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MEMORANDUM REPORT 69-7
A DETERMINATION FOR THE NAVY OF ZERO HEARING
LEVEL FOR SPEECH

M4305.08-3003D.01

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Investigator
James F. Willott

Submitted by:

J. Donald Harris
Head, Auditory Research Branch

Reviewed and Approved by:

Charles F. Gell

Charles F. Gell, M.D., D.Sc.(Med)
Scientific Director
SubMedResLab

Reviewed and Approved by:

Joseph D. Bloom

Joseph D. Bloom, CDR MC USN
Director
SubMedResLab

Approved and Released by:

J. E. Stark

J. E. Stark, CAPT MC USN
Commanding Officer
Naval Submarine Medical Center

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SUMMARY PAGE

THE PROBLEM

To be able to specify Normal Threshold in Speech in the Armed Forces by a standard test.

FINDINGS

A specific phonograph recording of phonetically-balanced monosyllabic word lists, the W-22 discs, were found to yield a mean Speech Reception Threshold of 25 db sound pressure level re 0.0002 μ bar for a group of 23 normal-hearing candidates for the Submarine School. This value is offered as a tentative standard for the armed forces as Zero Hearing Loss for Speech.

APPLICATION

The information presented in this report will be useful for medical and personnel specialists assessing the general speech communication ability of an individual.

ADMINISTRATIVE INFORMATION

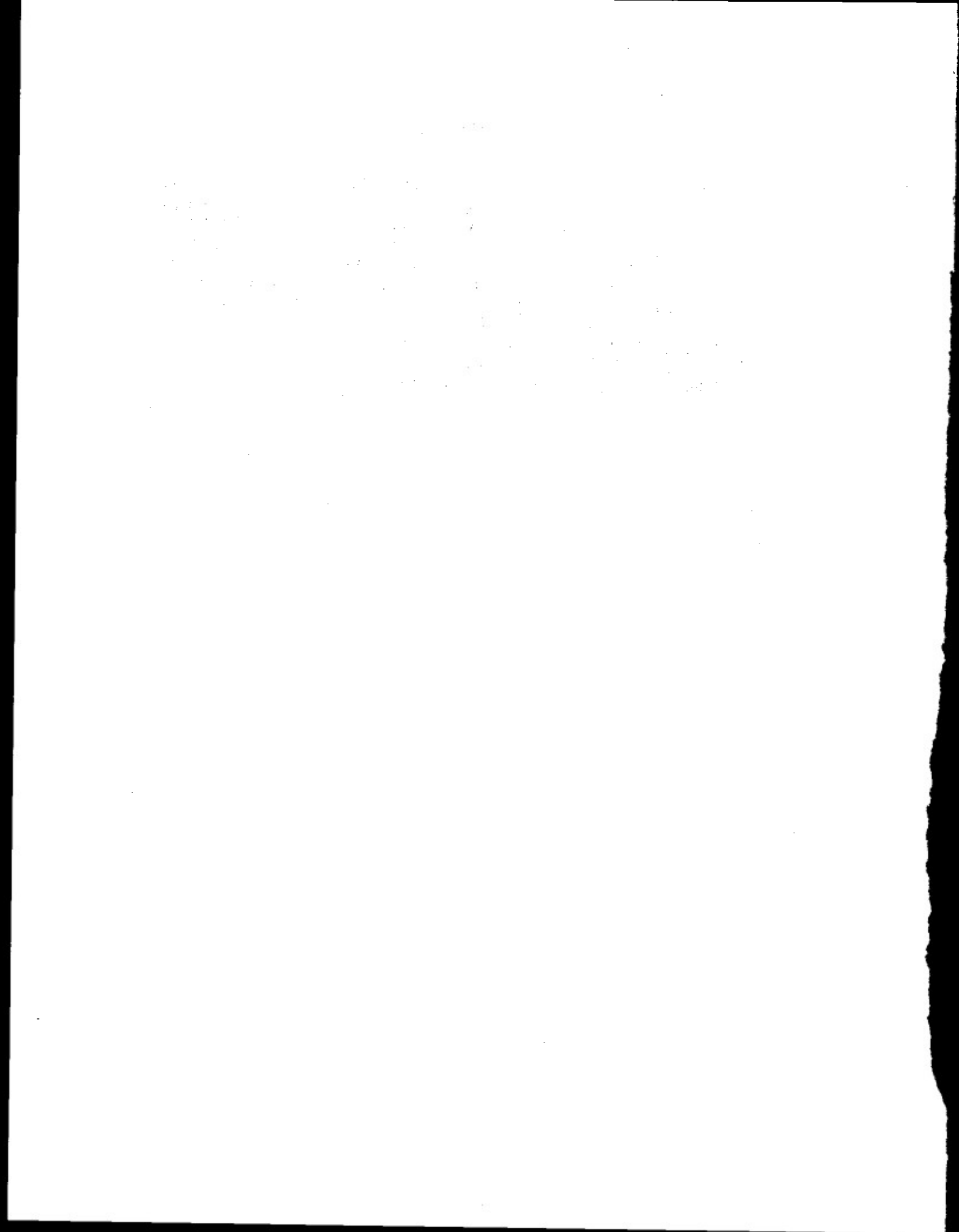
This investigation was conducted as a part of Bureau of Medicine and Surgery Research Work Unit M4305.08-3003-D—Validation of Speech Audiometry in Submarines. The manuscript for the present report was approved for publication on 25 July 1969, and designated as Memorandum Report No. 69-7. The present report is No. 1 on this Work Unit.

The author is a graduate student in the Psychology Department, Connecticut College, under ONR contract No. N00014-67-C-0466, working in the Auditory Research Branch, SubMedResLab on a part-time basis.

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ABSTRACT

Twenty three normal-hearing candidates for the Submarine Force were examined for Speech Reception Threshold (SRT) by speech audiometry using phonetically-balanced (PB) lists of monosyllables instead of the usual spondee words. Such PB words are felt to be considerably better in assessing the important frequency regions for daily speech communication, namely, 500-2000 cycles per second. The Navy threshold for SRT_{PB} is 25 db sound pressure level re 0.0002 dyne/cm², or 6 db higher than the standard $SRT_{Spondees}$. A standard speech audiometer, now calibrated for spondees according to USA Standards Institute specifications, can then be used with the PB lists by subtracting 6 db from the Hearing Level dial reading to arrive at the particular subject's SRT_{PB} .



A DETERMINATION FOR THE NAVY OF ZERO HEARING LEVEL FOR SPEECH

I. INTRODUCTION

The physical requirements of auditory acuity for entrance into the Submarine Force are based upon an average Hearing Level (HL) in each ear of no greater than 25 decibels (db) (ISO 1964 Standards), over the frequencies 500-1000-2000 cycles per second (c/s). National committees for several decades have held that HLs in excess of 25 db will result in some reduced ability to understand speech. The assumption is made, and supported by many studies, that acuity for speech, and for pure tones over these two octaves, are strongly related. It is important here to realize that what the Navy really desires is an estimate of how well the candidate can hear speech in his usual duties—the audiogram is taken largely to form such an estimate.

There is, however, a certain imprecision amounting to a blur of about ± 5 db in predicting the HL for speech in an individual ear from the average HL for pure tones in that ear. Furthermore, since important frequency cues for speech reception exist at regions higher than 2000 c/s, specifically, at 3000 c/s, an ear may be worse for speech than for pure tones confined to 2000 c/s and below. In such cases, one may have more confidence in the results of an actual speech reception test, if a good one were available, than in the prediction from a pure tone test.

The audiogram is also taken of course for medicolegal reasons, and there is no suggestion whatever that a speech reception test should supplant it. The prediction to HL for speech is good enough so that no risk is taken that a candidate will have a problem with speech reception if his average HL at 500-2000 c/s is 20 db (ISO) or better; or if the average pure-tone HL is 30 db or more, a candidate may at once be excused since he will almost certainly have some trouble understanding everyday speech.

If, however, an ear yields an average pure-tone HL of 20-30 db there is some uncertainty about whether he should be admitted, and

in these cases an actual speech test has the highest face validity.

The question then becomes, what speech test should be used in borderline cases. Here a guide should be furnished in the deliberations of national bodies assigned to the topic. The USA Standards Institute states¹ that Zero HL for Speech shall be 10 db SPL re 0.0002 dyne/cm² when the speech material consists of spondaic (two equally-stressed syllables) words. The meter reading of 19 db is that of a 1000-c/s tone recorded at the same level on a VU meter as the words. The specifications of equipment which will yield an acceptable Speech Reception Threshold (SRT) are also found in Reference 1.

Unfortunately, the standard spondee lists now in common use do not sample hearing ability above the 1000-c/s region. Quiggle, et al², offer the formula:

$$SRT_{\text{Spondee}} = 7.1 + 0.23 HL_{500 \text{ c/s}} + 0.54 HL_{1000 \text{ c/s}};$$
 adding $HL_{2000 \text{ c/s}}$ did not increase the predictability. On the other hand, if the equally-common monosyllable lists of the Phonetically Balanced (PB) type are used, the prediction formula definitely must include 2000 c/s, as follows³:

$$SRT_{\text{PB}} = 3 + 0.35 HL_{500} + 0.23 HL_{1000} + 0.41 HL_{2000}.$$

For a review of these and similar problems, including specific sources of equipment, lists, and procedures, see Reference 4.

It is concluded that the so-called PB monosyllable lists form a better estimate of the ability to hear speech over the octaves 500-2000 c/s than the spondees, and the "Normal" hearing for speech in the Navy should be provisionally based on the PB lists. This memo describes a determination of the SPL at that intensity of speech where the average submarine candidate can just repeat 50% of PB words.

II. METHOD

Subjects. Subjects were 23 Submarine Force candidates with pure-tone audiograms of 15 db HL or better from 250-4000 c/s (ISO).

Apparatus and Procedure. Pure-tone audiograms were taken by a standard group technique⁵ repeatedly shown to have high reliability and validity. Speech audiometry was performed with a Grason-Stadler Model 162 speech audiometer and a standard set of disc recordings of PB lists obtained from Technisonic Studios, Inc., St. Louis, Mo. The SPL output of the earphone was measured with a calibrated General Radio sound level meter and a National Bureau of Standards 9A coupler, using the 1000-c/s tone on the discs. Subjects listened to speech through the Telephonics Model TDH-39 earphone in an MX cushion provided with the speech audiometer, in a double-wall IAC Model 1202 sound-treated booth.

Each subject was presented with 20 words at the HL dial setting of -4 db (15 db SPL), then 20 words successively at settings 0, 4, 8, etc., until 90%-correct response was achieved. Before testing, each subject was told that a voice on the record would say, "You will say," followed by a word, which he was to repeat, guessing if necessary. Responses were transmitted via a high-fidelity intercom to the experimenter, who monitored the word list presentations and recorded the number of correct responses.

III. RESULTS AND DISCUSSION

The mean intelligibility, in percent words correct, is given in Fig. 1 as a function of intensity. The interpolation at the 50%-correct point is at the 5.7 (rounded to 6) db HL dial setting. This means that the PB lists must be about 6 db louder than the spondees for our subjects to reach 50% intelligibility. This is about the difference Hudgins, et al⁶, found between these two types of speech when administered by a monitored live voice.

The 6-db HL dial setting yields 25 db re .0002 μ bar for the calibrating tone on the record. This is almost exactly the value found by Hirsh, et al⁷, for 15 listeners meeting a criterion of 10 db HL (ASA, 1951) or better at all audiometric frequencies. These authors also found an SRT of 17.7 db HL for the W-2 lists of spondaic words, or a difference of $24 - 17.7 = 6.3$ db between the W-2 vs the

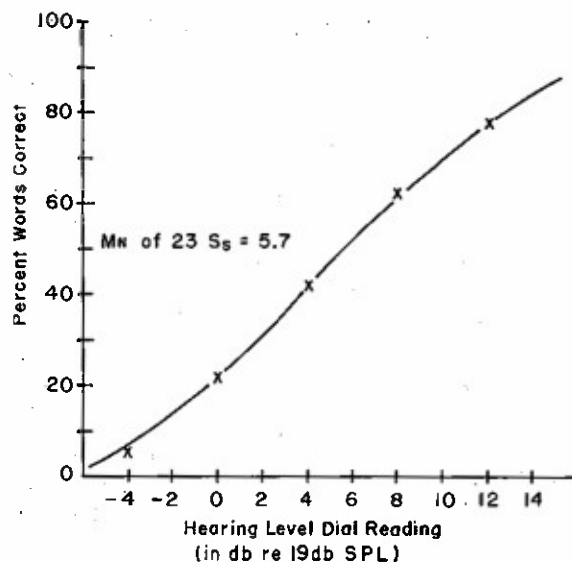


Fig. 1. Intelligibility Function for Phonetically-Balanced Words (W-22 Recording) for 23 S/M School Candidates.

Note: 50% Intelligibility (Speech Reception Thresholds) = 25 db Sound Pressure Level.

W-22 lists. Our finding for a second group of 16 S/M school candidates, given both these lists in group fashion, consists of a difference of $26.6 - 17.6 = 9.0$ db. The two sets of thresholds are identical for the spondees; our thresholds for the W-22 are a couple of db worse than for our first group given individual attention, and may have suffered slightly from the group method of presentation.

We may conclude that an increase of 6 db above the SRT for spondees yields the correct value of 25 db SPL as the zero HL for Speech_{PB} in our population, and that on our speech audiometer, which is calibrated for spondees as all speech audiometers are today, it is only necessary to subtract 6 db from all HL dial settings in order to read HL for Speech_{PB}.

If, as we here recommend, a Navy standard of 25 db SPL for PB lists be taken as the Normal Threshold Hearing Level for Speech, it is important to emphasize that this figure applies only to the so-called W-22 lists sold by the Technisonic Studios. These are a specially selected group of 200 monosyllables uttered by a specific talker. If another talker is used, or other PB lists, differences in SRT

of up toward 10 db have been found. For example, Davis, et al⁸, using the 1000-word PB lists of the Harvard Psycho-Acoustic Laboratory found an SRT of as much as 33 db SPL. In order then, to establish a measure of speech reception for an individual, to compare with a DOD-wide criterion, one cannot simply use a monitored live voice from any talker who happens to be available or any PB list which one finds in the appendix of some human engineering handbook.

The problem of what cut-off SRT should exclude an individual from S/M service cannot be solved from these data. The problem has two aspects, medical and psychological. We can say from statistical bases that "Normal" hearing should be 25 ± 3 standard deviations, which from our individual data (S.D. = 3.74 db) works out to 13.8 — 36.2 db. Thus, an SRT over 11.2 on the Hearing Level dial should characterize an ear as abnormal, and in need of otological examination. While this is probably true, nevertheless there are many ears with such losses or greater, in need of no further medical treatment, and who, on psychological grounds of adequate ordinary communicability, should by no means be excluded from any military duties (except perhaps some requiring rather unusually acute hearing in this frequency range). The question, then, of what SRT scores should be set as criteria for specific tasks must be left to a later report.

IV. SUMMARY

Twenty-three normal-hearing candidates for the Submarine Force were examined for Speech Reception Threshold (SRT) by speech audiometry using phonetically-balanced (PB) lists of monosyllables instead of the usual spondee words. Such PB words are felt to be considerably better in assessing the important frequency regions for daily speech communication, namely, 500-2000 cycles per second. The Navy threshold for SRT_{PB} is 25 db sound pressure level re 0.0002 dyne/cm², or 6 db higher than the standard $SRT_{Spondees}$. A standard speech audiometer, now calibrated for spondees according to USA Standards Institute specifications, can then be used with

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