CODE MODELS OF SENSORY INFORMATION FROM SKIN Analyzer Periphery

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Experimental studies on the relations between the afferent flows in Aβ-, Aδ-, and C-fibers of a skin nerve for different stimulations of skin receptors provided the basis for modeling of various digital and graphic codes of known and unknown sensations.

INTRODUCTION

Models of a code for external stimulation in afferent activity basically have the purpose of describing the principles of coding in a single transmission channel (nerve fiber) [1, 6, 8]. The basis for developing the models was the results of electrophysiological investigations. The results were obtained using a lead from an afferent fiber bound with one receptor. However, such an approach could not provide a complete representation of the codes of pulses arriving in the central nervous system in response to natural stimulations of the skin [5]. No matter what small object (for example, a hair) touched the skin, it unavoidably deforms a certain area of skin and excites several receptors. Information on such stimulation in the form of pulses is transmitted in a parallel manner along many nerve fibers at different conductance rates. Thus, the activity of a certain structure or space-time pattern arrives in the central nervous system.

Integrative methods were employed to analyze the afferent activity elicited by the activation of an entire receptor field and demonstrated differences between pulse flows in mechanical, temperature, and pain sensations on skin receptors. These differences are in the distributions of current densities along the main groups of afferent fibers: Aβ, Aδ, and C [2, 9].

Figure 1 presents graphs of the relations of pulse currents in Aβ, Aδ-, and C-fibers of a skin nerve in a cat in response to stimulation of the receptors by touch, using a cold or air current on the fur or by means of pricking. It is apparent that the number of active fibers, the frequency of pulsation in them, and the temporal parameters under conditions of the use of each stimulus differ markedly. This figure does not show the low-frequency tonic activity in Aδ- and C-fibers. This activity decreases with moderate thermal stimulation of the skin receptors [3, 7].

The quantitative characteristics of afferent currents that were determined in animal trials are described by codes that arise in response to actual stimulation of the skin receptors. We know that the relation of the activity in A- and C-fibers is very important. It has been experimentally demonstrated that nociceptive reaction occurs when the afferent current in the C-fibers in comparison with that in the A-fibers differs in the great density of pulsation. However, if we artificially increase the current density in the A-fibers, the nociceptive reaction stops [4].

METHODS

Our code model in the skin analyzer periphery is based on statistical probability combinations of parameters of the current densities in modal groups of nerve fibers. The number of physiologically significant combinations is determined using the equation

\[ 1 + R^{N(S-l)} \frac{N-l}{N} R^{(N-l)(S-l)}, \]

where S is the number of parameters that describe the afferent current along the fibers of a

Fig. 1. Structure of afferent currents in Aβ, Aδ, and C groups of fibers when skin receptors are exposed to various stimuli. Z axis is the relative number of active fibers; X axis is the time, sec; Y axis is the frequency of afferent pulses. The arrows mark the moment at which the stimulus is given. 1) Tactile stimulus (pin touching, 5 pins per cm², 0.005 N per pin); 2) cold exposure (at 10 deg, 1 deg C/sec); 3) air current (4.2 Pa); 4) pain stimulus (needle prick, five needles per 1 cm², 0.05 N per needle).

RESULTS AND DISCUSSION

The afferent current may be more completely described with five parameters. Since the code is characterized by the distribution of pulse currents in three groups of nerve fibers, 15 parameters were examined in the model. Taking into account the fact that only two conditions of each parameter are significant, and each change of even a single parameter creates a new code, we obtained 4,913 code combinations.

The model built using nine parameters in which the afferent flow was characterized by...