

## TONIC REFLEXES IN MAN

### COMMUNICATION 1. THE UNCONDITIONED PROPRIOCEPTIVE TONIC REFLEX FIRST DESCRIBED BY

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Although proprioceptive tendon reflexes had been well studied even in the 19th century, the first mention of tonic reflexes (in the frog) was made in 1860 in the work of P. Brongeeest [9]. Fundamental experimental investigations on the tonic reflex in warm-blooded animals were performed in the first quarter of the 20th century (Sherington [8] — proprioceptive tonic reflexes, Magnus [10] and I. S. Beritov [1] — labyrinthine tonic reflexes, Magnus [10] — cervical tonic reflexes, and so on).

Tonic reflexes in man have been studied mainly by clinical observation (the so-called postural reflexes). A characteristic proprioceptive tonic reflex, found in healthy persons, was described in 1925 by A. A. Ukhtomskii [6]. This reflex is produced in the muscles of the upper and lower limbs of man as a result of preliminary isometric contraction (withdrawal of support from the hand or foot) and arises in consequence of the fact that as the withdrawal ceases, the hand (or foot) smoothly and easily and involuntarily for the subject is raised through a greater or lesser angle and, after being held for a while, it falls. This reflex, the mechanism of which is of great interest and which is a useful test for studying the regulation of tonus in man, has only recently been added to the list of systematic investigations. V. G. Kunevich [3] studied the magnitude, degree of symmetry and variability of this reflex and gave his results in graphic form, showing its variation.

Regarding this reflex as an element of the tonic function of the skeletal muscles in man and intending to study the influence of the cerebral cortex on muscular tone, in 1951 we produced a conditioned tonic reflex (on the basis of the reflex described by A. A. Ukhtomskii) and discovered its characteristic feature — the necessity of applying the conditioned stimulus not before the beginning but before the end of withdrawal, and also the relative difficulty of its extinction [E. P. Kesareva, (2, 5)].

In the present article we present an analysis of the characteristic features of this unconditioned reflex as shown by observations on many human subjects including observations during production of conditioned reflexes, and also an analysis of the relationship of these features to the ordinary activity of man.

### EXPERIMENTAL METHOD

For recording the reflex we used: 1) the method of graphic recording of muscular tone — myotonography — systematically used by us since 1951 [5, 7] and 2) visual observation of the range of elevation of the arm (with an accuracy of 5°). Withdrawal was carried out by tightly stretched rubber bags (Riva-Rocci cuffs), connected to a mercury manometer for measuring the force of withdrawal (in millimeters of mercury). To record reflex muscle tone in accordance with the biomechanical character of the withdrawal producing the reflex, we chose the deltoid muscle; the tone of this muscle can be recorded with practically no effect by the other muscles on the recording device.

A. A. Ukhtomskii [6] pointed out that the reflex is obtained by withdrawal lasting 0.5-1 minute. A special series of experiments in which withdrawal continued from 15 seconds to 2 minutes showed that the most useful duration of withdrawal is 30 seconds, since with a shorter duration the reflex is not always found and a longer duration is pointless since it fatigues the subjects and only slightly strengthens and extends the reflex. For this reason in all experiments with unconditioned and conditioned reflexes we maintained withdrawal for 30 seconds.

### EXPERIMENTAL RESULTS

In the great majority of subjects observed, the reflex was found to be very variable in its parameters. In this respect our results agree with those of V. G. Kunevich [3]. However this variability observed is not accidental but reflects the character of habitual human motor activity and depends on the preexisting development and training of the motor analyzer.

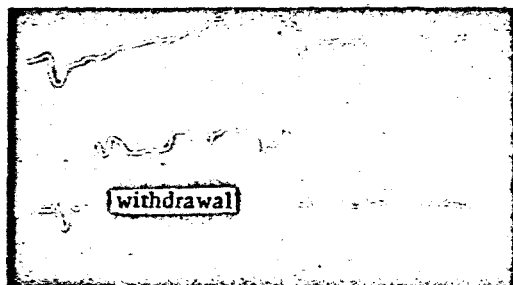


Fig. 1. Myotonogram of withdrawal and of the "latent" reflex in the subject N. P. (male, aged 27, Grade I gymnast). Force of withdrawal ( $\leftarrow \rightarrow$ ) 20-25 mm mercury. Interpretation of curves (from above downward): right deltoid muscle, left deltoid muscle, time in seconds.

The duration of reflex elevation of the arm, from first determinations, varies from 10 seconds to 1 minute and sometimes 2-3 minutes, depending on the form of activity of the subject; it is shorter in untrained persons and athletes engaged in speed training mainly of the lower limbs — in runners (8-20 seconds), longer in pole vaulters (20-50 seconds) and longest in gymnasts (1-3 minutes).

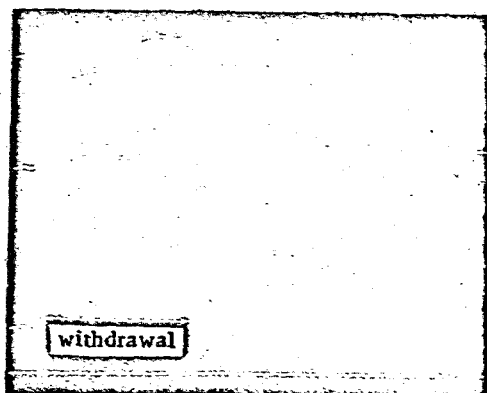


Fig. 2. Myotonogram of withdrawal and of a typical tonic reflex in the subject M. Z. (male, 21 years, gymnast and Grade 3 pole vaulter). Force of withdrawal ( $\leftarrow \rightarrow$ ) 45 mm mercury. Elevation of the arm begins at once. After 11 seconds the arm is raised to 110°, kept there until 21 seconds, then slowly falls (56 seconds altogether). Interpretation as in Fig. 1; time — 2 seconds.

The height of the reflex elevation of the arm also depends on the habitual motor activity and varies sharply — from contraction of the muscles without raising the arm from the trunk and elevation to 60-90°. In untrained subjects it reached 20-45°, in pole vaulters and runners — 60-90°. The most characteristic reflexes were found in highly qualified gymnasts (Grade I and Masters of Sport): in them the reflexes, as a rule, either were not apparent or else after withdrawal there was observed a prolonged, visually discernible contraction of all the visible muscles of the right arm, and on the myogram there appeared a prolonged, weak rise in the curve (Fig. 1). This reaction of a "latent reflex" in gymnasts was not found in those with shorter training, but a typical tonic reflex was observed (Fig. 2). From the character of the myogram in different persons the reflex is either more sudden and shorter than on the myogram shown here or, on the other hand, the curve may rise gradually and then rapidly fall.

If the subject takes part often in single or serial experiments during which withdrawal is repeated, the reflex undergoes a regular modification. The essence

of the change is that the magnitude of the reflex increases and its duration becomes shorter. These changes in the unconditioned reflex arise very sharply during the formation of the conditioned reflex, particularly during production of differential and extinctive inhibition. It can be said that the tonic reflex as it were loses its tonic properties and becomes phasic, resembling tendon reflexes [5].

Changes in the Unconditioned Reflex of the Right Deltoid Muscle Observed During Development and Consolidation of a Conditioned Reflex

Date of Experiment	No. of reflex*	Magnitude of reflex	Duration of reflex (in sec)
27/X 1951	1	25°	41
	2	50°	44
	7	65°	31
30/X 1951	8	75°	43
	11	80°	27
	13	85°	28
	15	90°	20
	23	95°	20
1/XI 1951	28	120°	26
28/XI 1951	30	120°	25
	32	130°	23
6/XII 1951	37	130°	19
24/XII 1951	45	150°	13
4/I 1952	50	120°	9
22/IV 1952	57	110°	12
28/IV 1952	73	145°	10
25/VI 1952	82	170°	15

\* The number of the reflex is counted by the order of application. On strengthening the withdrawal unconditioned reflexes were produced, without strengthening—conditioned. In the table only unconditioned reflexes are included.

In whom conditioned tonic reflexes were produced. Thus in subject A. N., in whom during conditioned reflex experiments in 1951-1952 the magnitude of the reflex rose from 90-140° to 145-160°, while the duration diminished from 15-50 to 5-7 seconds, the observation was repeated two years later with production of an unconditioned tonic reflex (April 27, 1954). On the first test, after withdrawal from the left arm for 30 seconds with a force of 35-10 mm mercury the reflex reaction after 7 seconds amounted to 165°, falling rapidly to 90° and then very slowly ending after 45 seconds. The right arm also gave a reflex of magnitude 165° and duration 48 seconds, but on repetition of the reflexes they were found to be much shortened, in the left arm to 11 seconds and in the right to 16 seconds.

Thus the characteristic features of the unconditioned proprioceptive reflex are determined by the character of the habitual, i.e. conditioned reflex motor activity.

#### SUMMARY

Proprioceptive tonic reflex first described by A. A. Ukhtomskii was investigated with the aid of myotography in sportsmen and untrained persons on deltoid muscle. It was established that the character value and duration of the reflex depends on the previous motor habits of man. In repetition of the reflex in chronic experiments (formation of conditioned reflexes) the value of unconditioned reflex is increased, while its duration is shortened.

We give a table compiled from the results of experiments during formation of conditioned reflexes in the subject N. S. (male, 23 years). During prolonged observations on this subject N. S., in the course of production of conditioned reflexes, the magnitude of the unconditioned reflex rose from 25 to 170° and its duration diminished from 41-44 to 10-15 seconds. The development of this process is illustrated in the diagram which shows changes in the magnitude and duration of the unconditioned reflex during prolonged observations (Fig. 3).

These results which we obtained may be looked upon only from the position of the unity of congenital and individually acquired activity, from the position of the interdependence of unconditioned and conditioned motor reactions. The unconditioned tonic reflex in man is as it were the consequence of pre-existing voluntary motor activity which, according to I. P. Pavlov [4] is conditioned reflex in nature. For this reason in gymnasts, in whom in the course of their training prolonged static contractions of the muscles are applied, an inertia of the excitatory process in the cortical end of the motor analyzer is probably created, masking the unconditioned proprioceptive reflexes.

The correctness of this explanation is confirmed by results obtained in observations on pole vaulters (who also have typically powerful muscular development). Usually performing brief contractions, consequently demanding great concentration and mobility of the process of excitation in the motor analyzer, gives strongly marked proprioceptive reflexes in the form of elevation of the arm. This view is supported also by the long preservation of the change in the unconditioned reflex in subjects

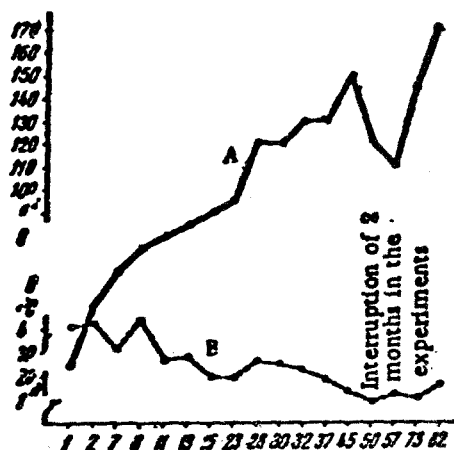


Fig. 3. Diagram of the changes in magnitude and duration of the unconditioned proprioceptive tonic reflex in the subject N. S. in the course of experiments in the formation of a conditioned tonic reflex.  
 A) magnitude of the unconditioned reflex in degrees;  
 B) duration of the unconditioned reflex in seconds;  
 the figures on the abscissa — serial numbers of the unconditioned reflexes during the prolonged experiments.

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\* In Russian.

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