Table 1 that during the first two days the secretion was decreased in 2 experimental dogs, and in the others it was almost unchanged. On the 3rd day an increase in the secretion of saliva was observed in all the experimental animals. In the subsequent experiments the level of secretion in two dogs exceeded its level in the control experiments by 20-30%; the greatest increase in secretion was observed in response to the action of light (38%); the secretion in the other two animals, on the other hand, was 10-30% below the original level.

In the third series of experiments stimuli lasting 30 seconds were used, and the first tests again caused a change in the course of secretion: its rate was increased by 15-30% compared with that observed during application of the stimuli lasting 2 seconds. These changes in the course of secretion continued for 2-3 days, but despite fluctuations, the volume of secretion as a whole exceeded the initial level.

TABLE 1. Results of the Second Series of Experiments in Which Stimuli of a Duration of 2 Seconds were Applied

Dog	Mean magnitude of secretion in control series	Magnitude of secretion on different days of the experiment			Mean value of secretion in experiment
		1st	2nd	3rd	
Druzhok	60	46	54	76	74
Dzhul'bars	42	45	50	88	54
Kosman	49	55	35	65	34
Pirat	62	36	46	69	56

TABLE 2. Mean Volume of Conditioned Secretion (in drops) in Response to Stimuli of Different Duration

Dog	Duration of isolated action of stimulus								Over-all increase in secretion (in %)
	30	2	30	2	30	2	30	2	
Druzhok	60	74	92	93	89	89	102	99	70
Dzhul'bars	42	54	53	43	58	51	56	50	33
Kosman	49	34	44	24	67	58	66	60	35
Pirat	62	56	65	51	61	44	64	55	No change

In the fourth series of experiments the application of stimuli of short duration was repeated. As a result, at first the course of secretion was modified and its volume decreased. After working for 10 days with these short stimuli, we resumed work with the 30-second stimuli. In response to their application the volume of secretion at once rose and remained on a still higher level.

During the subsequent replacement of stimuli of one duration by those of another, basically the same pattern was observed, the only difference being that the change in the course of secretion was very slight and its volume did not increase but remained as before. The degree of increase of secretion as a result of the change from 2-second stimuli to 30-second stimuli was closely connected with the length of time during which the first stimulus was applied. The longer it was applied, the smaller the increase in secretion of saliva. This finding may be explained by the development of delayed inhibition.

It is clear from Table 2 that as a result of the successive alternation of stimuli of different duration the conditioned reflexes were increased by 35-70%.

Meanwhile, in experiments carried out on the same animals during the same period of time but using stimuli of equal duration, with the continuing stimulation the reflexes diminished. The reflexes did not diminish at the same rate in all the animals. For instance, in Druzhok and Pirat, during work with stimuli of equal duration, the volume of secretion fell after 2 months by only 10%, whereas in Dzhul'bars and Kosman, on the other hand, after 25 experiments the volume of secretion in response to 30-second stimuli fell by 30%, and that in response to 2-second stimuli by 50%.

These results show that on changing to the new series of experiments for the first few days a decrease in secretion and a change in the course of the conditioned excitation were observed, after which the functional tone of the cerebral cortex was raised, leading to an increase in secretion. The change to a higher functional level of conditioned-reflex activity, resulting in an increased working capacity of the cortical cells, is evidently due to the reorganization of the nervous processes, the duration of which is continually being shortened as the experiments proceed. In other words, the rate of establishment of the new functional level in the course of repetition of the alternating series with stimuli of different duration continued to increase.

This result shows that training of the cortical nervous processes brings about a rapid change to a higher limit of working capacity of the cortical cells.

As a result of the reorganization of the original course of conditioned excitation, activation of the cortical nervous processes takes place, leading to the establishment of a new functional level for the cerebral cortex, which is fixed by the animal's nervous system and reproduced in the subsequent series of experiments under the influence of stimuli of different duration. This increase in the functional level of the cortex has limits. For instance, we observed the maximal increase in secretion in the first 4 series of experiments, whereas in the next 3 series the secretion increased to a lesser degree, and was generally maintained at the high level previously established.

It must be pointed out that the degree of increase in the working capacity of the cortical cells depends on the type of the animal's nervous system and on the initial functional state of the cerebral cortex. In Pirat, for instance, the magnitude of the conditioned reflexes in the control experiments was comparatively high, and the dog worked almost to the limit of the functional powers of the nerve cells. Hence when the duration of the stimuli was alternated, the functional level was not raised for so long as in the other dogs, and therefore the limit of working capacity of the cortical cells was not increased. During the control experiments the remaining dogs worked below the limit of working capacity of their cortical cells. Accordingly, the alternation of the duration of the stimuli was a stimulus for a further increase in the strength of their cortical activity.

It may be concluded from the findings described above that during the successive application of conditioned stimuli of different duration the level of working capacity of the cortical cells is raised. The degree of this elevation depends on the type of the animal's nervous system, the initial functional level of the conditioned reflex activity, and the phase in which the switch from a stimulus of one duration to a stimulus of another took place.

In our opinion, this investigation shows that during the performance of fundamentally the same activity, a variation in the duration of its links may be a favorable factor bringing about the maintenance of a high functional level and an increased working capacity of the cortical cells.

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