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SUMMARY

Fifteen subjects were each given separate 15-minute exposures to three bandwidths of fatiguing sound (whole octave-band and 1/3 octave-band centered at 1000 Hz, pure tone of 1000 Hz) presented in three modes (constant level, variable level, intermittent). The 1/3 octave-band sound pressure levels (SPL) were 5 dB below the whole octave-band levels for the various exposure conditions which, according to the CHABA (Committee on Hearing, Bioacoustics and Biomechanics) criteria, should have yielded equivalent threshold shifts (TTS). The pure tone SPLs equaled the 1/3 octave-band levels for one set of exposures, and were 3 dB lower in another set. These latter conditions were intended to verify the increased noxiousness of pure tone versus narrow band noise stimulation, also specified in the CHABA criteria. An additional aim of the study was to determine differences in TTS due to mode of sound presentation. Of particular interest here was the adequacy of the CHABA procedure for using constant level limits to rate also the noxiousness of variable level exposures. Comparisons of the TTS produced by the different bandwidths and modes of noise presentation suggested that the CHABA criteria may err on the conservative side especially in rating the hazards to hearing of 1/3 octave-band and variable types of noise exposure. Implications of these findings as regards critical band-TTS notions and the action of the acoustic reflex were noted.

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INTRODUCTION

The latest CHABA[1] noise criteria for safeguarding hearing consider a whole octave-band of noise to be as noxious to hearing as a 1/3 octave-band of noise, having the same center frequency, but 5 dB less in intensity (Kryter, Ward, Miller and Eldredge, 1966). Accordingly, the permissible limits cited in these criteria for assorted constant level, variable level, and intermittent noise conditions are each 5 dB higher for a whole octave-band than for a 1/3 octave-band with the same center frequency. Comparable exposures to pure tones of low frequency require still more stringent limits than those for the 1/3 octave-bands. The permissible levels for pure tones, relative to those for 1/3 octave-bands in the same frequency region, become progressively stricter with decreasing frequency below 2000 Hz. The basis for these pure tone specifications has been explained by Ward and involves differential aspects of the middle ear muscle reflex and its consequent attenuation of sounds entering the cochlea (Ward, 1962, 1966).

The composers of these criteria acknowledged that more information was needed to verify the aforementioned bandwidth differences in potency for causing threshold loss, and this study is in response to that need. Specifically, the intent here is to compare temporary threshold shifts (TTS) in hearing resulting from constant level, variable level, and intermittent exposures to 3 bandwidths of fatiguing sound, namely, a whole octave-band and 1/3 octave-band centered at 1000 Hz, and a 1000 Hz pure tone. To conform with the CHABA criteria, the whole octave-band noise levels were set 5 dB greater than the 1/3 octave-band levels for the 3 exposure modes which, if the criteria were correct, would produce equivalent TTS. The pure tone intensity was set equal to and also 3 dB below that of the 1/3 octave-band noise levels as presented under the constant, variable, and intermittent exposure conditions. These pure tone settings were intended to confirm the increased hazard of pure tone vs. narrow band noise exposure as specified in the CHABA criteria for frequencies below 2000 Hz.

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1 CHABA refers to the National Academy of Science-National Research Council Committee on Hearing, Bioacoustics, and Biomechanics.

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A secondary aim of this study was to note any apparent TTS differences due to variation in exposure mode for the aforementioned bandwidth conditions. Of particular interest in this latter evaluation was the adequacy of the proposed CHABA procedures for applying constant level noise criteria to rate also variable level exposures.

METHODOLOGY

SUBJECTS AND TEST CONDITIONS

Fifteen college males (18-25 years of age) with no otological defects and with hearing levels within 15 dB of the ISO audiometric '0' reference for frequencies 250-8000 Hz, were used as listeners. The otological and audiometric examinations were given during each subject's first laboratory visit which also included familiarization trails with the test procedures to be used during the experimental noise exposures. There followed 9 separate noise sessions for each listener, exhausting all possible exposure combinations of 3 bandwidths (whole and 1/3 octave-band noise centered at 1000 Hz, and 1000 Hz pure tone) and 3 modes of presentation (constant level, variable level, and intermittent). These 9 noise conditions were randomized in their order of occurrence across the subject group. A 10th and final session was given in which the 1000 Hz tone was again presented, but at exposure levels 3 dB below those used in its previous tests. For this final pure tone condition, called Pure Tone II, the 15 listeners were divided into three 5-man groups with the members of each group receiving one of the three possible modes of exposure to the tone. Hence, the Pure Tone II exposure results were based on 5 subjects while the exposure results from all other conditions of testing were based on 15 subjects.

Figure 1 indicates the sound pressure level (SPL) values (in dB re .0002 microbar) for the various bandwidth conditions as presented in the constant level, variable level, and intermittent exposure modes. Note that the whole octave-band levels for the different exposure modes are set 5 dB higher than the 1/3 octave-band values. The pure tone levels in one set of conditions (Pure Tone I) are equal to that of the 1/3 octave-band, and in another set (Pure Tone II) are 3 dB less.

Only left ears were exposed to the noise conditions described in Figure 1; right ears being plugged with wax-impregnated cotton. Exposure durations in all instances were limited to 15 minutes, and 72-96 hours intervened between any two successive noise sessions for a given subject.

NOISE GENERATION AND MEASUREMENT

Tape recordings were utilized to insure reproducibility of the specified noise exposure conditions. The octave-band noise signals were originally generated by passing the output of a noise generator (Grason-Stadler 455 B)[2] through two filters (both Allison 2 AB). For the octave-band signal, the low and high frequency nominal cut-off settings of both filters were set at 700 and 1400 Hz, respectively. Filter settings of 900 (low cut-off) and 1140 Hz (high cut-off) were used for the 1/3 octave-band signal. These filtered outputs were fed into a tape recorder (Ampex 351) whose tape speed was 15 inch/sec. For the pure tone condition, a beat-frequency oscillator (B and K Type 1014) was substituted for the noise generator and fed through the two filters into the tape recorder. The filter settings for the pure tone were the same as those used for the 1/3 octave-band signal. Relative changes in the recorded signal levels to conform to the prescribed variable level conditions were accomplished by adjustments of a decade attenuator (Hewlett Packard 350 D) inserted between the noise generator (or pure tone oscillator) and the filters. A stop-watch timed the different level segments constituting the variable level conditions. Recordings of the intermittent test conditions were made in similar fashion, the "quiet" periods being obtained by reducing the record-level of the tape recorder to a predetermined low value for the specified "quiet" durations. This record-level setting, upon reproduction, produced a noise or tone level of 70 dB at the listener's ear.

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2 Mention of commercial products does not constitute endorsement by the Public Health Service.

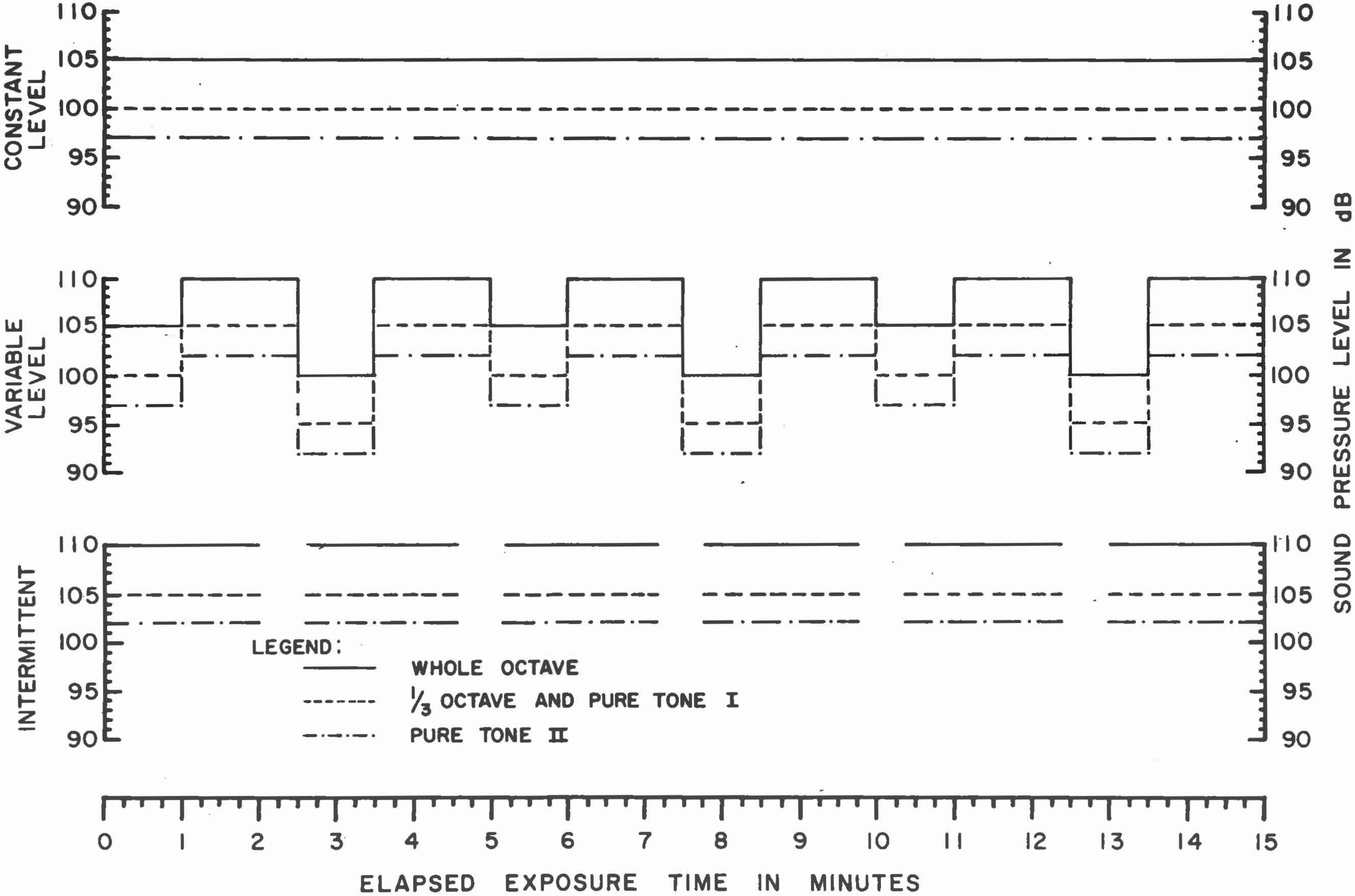

Figure 1. Description of the sound pressure levels (SPL in dB re .0002 microbar) constituting the constant level, variable level and intermittent exposure conditions for the three bandwidths of fatiguing sound. The breaks in the intermittent exposures refer to "quiet" periods of 70 dB SPL.

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In creating the actual exposure test conditions, the recorded signals were played back through the same filters and filter settings used in their original recording, amplified (MacIntosh MC40) and supplied to a speaker (University BLC) in a sound-deadened room. The playback level of the recording was adjusted to generate SPL values complying with those shown in Figure 1 for the various exposure conditions. These measurements were taken at the left ear position of the listener by a condenser microphone (B and K Type 4132) coupled to a spectrometer (B and K Type 2112). Monitoring of such sound levels during each test exposure showed less than 1 dB variation from the SPL values stipulated in Figure 1. Spectral analysis of the whole octave-band noise condition played back at 105 dB SPL, and the 1/3 octave-band noise and pure tone conditions reproduced at 100 dB SPL are described in Figure 2. Differences between the 3 bandwidths are readily apparent.

MEASUREMENT OF TTS

Hearing threshold levels were determined for frequencies 500, 1000, 1500, 2000, 3000, and 4000 Hz before and after each exposure to the fatiguing noise or tone conditions. The tones were produced by a beat-frequency oscillator (B and K Type 1014) and passed through a motor-driven recording attenuator (Grason-Stadler E3262A) to the left phone of a set of TDH-39 earphones set in MX/41 AR cushions. Each tone was presented for 30 seconds in which time the subject controlled the attenuator so as to oscillate about his hearing threshold for the tone. The attenuation rate was 4 dB/sec. The frequencies were tested in an ascending order in both the pre- and post-exposure testing. During the post-exposure test, the listener was allowed to stabilize his 500 Hz threshold at 1-1/2 minutes after noise cessation, the actual post-exposure test commencing at 2 minutes. Threshold values were taken as the mid-points of excursion for the frequencies under test.

RESULTS AND DISCUSSION

GENERAL FINDINGS

Each listener's TTS for each noise condition was obtained by comparing his pre- and post-exposure hearing threshold levels at the various

TABLE I

Means ($\bar{x}$) and Standard Deviations (SD) of Threshold Shifts in Hearing

Levels (in dB) by Bandwidth and Mode of Noise Exposure

Constant Exposure Mode

	Test Frequency (Hz)											
	500		1000		1500		2000		3000		4000	
Bandwidth	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Whole Octave-band	-1.2	7.1	8.5	4.8	15.5	5.2	14.1	4.6	9.8	3.8	10.5	3.9
1/3 Octave-band	-0.2	2.0	2.5	3.3	13.0	5.2	9.9	4.1	8.1	5.5	5.4	4.7
Pure Tone I	4.0	5.2	6.6	6.1	18.6	4.5	12.9	4.9	10.0	4.0	9.6	4.8
Pure Tone II	2.0	3.5	5.7	3.8	14.9	4.7	9.7	3.5	8.8	1.6	9.8	4.5
(Pure Tone II Medians)	(3.0)	---	(7.0)	---	(13.0)	---	(10.0)	---	(9.0)	---	(7.5)	---

NOTE: Negative TTS values indicate hearing is better after exposure than before.

TABLE I (continued)

Means ($\overline{x}$) and Standard Deviations (SD) of Threshold Shifts in Hearing

Levels (in dB) by Bandwidth and Mode of Noise Exposure

Variable Exposure Mode

	Test Frequency (Hz)											
	500		1000		1500		2000		3000		4000	
Bandwidth	$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD
Whole Octave-band	0.2	2.3	6.8	3.9	12.7	5.6	11.2	4.2	9.4	4.1	7.7	3.8
1/3 Octave-band	-0.1	1.5	4.4	4.2	10.0	5.3	7.9	3.8	6.5	3.2	6.5	3.8
Pure Tone I	2.1	4.5	2.8	2.9	14.0	6.1	12.4	5.1	8.2	4.9	8.9	5.0
Pure Tone II	-0.1	2.1	4.2	2.8	13.0	2.7	8.9	2.8	4.7	1.5	3.4	1.2
(Pure Tone II Medians)	(-1.0)	---	(4.0)	---	(12.5)	---	(10.0)	---	(5.0)	---	(4.0)	---

NOTE: Negative TTS values indicate hearing is better after exposure than before.

TABLE I (continued)

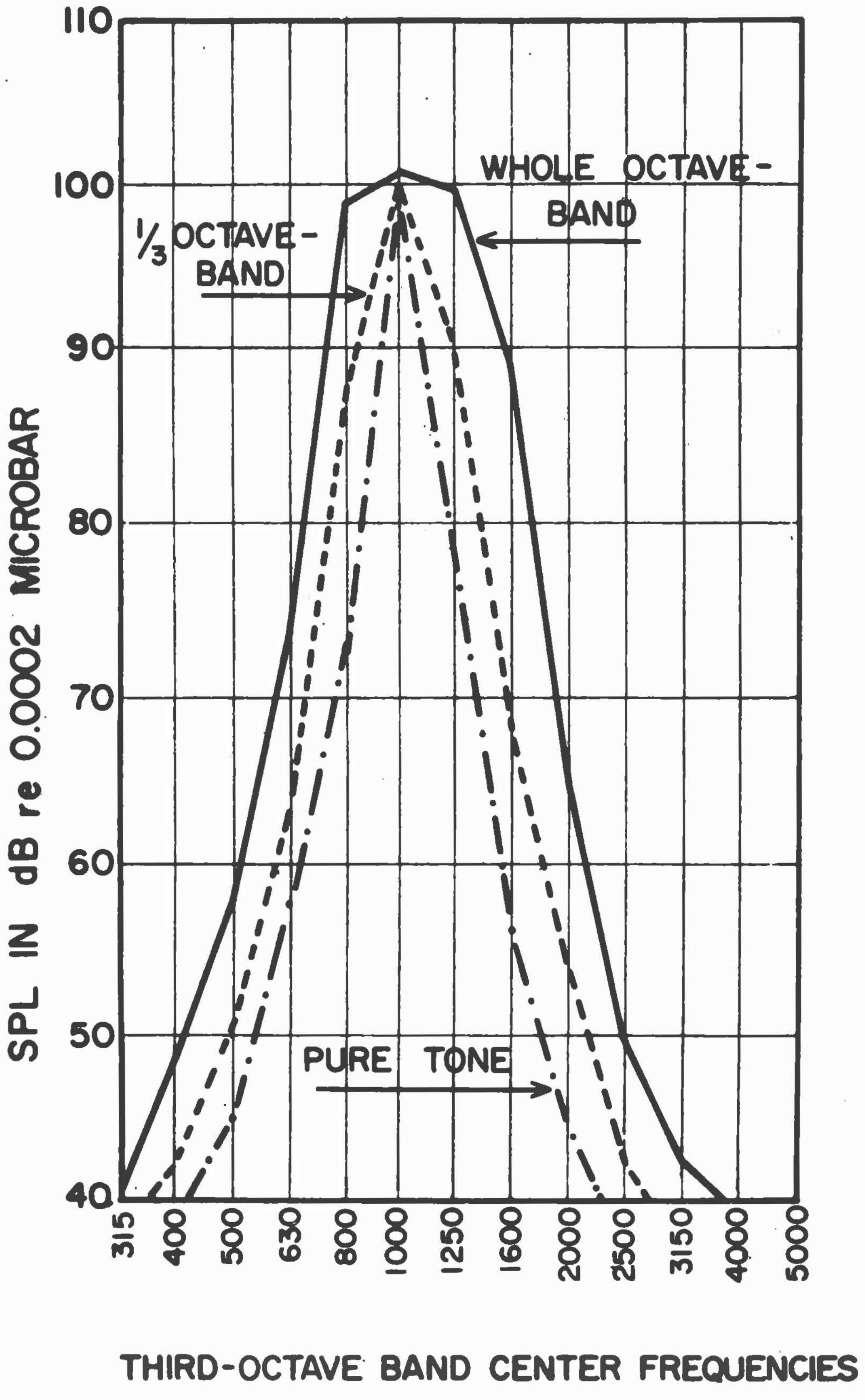
Means ($\overline{x}$) and Standard Deviations (SD) of Threshold Shifts in Hearing

Levels (in dB) by Bandwidth and Mode of Noise Exposure

Intermittent Exposure Mode

	Test Frequency (Hz)											
	500		1000		1500		2000		3000		4000	
Bandwidth	$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD
Whole Octave-band	-0.4	4.7	4.1	3.9	12.5	6.5	11.3	5.7	7.8	4.1	6.0	4.5
1/3 Octave-band	-2.9	4.8	1.6	2.4	9.4	4.8	8.2	4.5	3.9	3.1	4.3	3.6
Pure Tone I	-2.7	3.4	3.8	4.8	12.9	5.7	8.5	3.2	6.7	4.2	7.1	6.1
Pure Tone II	-1.7	1.6	-0.2	1.5	9.5	5.7	9.2	1.2	6.8	4.9	1.9	2.4
(Pure Tone II Medians)	(-1.0)	---	(-2.0)	---	(10.0)	---	(9.0)	---	(5.0)	---	(1.0)	---

NOTE: Negative TTS values indicate hearing is better after exposure than before.


110
100
90
80
70
60
50
40
SPL IN dB re 0.00002 MICROBAR
WHOLE OCTAVE-BAND
1/3 OCTAVE-BAND
PURE TONE
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
THIRD-OCTAVE BAND CENTER FREQUENCIES

test frequencies. The means and standard deviations of these TTS data for the entire subject group are classified by frequency and exposure conditions in Table I. Median TTS values are also given for the Pure Tone II data since the means here, being based on a few subjects (N=5), could have been unduly influenced by extreme individual scores. The means and medians reported for the Pure Tone II exposure are quite similar, however, suggesting that this was not the case. The amount of TTS variability revealed by the standard deviations found for the Pure Tone II conditions also shows no unusual variance; if anything, it is typically smaller than that noted for the other conditions of noise exposure at the different test frequencies. In Figure 3 appear the mean TTS values for each noise exposure condition after being adjusted by functions (Kryter, 1963) designed to reflect TTS measurements at 2 minutes post-exposure for all test frequencies, abbreviated as TTS_2.

Table I shows the mean TTS to reach maximum values at 1500 and 2000 Hz irrespective of noise exposure condition. The Pure Tone I and whole octave-band noise conditions show greater threshold shifts at these two frequencies than do the 1/3 octave-band noise or Pure Tone II conditions for each exposure mode. The maximum bandwidth difference in TTS is 5.6 dB and occurs in comparing threshold shift for the Pure Tone I and the 1/3 octave-band noise for constant exposure conditions at 1500 Hz. Smaller TTS differences due to bandwidth variation are apparent at the other test frequencies with the Pure Tone I or whole octave-band noise condition causing more threshold shift with few exceptions. The TTS_2 data in Figure 3 indicates results similar to Table I except that the shifts for the higher frequencies are greater in the figure, and the bandwidth differences in TTS_2 are also somewhat increased. The maximum bandwidth difference in TTS_2 is 6.1 dB as observed for the same bandwidth and test frequency conditions previously noted.

Table I and Figure 3 show that constant level exposures produce greater threshold shifts than do the variable and intermittent modes of exposure for comparable bandwidth and test frequency conditions. Similar comparisons between the variable and intermittent modes reveal much smaller differences with the variable exposures causing slightly more shift in most but not all instances.

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BANDWIDTH VARIATION AND TTS

Bandwidth X frequency X subjects analyses of variance were performed separately by exposure mode on the TTS_2 data. (The TTS_2 data for the Pure Tone II conditions were not included in these analyses since it would have caused an unbalanced statistical design.) Main effects of bandwidth, frequency, and subjects were found to be statistically significant in each variance analysis. Bandwidth X frequency, frequency X subjects, and bandwidth X subjects interactions were also significant in analysing the TTS_2 data for the variable noise exposure mode, and the frequency X subject interaction proved significant in evaluating the TTS_2 data from the intermittent exposures. None of these interactions were found significant for the constant exposure conditions. Why significant interactive effects occur for some modes of noise presentation and not others is not readily explainable.

Individual t-tests were used to probe the reliability of bandwidth differences in TTS_2 for the various exposure modes. Such tests were performed only at 1500 and 2000 Hz where the threshold shifts were most prominent. Table II summarizes the results of these tests. The differences between the whole octave-band and 1/3 octave-band TTS_2 are significant at 1500 Hz for the constant level and intermittent modes of noise presentation. At 2000 Hz, the whole octave-band TTS_2 significantly exceeds the 1/3 octave-band TTS_2 for all exposure modes. These findings would indicate that the CHABA requirement for lowering the 1/3 octave-band levels by 5 dB relative to the whole octave-band settings produces an error on the conservative side, at least for the exposure frequencies and test conditions used here. The whole octave-band versus 1/3 octave-band differences noted at 1500 and 2000 Hz, however, are maximally 5 dB and generally less than 4 dB. Such small differences may have little importance for practical purposes.

Ward (1962, 1966) has questioned the need for more stringent limits for 1/3 octave-band or narrower bands of noise consisting of sound frequencies above 2000 Hz. He presents evidence to show that equally intense sounds above 2000 Hz produce the same TTS, given whole octave-band or smaller bandwidths of noise exposure even including those to a pure tone. Carter and Kryter (1962), however, have found about 4 dB more tolerance per octave-band noise as compared with

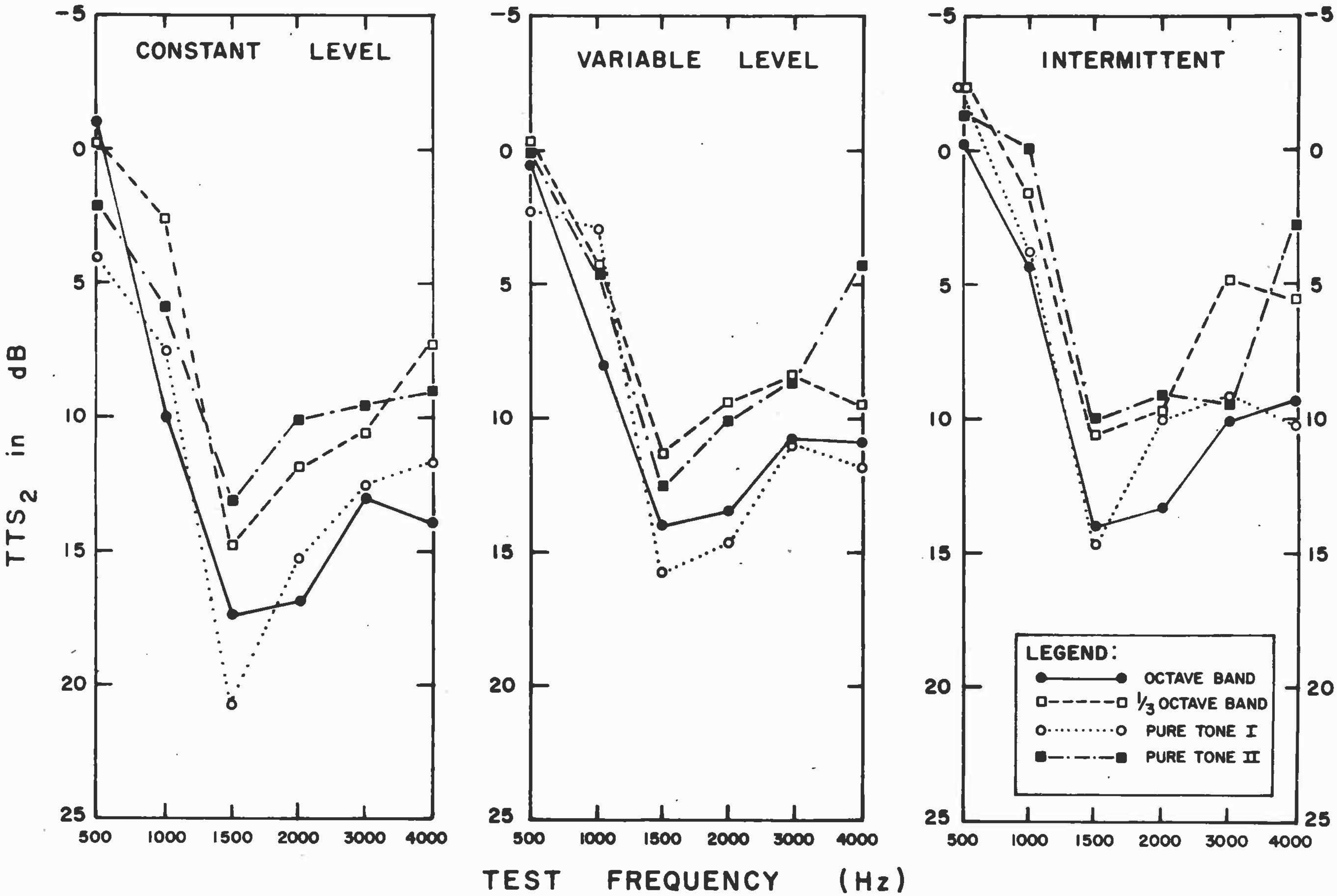

Figure 3. TTS_2 at different test frequencies following constant level, variable level and intermittent conditions of exposure to octave-band and 1/3 octave-band noise centered at 1000 Hz, and to a 1000 Hz pure tone.

TABLE II

Evaluation of Mean Bandwidth Differences in TTS_2 (in dB) at 1500 and 2000 Hz When Classified by Mode of Noise Exposure

Exposure Mode	Pure Tone I vs. Whole Octave-band	Pure Tone I vs. 1/3 Octave-band	Whole Octave-band vs. 1/3 Octave-band
	Test Frequency: 1500 Hz		
Constant Level	3.3*	6.1**	2.8*
Variable Level	1.8	4.5**	2.6
Intermittent	0.7	4.2**	3.5*
	Test Frequency: 2000 Hz		
Constant Level	-1.6	3.5**	5.0**
Variable Level	1.4	5.4**	4.0**
Intermittent	-3.4	0.2	3.6**

** Significant $p < .01$

* Significant $.01 < p < .05$

1/3 octave- or narrower bands of noise having similar band center frequencies and encompassing sounds ranging from 300 to 4800 Hz. These latter data seem to be the basis for the 5 dB difference between whole octave and 1/3 octave-band limits described by the CHABA criteria. Further study of the TTS generating power of octave-band, 1/3 octave-band and pure tones for frequencies above 2000 cycles will be necessary to clarify the discrepancy between Ward's and Carter and Kryter's findings.

Table II also shows that the Pure Tone I TTS_2 was reliably greater than the 1/3 octave-band TTS_2 for all modes of noise presentation at 1500 Hz, and for the constant and variable modes at 2000 Hz. The Pure Tone I condition also caused significantly more shift than the whole octave-band noise condition at 1500 Hz for the constant level exposure.

The failure of the Pure Tone I and 1/3 octave-band conditions of equal intensity to yield similar TTS is in disagreement with Carter and Kryter's contention that the critical bandwidth for TTS appears to be of the order of a 1/3 octave. If so, equally intense exposures to the 1/3 octave-band noise and to the 1000 Hz tone centered in that band should have given rise to equal threshold shifts. The greater threshold shift for the pure tone in this instance might be due to the reputed inability of the middle ear muscles to maintain reflexive attenuation of pure tone sounds. That is, the middle ear muscles, once activated, are sustained more by a noise than by a tone. Hence, more pure tone energy might be reaching the inner ear, relative to that for a noise at the same exposure level, and therein causing more fatigue. Differences in the prolongation of reflexive protection to pure tones as compared with broader bands of noise, plus the fact that the reflex causes little attenuation for sounds above 2000 Hz (Reger, 1960), undoubtedly complicate the development of any critical band notion for TTS.

Table III compares the TTS_2 at 1500 Hz and 2000 Hz for the Pure Tone II exposures with that found for the same 5 subjects when tested under the whole octave-band and 1/3 octave-band conditions. The Pure Tone II shifts are slightly greater than those noted for the 1/3 octave-band exposures and slightly less than those noted for the whole octave-band conditions. Only one comparison (Pure Tone II vs. 1/3 octave-band, variable level at 1500 Hz) yields a significant difference based upon a simple sign-test evaluation (Siegel, 1956).

TABLE III

Differences in Median TTS_2 Between Pure Tone II, Whole Octave-Band and 1/3 Octave-Band Conditions at 1500 and 2000 Hz Classified by Presentation Mode

Exposure Mode	Pure Tone II vs.	Whole Octave-band	Diff.	Pure Tone II vs.	1/3 Octave-band	Diff.
Test Frequency: 1500 Hz						
Constant	13.0	14.0	-1.0	13.0	14.0	-1.0
Variable	12.5	15.5	-3.0	12.5	9.0	3.5*
Intermittent	10.0	8.5	1.5	10	8	2.0
Test Frequency: 2000 Hz						
Constant	10.0	11.0	-1.0	10.0	8.5	1.5
Variable	10.0	12.0	-2.0	10.0	6.0	4.0
Intermittent	9.0	7.0	2.0	9.0	9.0	0.0

* Significant $.01 < p < .05$

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These findings would suggest that a 1000 Hz tone should be set at least 3 dB below the level of a 1/3 octave-band of noise, also having a center frequency of 1000 Hz, and not more than 8 dB less than a similarly centered whole octave-band of noise in order to cause equinoxious effects on hearing. In this regard, the CHABA limit for single one day exposures of 15 minutes (the exposure duration in this study) to a 1000 Hz tone is about 3 dB less than the permissible level noted for the 1/3 octave-band noise centered at 1000 Hz, and 8 dB below the limit for the encompassing whole octave-band.

EXPOSURE MODE AND TTS

The CHABA limits proposed for constant exposure conditions can be also applied to variable level exposures providing that (a) the noise does not remain at a single level for more than 2 minutes, and (b) the level never drops below 85 dB per whole octave-band. The level-time conditions of the variable exposures in this study met these prerequisites. In applying the constant level criteria to variable level condtions, it is necessary to compute a time-weighted average of the constituent sound levels so as to take account of the percentage of time that each level is present during the total exposure period. Such averages, as computed for the variable level conditions used here, were 2 dB greater than the exposure levels specified for the constant level conditions. Consequently, it would be expected that the TTS produced by the variable level conditions would be slightly greater than that found for the constant level exposures. To the contrary, however, TTS_2 comparisons between the constant and variable exposures by bandwidth found the constant level conditions to cause significantly greater threshold shifts at 1500 Hz and 2000 Hz in all but one case. These comparisons are summarized in Table IV. Such results suggest that the CHABA procedure for evaluating variable level exposures, as described above, yields conservative estimates of noise hazards to hearing. Perhaps variation in noise level offsets the adaptive processes of the acoustic reflex which, in turn, retards the development of TTS. Whether similar results will be found for longer periods of exposure to varying levels of noise remains to be determined.

TABLE IV

Evaluation of Mean Presentation Mode Differences in TTS (in dB) at 1500 and 2000 Hz When Classified by Bandwidth

	Test Frequency: 1500 Hz		
Bandwidth	Constant vs. Int.	Constant vs. Var.	Variable vs. Int.
Whole Octave-band	3.4*	3.4*	0.0
1/3 Octave-band	4.1**	3.4*	0.9
Pure Tone I	6.0**	4.9*	1.1

	Test Frequency: 2000 Hz		
Bandwidth	Constant vs. Int.	Constant vs. Var.	Variable vs. Int.
Whole Octave-band	2.9	3.5*	-0.6
1/3 Octave-band	1.3	2.4*	-1.1
Pure Tone I	5.3**	0.5	4.8**

* Significant $.01 < p < .05$

** Significant $p < .01$

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Table IV also shows that the intermittent exposures to the various bandwidths produce less threshold shift than the constant level exposures in the 6 specified comparisons. These results occur despite the fact that the on-time segments of the intermittent exposure, constituting 80% of the total period, contain sound levels 5 dB higher than the constant level conditions (See Figure 1). Obviously, the quiet periods intervening during the intermittent exposure conditions allowed for some recovery from the fatiguing sounds. On the other hand, the intermittent and variable level conditions appear to yield similar amounts of TTS. As just noted, the TTS for the variable exposure conditions might have been reduced due to noise level variation countering the adaptation of the acoustic reflex. Consistent with this explanation is the fact that the largest differences observed between the intermittent and variable conditions occurred for the pure tone exposures where the reflex would be ineffectual. Again, whether similar findings would occur with longer exposures remains to be seen.

RECAPITULATION AND CONCLUSIONS

Threshold shifts in hearing were noted following 15-minute exposures to three bandwidths of fatiguing sound (whole octave-band and 1/3 octave-band of noise centered at 1000 Hz, pure tone of 1000 Hz) presented in three different modes (constant level, variable level, intermittent). Consistent with the CHABA criteria, the 1/3 octave-band levels were set 5 dB below the whole octave-band levels in order to produce equivalent threshold shifts under the specified exposure conditions. The pure tone levels were set equal to those of the 1/3 octave-band exposures in one case, and 3 dB lower than the 1/3 octave-band conditions in another case in order to assess the increased noxiousness of pure tone vs. wider bands of sound stimulation as specified by the CHABA criteria.

Major findings and conclusions were as follows: (1) Threshold shifts for the 1/3 octave-band exposures produced smaller threshold shifts than the whole octave-band conditions. This would suggest that the CHABA specification prescribing 5 dB more stringent 1/3 octave-band limits, relative to those of an octave-band of the same center frequency, tends to error on the conservative side. (2) Pure tones, set equal in intensity to 1/3 octave-band exposure levels, produce threshold shifts in excess of those found for the 1/3 octave-band conditions. Such findings are in disagreement with the notion that the critical band for TTS is about 1/3 octave in width. Pure tone exposure levels set 3 dB below the 1/3 octave-band intensity yielded threshold shifts equivalent to those produced by the 1/3 octave-band exposures. (3) Variable exposures, though slightly greater in average intensity level than the constant exposure conditions, produced less TTS than that found for the constant level exposures, irrespective of bandwidth. The variable level conditions also yielded about the same amount of threshold shift as did the intermittent exposure conditions utilized in the study. Constant exposure conditions for all bandwidths caused greater TTS than the intermittent exposures.

Differences in TTS produced by mode of sound presentation were explained in terms of the action of the acoustic reflex as were TTS differences between pure tone and narrow-band exposure conditions.

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