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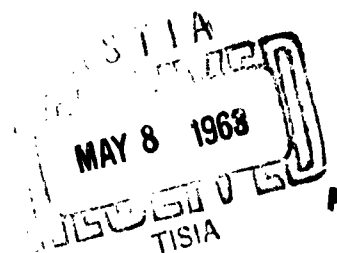
US ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 567

**TEMPORARY THRESHOLD SHIFT FOR "NORMAL"
SUBJECTS AS A FUNCTION OF AGE AND SEX**

**Michel Loeb, Ph. D.
Maj John L. Fletcher, MSC**



**UNITED STATES ARMY
MEDICAL RESEARCH AND DEVELOPMENT COMMAND**

1 May 1963

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**Military Psychophysiological Studies
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ABSTRACT

TEMPORARY THRESHOLD SHIFT FOR "NORMAL"
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OBJECT

To determine whether there are variations in temporary threshold shift (TTS) for normal individuals exposed to intense (110 dB), broad band (1200-2400 cps) noise as a function of age and sex.

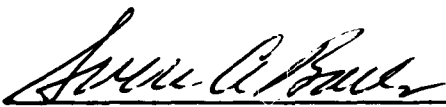
RESULTS

At 2,000 cps there was considerably less TTS for males than for females. At 4,000 cps no such differences were observed. The smallest difference in TTS for men and women was observed for subjects under 30.

CONCLUSIONS

The significant differences may have indicated that susceptible males more frequently sustain a permanent loss and so would be ineligible as subjects for this kind of experiment. There is no support from these data for the hypothesis that males are biologically more susceptible to hearing loss than females.

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TEMPORARY THRESHOLD SHIFT FOR "NORMAL" SUBJECTS AS A FUNCTION OF AGE AND SEX*

I. INTRODUCTION

A number of studies (e. g., Glorig, Wheeler, Quiggle, Grings, and Summerfield, 1957) have shown that hearing loss is more frequent among men than women. Others (e. g., Glorig and Davis, 1961) have demonstrated a progressive loss of auditory acuity with advancing age. However, older individuals, especially men, frequently have been exposed to intense noise. It has never been satisfactorily resolved, however, whether the sex and age differences are attributable to differences in noise exposure, biologically determined susceptibility, or a combination of these factors. Nor do we know whether susceptibility to loss increases with age or differs as a function of sex for individuals with apparently normal hearing.

These questions are not amenable to direct test, at least not with human subjects. If one is willing to assume, as some have, that the same factors underlie temporary threshold shift (TTS) and permanent threshold shift (PTS), then some experimentation is possible. Ward, Glorig, and Sklar (1959), who make this assumption, obtained no significant differences in TTS for young normal male and female college students exposed to 1200-2400 cps random noise at 100 dB (SPL). They concluded that the data suggest no biological basis for differential susceptibility of men and women. They suggested, however, that there is a possibility that with increasing age, susceptibility might increase faster for men than for women. The present experiment was designed to explore these questions further by measuring TTS for normal males and females in various age groups.

II. PROCEDURE

Subjects. Subjects were recruited from the University of Louisville, from the US Army Medical Research Laboratory and other organizations at Fort Knox, Kentucky, and from the civilian dependent population of Fort Knox. All of these were paid for their services. Pulse-tone sweep frequency audiometry was performed on all the subjects in a sound-deadened chamber with an ambient SPL of 40 dB. All subjects accepted for the experiment had thresholds no more than 20

*This investigation was aided by a contract between the University of Louisville and the Office of The Surgeon General, Department of the Army. We are especially grateful to Dr. John R. Binford of the University of Louisville for administrative aid.

dB above "normal" at any frequency between 125 and 4,000 cps. Five age categories were established: less than 30 (actually 16-29), 30-39, 40-49, 50-59, and more than 59 (actually 60-72). Ten male and 10 female subjects meeting the selection criterion were obtained for each age category.

Test Session. Immediately after the audiometric screening the selected subjects were given practice tracking their thresholds at 2,000 and at 4,000 cps. The noise exposure test session was on a day subsequent to the preliminary session, usually within a week. At the beginning of the test session, each subject tracked his pulsed tone threshold at 2,000 cps for 25 sec; then the test frequency was switched to 4,000 cps and each tracked his threshold at that frequency for 25 sec. He was then exposed to a 1200-2400 cps random noise at 110 dB (SPL) for 12 minutes. A post-exposure procedure, identical to the pre-exposure one, was initiated 105 sec following termination of the noise. Pre-exposure thresholds for 2,000 cps and 4,000 cps were taken as the average of the last three peaks and troughs on the Békésy record. Post-exposure thresholds were taken as the average last three peaks and troughs at 2,000 cps (roughly 120 to 135 sec post-exposure) and the first three peaks at 4,000 cps (roughly 140 to 155 sec).

Post-Exposure Audiograms. Audiograms were taken a week after the test session on all but the US Army Medical Research Laboratory and University of Louisville staff members to check for possible residual threshold shifts. No appreciable residual shifts were noted.

Apparatus. Discrete frequency threshold measurement, as well as standard audiometry, was performed with the Grason-Stadler E-800 Békésy audiometer. The exposure noise was produced by feeding the output of the noise generator in the Grason-Stadler audiometer through a Krohn-Hite filter (nominal cut-off 24 dB/octave) and a McIntosh MC 30 amplifier into a TDH-39 earphone. Sound intensity was measured with a Brüel and Kjaer Model 4132 microphone with a 6 cc coupler and a Model 2111 audio spectrometer.

III. RESULTS

Pre-Exposure Audiograms. The criteria for selection of subjects were such that some initial differences between groups might be obtained. Ideally, this variability could be eliminated by matching subjects within groups, but such a procedure would require an enormous pool of subjects. Mean thresholds at 500, 1,000, 2,000 and

4,000 cps for each of the age and sex groups are shown in Figure 1. Table 1 presents a statistical analysis of the differences. A Lindquist Type III analysis of variance (Lindquist, 1953) was employed to test the significance of the differences.

TABLE 1
Analysis of Variance for Pre-Exposure Audiograms

Source	df	MS	F
Between Subjects	99		
Sex (S)	1	8.1	< 1.00
Age (A)	4	41,006.8	< 1.00
S x A	4	21,084.6	< 1.00
Error _b	90	59,894.2	
Within Subjects	500		
Frequency (F)	5	460,231.0	77.62*
F X S	5	26,105.8	4.40*
F X A	20	5,261.5	< 1.00
F x S x A	20	21,690.2	3.66*
Error _w	450	5,929.2	

*Significant beyond the 0.01 level.

Initial auditory acuity did not vary significantly as an over-all function of age or sex, but there were significant variances associated with frequency; the interaction of frequency and sex; and the interaction of age, frequency, and sex. The frequency effect is principally attributable to the fact that the threshold was appreciably higher for all groups at 4,000 cps than for other frequencies. Some differences possibly attributable to age and sex are apparent at 500 cps, but as the energy of the exposure noise was concentrated in the 1200-2400 cps range, this would appear to be of little importance. At 1,000 cps women below 30 apparently were 8.0 dB superior in acuity to men in the same age range. Acuity differences for other age groups at this frequency were small (3 dB or less), and probably of no statistical or practical significance. At 2,000 cps women were superior in acuity to men by 5.2 dB in the group under age 30 and by 5.3 dB in the age group 30-39; they were inferior to men by 2.2 dB in the group 40-49 years, by 2.6 dB in the group aged 50-59, and by 0.25 dB in the group

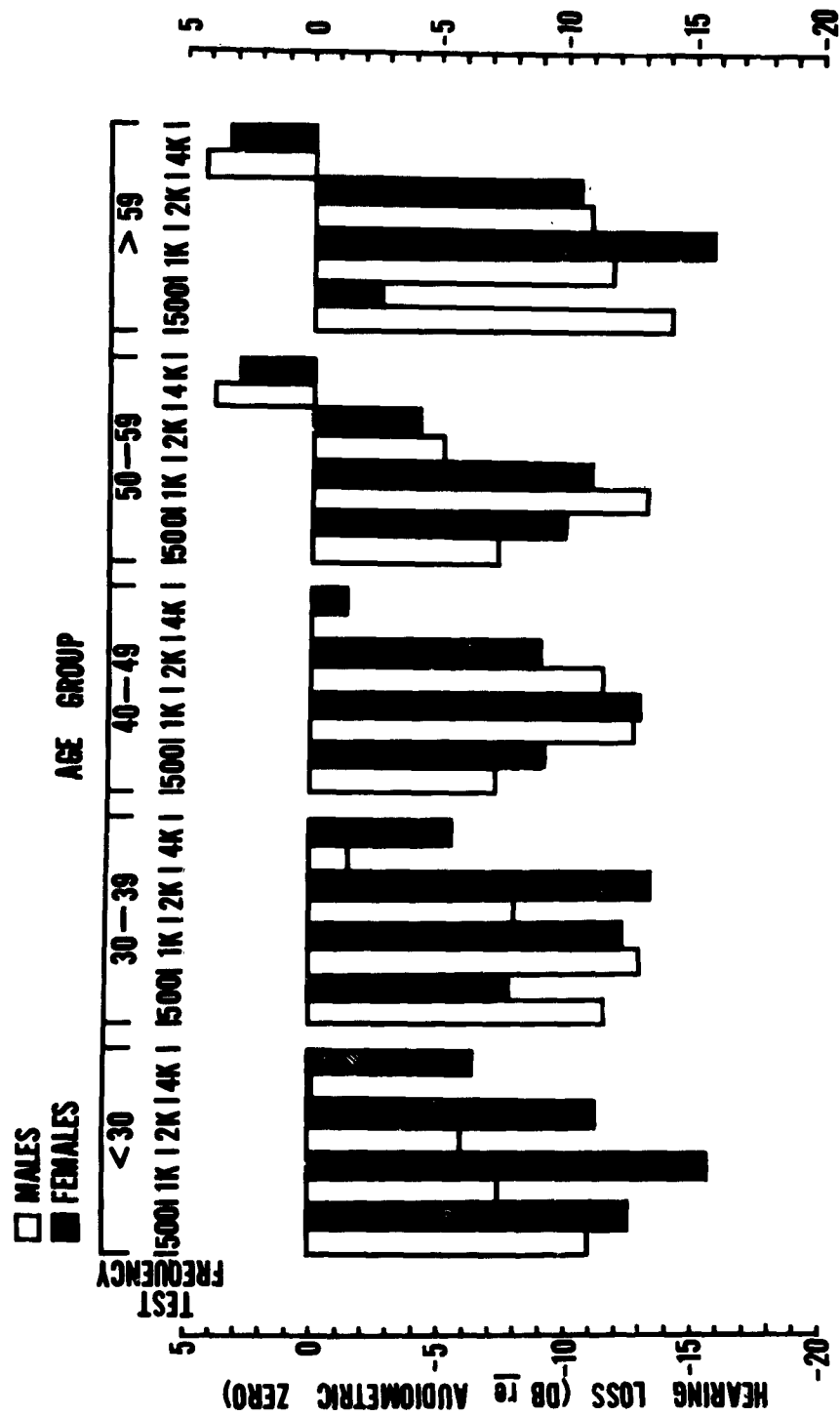


Fig. 1. Pre-exposure audiograms.

aged 60-72. At 4,000 cps females were superior in sensitivity by 6.4 dB in the age group under 30 and by 4.2 dB in the age group 30-39; differences in other age groups were on the order of a decibel or less.

It is noteworthy that, except at 4,000 cps, mean thresholds were appreciably below "normal" (i. e., audiometric zero). There are probably several reasons for this: (1) If individuals are so selected that they are not appreciably below normal acuity at any test frequency, they probably will be above average acuity at most test frequencies. On the basis of other studies we would expect least acuity at 4,000 cps. (2) It is generally considered that the American "norms" are slightly high if individuals are tested in acoustically adequate testing environments and adequately adjusted to test procedures. (3) Thresholds were probably somewhat lower because the tones were pulsed (Garnor, 1947).

Threshold Shifts. Figure 2 shows threshold shifts at 2,000 and 4,000 cps. Tables 2a and 2b summarize the results of a two-factor analysis of variance (Lindquist, 1953) for threshold shifts at these frequencies.

TABLE 2
Analysis of Variance for TTS Data

Source	df	MS	F
a. 2,000 cps			
Age (A)	4	92.5	< 1.0
Sex (S)	1	1,407.0	14.4*
Cells	9	-	-
A x S	4	88.9	< 1.0
Within	90	98.0	-
b. 4,000 cps			
Age (A)	4	66.0	< 1.0
Sex (S)	1	10.2	< 1.0
Cells	9	40.6	-
S x A	4	22.9	< 1.0
Within	90	73.7	-

* Significant beyond the 0.01 level.

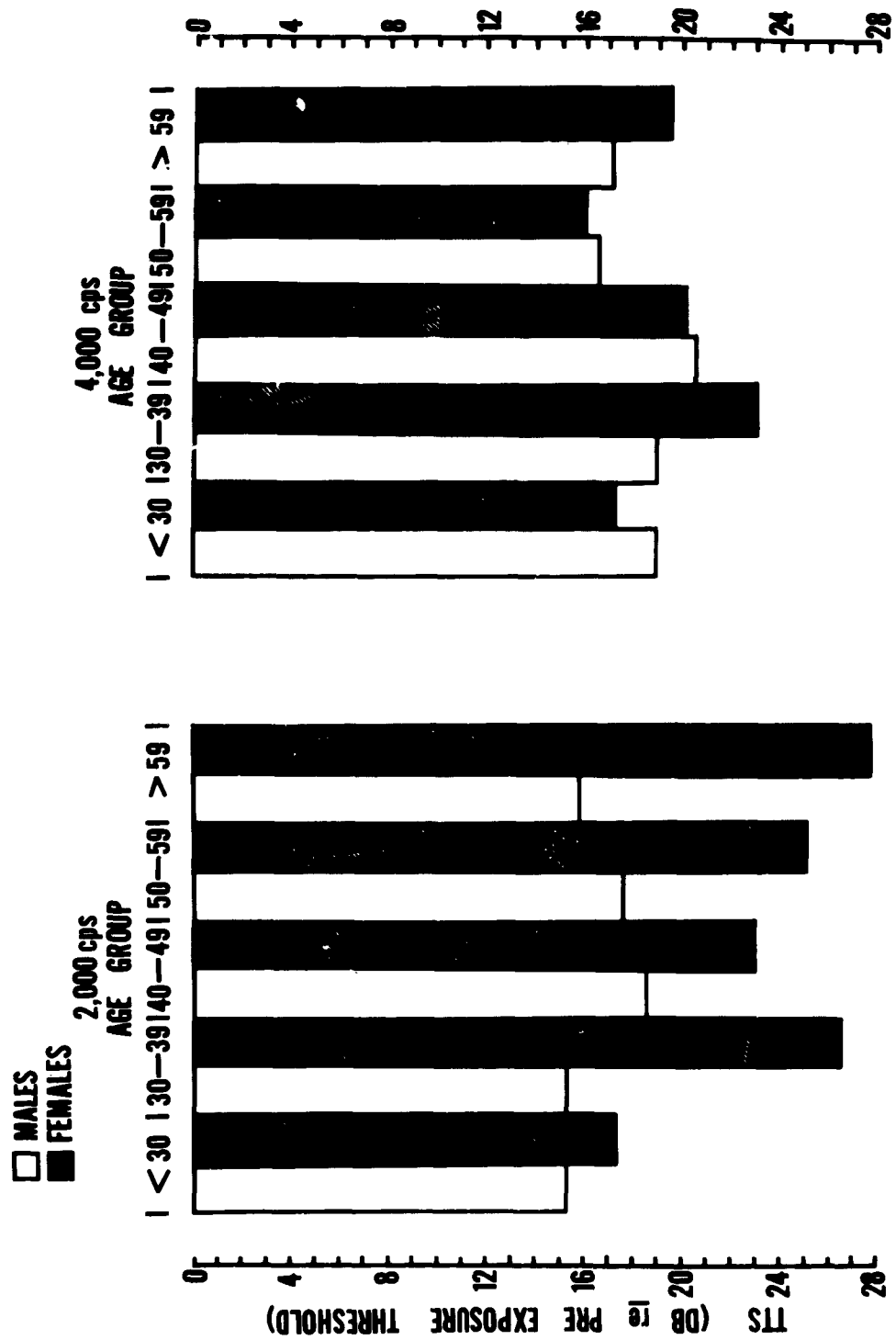


Fig. 2. Temporary threshold shift.

At 2,000 cps, the TTS for all age groups was greater for women than for men. The difference in over-all mean threshold shift attributable to sex was highly significant ($p \leq .01$). None of the interactions was statistically significant. It should be noted, however, that the smallest difference (2.0 dB) between men and women was for individuals under 30. This is generally in accord with the findings of Ward *et al* (1959) who found a very small, non-significant difference between sexes, but TTS in their experiment was slightly greater for men. Larger differences in TTS (4.5 - 11.5 dB) were observed in this experiment for other age groups. The magnitudes of the differences did not appear to be correlated with age or with initial group audiometric thresholds, but TTS at 2,000 cps was greater for women in all age groups.

Shifts in threshold at 4,000 cps apparently did not vary in any significant way as a function either of age or sex.

IV. DISCUSSION

There are several ways of viewing the differences in threshold with sex and age in the general population. If differences are primarily dependent on biologically determined susceptibility, then even for relatively young groups, males should show more TTS. This did not occur in the present experiment or in that conducted by Ward *et al*. If there is a sex difference in susceptibility appearing only with increasing age, then males should show more TTS at higher ages. If differences in acuity associated with age and sex are attributable almost entirely to differences in cumulative noise exposure (i.e., there are no biological bases for susceptibility), it would seem that TTS should be independent of age and sex for normal subjects. This was true for the TTS at 4,000 cps, but not for that at 2,000 cps. If there are considerable individual differences in susceptibility independent of age or sex, and if men as a group are exposed to more noise than women, we would predict that susceptible subjects--especially older susceptible men--would have increased losses and so would be ineligible for a procedure such as that employed in this experiment. If so, then more TTS would be expected for women than for men, as more of our normals would be susceptible individuals not previously exposed to appreciable high level noise. Such a selection process should be more noticeable at more advanced ages, but individuals over 30 years of age frequently have completed their obligatory military training, are less likely to be involved in recreation with high noise exposure (e.g., hunting), have assumed a stable occupational pattern, and no longer vary greatly in their exposure pattern. Of course, there are individuals who are exposed to high noise levels

at an advanced age because of their occupation but these were excluded from this experiment.

The fact that a very small sex difference in the 2,000 cps TTS occurs for the group under 30, while larger sex differences were found for the older groups is consistent with this last (post hoc) explanation. However, if the explanation were entirely correct, we might also expect sex differences in TTS at 4,000 cps, and these were not obtained.

In any event, there is no evidence from this study or from other TTS studies that men are biologically more susceptible to traumatic hearing loss than women, nor is there any evidence that susceptibility to noise-induced loss increases with age. It would seem advisable to replicate the experiment employing a larger number of subjects in the various groups, individually matched for initial acuity, or at least with more closely matched groups.

It has been suggested (Lawrence, 1963) that there are physiological factors controlling recovery from acoustic insult not predictable from initial loss (TTS). It is not known to what extent this is true, but to the extent that it is true, the conclusions cannot be generalized for permanent hearing loss.

V. SUMMARY

Fifty "normal" men and 50 "normal" women, divided into five numerically equal age groups, were exposed to 12 minutes of 1200-2400 cps random noise at 110 dB (SPL), and temporary threshold shift (TTS) at 2,000 and 4,000 cps was measured approximately 2 minutes after the exposure. A significantly greater TTS for women than for men was noted at 2,000 cps. Though no general trend with age was observed, the smallest difference in TTS between sexes was noted for the youngest group (those under 30). No significant differences in TTS attributable to age or sex were noted at 4,000 cps. Interpretations of the findings are presented. The general conclusion is that no evidence for biological difference in susceptibility as a function of age or sex may be adduced on the basis of data from this investigation.

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AD	Accession No.	UNCLASSIFIED	AD	Accession No.	UNCLASSIFIED
US Army Medical Research Lab, Ft. Knox, Ky.	US Army Medical Research Lab, Ft. Knox, Ky.	TEMPORARY THRESHOLD SHIFT FOR "NORMAL"	US Army Medical Research Lab, Ft. Knox, Ky.	US Army Medical Research Lab, Ft. Knox, Ky.	TEMPORARY THRESHOLD SHIFT FOR "NORMAL"
SUBJECTS AS A FUNCTION OF AGE AND SEX - M. Loeb and J. L. Fletcher w/tech asst of D. Isaacs, C. E. Guthrie, and W. H. Williams	SUBJECTS AS A FUNCTION OF AGE AND SEX - M. Loeb and J. L. Fletcher w/tech asst of D. Isaacs, C. E. Guthrie, and W. H. Williams	1. Susceptibility to hearing loss 2. Audition	SUBJECTS AS A FUNCTION OF AGE AND SEX - M. Loeb and J. L. Fletcher w/tech asst of D. Isaacs, C. E. Guthrie, and W. H. Williams	SUBJECTS AS A FUNCTION OF AGE AND SEX - M. Loeb and J. L. Fletcher w/tech asst of D. Isaacs, C. E. Guthrie, and W. H. Williams	1. Susceptibility to hearing loss 2. Audition
Report No. 567, 1 May 63, 9 pp & i - 2 illus - 2 tables - DA Project	Report No. 567, 1 May 63, 9 pp & i - 2 illus - 2 tables - DA Project	No. 3A012001A800, Unclassified Report	Report No. 567, 1 May 63, 9 pp & i - 2 illus - 2 tables - DA Project	Report No. 567, 1 May 63, 9 pp & i - 2 illus - 2 tables - DA Project	No. 3A012001A800, Unclassified Report
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