EXCITATORY INTERACTIONS IN NEURONAL NETWORKS
WHICH INCLUDE CELLS OF THE AUDITORY CORTEX AND
THE MEDIAL GENICULATE BODY

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The use of the method of cross-correlation analysis to elucidate the interactions between simultaneously
recorded neurons from various loci of the auditory cortex (AC) and the medial geniculate body (MGB) has
made it possible to identify the following characteristics of the functional organization of the excitatory
interactions in the thalamocortical neuronal networks: the interdependant impulse action of neurons located
at various loci of the AC and MGB was determined by reciprocal excitatory connections; the efficiency of the
connections between neurons of the AC, 400-500 µm apart, and between tonotopically associated neurons of
the AC and MGB was approximately identical (associations were identified in 12% of the cases); the
"divergent" properties of the MGB (AC) neurons were manifested in the fact that one and same neuron could
simultaneously excite both neighboring cells and neurons from one or several loci of the AC (MGB); the
"convergent" properties of the AC and MGB neurons were manifested in the fact that cells located at various
loci of the AC and MGB simultaneously excited one neuron. The results make it possible to explain the
deviations observed in the investigation of RF of neurons of the AC and MGB from the principle of tonotopical
organization. It is hypothesized that the character of the organization of the excitatory connections in the
thalamocortical networks may promote the creation of the necessary conditions for the modification of the
efficiency of synapses between all of the elements of the network during the stimulation of individual elements.

It is known that field A1 of the auditory cortex (AC) and the ventral portion of the medial geniculate body (MGB) are
characterized by tonotopical organization [17, 18, 19, 25]. Thus, cells which are located in the rostral portion of the A1 field
respond primarily to high frequency tones, while those which are caudally placed respond to low frequency tones [19]. In the
MGB, cells responding preferentially to tones of various frequencies are disposed in the dorsoventral direction [18]. However,
significant deviations from this principle have also been found. For example, we recorded, in the rostral portion of the A1 field,
the activity of cells, the receptive fields (RF) of which were characterized by a low preferred frequency, while in the caudal
portion we recorded cells responding primarily to high frequency tones [6]. Moreover, neurons more than 1 mm apart from
one another which had similar RF, and cells lying within the recording area of one microelectrode (ME) which had different
RF were found at the same time. This is also suggested by the data of other investigations of the RF of neighboring neurons
both in the AC [12] and the MGB [18].

The functional characteristics of neurons of the new cortex and, in particular, their RF, apparently must be determined
to a substantial degree by the organization and efficiency of the synaptic connections in networks which include neurons of the
cortex and the corresponding projection nuclei of the thalamus. Deviations from the principle of tonotopical organization may
partially be explained by cortical interactions. The similarity of the RF of remote neurons may be the result of the horizontal
spread of excitation in the cortex, which, as is indicated in studies [11, 13], is highly efficient. This hypothesis is confirmed
by data on the strong correlation in the activity of neurons of the cortex which have similar RF and which are 2 mm apart from
one another [23].
Fig. 1. Interdependant activity of neurons recorded with different amplitudes of the action potentials (AP). A) Representation of the AP of neurons whose activity was recorded by one ME in the form of "clusters" in a two-dimensional coordinate space; B) example of a CCH reflecting a monosynaptic excitatory connection. C) Example of a CCH reflecting the action of a "common source," on which an excitatory interaction was superimposed; D) example of a CCH which reflects the simultaneous activation of neurons; E) example of a CCH which reflects the action of a "common source." Along the ordinate: number of spikes; along the abscissa: time, msec. All CCH plotted without regard to the action of the stimulus. The zero time marker, in the middle of the abscissa.

In addition, thalamocortical connections which in the main determine the topical organization must influence the functional characteristics of neurons of the new cortex. Deviations from the topical organization may occur if the axonal collaterals of one thalamic neuron efficiently excite not only the group of neighboring cells of the cortex belonging to one column, but remote neurons as well, and thus provide for the similarity of their RF. In turn, if axons of cells from remote loci of the thalamus which have different RF terminate in the same segment of the cortex, and if their influence on each of the neighboring cells is not identical, then the RF of the latter will also be different.

It seemed of interest in connection with these hypotheses to investigate the character, efficiency, and principles of organization of connections functioning simultaneously in the thalamocortical neuronal networks, which include a large number of elements from various segments of the MGB and AC. Numerous data regarding the excitatory and inhibitory interactions between neurons of the new cortex and the corresponding projection nuclei of the thalamus have been obtained using electrophysiological methods [3, 24]. Morphological investigations have made a major contribution to the description of the