SINGLE UNIT RESPONSES OF THE DENTAL PROJECTION AREA OF THE RABBIT SENSOMOTOR CORTEX TO PHOTIC, ACOUSTIC, AND NOCICEPTIVE STIMULATION OF THE DENTAL PULP

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In experiments on waking rabbits interaction between acoustic (tones, clicks), photic, and nociceptive excitation arising during stimulation of the dental pulp on sensomotor cortical neurons in the region of representation of dental afferents was investigated by a microelectrode technique. Bisensory and polysensory convergence of excitation was shown to take place on the cells in this region. It is suggested that convergence of excitation lies at the basis of the mechanisms of formation of the integral systemic nociceptive response to stimulation of the dental receptors.

KEY WORDS: dental projection area; convergence; dental pulp receptors; pain.

Convergence of excitation of different sensory modalities on brain neurons, a subject which many investigators are currently studying, lies at the basis of analysis and synthesis of external and internal environmental stimulation and enables the body to form integrated adaptive reactions adequate to ensure achievement of the final result of adaptation [1]. One such useful final result of adaptation in the functional system of the nociceptive response to stimulation of the dental receptors, is abolition of the action of the harmful agent [4] and the removal of the various automatic motor and emotional changes (cardiac activity, blood pressure, respiration) accompanying dental pain [6]. An important role in these processes is played by the convergence of excitation on neurons of various brain structures, which is reflected in the responses of their cells.

The object of this investigation was to study unit responses in the somatosensory system and, in particular, of the dental projection cortex on photic, acoustic, and nociceptive stimulation of the dental pulp.

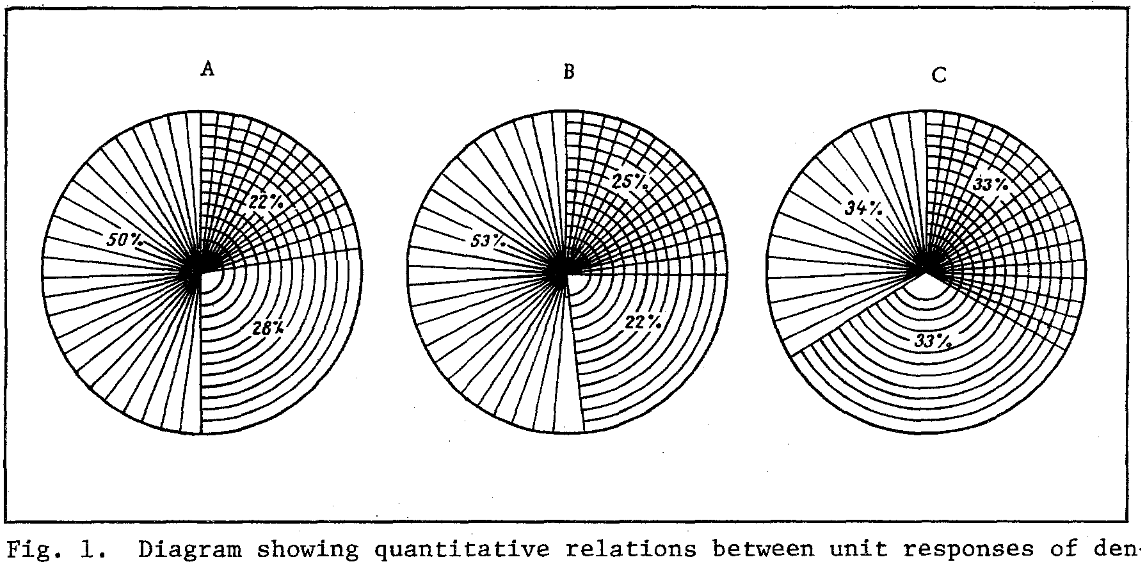

Fig. 1. Diagram showing quantitative relations between unit responses of dental projection area of sensomotor cortex to acoustic — tones (A) and clicks (B) — and photic (C) stimulation. Explanation in text.

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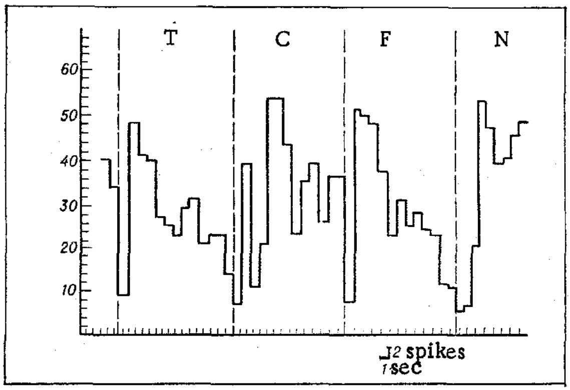

Fig. 2. Histogram of discharge activity of neuron responding equally (by inhibition of spike activity) to tones (T), clicks (C), flashes (F), and nociceptive stimulation (N) of pulp of upper incisor. Abscissa, number of spikes generated by neuron per second; ordinate, time (in sec).

EXPERIMENTAL METHOD

Responses of 100 neurons of the sensomotor cortex in the projection zone of dental receptors were investigated in experiments on 14 waking rabbits. Unit activity was recorded by glass microelectrodes filled with 2.5 M KCl (diameter of tip 1-2 μ, resistance 5-10 MΩ). The electrodes were connected alternately to a UBP 1-02 cathode follower. Unit discharges were recorded on a two-channel electromyograph. Changes in the discharge patterns of the neurons were recorded in response to acoustic and photic stimulation and nociceptive stimulation of the dental pulp. The dental pulp was stimulated by single square pulses of current of threshold intensity (1 ± 0.5 V, 1 msec). The results were subjected to statistical analysis. Analysis of changes in the spike discharge of 100 neurons in the dental projection area of the sensomotor cortex in response to a series of stimuli (tone—click—light—nociceptive stimulation of the tooth) showed the following results: 83 of 100 cells responded to a series of stimuli presented to the animal and 17 neurons did not respond. Of the total number of responding neurons (83, 100%), 62 (75%) modified their spontaneous discharge in response to a pure tone, 31 of them (50%) by an increase in the spontaneous discharge frequency, 17 (28%) by a decrease in the spontaneous frequency (inhibition), and 14 cells (22%) by a polyphasic response (Fig. 1A). Of the 83 responding cells, 55 (66%) changed their spontaneous discharge frequency in response to clicks. Of the total number of neurons responding to clicks, 29 (53%) increased their discharge frequency (excitation), 12 neurons reduced their frequency (inhibition), and 14 cells (25%) gave a polyphasic response (Fig. 1B). A response to flashes was given by 58 cells (70%), 20 of which (34%) responded by an increase in the spike frequency, 19 cells (33%) by inhibition of discharges, and another 19 neurons (33%) gave a polyphasic response (Fig. 1C). In response to nociceptive stimulation of the dental pulp of an upper incisor, 72 cells altered their spontaneous discharge pattern. Of this number 31 (43%) responded by excitation, 22 (31%) by inhibition of spike activity, and 19 cells (26%) gave a polyphasic response. Of the total number of responding cells (83) of the dental projection area of the sensomotor cortex, 54 (65%) were polysensory, 20 (24%) were bisensory, and 9 cells (11%) were monosensory. Unit responses of the dental projection area of the somatosensory cortex to different sensory stimuli were either different or similar in character. In particular, as will be clear from the histogram of discharge activity of a neuron illustrated in Fig. 2, the cell responded equally — by inhibition of spike activity — to both nonnociceptive (pure tones, clicks, flashes) and to nociceptive stimulation of the pulp of the upper incisor. The cell responded to nociceptive stimulation of the tooth by more prolonged inhibition of spike discharges. Such a marked response, it can tentatively be suggested, is attributable to the fact that nociceptive stimulation is of greater biological significance to the organism.

Responses such as these can be interpreted as polysensory on the basis both of a change in spike activity in response to peripheral stimulation and of the appearance of responses of the neuron to photic and acoustic stimulation after nociceptive stimulation of the dental pulp [4]. The explanation evidently lies in the strengthening of ascending activating influences of subcortical formations on the cortex, which is expressed as an increase in the volume of convergence on the neurons and their ability to give polysensory responses.

The results thus suggest that interaction between excitation of different sensory modalities can take place on neurons of the dental projection area. Excitation of at least two modalities converges on 20 (24%) of the 83 responding neurons, and excitation from nociceptive receptors of the tooth and photic and acoustic receptors converged on 54 (65%) cells. This is evidence that bisensory and polysensory convergence of excitation takes place on neurons of the dental projection area. The percentage of polysensory neurons in the dental projection area of the cortex, as in other parts of the sensomotor cortex, is very high [2, 3, 5]. Convergence of excitation of cells of the dental projection area of the sensomotor cortex, it can be postulated, provides the basis for the analysis of integration of afferentation, integrated dynamically into the cardinal mechanisms of the functional system formed during nociceptive stimulation of the dental pulp and aimed at achievement of the useful adaptive end result.

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