RELATIONSHIP BETWEEN THE DURATION OF DEPRESSION OF THE PRINCIPAL CORTICAL RHYTHMS AND THE LATENT PERIOD OF THE MOTOR REACTION IN MAN

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To compare the changes in the electrical activity of the brain and in conditioned-reflex activity in man, some authors have taken into account the depression of the α-rhythm and the latent period of the motor reaction.

In some cases a definite parallel has been discovered between the changes in these indices, for with an increase in the length of the latent period of the motor reaction, the phase of depression of the α-rhythm is intensified, while if the latent period is shortened, the depression is diminished [1-3, 5, 8, 11].

The object of the present investigation was to determine whether the relationship described above between the changes in the latent period of the motor reaction with variations in the duration of depression of the rhythms is present not only in the part of the brain specific relative to the signal or reaction, but also in a part not directly concerned with the organization of this connection.

EXPERIMENTAL METHOD

The motor reaction selected was squeezing a dynamometer, as used by V. M. Abalakov, with a force of between 14 and 20 kg, and the conditioned stimulus was a sound. Bipolar recordings were made of the EEG in the parieto-occipital and sensory motor areas of the left and right cerebral hemispheres, the EMG of the flexors of the right hand, the ECG, respiration, and the marker of the stimulus in response to which the movement began. The recording of the stimulus marker and the electrical activity of the muscles made it possible to estimate the latent period of the reaction.

The recordings were made on an Alvar eight-channel electroencephalograph.

Since the acoustic stimulus used in the investigation is nonspecific for the optic and motor cortex (which is evidently why the reaction of the EEG to it is extinguished so quickly), the principal active stimulus when the experiments were carried out in this way was the powerful stream of impulses running from the proprioceptors, during the muscular effort, mainly to the sensory motor area of the brain.

Altogether three series of investigations were carried out.

Before proceeding with the main series, the subject's orienting reaction to the acoustic stimulus was extinguished.

In series I the subject was instructed to reproduce the squeezing movement accurately and of his own accord with his eyes closed. He then reproduced the same movement, but this time the experimenter told him if he had made a mistake.

In series II the subject first reproduced the movement accurately, and then not merely accurately but also quickly.

In series III the movement was reproduced accurately and quickly with and without sensory differentiation (in response to one accoustic stimulus the task had to be performed, while in response to another this had not to be done). Series II and III were carried out before, and then after physical exercises.

Altogether 116 investigations were made, and in each experiment there were 10-15 movements.

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TABLE 1. Latent Period of Appearance of Electrical Activity of Muscles (in sec); 1) and Duration of the Phase of Depression of the Principal Rhythms of the Brain (in sec) in the Occipital Regions of the Right (2) and Left (3), and Also in the Sensorimotor Areas of the Right (4) and Left (5) Hemispheres during Reproduction of Movements

Statistical Index	1	2	3	4	5
	Without verbal correction				
$M \pm m$	0,68±0,025	1,11±0,48	1,1±0,50	1,7±0,51	2,2±0,56
	With verbal correction				
$M \pm m$	0,95±0,023	1,08±0,39	2,5±0,75	3,7±0,65	4,0±0,4
P	<0,001	>0,5	>0,1	<0,05	<0,01

EXPERIMENTAL RESULTS

When the movements were reproduced with verbal correction, the latent period of appearance of the electrical activity of the muscles and also the duration of depression of the α-and Rolandic rhythms of both hemispheres were longer than when the same movements were reproduced without verbal correction. However, whereas the differences in the latent period of the motor reaction in these cases were statistically significant, the differences in the duration of the phase of depression were significant only in the sensorimotor areas, and in the occipital region of the right hemisphere the differences were not significant, while in the rest they possessed the character of a tendency (Table 1).

During the task of reproducing the movement accurately the latent period of the motor reaction and also the phase of depression of the α-and Rolandic rhythms were longer than during the task of reproducing the movement both accurately and quickly. In the latter case the differences between the latent periods of the reactions also were statistically significant. So far as the phase of depression is concerned, the difference was significant only in the sensorimotor areas of the right and left hemispheres, while in the occipital regions it had the character of a tendency, more marked before the training exercise and less marked after it (Table 2).

The introduction of sensory differentiation during reproduction of the movement led to an increase in the latent period of the reaction and intensification of the phase of depression of the rhythms in the motor and optic areas of the brain.

The differences in the latent period of the movements during reproduction with and without sensory differentiation were statistically significant. The differences in the duration of the phase of depression in this case were significant only in the sensorimotor areas, in the right occipital region they were not significant, and in the left occipital region they had the character of an ill-defined tendency. After the training exercise similar results were obtained (Table 3).

The results of comparison of the latent period of the reaction and the duration of the phase of depression of the principal rhythms in different parts of the brain showed that the close relationship between these two indices described previously is not always observed. It is found clearly only in cases when the latent period of the motor reaction is compared with the change in rhythm in that part of the brain to which the stimulus or movement is addressed. For instance, several of the authors cited above found a relationship between the variations in the latent period of the motor reaction and the duration of the phase of depression of the α-rhythm in the occipital region in response to photic stimuli.

In the present investigation the same relationship was found between the variations in the latent period of the motor reaction (in the form of a force of 14-20 kg) and the duration of depression of the Rolandic rhythm of the sensorimotor area, the central end of the motor analyzer, but this relationship was not found in the occipital region (it will be recalled that the investigation was carried out with an acoustic stimulus instead of a photic stimulus).

The different parts of the cortex are projection zones of different parts of the receptor surface. We know that the optic and motor areas are particularly highly specialized [11, 12]. Distribution and conduction

TABLE 2. Latent Period of Appearance of Electrical Activity of the Muscles(in sec); 1) and Duration of Phase of Depression of the Principal Cortical Rhythms (in sec) in the Occipital Regions of the Right (2) and Left (3), and Also in the Sensorimotor Areas of the Right (4) and Left (5) Hemispheres during Reproduction of Movements

Time of investigation	Statistical index	Accurately					Accurately and quickly				
		1	2	3	4	5	1	2	3	4	5
before training	$M \pm m$ P	0,41±0,018	0,6±0,076	1,1±0,11	2,0±0,11	2,4±0,13	0,16±0,015 <0,001	0,5±0,04 >0,2	0,8±0,013 >0,05	1,5±0,14 <0,02	2,0±0,09 <0,02
after training	$M \pm m$ P	0,39	0,4±0,06	0,7±0,06	1,7±0,06	2,2±0,02	0,15±0,07 3,7 <0,02	0,4±0,05 0	0,6±0,07 1,1 >0,2	0,9±0,13 5,0 <0,001	1,36±0,16 5,0 <0,001

TABLE 3. Latent Period of Appearance of Electrical Activity of the Muscles(in sec); 1) and Duration of the Phase of of Depression of the Principal Rhythms (in sec) in the Occipital Regions of the Right (2) and Left (3), and Also in the Sensorimotor Areas of the Right (4) and Left (5) Hemispheres during Reproduction of Movements

Time of investigation	Statistical index	Without differentiation					With differentiation				
		1	2	3	4	5	1	2	3	4	5
before training	$M \pm m$ P	0,16±0,015	0,5±0,04	0,8±0,013	1,5±0,14	2,0±0,09	0,33±0,043	0,6±0,13 50 >0,5	1,0±0,18 71 >0,2	2,1±0,28 92 >0,05	2,8±0,29 98 <0,05
after training	$M \pm m$ P	0,15±0,07	0,4±0,05	0,6±0,07	0,9±0,13	1,36±0,16	0,32±0,018 <0,05	0,5±0,047 >0,2	0,8±0,13 >0,2	1,7±0,22 <0,01	2,4±0,20 <0,001

of impulses take place in the cortex, and they spread within the structures in accordance with definite principles of spatial organization. This is expressed in the EEG in the form of a "funnel" [4, 6, 7, 9].

The changes in the spatial distribution of the incoming information depend on its distribution in time, because the information travels along very complex multineuronal chains. Some time is necessary to travel along this path, and the more complex it is the more time is needed. This factor is evidently reflected, on the one hand, in the variations of the latent period of the motor reaction, and on the other hand in the duration of the changes taking place in the electrical activity of the brain.

In connection with the spatial distribution of excitation in the cortex the changes in the passive zone may be very slight, so that the variations in depression of the α-rhythm in the occipital region were not statistically significant, whereas in the active sensorimotor region they were significant and took place in the same direction as the variations in the latent period of the motor reaction.

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