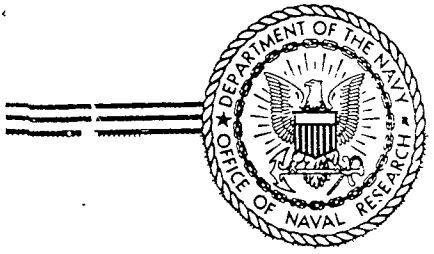

SPECIAL DEVICES CENTER
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TECHNICAL REPORT - SPECDEVCEN 104-2-38

THE RELATION BETWEEN DURATION OF EXPOSURE TO HIGH LEVEL NOISE AND LISTENER ACCURACY

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FOREWORD

Purpose

The effects of noise on human physiology and behavior in industry and military establishments are matters of increasing concern to leaders in these fields. Many aspects of the problem have been investigated and a considerable body of knowledge has been accumulated. It is known, for example, that even brief exposure to high level noise results in a temporarily raised hearing threshold, an arbitrarily induced partial deafness, when the post-exposure hearing test is conducted in a quiet environment.

The present experiment was designed to discover whether noise exposure results in impaired listening ability in a situation in which the individual remains in the noise environment and the listening test stimuli are presented at a constant level with respect to the noise level.

For this purpose, four Listening-in-Noise tests were administered to an experimental and a control group. Between tests, the experimental subjects removed their headphones in the presence of the test noise; the control subjects removed their headphones when the testing noise was cut off and spent the interval between tests in quiet. Within both groups, subjects were exposed to noise and tested over a fifty-minute period while others were tested over a period of three hours and twenty-five minutes.

Results

The results obtained from 198 subjects can be summarized as follows:

1. During either period, listener performance was not affected by exposure to noise between tests.

2. The performances of experimental and control groups were parallel from test to test.

3. During the fifty-minute period, successive test scores were significantly different; during the three-hour and twenty-five minute period, successive test scores were not significantly different.

Implications

From this study, the maintenance of adequate signal strength in voice communications channels would appear to assure the necessary conditions for satisfactory hearing in noise. The desirability of noise reduction in ships and aircraft is obvious and is, in no way, affected by these experimental findings.

Although the results of this study indicate that a decrement in listening ability does not occur under exposure to three hours and fifty minutes of noise, more extensive research is required to determine whether a decrement would occur over a longer exposure period.

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BRIEF OF THE STUDY

Introduction

That prolonged exposure to intense noise impairs the ability to listen in normal, quiet environment is well documented in clinical and research literature; but, although clinical reports (1) indicate that the ability to listen in noise is not adversely affected by exposure to noise, this fact has not been demonstrated in research literature.

From a military operations point of view, the effect of noise exposure upon the ability to listen in the presence of noise is of great importance, since personnel so exposed often remain in the noise environment for prolonged periods of time during which the ability to listen to speech is crucial. A case in point is the pilot of a military aircraft. Is his prolonged exposure to high level airplane noise going to result in impairment of his ability to hear speech signals from the control tower or from other aircraft? This investigation represents an attempt to answer this question.

The purpose of this research was to determine if exposure to high level noise for periods of one or three hours resulted in any impairment of ability to hear speech in noise.

Procedure

Four forms of the multiple-choice Listening-in-Noise (L-i-N) Test were developed from an item analysis of a standard intelligibility test (2). Each form is made up of fifty words and each word is presented within a block of four similar words. The listener is instructed to cross out the word in each group that he hears.

The tests were recorded on a magnetic tape recorder (Presto PT6-j). The talker monitored his voice on a VU meter during the recording session so that the peak intensity of each word was 70 db. The tapes were dubbed onto aluminum base, acetate discs using a Presto 8D-G cutter and associated amplifiers to facilitate playback. A 1000 cps calibration groove was recorded on each disc so that the playback gain could be equated from test to test. A schematic diagram of the apparatus used is shown in Appendix A.

The subjects for this experiment were 198 male undergraduate students ranging from 19 to 32 years of age. Of these, 99 served as experimental subjects and 99 served as control subjects. A further division of the sample was made. Within both experimental and control groups, 80 subjects were exposed to noise and tested in a fifty minute period, while the remaining 19 subjects were exposed and tested over a period of three hours and twenty-five minutes.

Subjects were brought to the testing room (reverberant chamber) ten at a time. (In the three hour portion of the experiment, two of the four panels, one experimental and one control, had nine subjects each. The seating arrangement of subjects in the reverberant chamber is shown in Figure 1.) Between tests, the experimental subjects removed their headphones in the presence of the test noise, whereas the control subjects removed their headphones when the testing noise was cut off and spent the interval between tests in quiet. For all groups of subjects, the ambient noise in the reverberant chamber was 115 db re 10^{-16} watt/cm^2. The signal-to-noise ratio was -3.33, the signal being 99.42 db and the attenuated noise inside the earphone calculated to be 102.75 db (4).

After a short indoctrination period on the use of the headphones, taking of the sample exercise, etc., the first test was given. For those participating in the fifty minute experiment, a second test was given five minutes after completion of the first test, the third test was administered five minutes after the completion of the second test, and the fourth test was administered ten minutes after the completion of the third test. Each test took approximately three minutes. For those participating in the three hour experiment, tests were administered at hour intervals after the first test. In order that no test should have the advantage of a given position, tests were so arranged within listening groups that they appeared an equal number of times in each position.

Each subject was given a multiple-choice answer booklet in which to mark his answers. A listener's score was his percent correct responses.

Results

The statistical treatment of the data is presented in Appendix B. The mean listener accuracy scores for each test are shown in Table I. It will be noted that test scores for experimental versus control subjects in the fifty minute portion of this experiment are not materially different. It will also be noted that within both experimental and control groups there are test-to-test differences of some magnitude (statistically significant).

The results noted for the fifty minute portion of the experiment are seen to be duplicated in the longer exposure portion, that is, experimental and control groups are not significantly different in test scores. A graphical representation of the results obtained from the experimental groups is shown in Figure 2.

Discussion

It can be seen on Figure 2 that the abscissa is a time scale and that the four tests were administered with different time intervals for the fifty minute portion and the longer portion of the experiment.

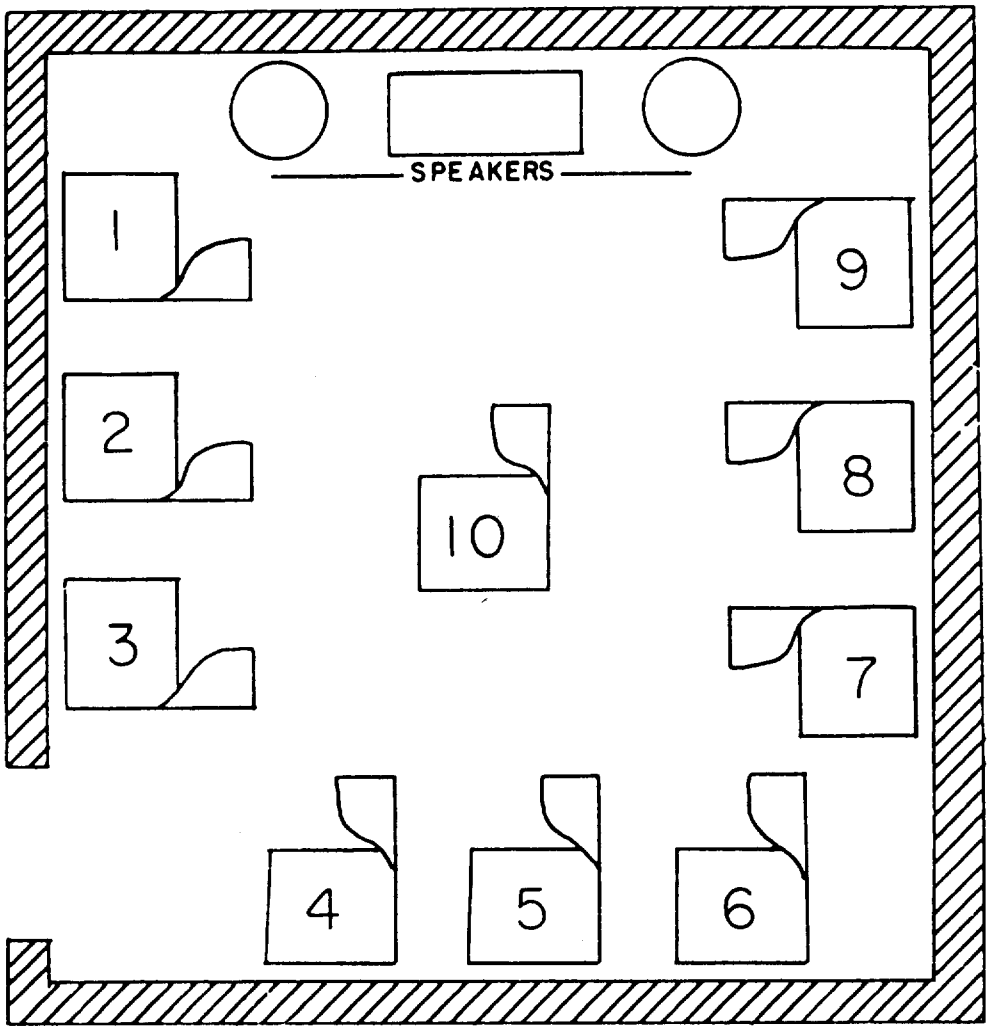

FIG. 1 : SEATING POSITION OF SUBJECTS IN EXPERIMENTAL ROOM.

TABLE I

Listener Accuracy Scores in Percent

50 Minute Exposure

Group	Test I	II	III	IV	Total
Experimental	64.2	67.2	70.4	69.9	67.9
Control	64.6	66.6	68.6	69.4	67.3
Combined	64.4	66.9	69.5	69.6	67.6

3 Hour and 25 Minute Exposure

Group	Test I	II	III	IV	Total
Experimental	69.9	70.8	70.4	68.7	70.4
Control	68.5	73.2	70.3	72.0	71.0
Combined	69.2	72.0	70.4	70.4	70.7

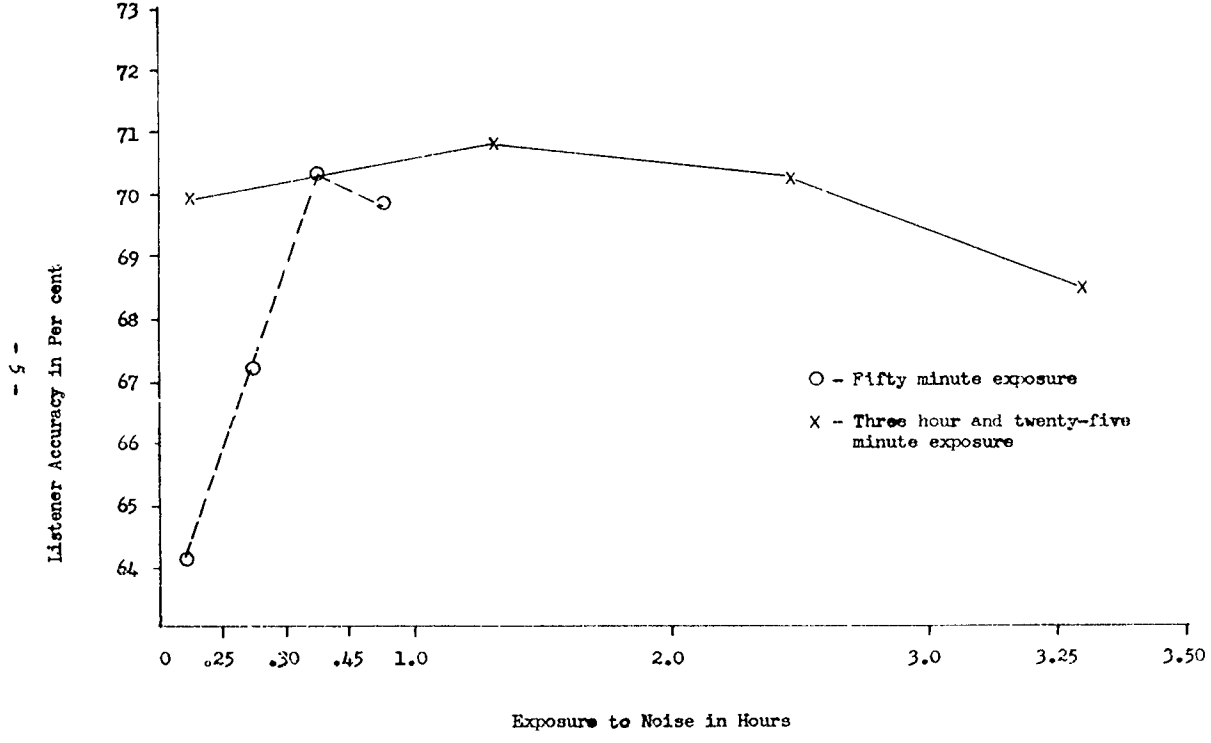

Figure 2. Graphic presentation of listener accuracy scores as a function of duration of exposure to high level noise for the experimental groups

Thus, Test I is comparable in time for all subjects, but Test IV for the fifty minute subjects corresponds approximately to Test II for the subjects in the three hour and twenty-five minute portion of the experiment.

For the fifty minute exposure period, the among-tests difference can be seen to be essentially linear. This linear effect was tested, and the results (see Table II) support this assumption of linearity. Thus, it would seem that during a fifty minute exposure to high level noise a large degree of practice occurs, but no fatigue due to repetition of the task and no decrement in listener accuracy due to exposure to high level noise occur.

Referring again to the approximate correspondence in time of Test IV of the fifty minute exposure period to Test II of the three hour and twenty-five minute exposure period, it should be noted that the practice effect which occurred over the four tests during the fifty minute exposure period is essentially the same amount as between Test I and Test II of the three hour and twenty-five minute exposure period. However, it will be remembered that the test to test difference was not significant for the three hour and twenty-five minute period. This may be due in part to the small number of subjects available for such prolonged exposure to high level noise, 38 subjects or 4 listening panels. More extensive research over the longer exposure period should be performed.

Further inspection of Figure 2 reveals that after the peak of practice (or adaptation) is reached at the end of approximately one hour, no significant decrement in listening accuracy occurs during the next two hours of exposure to noise. Because no difference was found between the experimental and control groups in either the fifty minute or the three hour and twenty-five minute portion of the experiment, it must be assumed that the slight decrement on Test IV of the fifty minute exposure period and after Test II of the three hour and twenty-five minute exposure period was due to chance alone.

APPENDIX A

Arrangement of Instrumentation

A schematic diagram of the apparatus used in this investigation is shown in Figure 3. The code numbers in the blocks represent the following equipment:

Speech Channel

1. Gray phono pickup; "flat" equalization
2. Pre-amplifier, Presto, Model 39B
   a. 50 ohms impedance
3. Speech amplifier, Device 8-I, Serial No. 13
   a. Phone-input jack
   b. 500 ohm fixed load
   c. 200 ohm output to distribution panel
4. Vacuum tube voltmeter, Ballantine Model 300
   a. 1.0 volt range
5. Headphones in test room, 10 pairs
   a. All phones are Type ANB-H-1A with ear seals, Type NAF-48490-1

Noise Channel

6. Harvard Noise Generator
7. Pre-amplifier
8. Power amplifier, RCA Model MI-12235
9. Two speakers, RCA Model MI-2656A and one Jensen Type EP-805 Sound Level Meter
10. Microphone, WE Type 633A, connected to low impedance transmission line
11. Sound Level Meter, Western Electric, Type RA-358
12. Filter set, Western Electric, Type RA-360

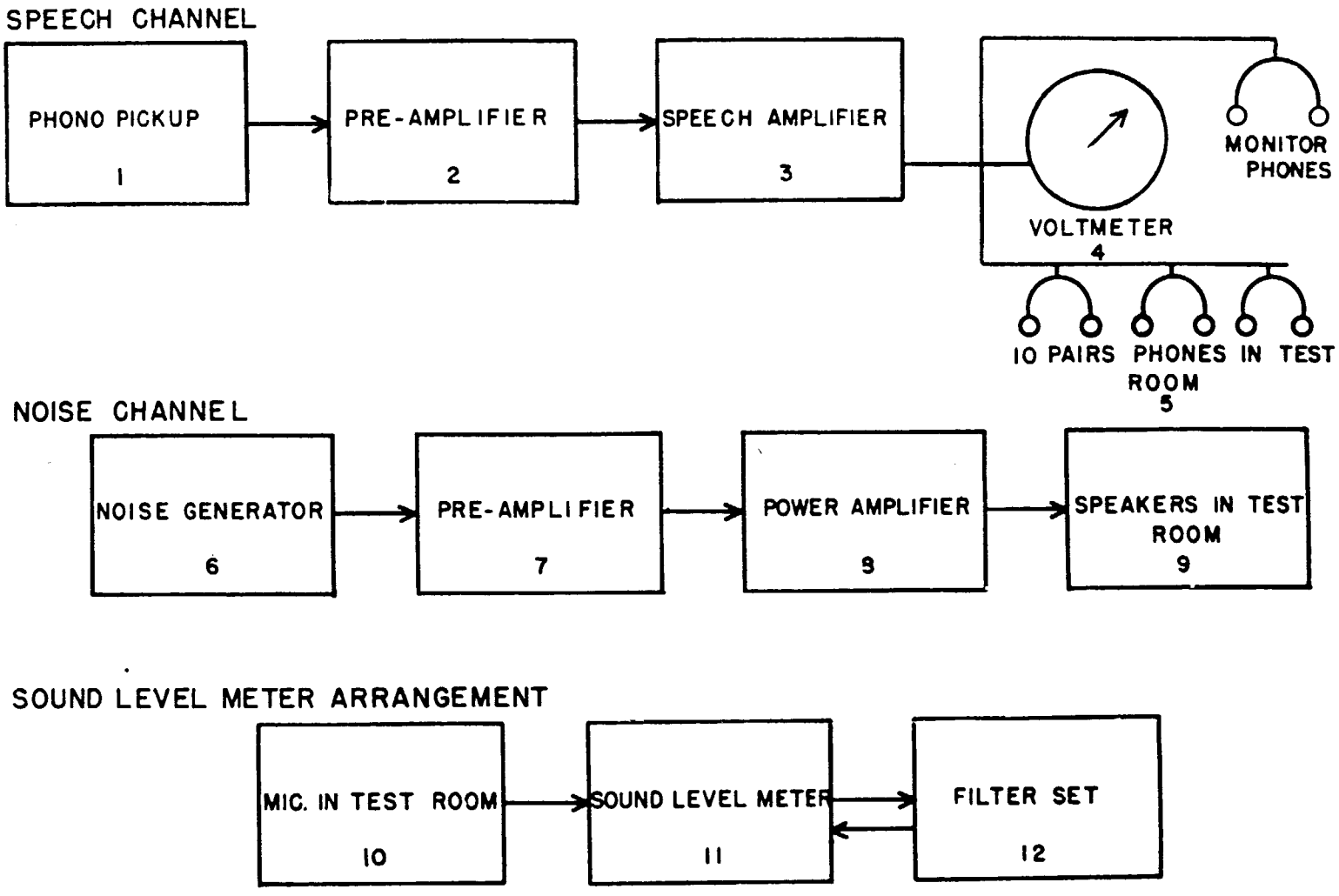

FIG.3: SIMPLIFIED BLOCK DIAGRAM OF EQUIPMENT ARRANGED FOR INVESTIGATION OF LISTENING TO SPEECH-IN-NOISE.

APPENDIX B

Statement of Hypotheses and Tables of Results of Statistical Tests

The hypotheses, stated in the null form, subjected to statistical test by the method of analysis of variance were the following:

1. Within the fifty minute portion of the experiment, there are no significant differences:

   a. Between the experimental and control groups.

   b. Between the successively administered tests.

   c. In the order of the tests within each group.

2. Within the three hour and twenty-five minute portion of the experiment, there are no significant differences:

   a. Between the experimental and control groups.

   b. Between the successively administered tests.

   c. In the order of the tests within each group.

As is to be seen in Table II, hypothesis 1a is accepted, 1b is rejected and 1c (tested by the Trials x Groups Interaction) is accepted.

In summary of the 50 minute portion of the experiment:

A. Listener performance was not affected by exposure versus non-exposure to noise between tests;

B. Successive test scores were significantly different, the rising trend probably being indicative of a learning factor; and

C. The performances of experimental and control groups were parallel from test to test.

Table III reveals the results of the analysis of variance for the three hour and twenty-five minute portion of the experiment. Hypotheses 2a, 2b, and 2c are accepted on the basis of this analysis. In summary of the three hour and twenty five minute portion of the experiment:

A. Listener performance was not affected by exposure versus non-exposure to noise between tests;

Table II

Analysis of Variance of Listener Accuracy Scores

for the 50 Minute Exposure Period

Source		df	Mean Squares	F-ratio	P
Between Experimental and Control Groups		1	71.55		NS
Between Panels Within Groups		14	849.36		
Between Tests		3	1018.85	6.48	< 1%
Linear	1		2756.52	17.54	< 1%
Quadratic	1		247.51	1.57	NS
Cubic	1		52.52		NS
Tests x Groups		3	30.43		NS
Tests x Panels		42	157.20		
	Totals	63			

B. Successive test scores were not significantly different (although the rising trend noted in the fifty minute portion is to be noted here also); and

C. The performances of experimental and control groups were parallel from test to test.

TABLE III

Analysis of Variance of Listener Accuracy Scores

for the 3 Hour and 25 Minute Exposure Period

Source	df	MS	F-ratio	Probability
Between Experimental and Control Groups	1	35.05		NS
Between Panels Within Groups	2	244.54		
Between Tests	3	271.98	4.26*	NS
Tests x Groups	3	42.92		NS
Tests x Panels	6	63.83		
Total	15			

*$F_{0.95}(3,6) = 4.76$

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