influence of EGF deficit on the mitotic rate was eliminated. It may be that the relatively high proportion of nuclei that incorporated ^{3}H-thymidine in the test mice was due to delayed DNA synthesis. Further studies are necessary to check this possibility.

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Optimization of the Process of Instrumental Conditioning with a Low Intensity of Conditioned Stimulus

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The influence of the probability of a random correct instrumental response (PRCR) on the rate of conditioned-reflex for different modes of reinforcement was previously shown by us [2,3]. The number of instrumental responses in the initial stage of training which are performed in connection with the conditioned signal and which are correspondingly reinforced depends on the level of PRCR. This in turn influences the interplay of information between the individual and the environment and, ultimately, the rate of reflex formation. It has been established that there are optimal and pessimal values of PRCR [2,3]; some mechanisms of the corresponding modulation of tentative-exploratory activity have been discovered [4,5], and a method of theoretical assessement of PRCR has been developed [1,5]. At the same time, all the above-mentioned studies were carried out under conditions of quite a high intensity of conditioned stimuli, known to exceed the threshold of sensory perception.

The aim of the present study was to investigate the possibility of optimizing the learning process at a low (near-threshold) intensity of the conditioned signal by selecting the appropriate PRCR value.

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MATERIALS AND METHODS

Experiments were carried out on nonpedigree male rats weighing 250-310 g. The animals were as-

TABLE 1. Conditions of Elaboration of an Instrumental Defense Response

Group	Mathematic expectancy of PRCR	Duration of conditioned stimulation, sec	Duration of intervals between stimuli, sec	Intensity of conditioned stimulation, dB
1	0.05	2	38	60
2	0.05	2	38	20
3	0.25	10	30	60
4	0.25	10	30	20
5	0.05	4	76	60
6	0.05	4	76	20
7	0.25	4	12	60
8	0.25	4	12	20

signed to 8 groups, 9 animals in each. An instrumental defense response of pressing the lever was elaborated by the presentation of an acoustic conditioned signal with a frequency of 500 Hz. Electrodermal stimulation of the paws via the floor grid (20-30% above the pain threshold and lasting 5 sec) served as the unconditioned stimulus. If the animal pressed the lever before the end of the period of stimulation, the latter was discontinued. The rats were not subjected to the next electrical stimulation when the instrumental response was correctly performed (the lever was pressed within the period of presentation of the acoustic signal). An intense acoustic signal (level of sound pressure 60 dB) was used in groups 1, 3, 5, and 7, and a weak signal (20 dB) in groups 2, 4, 6, and 8. The experimental conditions were so chosen that the duration of the intervals between the stimuli and/or the intensity of the conditioned stimuli were different in the groups with equal mathematical expectancy of PRCR (Table 1). When the time distribution of exploratory responses was uniform (before a correlation was revealed between the conditioned stimulus and reinforcement) the apriori probability of randomly correctly pressing the lever in the presence of the sound signal constituted 2 sec + 38 sec = 0.05 in groups 1 and 2, 10 sec + + 30 sec = 0.25 in groups 3 and 4, and so on.

The whole experiment was automatically controlled with the aid of a Commodore-64 computer (Germany). Daily, 40 pairings were presented in each experiment. The time of pressing the lever, the duration of electrodermal stimulation, as well as a 2-sec period after it (necessary for cessation of chaotic movements and for restoring exploratory activity) were not taken into account when determining the duration of the conditioned stimulus and the interval between signals. The reflex was considered to be conditioned when the increase of the number of correct responses over the apriori level of their random performance was statistically reliable ($p<0.05$) [1].

RESULTS

Paired analysis was performed for experimental groups of animals trained with similar durations of presentation of the conditioned stimulus and of the intervals between stimuli (Table 2). In our view, all the other possible combinations of pairs of experimental groups (1 - 3, 1 - 4, 2 - 5, etc.) proved to be of little informative value in terms of elucidating the influence of PRCR on the conditioning process, because the effect of additional factors - absolute duration of the presentation of the conditioned stimulus and the interval between stimuli - should be taken into account in these cases (Table 1). At the same time, a change in any above-mentioned parameters itself is known to have a marked and frequently nonuniform effect on the conditioning process [6-8].

As seen from Table 2, the intensity of conditioned stimulation produced different effect on the rate of conditioning depending on PRCR. For instance, in groups 1 and 2 (PRCR = 0.05) a decrease of the intensity of the sound signal led

TABLE 2. Correlation between the Number of Instrumental Responses Necessary for Conditioning and the Value of PRCR and the Intensity of Conditioned Stimulation

PRCR	Number of responses for strong conditioned stimulus (60 dB)	Number of responses for weak conditioned stimulus (20 dB)	*t*-test
0.05	57.5±11.7 (1)	149.7±39.6 (2)	2.24
0.25	123.3±30.4 (3)	144.0±31.1 (4)	0.48
0.05	30.6±6.9 (5)	176.1±30.1 (6)	4.71
0.25	105.2±38.6 (7)	72.7±23.1 (8)	0.72

Note. The numbers of the experimental groups are shown in parentheses.

to a marked slowing of the process of learning ($p<0.05$). A similar result was obtained for groups 5 and 6, this being consistent with the data of a number of authorities [11,12]. A devaluation of the informational significance of exploratory instrumental responses under conditions of insufficiently reliable perception of a weak conditioned signal underlies the above regularity. At the same time, we have to confirm the earlier deduced conclusions [2,3] that a PRCR of 0.05 is pessimal for learning and hinders the process of informational interaction between the subject being trained and the environment.

A different situation was observed for a PRCR of 0.25. As was shown by paired analysis for groups 3 - 4 and 7 - 8, changes of the intensity of the acoustic stimulus did not cause uniform and significant changes of the rate of reflex conditioning. The fact that a PRCR value of 0.25 may be regarded as optimal for learning [2,3] is of special interest. Evidently, the informational significance of each exploratory response increases so much under these conditions that it counteracts the unfavorable effect of the low intensity of conditioned stimulation. This result occurs irrespective of changes of the duration of conditioned stimulation and/or the intervals between stimuli (Table 1) if the PRCR remains unchanged. Apparently, the most marked effect on the dynamics of the learning process is exerted not by the absolute time intervals, but by the relative values (PRCR). This assumption is in tune with the opinion of a number of authors [9] who have pointed to the importance of relative parameters in the wide variation of the duration of conditioned stimulation and the intervals between stimuli.

The ratio between the duration of the conditioned stimulus and the total duration of the cycles a priori determines the probability of random correct performance of instrumental responses, because the time distribution of exploratory responses is more or less uniform. In turn, this value must markedly affect the number of positive and negative reinforcements received by the animal under different regimes of training, i.e., the interplay of information between the individual and the environment. Hence, in the case of PRCR values optimal for conditioning the dependence of the rate of reflex elaboration on various unfavorable factors is weakened. In particular, the results reported here are evidence of the possibility of selecting the proper PRCR values to optimize the process of instrumental conditioning when the intensity of the conditioned signal is low, and not only in the case of a probability-type reinforcement (as was shown previously [2,3]).

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