EXPERIMENTAL STUDY OF THE FUNCTION OF THE ACOUSTIC ANALYZER IN MAN USING THE METHOD OF INVESTIGATION OF FUNCTIONAL MOBILITY

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The method of threshold determination is usually used during the study of the function of any sense organ in order to define its level of sensitivity. In particular, the method most widely used for determining the functional state of the acoustic analyzer is the method of measurement of the thresholds of audibility (audiometry) or the thresholds of discrimination. The attempt to study the function of the analyzers by electrophysiological methods are not always justified, for although such methods may enable some mechanisms of their activity to be studied, they cannot provide all the details characterizing the function of perception. I. P. Pavlov used the method of conditioned reflexes for this purpose.

Any external stimulus adequate for a particular sense organ is inadequate and irrelevant for another sense organ. Although irrelevant, however, it does influence the function of this analyzer. Several authors [3, 5-7] observed a complex relationship between the optic and acoustic analyzers. The character of the influences of inadequate stimuli on the function of a given analyzer is varied. From their special study of this problem, P. G. Snyakin and A. P. Anisimova [11] concluded that this fact may be explained by differences in the functional state of the cerebral cortex, determining the character and the direction of the reaction. However, after a certain period these inadequate stimuli become indifferent, and if they are then reinforced by unconditioned stimuli, they may become conditioned stimuli.

In the 1930s it was shown that conditioned-reflex changes could be produced in the level of photic sensitivity [3, 5-7]. In more recent investigations [1, 2, 4, 8-10, 15, 16] results were obtained showing that if various inadequate stimuli were reinforced by adequate photic stimulation, not only the sensitivity, but also the level of mobilization of the photoreceptors was changed. Hence, on the one hand, it was shown that conditioned-reflex changes may take place in the functional tuning of the optic and other analyzers [10, 12-14]. On the other hand, these facts demonstrated the possibility of using the method of functional mobility for studying the cortical neurodynamics and they laid the foundations of the study of the function of the analyzers by means of this method of investigation.

This paper describes the results of observations undertaken to show how the method of investigation of functional mobility can be used to study the analyzer function of the acoustic analyzer. The criterion which was used was the level of mobilization of the photoreceptors of the retina along the horizontal diameter of the field of vision, determined by means of a type PRP projection perimeter.

EXPERIMENTAL

The investigation was conducted in an experimental darkroom. After preliminary adaptation to the darkness, the horizontal diameter of the field of vision was measured. For the next 15 sec a light was switched on (100 lx) and was used as the unconditioned stimulus. Illumination always caused narrowing of the field of vision, the initial limits of which were restored after 2-3 min. A conditioned reflex was then formed in response to an acoustic

TABLE 1. Formation of a Conditioned Reflex (to a Tone of 500 cps) and of Differentiation (to a Tone of 100 cps)

Time	Test no.	Conditioned stimulus (pitch of tone in cps)	Change in horizontal diameter (in degrees)	Unconditioned stimulus (light, duration of action in sec)	Change in horizontal diameter (in degrees)
10 h 35 min	61	500	4	15	10
10 h 37 min	62	500	8	15	17
10 h 39 min	1	100	4	15	–
10 h 42 min	2	100	2	15	–
10 h 45 min	63	500	3	15	10
10 h 47 min	3	100	2	15	–
10 h 49 min	64	500	5	15	12
10 h 51 min	4	100	0	15	–
10 h 53 min	65	500	3	15	9

TABLE 2. Formation of Differentiation to a Tone of 300 cps

Time	Test no.	Conditioned stimulus (pitch of tone in cps)	Change in horizontal diameter (in degrees)	Unconditioned stimulus (light, duration of action in sec)	Change in horizontal diameter (in degrees)
10 h 35 min	107	500	6	15	18
10 h 37 min	20	100	0	15	–
10 h 40 min	108	500	11	15	21
10 h 43 min	2	300	0	15	–
10 h 45 min	109	500	1	15	7
10 h 47 min	110	500	4	15	11
10 h 50 min	3	300	0	15	–
10 h 53 min	111	500	6	15	13

TABLE 3. Formation of Differentiation to a Tone of 450 cps

Time	Test no.	Conditioned stimulus (pitch of tone in cps)	Change in horizontal diameter (in degrees)	Unconditioned stimulus (light, duration of action in sec)	Change in horizontal diameters (in degrees)
10 h 50 min	133	500	4	15	19
10 h 53 min	1	450	0	–	–
10 h 55 min	134	500	6	15	19

stimulus. The conditioned stimulus was a musical note with a frequency of 500 cps and a loudness of 10 dB, produced by a type ZG-10 sound generator. This sound was always reinforced by a photic stimulus. The strength of the unconditioned and conditioned reactions was judged by the change in the size (narrowing) of the horizontal diameter of the field of vision during the action of the corresponding unconditioned (photic) and conditioned (acoustic) stimulus by comparison with its initial size (after dark adaptation).

RESULTS

After several combinations of the tone of 500 cps and the light, a conditioned reflex was formed to this acoustic stimulus, and was expressed by the fact that the isolated action of the tone of 500 cps caused narrowing of the horizontal diameter of the field of vision of the preliminarily dark-adapted eye. After the appearance of a stable conditioned reflex, differentiation to a sound of different frequency or loudness was formed. The development of differential inhibition, of course, lay at the basis of the analysis.

In the first place, differentiation was formed between comparatively widely different notes (500 and 100 cps). Usually a reaction of generalization was observed (Table 1).

During the first tests of the tone of 100 cps (without reinforcement by the photic stimulus) the narrowing of the field of vision which was produced was almost the same as that produced by the tone of 500 cps, but with the fourth test the differential agent (tone of 100 cps) obtained a zero reaction, demonstrating the development of a process of inhibition. In all subsequent tests the tone of 100 cps caused no narrowing of the field of vision, unlike the tone of 500 cps, which was a positive conditioned stimulus. Hence, the simple analysis of two acoustic stimuli took place.

To determine the degree of acoustic analysis, the two differential tones had to be brought closer together. A tone of 200 cps was now differentiated from the tone of 500 cps. On its first application the tone of 200 cps gave a zero reaction—i.e., it was generalized with the tone of 100 cps, the stable differential agent. Next, differentiation was formed between the tone of 500 cps and one of 300 cps, which at first was generalized with the positive conditioned stimulus—the tone of 500 cps. In response to its application, the horizontal diameter of the field of vision was narrowed by 3°. However, at the 2nd, 3rd, and subsequent tests, the tone of 300 cps gave zero reactions without reinforcement (Table 2).

After this degree of analysis had been established, the next step towards its more accurate determination was taken. For this purpose a tone of 400 cps was used as differential agent. In this case, too, during differentiation of a tone of 400 cps from one of 500 cps, generalization was observed at the first test, but at the second test the application of the tone of 400 cps gave a zero reaction. Finally, after stable differentiation had been obtained to the tone of 400 cps, a tone of 450 cps was used as the differential agent (Table 3). It follows from Table 3 that the tone of 450 cps gave a zero reaction at its first test. This means that the tone of 450 cps, when applied without reinforcement, was easily differentiated from the tone of 500 cps, the positive acoustic stimulus, which always produced narrowing of the horizontal diameter of the field of vision.

If the two tones to be differentiated were brought still closer together, the degree of analysis of the acoustic stimuli could be determined with the required accuracy in relation to the change in the horizontal diameter of the field of vision. In this case the retina was the effector through which the degree of analysis of the acoustic stimuli was determined. The results of the observations described above demonstrate that the change in the functional tuning of the optic receptor system may be used to judge the analytical activity of the acoustic analyzer. The functional tuning of one receptor system, modified as a result of reflex action, is an index of the degree of analysis of another receptor system. The method of functional mobility, which enables the functional tuning of a given receptor system to be defined under the influence of both unconditioned and conditioned stimuli, may be used to study the analytic activity of any human analyzer.

The results obtained are also of considerable interest from the point of view of the interaction between different analyzers.

SUMMARY

The article presents the findings of a study of the analytical function of the acoustic analyzer in man with the use of the functional mobility of the retina as an index. The possibility is shown of characterizing the functioning of one analyzer system by means of changing the reflex adjustment of another analyzer system.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. ***Some or all of this periodical literature may well be available in English translation.*** **A complete list of the cover-to-cover English translations appears at the back of this issue.**