Semiannual Report, Contract Nonr-3579(04)
1 June 1966 through 30 November 1966
Supported by Fund Transfer R-129 from
Office of Grants and Research Contracts,
National Aeronautics and Space Administration

and

Tenth Quarterly Status Report
NASA Number R-129-09-030-017
1 September 1966 through 30 November 1966

25 January 1967

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by

Lloyd A. Jeffress

I. STATUS OF PROPOSED PROBLEM

A. Method of Free Response
(C. S. Watson and T. L. Nichols)

Work on the problem has been completed and a paper covering part of the work will be delivered at the December 1966 meeting of the American Association for the Advancement of Science. An abstract of the paper is included in the appendix.

B. Detection Performance and Two Parameters of the Auditory Stimulus
(T. L. Nichols)

Work on the problem has been completed. A paper covering part of the work was presented at the November 1966 meeting of the Acoustical Society of America. An abstract of the paper appears in the appendix, and the study is being prepared for publication.

C. Effects of Visual Adaptation of the Detection of a Visual Stimulus
(G. H. Jacobs and H. A. Gaylord)

Detection of a brief visual stimulus in the presence of "noise" generated by chromatic and achromatic adaptation is being studied. The preexposure to light appears to generate neural activity which acts as a kind of "noise" in the detection process. The subjects' responses are in the form of rating, so that ROC curves can be obtained from the experimental data.

D. Signal Detection and the Width of Critical Bands
(R. B. Evans and L. A. Jeffress)

Work on this problem is underway. The preliminary results suggest that the band for a 500 Hz signal is narrower than many estimates have indicated, and that the shape is decidedly asymmetrical. The availability of the new recording system (described in paragraph F) makes possible the taking of data for several different signal levels in a single sitting, so that psychometric functions for the various filter combinations will be generated.

E. Psychometric Functions for an Ear Model: Effect of Duration
(L. A. Jeffress and A. D. Gaston, Jr.)

This work has been completed and is appearing as an article in the February issue of the Journal of the Acoustical Society of America. Offprints will be distributed as a Defense Research Laboratory Acoustical Report.

F. Programming, Punched-Card Recording Equipment
(A. D. Gaston, Jr.)

This equipment has been finished and has been in operation for several weeks. The punched-tape programmer can present noise alone and/or seven different levels of signal to four subjects at a time. The magnitude of the stimulus and whether it occurred in the first or second interval is punched on an IBM card. The next four columns record the subjects' responses, and these may be yes-no, first-or-second interval, or a 10-point rating response. The sequence is repeated so that 16 stimuli and the corresponding 64 responses are recorded on a single card. Programs for the CDC 3200 computer have been written to process the data and yield P(C) and d' for two-alternative, forced-choice trials, and ROC curves for the rating experiments. The equipment is sufficiently versatile so that it also permits automatic programming and recording of pedestal experiments and experiments in pitch discrimination. A detailed description of the equipment is being prepared for issuance as a Defense Research Laboratory Acoustical Report.

G. <u>ROC Curves for Multilevel Signals</u>
(A. Tucker and R. B. Evans)

ROC curves are being obtained from four subjects, using the apparatus described in paragraph F. Preliminary findings indicate that smooth ROC curves are obtainable with remarkably few trials, compared with what would be required if each of the signal levels used were employed in single-level experiments. A paper describing the results is being presented at the April 1967 meeting of the Acoustical Society of America. An abstract of the paper is presented in the appendix.

H. <u>A Binaural Electrical Model</u>
(L. A. Jeffress and A. D. Gaston, Jr.)

A binaural electrical model has been constructed which appears to give masking-level differences similar to those with human observers, and which shows a similar dependence on signal duration. A paper describing the model is being presented at the April meeting of the Acoustical Society of America. An abstract of the paper is presented in the appendix.

APPENDIX

ABSTRACT

Performance of Listeners and of an Artificial Ear on a Vigilance Problem

by

Charles S. Watson*

It has been shown that a human listener, when detecting a signal in a noise background, behaves as though he is measuring the maximum amplitude of the output of a signal processing device consisting of a filter, followed by a rectifier and a leaky integrator. This result has been useful in both measuring, and in predicting, the listener's ability to distinguish between background noise (N) and noise to which some signal has been added (SN), when the listeners are informed of the exact instant at which a signal may be presented. When the listeners are not so informed, their problem becomes more difficult: the task is that which has been called vigilance or "watchstanding".

This paper applies the filter-rectifier-integrator model to the vigilance case. It is concluded that here too the listener behaves as though he is measuring the output of a simple signal processor. Here, however, he does so continuously, and responds whenever the output exceeds some preselected criterion value. Distributions of the amplitudes associated with SN and N, in such a case, thus must be inferred from distributions of response latencies. A technique for using response latency to estimate a real listener's ability to resolve SN and N is proposed, based on the assumption that amplitude and latency have the same inter-relation for a real listener as for the model.

This approach to the general problem of detection when the exact instant of (potential) signal occurrence is not defined is quite simple, but it is fundamentally different from some earlier approaches in the context of detection theory. Specifically, this continuous detection problem has previously been

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Paper presented at the December 1966 Meeting of the American Association for the Advancement of Science, Washington, D. C.

converted to a discrete one, by assuming that the listener quantizes time into a series of intervals, and that he makes a separate decision following each such interval. Present results suggest that the behavior of both an analog ear and of real listeners may be described quite well without resorting to the time-quantizing assumptions.

These conclusions were reached through a series of experiments in which an electronic analog to the auditory system as well as human listeners were studied. Both simulated and real listeners detected tonal signals in noise, with and without defined observation intervals. The similarity of the performance of real and analog listeners appears to be based in relatively simple relations between amplitude and response latency for both.

ABSTRACT

ACOUSTICAL SOCIETY OF AMERICA, NOVEMBER 1966

Detection Performance and Two Parameters of the Auditory Stimulus. Thomas L. Nichols and Lloyd A. Jeffress, Department of Psychology and Defense Research Laboratory, The University of Texas, Austin, Texas 78712. Four subjects were run in a conventional yes-no psychophysical experiment in auditory masking. The stimulus consisted of a 250 msec burst of wide-band white noise. On 50 percent of the trials, a 500 Hz sinusoidal signal was added to the noise burst. On each trial a record was made of the stimulus (N or SN), the subject's response ("yes" or "no"), his response latency, and two physical measures of the stimulus. These were obtained by using an electronic ear model consisting of a narrow-band filter (simulating the subject's critical band), followed by a rectifier and two measuring devices. One of these determined the magnitude of the largest envelope peak occurring during the stimulus interval, and the other, the average voltage of the stimulus envelope. A series of multiple linear regression equations were constructed to determine the independent contribution of each of the electrical measurements to predicting the nature of the stimulus (N or SN), and the subject's response. The average voltage of the envelope was found to be the more efficient predictor of both stimulus and response. The maximum amplitude was a poor predictor, and added little to that furnished by the average voltage. [Work supported by a contract with the Naval Ship Systems Command, Department of the Navy, and a grant from the National Aeronautics and Space Administration.]

ABSTRACT

ACOUSTICAL SOCIETY OF AMERICA, APRIL 1967

ROC Curves for Multiple Signal Levels in a Detection Task. Ann Tucker, Rand B. Evans (nonmember), and Lloyd A. Jeffress, Department of Psychology and Defense Research Laboratory, The University of Texas, Austin, Texas 78712. Seven signal levels were presented to four observers in a pseudo-random fashion. A 500 Hz tone was used, and the signal duration was maintained at 100 msec with a rise-decay time of 10 msec. Wide-band (100-3000 Hz) continuous noise was used as the masker. The listening interval was indicated by a light, and observers were instructed to classify or rate the loudness of the masked signal, by using one of 10 ordered push buttons. On some trials noise alone was present; on the remaining, $(2E/N_o)^{1/2}$ ranged from 2.0 to 5.0. ROC curves were plotted for each signal level, and a remarkably small number of trials was needed to yield satisfactory curves. The multiple-level rating procedure yields smooth curves for seven signal levels in about the same time previously needed for only one level. The observer's task, to rate the loudness of the stimulus, appeared to be simpler than that of earlier studies, in which he was asked to rate his "certainty" that a signal was present. [Work supported by a contract with the Naval Ship Systems Command, Department of the Navy, and through a grant from the National Aeronautics and Space Administration.]

ABSTRACT

ACOUSTICAL SOCIETY OF AMERICA, APRIL 1967

An Electrical Model for Binaural Detection. Lloyd A. Jeffress and Audley D. Gaston, Jr., Department of Psychology and Defense Research Laboratory, The University of Texas, Austin, Texas 78712. An electrical model that takes a running average of interaural time differences yields results similar to human performance under several binaural conditions, NOSπ, NπSO, and NOSm: with continuous noise and gated signal. It shows a response to signal duration similar to that given by people. Previous models, such as the theta model and the E-C model, have no provision for handling the case of the continuous noise and gated signal, and leave the effect of signal duration under these conditions unaccounted for. The device achieves its measurement of time difference by amplifying and clipping the inputs from the two channels, subtracting one from the other, and discarding differences of one sign while averaging those of the other. The voltage being averaged can be expressed by the following equation:

$E = E_i \frac{e^{t/RC} - 1}{e^{T/RC} - 1}$, where _t_ is the time that, say, the left ear leads the right, T is the period of the center frequency of the narrow-band noise, and E_i is the magnitude of the rectangular input voltage. [Work supported by a contract with the Naval Ship Systems Command, Department of the Navy, and through a grant from the National Aeronautics and Space Administration.]

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