THE RELATION OF HUMAN VASCULAR REFLEXES TO THE TYPE OF HIGHER NERVOUS ACTIVITY

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The particular type of higher nervous activity characteristic of an individual is of considerable importance in the practice of medicine, teaching, psychology, and other sciences. Long ago S. P. Botkin [1] observed a relationship between the course of an illness and the condition of the central nervous system. In many Russian clinics (M. V. Chernorutskii [9], K. G. Nikulin [2], I. I. Speranskii [5], and others), various means are being used to determine the type of higher nervous activity of the patient in order to enable more effective therapeutic methods to be applied.

In the present work we have attempted to apply the method of vascular reflexes to determine objectively some typological features of human higher nervous activity.

It is not by chance that the vascular reaction has been chosen as an index of the cerebral nervous processes. K. M. Bykov and A. A. Rogov [4], and A. T. Pshonik [3] have shown that there is a very close relationship between the two phenomena. Several authors [3, 4, 6, 7] who have used the plethysmographic method have demonstrated the influence of cortical processes on the curve obtained.

METHOD

Our observations were made on 70 healthy human subjects who were maintained under almost uniform living conditions, nutrition, and work. A study was made of their personal characteristics and family background, and observations were made on their behavior. The personal details were drawn up according to the scheme developed by Professor F. P. Maiorov. The vascular reaction was recorded plethysmographically. The correlation of the objective vascular measurement with the personal data represented a qualitative study of human higher nervous activity.

Measurements were made of the vascular reflexes as affected by orienting reactions and by conditioned and unconditioned stimuli.

The unconditioned stimuli used were cold or heat applied to the forearm of the limb on which the measurements were made. In addition, a powerful buzzer and a weak bell were used as remote stimuli. The unconditioned stimuli were applied for 30 sec at intervals of 5-6 min.

The conditioned reflex was developed by A. T. Pshonik's method. The essential feature of this procedure is that by using the second signalling system which is characteristic of man, the experimenter informs the subject about the relationship between the conditioned and unconditioned stimuli, and thereby makes it unnecessary to present the two stimuli together a large number of times. As a result, the conditioned reflex in a healthy subject is formed at the first combined presentation.

The principal vascular conditioned reflexes were those obtained in response to "buzzer + cold" and "bell + heat". The combined stimuli were applied at intervals of 5-6 min, and established the first set of conditioned reflexes. The second pair of stimuli represented a reversal of the first, so that instead of "buzzer + cold", "buzzer + heat" was presented, and likewise "bell + cold" was substituted for "bell + heat". The unconditioned stimulus was presented 30 sec after the onset of the conditioned signal, and the two were continued together for 30 sec.

RESULTS

The plethysmographic curves obtained gave some indication of the typological features of human higher nervous activity.

A physiological analysis of the orienting reflex is very important in connection with higher activity types. Until now, insufficient attention has been paid to this reaction, but nevertheless the orienting reflexes represent the most numerous and biologically important class.

From the effect of orienting reactions on the plethysmographic curves and from observations on the pulse rate we were able to distinguish individuals having different types of higher nervous activity. Thus, for instance, for subjects with a strong and balanced type of nervous system, the plethysmogram curve is undulating, and rapidly passes over to the "zero" type. This is shown

in the curves of the subject K-a, aged 24, which are shown in Fig. 1, a, b. It can be seen that third order waves are present, and these give the plethysmogram its undulating appearance. When further traces are recorded, the third order waves gradually disappear. By the end of the experiment, the plethysmogram had changed into the "zero" type. This result indicates the rapid adaptation of the individual to the laboratory conditions.

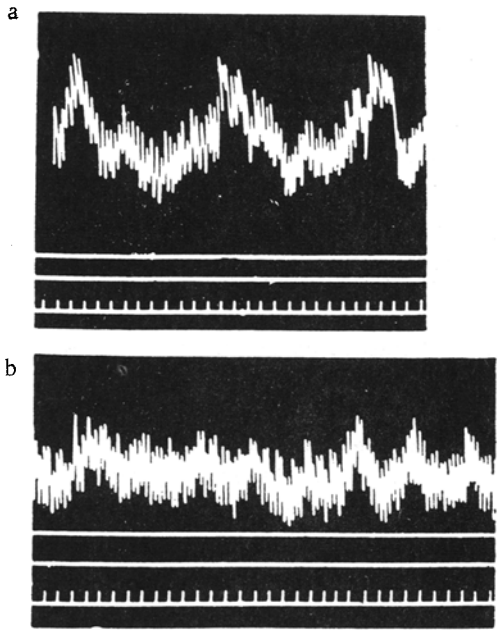

Fig. 1. Human plethysmograms. a) Undulating type; b) "zero" type. Curves from above, downwards: vascular response; conditioned stimulus; unconditioned stimulus; time marker.

In subjects having a strong unbalanced type of nervous system, the undulating type of curve was most common, and as a rule these did not pass rapidly into the "zero" type. A "zero" plethysmogram might be obtained sometimes, but it would then change back to the undulating type at the next test; the curves show a rhythmical pulse wave.

In subjects with a weak type of nervous system, the vascular responses are mostly arrhythmical; the variations occur on both sides of the baseline. A typical curve is that of B-i, aged 22 (Fig. 2). In this curve the undulations and irregular rhythm can be clearly seen, and there are sudden drops and more sudden elevations of the curve, which resemble a motor response. These typical irregularities were not observed in any members of the strong type of nervous activity.

Because of the multiplicity of vascular responses in human subjects having different types of higher nervous activity, it is not sufficient to determine the type to which the individual belongs in terms of the orienting response. For a complete assessment, account

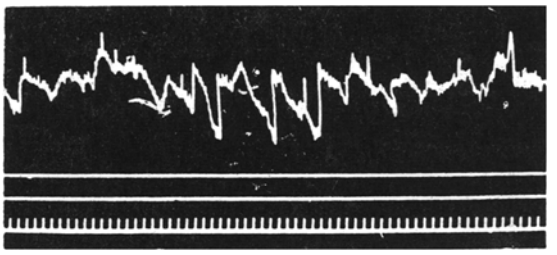

Fig. 2. Arrhythmical undulating plethysmogram. Curves from above, downwards: vascular reaction; conditioned stimulus; unconditioned stimulus; time marker.

must be taken of vascular reactions obtained in response to both conditioned and unconditioned stimuli .

A. A. Rogov [4], A. T. Pshonik [3], and others have shown that at the first stage of an investigation the vascular response to any unconditioned stimulus consists of a constriction of the blood vessels, so that the plethysmogram curve falls. Differentiation of the vascular reaction to correspond with the stimulus occurs much later. This result was completely confirmed in our tests. It is true that the vasoconstrictor response to the unconditioned stimulus was not the same in all subjects: in some it was better shown than in others, while in certain cases it was masked. We have found that these differences in the reactions depend on the different types of higher nervous activity.

In subjects of the strong and balanced type, the vascular response to unconditioned stimuli is well shown, and in the first stage, the vasoconstrictor response predominates. In the strong unbalanced type, the vascular response to the unconditioned stimulus is masked by the undulations in the curve. The preponderance of the inhibitory processes has the effect that there is no reaction to the unconditioned stimulus. In subjects having the weak type of nervous system, as a rule, the responses are irregular and complicated by motor reactions.

I. P. Pavlov's work on types of nervous systems was based on the study of conditioned reflexes. His principal task was to study higher nervous activity in man. The first human conditioned vascular reflex and its differentiation was effected by I. S. Tsitovich [8] in 1918.

In subjects with the strong and balanced type of nervous system, as a rule, the vascular responses were well developed. Figure 3 shows the plethysmogram of R-v, aged 24, who was of this type. There was a well developed vascular reaction in response to the combination "buzzer + cold": the vessels contracted sharply and almost immediately in response to the conditioned stimulus, and there was a further contraction to the unconditioned stimulus. Here, the vascular response was superimposed on the original "zero" plethysmogram; there was considerable variation in pulse amplitude. The curve was obtained on the first day, in response to the second application of the signals as described above.

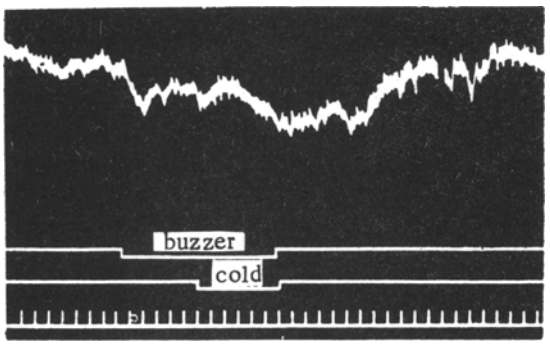

Fig. 3. Vascular conditioned reflex in response to "buzzer + cold". Curves from above, downwards: vascular response; conditioned stimulus; unconditioned stimulus; time marker(5 sec)

This marked vascular constriction developed immediately after verbal instruction concerning the combination of stimuli to be presented.

When the inhibitory process preponderates, conditioned vascular reflexes are inhibited.

In subjects of the strong and unbalanced type, conditioned reflex responses are often undulating. In subjects with a weak type of nervous system, they quite frequently fail to develop, or else develop paradoxically, with irregular pulse variations and with superimposed motor responses. Verbal instruction may elicit a vascular response, but sometimes there is none. Consider the plethysmogram of K-v, aged 29, who had a weak type

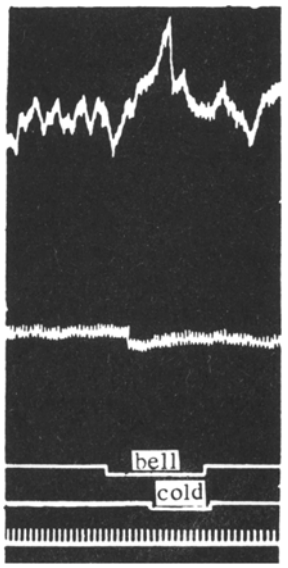

Fig. 4. Paradoxical conditioned vascular reaction to the combination "bell+ cold". Curves from above, downwards: vascular reaction; pneumogram; conditioned stimulus; unconditioned stimulus; time marker (3 seconds).

of nervous system (Fig. 4). It can be seen that there is a paradoxical conditioned vascular reaction to the combination "bell + cold". The plethysmogram shows irregular pulse fluctuations with some small superimposed motor effects.

A careful analysis of the vascular reactions occurring in the experiments just described showed that in each case the functional condition of the cerebral cortex could be determined. When a number of recordings of the vascular responses of a subject at rest are made, if the cortical processes are equilibrated, the undulations in the curve usually cease. The degree of equilibration will be indicated by the rate at which the undulations die away. When they persist, unbalanced cortical processes are indicated. In subjects with the weak type of nervous system, the vascular responses are usually irregular, and the deviations occur on both sides of the baseline.

We took as normal the vascular response of a subject having equilibrated cortical processes.

When the vascular response to unconditioned stimuli is better developed than normally, and when it is maintained for a considerable time without returning to the initial level, then in the individual the excitatory process preponderates over the inhibitory. If in response to the unconditioned stimulus, the vascular change is indefinite or absent, then the inhibitory process preponderates over the excitatory. Usually, in subjects of the strong and balanced type, unconditioned vascular responses are well shown and consist in a constriction of the blood vessels. An unconditioned vascular reflex in subjects of the strong unbalanced type of nervous system produces a plethysmogram in which the undulations are maintained up to the time of the application of the unconditioned stimulus, and they continue after it has been withdrawn. Irregular pulse beat and motor responses are characteristic for the unconditioned vascular reflexes in subjects having the weak type of nervous system. In people of this type, there is not always a definite constriction of the blood vessels; frequently the reaction fails to occur, or else is paradoxical.

Similar effects are observed during the formation of conditioned vascular reflexes. Typically, at the first combined application following verbal instruction, in people of the strong balanced type, the vascular response is well shown.

It should be noted that differences in the lability of the cortical processes was not established by us for all the subjects. In all the 70 people investigated, the reversal of the conditioned reflexes occurred equally rapidly. It must be supposed that the mobility of the cortical processes in man is so high by comparison with animals that reversal as a test for mobility is too easy a task whatever type of nervous system the subject may possess. A more precise method is required to determine differences in lability.

Thus, vascular response may serve as a criterion by which to determine certain typological features

of higher nervous activity in man, and principally to distinguish between balanced and unbalanced types.

SUMMARY

A plethysmographic study was made of oriented vascular reactions, unconditioned vascular reflexes, and conditioned reflexes in 70 healthy individuals living in similar conditions. The vascular reactions enabled an assessment to be made of certain typological features of higher nervous activity, particularly of equanimity and inhibitory power.

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