CORRELATION BETWEEN MOTOR AND ELECTRO-ENCEPHALOGRAPHIC COMPONENTS OF THE ORIENTING REFLEX TO TACTILE STIMULATION OF VARIOUS AREAS OF THE SKIN

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The electrocorticographic and motor components of orienting reflexes in rabbits differ in certain respect depending on localization of the tactile stimulus. In the author's opinion, stimulation of different areas of the skin may evoke biologically different orienting responses depending on their special ecological characteristics.

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The motor and autonomic manifestations of the orienting reflex (OR), together with its central mechanisms, have been studied in detail in recent years. Attention has been concentrated mainly on the investigation of the electroencephalographic component of the OR, appearing as an arousal reaction (desynchronization of the EEG) [1-3, 7]. However, whether the motor and autonomic components or the EEG components of the OR are to be analyzed, attention must be directed not only to the intensity of the stimulus and the number of its applications, but also to the ecological characteristics of adequate stimuli [2, 4], and also the distinguishing features of the functional and structural organization of individual analyzers.

The ecological adequacy of stimuli is best studied by using a single analyzer and keeping the modality of the stimulus (for example, cutaneous) unchanged, because both the density of afferent fibers in the peripheral part of the analyzer and the scale of representation in its central structures are closely correlated with the biological properties of skin reception in animals of different species [9, 10]. Only a few investigations have been conducted on this subject, in which changes in the EEG during cutaneous stimulation in man have been studied [6].

The object of the present investigation was to study the behavioral and electroencephalographic components of the OR in rabbits during adequate stimulation of different parts of the skin.

EXPERIMENTAL METHOD

Experiments were performed on 14 rabbits. Stainless steel needle electrodes were inserted into various parts of the somatosensory cortex (SEC) corresponding to projections of the limbs, trunk, and head, and pushed into the bone for a distance of 1 mm. The interelectrode distance was 2.5 mm. The ECoG was recorded during each application of the stimulus on a 4-channel ink-writing electroencephalograph (bandwidth from 1 to 40 cps). The ECoG was recorded by bipolar or chain methods. The actogram was recorded on the same strip of paper. The stimulus (a vibrator 2.5 cm in diameter, acting for 3 sec) was applied to the skin of the head (the upper lip) and hind limb (leg, thigh). The rabbit was placed in a hammock in a screened, soundproofed room. The vibrator was applied about 20 times in the course of an experiment, and the experiments were performed on alternate days. The intervals between stimuli were from 0.5 to 5-6 min. The magnitudes of the electroencephalographic indices were analyzed by statistical methods: The presence and duration of general and local EEG desynchronization, and also of synchronized rhythms were taken into consideration and compared with behavioral responses.

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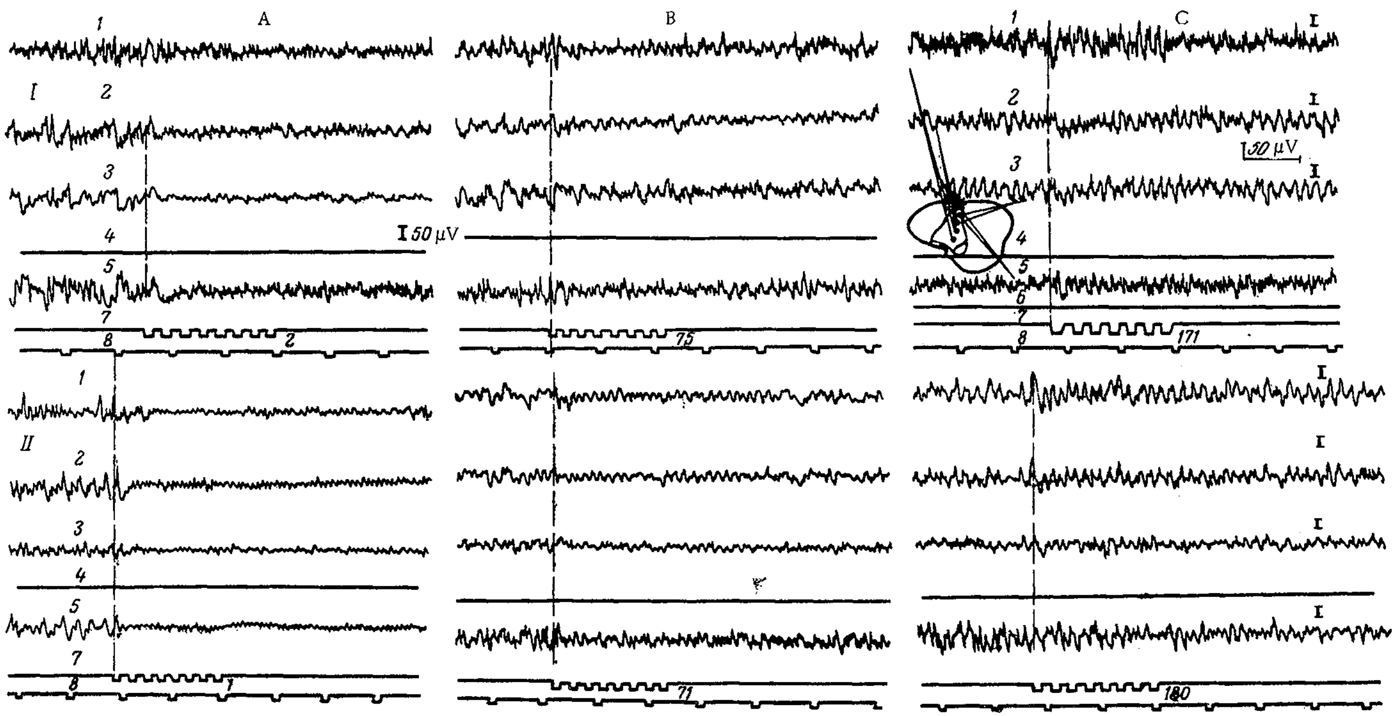

Fig. 1. Dynamics of ECoG in response to tactile stimulus at beginning (A), in middle (B), and at end (C) of extinction of OR from skin of the head (I) and limbs (II). From top to bottom: 1, 2) recordings from projection of muzzle; 3, 5) trunk and limbs; 4) actogram; 7) marker of application of vibrator; 8) time marker (1 sec; rabbits Nos. 8 and 9). Calibration 50 μV.

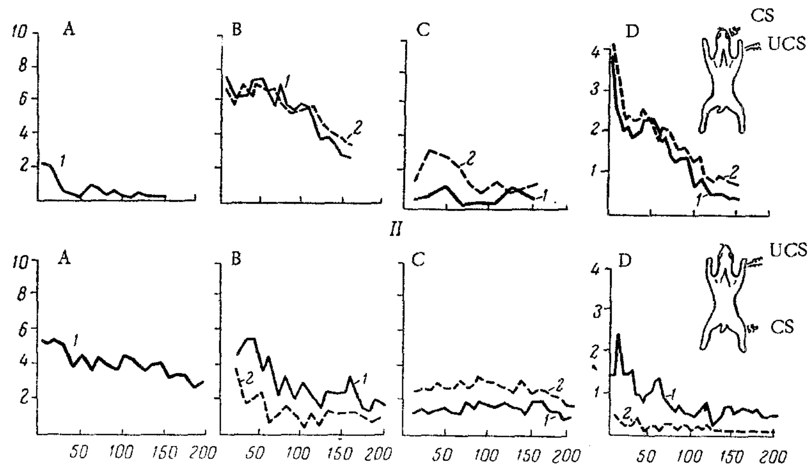

Fig. 2. Characteristics of behavioral and ECoG components of orienting reflex during stimulation of skin of the head (I), limbs, and trunk (II) (mean for each choice). A) Discernibility of motor components; B) desynchronization of ECoG; C) of synchronized rhythms; D) mean duration of desynchronization of ECoG in five successive applications. Abscissa – serial No. of stimulus; ordinate – discernibility of corresponding components in each ten successive applications (A – C), seconds (D). 1) Dynamics of ECoG in cortical projections of skin of trunk and limbs (for B, C, D); 2) in projection of head. On the right of the figure (above and below): scheme of location of conditioned (CS) and unconditioned (UCS) stimuli.

EXPERIMENTAL RESULTS AND DISCUSSION

Two series of experiments were performed. The OR in response to stimulation of the skin of the head were studied in series I and to the skin of the limb and trunk in series II.

In response to the first applications of the stimulus a generalized and most prolonged desynchronization of bioelectrical activity affecting the whole SSC was observed (Fig. 2, I, A and II, A). With repeated applications of the vibrator the conspicuousness and duration of the periods of general desynchronization diminished rapidly, so that changes in the type of local desynchronization of the ECoG, taking place only in the SSC or in various parts of it were the predominant manifestations (Fig. 2, I, B, D and II, B, D). Whereas in the experiments of series II the signs of local desynchronization of the EEG were most clearly visible (Figs. 1, II, B and 2, II, B) and were observed mainly in the cortical representation of the limbs and trunk, in series I a more diffuse desynchronization of the ECoG was observed, i.e., in the representation of the head and also of the trunk and limbs (Fig. 2, I, B). There is reason to suppose that this difference is connected with the spread of excitation over a wider area of the cortex during stimulation of the skin of the head.

Simultaneously with the shortening of duration of both generalized and local desynchronization of the ECoG in response to the stimulus, low-frequency synchronized activity (4-7 cps) appeared (Fig. 1, I, B and II, B). Changes of this type in the ECoG were most frequently seen in the experiments of series II (Fig. 2, II, C).

At the very end of extinction of the OR, the ECoG in response to stimulation showed short and less constant changes, although they never completely disappeared (Fig. 1, I, C and II, C).

Differences in the motor manifestations of the OR were more marked than the ECoG changes. In series I, for instance, the motor component of the OR was observed only during the first day of the experiment, and on subsequent days, it appeared only occasionally (Fig. 2, I, A). In this series the motor response (when it appeared) took the form of slight nodding of the head, blinking, or an increase or cessation of the respiratory movements of the alae nasi. Conversely, in the experiments of series II, the motor response was strong and prolonged. The animals responded to stimulation by the vibrator with a generalized motor response, by shaking (at the first extinctions), and by turning the head toward the side of stimulation, and this response was marked by a considerable after-effect. In the pauses between stimuli, the animals frequently made voluntary movements. Extinctions of the OR took place after 130-140 applications of the vibrator (see Fig. 2, I, A and II, A).

It may also be seen in Fig. 2 that in the experiments of series II a more complete parallel occurred between the changes in motor and ECoG components of the OR, in agreement with data in the literature [3, 8]. Hence, in the experiments of series I and II, the electroencephalographic changes during extinction of the OR are similar in character, whereas the discernibility and magnitude of the motor components differ sharply.

It may be postulated that an orienting reaction of the "hiding" or "pretending to be dead" type (Pavlov's natural caution reflex [5]) is evoked principally from the skin of the head.

This interpretation explains why "poverty" of movements is observed and why the dynamics of the ECoG in the experiments of series I were those usually observed for extinction of the OR. Evidently, when analyzing changes in the EEG, more attention should be paid to the ecological adequacy of the stimulus, reflected, in particular, in the skin analyzer in the fact that stimulation of different skin areas may evoke biologically different orienting reactions.

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