THE CONSTANCY OF CONDITIONED RESPIRATORY REFLEXES AND ITS USE AS AN INDEX OF THE CORTICAL DYNAMICS IN MAN

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Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 50, No. 7, pp. 13-17, July, 1960
Original article submitted September 26, 1959

Many authors have drawn attention to the inconstancy of the various forms of conditioned reflexes in man and animals. Descriptions have been given, for instance, of the periodic disappearance of an induced motor reflex [12], and of the inconstancy of the salivary [9], respiratory [3, 4, 10], speech-motor [5], and other reflexes in man.

It should be mentioned that this disappearance of the reflexes in the investigations by the authors cited above was not associated with the action of any relevant factors causing the external or internal inhibition of these conditioned reflexes. We consider that the fact that such a "spontaneous" inhibition of the conditioned reflexes may occur merits special attention and analysis.

In this communication we describe the results of an investigation of the dynamics of the conditioned respiratory reflexes of the healthy adult human subject.

EXPERIMENTAL METHOD

The investigations were carried out on 34 athletes. Three forms of conditioned respiratory reflexes were studied: to a direct stimulus (ammonia vapor), to vocal reinforcement (the words "hold the breath"), and to mental reproduction of muscular work, actually carried out a minute before the investigation. A more detailed account of the technique of the investigation has been given earlier [1]. The first two types of conditioned reflexes were expressed by holding the breath, and the third by an increase in the rate of respiration. The conditioned and differential stimuli consisted of different tones from a sound generator. The use of positive and inhibiting signals was not in the form of a stereotype. The respiratory reactions were recorded pneumographically

EXPERIMENTAL RESULTS

Conditioned reflexes to the direct stimulus were formed in all the subjects, up to 20 combinations being required at most for this purpose, and their final consolidation required a further 3 to 50 combinations. Conditioned reflexes to vocal reinforcement were formed in 96% of persons, and to mental reproduction of muscular work, in 78%. The formation of the last two types of conditioned reflexes required not more than ten combinations in the great majority of subjects. These reflexes were consolidated at the same time as they were formed. It must be pointed out that there is no single criterion in the literature of the consolidation of a conditioned reflex [6, 7, 8, 11, 13]. We considered that the conditioned reflex was consolidated if it appeared in five successive tests.

After the above-mentioned types of respiratory conditioned reflexes had been consolidated, for the next few days we studied the pattern of their appearance. It was found that conditioned respiratory reflexes appear constantly in only a few persons; in the overwhelming majority of subjects inhibition of the conditioned reflexes is observed in occasional tests, and in some, even throughout occasional days of the experiment. Under these circumstances absence of reflexes is not caused by the manifestation of any form of inhibition (external or internal) that could be accounted for.

Special attention was directed to the development of the conditioned reflex in the first test on each day of the experiment. In a group of subjects, for instance, it was inhibited in each experiment, in others, for the first 3-6 experiments. In a small proportion of subjects the reflex to the first test was always well marked (see Table).

It is apparent from the table that at the beginning of the experiment the reflex to mental reproduction of muscular work was subjected to the greatest degree of inhibition, and that which was most resistant was the reflex to vocal reinforcement. It must be stressed that restoration of the conditioned respiratory reflex is possible in some cases also without reinforcement by an unconditioned or vocal stimulus, but only after the repeated application of the isolated conditioned signal.

In a, b, e (Fig. 1; athletes V.D. and V.G.) are shown the conditioned respiratory reflexes to the mental reproduction of muscular work, in the form of a change in the frequency and amplitude of respiration, and also the absence of a respiratory reaction to the application of an inhibiting stimulus. The cuts from the pneumograms

Manifestation of Conditioned Respiratory Reflexes in the First Tests (as % of Total Number of Cases)

Presence of conditioned reflex	Conditioned reflex		
	to direct stimulus	to vocal reinforcement	to mental reproduction of muscular work
Reflex always present initially in experiment	27.3	60.0	16.2
Reflex inconstantly present initially	57.6	16.7	33.3
Reflex always absent initially	15.1	23.3	50.5

indicate the beginning of the individual experiments. When the positive tone was discontinued (T-100+), in the first tests inhibition of the conditioned reflex was visible; a respiratory reaction appeared to the vocal reinforcement "Repeat mentally the exercises with the dumbbells" (RMED). In repetitions of the tests, the conditioned reflex was well marked. In c (athlete V.D.) inhibition of an already consolidated conditioned reflex is shown in the first test, formed in response to the vocal reinforcement "hold the breath". In the second test there was a well-marked conditioned reflex to the isolated application of the positive tone (T-2000+) in the form of holding the breath. In d (athlete V.D.) are shown the conditioned reflexes to the smell of ammonia. Inhibition of the conditioned reflex may be seen on withdrawal in the first test, and a well-marked reflex is present in the second test.

The inhibition of the conditioned reflex in the first test of the experiment may be regarded as a diminution of the ability to concentrate the process of excitation in time, which to some degree characterizes the strength of this process. The fact that inhibition of the conditioned reflex takes place initially in the experiment may therefore be used as an index for evaluation of the process of excitation.

The ratio between the number of tests in which the conditioned reflex was marked and the total of applications of the conditioned signal in this particular series of experiments, expressed as a percentage, was designated by us the index of constancy of the conditioned reflexes – the "total number of manifestations of the conditioned reflex in percent." In the calculations those tests were excluded in which a manifestation of inhibition that could be accounted for (for example: external, successive,

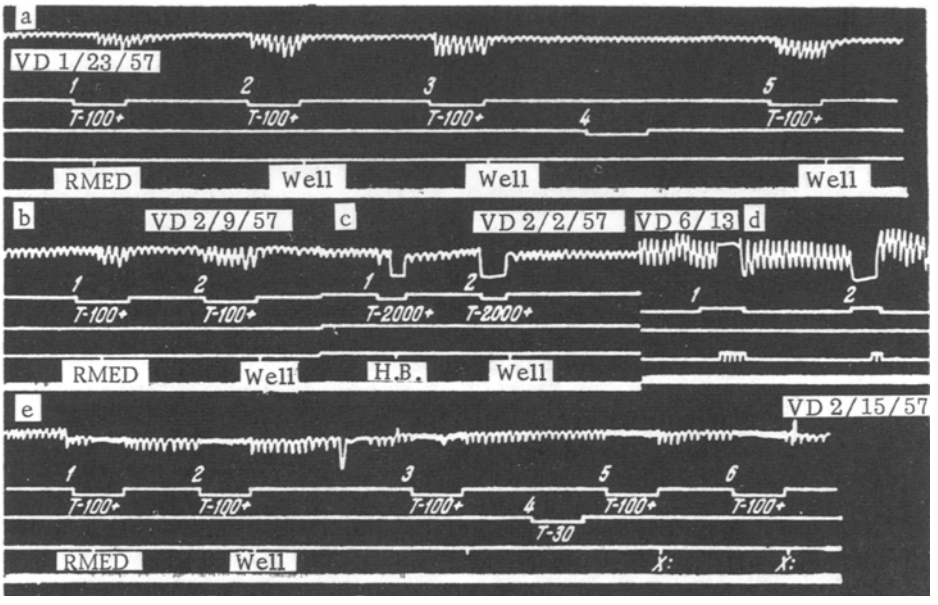

Fig. 1. Inhibition of the conditioned reflex initially in the experiment. Significance of the curves (from above,down): pneumogram; marker of action of positive conditioned stimulus; marker of action of differential stimulus; marker of reinforcement (speech or smell); time marker.

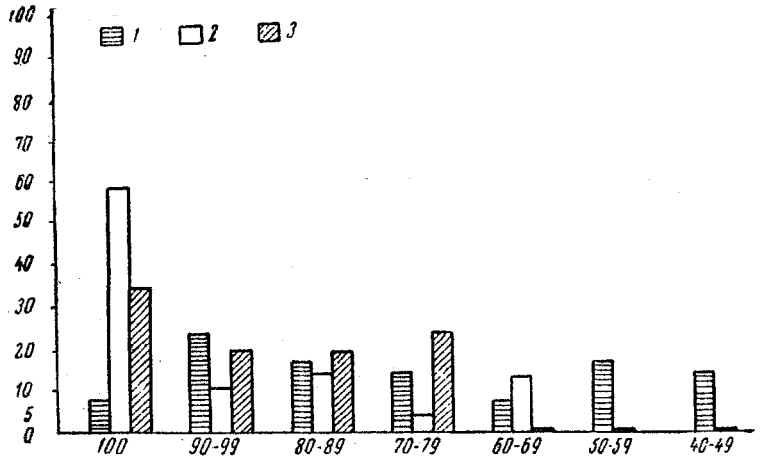

Fig. 2. Constancy of manifestation of conditioned respiratory reflexes. Along the axis of ordinates—number of persons (in %) in whom the index of "total number of manifestations of conditioned reflex in %" reached the value indicated in figures along the axis of abscissae. 1) Conditioned reflex to direct stimulus (ammonia); 2) conditioned reflex to vocal reinforcement; 3) conditioned reflex to mental reproduction of muscular work.

and so on) could be detected. These findings are shown in Fig. 2. We can see that absolute constancy of appearance of the conditioned reflex (100%) is observed most frequently in respect to reflexes formed to vocal reinforcement and next to those formed to mental reproduction of muscular work, i.e., to stimuli addressed to the second signal system. The conditioned respiratory reflexes to the direct stimulus (ammonia) were distinguished by the least constancy of manifestation. Under these circumstances a 100% manifestation of the conditioned reflex was observed in individual subjects only. In the case of reflexes to stimulation of the second signal system, the total percentage of manifestation was not less than 60, whereas in the case of reflexes to stimulation of the first signal system such a low index was observed in one third of all subjects.

It may thus be inferred that conditioned respiratory reflexes may be inhibited without the participation of any agents that are accountable for.

We regard this fact as the result of a constant struggle between the processes of excitation and inhibition, as takes place in the period of consolidation of the conditioned reflex. Analysis of the results obtained leads to the supposition that directly after the first period of consolidation of the reflex a "second period of consolidation" [2] may be seen, when the conditioned reflex is especially prone to inhibition from the second signal system. At this time inhibition of the conditioned reflexes may be observed not only in individual tests, but also in individual experiments. These phenomena have been described by other authors [4, 9, 11], who claim that the mechanism of this inhibition is associated with foci of excitation in the second signal system. T.V. Pleshkova [11], for instance, who examined the character of manifestation of the conditoned blinking reflex from the moment of "first appearance" to the state of "final consolidation", states that there were periods when the reflexes either were diminished or disappeared completely. This was attributed by the author to inhibition, external in its mechanism, from the second signal system. We fully share this point of view and consider that this greater proneness of the conditioned reflexes to inhibition exists only at a particular period of their formation. The duration and character of this period differ in different individuals.

The inhibition described is reversible in character, as is confirmed by the possibility of restoration of the conditioned reflexes by the application of conditioned signals even without reinforcement, and also by the creation of definite conditions of investigation in which inhibition from the second signal system is diminished as was described by V.A. Novi [9].

Having passed through the "second period of consolidation", when interaction between the processes of excitation and inhibition from both signal systems takes place, the conditioned reflex is consolidated to such an extent that in some persons it may even become inert. In some cases inhibition from the second signal system is preponderant, and the reflex may finally be inhibited even after it has been in existence a long time.

The total percentage manifestation of the conditioned reflex thus reflects the interaction between the fundamental nervous processes of excitation and inhibition, and also the neurodynamics during different functional states in man, and it may be used to define the higher nervous activity in man. Inconstancy in the

manifestation of the conditoned reflexes may be regarded as a physiological phenomenon reflecting the changing relationships between the internal and external environments of the subject under investigation.

SUMMARY

The author investigated the constancy of manifestation of the three types of conditioned respiratory reflexes elaborated in response to stimuli addressed to the first and second signalling systems in healthy adult athletes, i.e., to ammonia vapor, to speech reinforcement, and to mental reproduction of muscular work. The general percentage of conditioned reflex manifestation was determined in relation to the total number of positive signals. Inconstancy of conditioned reflex manifestation was regarded as a physiological phenomenon reflecting the dynamics of the between the external and internal environment of the subject to inhibition, evidently originating from the second signalling system. Inhibition of conditioned reflexes is noted during the first test on the day of experiment, lasting for a longer or shorter period in the course of the investigation; this is assessed as a decreased ability of the excitation process to be concentrated in time.

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