SHORT NOTE

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Responses of the auditory cortical neurons to complex sounds

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We have made experiments to find the sound stimulus which could elicit the sustained response in auditory cortical units of cats. We have already reported[1] that the auditory cortical units were divided into three groups based upon the response property to pure tones and bands of noise; PT units (which responded better to pure tones), BN units (which responded better to bands of noise) and NR units (which did not respond to these two stimuli). In the present experiments, responses of BN and PT units were analyzed by making three-dimensional representation in terms of stimulus frequency, intensity and spike count elicited. Synthesized formants were applied to NR units as a possible stimulus to evoke the sustained response.

Method

The experimental procedure was identical with that described in the previous paper.[2] Unanesthetized cats paralyzed with Flaxedil were used. Single unit isolation was accomplished from the left primary auditory cortex with glass micropipettes. Free-field acoustic stimuli were applied to the animal in a sound-proof room. The sound stimuli used were pure tones, bands of noise generated by amplitude-modulation, bands of noise generated by frequency-modulation, saw-toothedly amplitude-modulated tones, saw-toothedly frequency-modulated tones and synthesized formants. Detailed explanations of these sounds were described in the previous paper.[2]

Results and Discussion

For PT units, responses were recorded to pure tones at various frequencies and intensities. For each BN unit, we determined the best bandwidth at first which was independent of the center frequency. Then responses of the BN unit to bands of noise with the best bandwidth were examined at various center frequencies and intensities. Amounts of responses of these units were represented as iso-spike-count contour maps on a frequency intensity plane (for BN units the frequency axis represents the center frequency of the band of noise). There was the best intensity at every frequency and the discharge elicited decreased not only at lower but also at higher intensities. The response area of each unit extended over a wide frequency range but the effective frequency range was intervened by less effective frequencies. Consequently, several peaks of the spike count were exhibited within the response area. The results suggested that PT and BN units receive inputs from several different populations.

As reported in the previous paper,[2] we found the units which responded exclusively to a synthesized formants. Out of 30 NR units tested with synthesized formants, 10 exhibited sustained responses to the stimuli. The best formant frequencies of them were between 2000 and 23000 Hz. The effective range of formant frequency for each unit was so restricted that about 10% deviation of the formant frequency made the stimulus ineffective. The best bandwidth of components of the synthesized formant varied from 0 to 180 Hz. In some exceptional cases wide bands of noise centered at the best formant frequency were slightly effective. All of the units were unresponsive to saw-tooth amplitude-modulated tone. They might act as formant detectors in the cortical sound discrimination. The response properties of the formant detectors were well explained by a model of neuron networks in which a formant detector received inputs from many sharply tuned neurons with inhibitory areas at both sides of the excitatory area.

The BN units as well as the formant detectors were thought to receive the synaptic convergence, though effective stimuli of BN units were not so restricted as formant detectors. Further experiments will make the relationship between BN units and formant detectors clear.

References

1) N. Maruyama and K. Saitoh, J. Acoust. Soc. Jpn. (E), **2**, 131 (1981).
2) N. Maruyama, K. Saitoh, and M. Kudoh, Proc. Jpn. Acad. **55** (B), 413–417 (1979).