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PREDICTIVE MODEL OF THE AUDITORY PROCESS AS RELATED TO COMMUNIC--ETC(U)
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Studies involving the coding of complex stimuli in the cochlear nerve revealed that recovery functions for auditory nerve discharge rate following one minute exposures to tones resulted in increased rapidity of recovery as test tone intensity increased. Recovery time-constant is a monotonic decreasing function of test intensity and exposure intensity. Recovery of human detection thresholds were measured following similar exposures and it was found that recovery time-constant is a monotonically decreasing function of

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test-tone intensity but is a non-monotonic function of exposure tone intensity. Measurements of rate versus level functions for auditory nerve fibers for tone stimuli indicated there is a continuum of saturation behaviors related to fiber thresholds and that rate-level functions slopes depend on both frequency of tone and threshold of the fibers. A stimulus-response relation for two-tone stimuli was expanded to consider those where the ratio of component amplitudes were held constant. This case correspondes to a continuous spectrum signal (e.g., speech) whose spectrum is held constant while overall amplitude is varied. The first study of coding in the cochlear nerve was completed and published. It showed that the stimulus transformations performed by the avian cochlea are similar in most respects to those performed by the mammalian cochlea. Results dealing with the coding of stimuli in avian cochlear nuclei showed nucleus magnocellularis presents a homogeneous population of cells, whereas cells in the nucleus angularis are more complex and are of at least three types based on response and inhibitory areas.

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FINAL TECHNICAL REPORT - CONTRACT No. F44620-76-C-0066

PREDICTIVE MODEL OF THE AUDITORY PROCESS AS RELATED TO COMMUNICATION SYSTEMS

I. Coding of Complex Stimuli in the Cochlear Nerve

All of the work related to this part of the project has been published. A brief statement of results will be given here.

1. Adaptation in the Cochlear Nerve: Physiology and Psychophysics

A. Recovery functions for auditory nerve discharge rate following one-minute exposures to tones were measured with the following results:

- i. Recovery proceeds more rapidly as test tone intensity increases. Recovery time constant is a monotonic decreasing function of test intensity.
- ii. Recovery time-constant is a monotonically decreasing function of exposure intensity.

B. Recovery of human detection thresholds were measured following similar exposures with the following results:

- i. Recovery time-constant is a monotonically decreasing function of test-tone intensity.
- ii. Recovery time-constant is a non-monotonic function of exposure tone intensity, increasing at low levels and decreasing for higher levels.
- iii. The psychophysical results are predicted by a signal detection model based on the physiological results.

References:

Young, E. and Sachs, M. B., Recovery from sound exposure in auditory-nerve fibers, J. Acoust. Soc. Am. 54: 1535-1543 (1973).

Young, E. and Sachs, M. B., Recovery of detection probability following sound exposure: comparison of physiology and psychophysics, J. Acoust. Soc. Am. 54: 1544-1553 (1973).

Young, E. D., Recovery from Sound Exposure -- A Comparison of Psychophysics and Physiology, Ph.D. Thesis, Johns Hopkins University, 1972

2. Responses to Pure Tones

A. Rate versus level functions for auditory-nerve fibers for tone stimuli have been measured with a number of surprising new results:

i. There is a continuum of saturation behaviors related to fiber thresholds.

ii. Slopes of rate-level functions depend on both the frequency of tone and threshold of the fibers.

These results are accounted for by a model relating basilar membrane displacement to fiber discharge rate via a saturating nonlinearity.

References:

Sachs, M. B. and Abbas, P. J., Rate versus level functions for auditory-nerve fibers in cats: tone-burst stimuli, J. Acoust. Soc. Am. 56: 1835-1847 (1974).

3. Responses to Tone-Tone Stimuli

An earlier stimulus-response relation for two-tone stimuli has been expanded. The cases considered were those where the ratio of component amplitudes were held constant. This case corresponds to the situation in a continuous spectrum signal (e.g., speech) whose spectrum is held constant while overall amplitude is varied.

Gross differences in behavior were found for second tones above and below fiber CF. These differences were well accounted for by an extension of our single-tone model.

References:

Abbas, P. J. and Sachs, M. B., Two-tone suppression in auditory-nerve fibers: extension of a stimulus-response relationship, J. Acoust. Soc. Am. 59: 112-122 (1976).

Abbas, P. J., Discharge Rate of Auditory-Nerve Fibers to Two-Tone Stimuli: An Experimental Study and a Model, Ph.D. thesis, Johns Hopkins University, 1974.

Sachs, M. B. and Abbas, P. J., Phenomenological model for two-tone suppression, J. Acoust. Soc. Am. 60: 1157-1163 (1976).

II. Coding of Stimuli in the Avian Cochlear Nerve

The first study of coding in the cochlear nerve was completed and published. This study showed that the stimulus transformations performed by the avian cochlea are similar in most respects to those performed by the mammalian cochlea.

Reference:

Sachs, M. B., Lewis, R. H., and Young, E. D., Discharge patterns of single fibers in the pigeon auditory nerve, Brain Research 70: 431-447 (1974).

III. Coding of Stimuli in the Avian Cochlear Nuclei

This project has been completed and is being prepared for publication. The major results are:

A. Nucleus magnocellularis presents a homogeneous population of cells, characterized by responses to tones similar to those of fibers in the cochlear nerve. The one exception is that the response areas of these cells are flanked by inhibitory sidebands. Tones in these sidebands inhibit the cells' spontaneous activity.

B. Cells in nucleus angularis present a more complex picture. There are at least three types based on response and inhibitory areas:

i. Some cells show only excitatory responses.

ii. Some cells show a central excitatory response area flanked by inhibitory sidebands.

iii. Other cells show central inhibitory areas with complicated excitatory response bands.

There are at least four types of response patterns to tones in these cells. These are similar to those seen in mammalian cochlear nuclei:

i. Primary-like
ii. Pauser
iii. Onset
iv. Chopper

Reference:

Sachs, M. B. and Sinnott, J. M., Unit responses from the cochlear nuclei of the red-winged blackbird, Neuroscience Abstracts 2: 24 (1976).

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Sachs, M. B., Quantitative studies of the responses of auditory-nerve fibers to two-tone stimuli, in Sachs, M. B. (Ed.), The Physiology of the Auditory System: A Workshop, National Educational Consultants, Baltimore, Maryland, pp. 113-124 (1971).

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Young, E. D. and Sachs, M. B., Recovery from sound exposure: comparison of human performance and responses from single auditory-nerve fibers in the cat, J. Acoust. Soc. Am. 52: 131A (1972).

Sachs, M. B., Lewis, R. H., and Young, E. D., Some properties of response patterns in the cochlear nerve of the pigeon, J. Acoust. Soc. Am. 52: 142A (1972).

Abbas, P. and Sachs, M. B., Two-tone suppression in cat auditory-nerve fibers: comparison of frequencies above and below fiber CF, J. Acoust. Soc. Am. 55: 466A (1974).

Sachs, M. B., Abbas, P. J. and Bevan, M. F., Discharge rate as a function of stimulus level for tones or noise in cat auditory-nerve fibers, J. Acoust. Soc. Am. 55: 466A (1974).

Sachs, M. B. and Sinnott, J. M., Unit responses from the cochlear nuclei of the red-winged blackbird, Neurosciences Abstracts 2: 24 (1976).

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Sachs, M. B. (Ed.), The Physiology of the Auditory System: A Workshop, National Educational Consultants, Baltimore, Md. (1971).

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