VERIFICATION OF CRITICAL BAND HYPOTHESIS TO EXPLAIN THE DISCREPANCY IN THE AMOUNTS OF TTS PRODUCED BY NOISE AND TONES WHEN PRESENTED AT EQUAL INTENSITY AND FOR EQUAL DURATION

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Introduction

Pure-tones are assumed to be more dangerous than Octave-bands of noise (Anonymous, 1956). This was explained on the basis of critical-band hypothesis that stated that if a given amount of energy were concentrated within a single critical band, it would be more dangerous than if it were spread over several critical bands, e.g. over an octave (Kxyter, 1950). This critical band hypothesis is found not to be pertinent in explaining the different amounts of TTS (temporary threshold shift) produced by pure-tones and noise of same intensity level. (Ward, 1963). However an alternate hypothesis has been reported. Acoustic reflex is responsible for the difference in the amounts of TTS produced by octave-bands of noise and pure tones, below 2KHz, of same intensity. The action of middle ear muscles differs for noise and pure-tone stimuli. In the case of pure-tones, the muscles after an initial contraction rapidly relax and hence more energy reaches the cochlea and consequently TTS will be more, whereas noise produces a more sustained reaction (there will be continuous re-arousal of the reflex of the middle ear muscles, probably because of the random nature of the noise), thereby TTS will be less as the energy reaching the cochlea will be less.

The two hypotheses have been verified by some studies. It is reported that the TTS produced by a very narrow-band of low-frequency noise (one-eighth Octave in width), was consistently less than that by a pure-tone at the same frequency despite the fact that both stimuli are less than a critical band in width. (Ward, 1962, C). This evidence supports the acoustic-reflex hypothesis and also acts as a counter evidence to critical-band hypothesis. In another experiment, TTS was measured for tone and noise at equal intensity levels. Later TTS produced by tone (at the same intensity level), was again measured but this time the contralateral ear was stimulated by the noise of the same intensity. As mono-aural stimulation results in binaural reflex, there was a sustained reflex even in the ear which was receiving pure-tone. The result was that the TTS

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produced by the tone in this case, dropped to the same value as that produced by the noise. (Ward, 1962). This study again supports the Acoustic-reflex hypothesis.

The present paper deals with yet another study to verify the two hypotheses. It is known that the attenuation of sound by middle ear muscles' action for frequencies above 2 KHz is negligible. A pure-tone of 4 KHz and narrow-band noise centered around 4 KHz would be ideal stimuli to verify the hypotheses. The use of these two stimuli eliminates the problem of acoustic reflex as mentioned earlier. If critical-band hypothesis were to be correct, the 4KHz tone should produce more TTS than narrow band noise centered around 4 KHz when presented at equal intensity level and for equal exposure time. On the other hand, if the acoustic-reflex hypothesis were to be correct the noise should produce same or more TTS than the 4 KHz tone as the attenuation of noise by the action of middle ear muscles is ruled out.

Procedure

Subjects: The total number of subjects tested were five normal hearing adults. Their thresholds for hearing at 4 KHz ranged from 0-5 dB.

Equipment: Arphi-audiometer (Model MK 700) calibrated to ISO standards was used. The audiometer had provision for narrow-band noise centered around 4 KHz.

All the subjects were tested in a sound treated room. Prior to the actual testing thresholds of subjects for 4 KHz, were obtained. Subjects were presented with pure tone at 4 KHz, at 105 dB SPL (TTS producing stimulus), for one-hour. Immediately after the termination of the TTS producing stimulus, subjects were again tested for their thresholds for 4 KHz tone. Threshold shifts were determined.

The subjects were tested after sufficient recovery time (at least 24 hours interval). This time, the TTS producing stimulus was narrow band noise (centered at 4KHz) at 105 dB SPL for one hour exposure time. The amount of TTS produced by this noise at 4 KHz was determined in all the subjects. All the subjects were retested for reliability, both for pure-tone and noise after sufficient recovery-time (at least 24 hours interval between one testing to other testing).

Results

The results obtained are shown in the Tables I and II.

As can be seen from the results, all the 5 subjects showed more TTS for narrow-band noise than for the pure-tone. Statistically the mean TTS values for pure tone and the noise are significantly different for both test and retest conditions, t-values being 6.04 and 11.5 for test and retest conditions respectively, show that the TT S was significantly more for noise than that for tone at both 0.05 and 0.05 levels, whereas the TTS produced for both tone and noise test

TABLE I. TTS produced by pure-tone

Test: Condition A				Re-Test: Condition C			
Subject	Threshold		TTS	Subject	Threshold		TTS
	Before	After			Before	After	
1.	0 dB	25 dB	25 dB	1.	0 dB	25 dB	25 dB
2.	5 d	35 dB	30 dB	2.	5 dB	35 dB	30 dB
3.	5 dB	25 dB	20 dB	3.	5 dB	35 dB	30 dB
4.	5 dB	35 dB	30 dB	4.	S dB	40 dB	35 dB
5.	5 dB	35 dB	30 dB	5.	5 dB	40 dB	35 dB

TABLE II. TTS produced by Narrow-Band Noise

Test: Condition B				**Retest: Condition D**			
Subject	Threshold		TTS	Subject	Threshold		TTS
	Before	After			Before	After	
1.	0 dB	45 dB	45 dB	1.	0dB	50 dB	50 dB
2.	5 dB	60 dB	55 dB	2.	5 dB	60 dB	55 dB
3.	5 dB	40 dB	35 dB	3.	5 dB	50 dB	45 dB
4.	5 dB	70 dB	65 dB	4.	5 dB	65 dB	60 dB
5.	5 dB	65 dB	60 dB	5.	5 dB	65 dB	60 dB

For condition M = 27; S.D.=4.47
For condition C M = 31; S.D.=4.18
For conditions A and C r = 0.43 ; MD=4.00; SD_D=4.18 ; SE_{MD}= 1.87; t=2.14
For condition B M = 53 ; S.D.= 13.51
For condition D M = 54; S.D.=6.52
For conditions B and D r = 0.77; MD=1.00; SD_D=7.42; SE_{MD}= 3.32; t=0.30
For conditions A and B M.D.=26; SD_D=9.5 ; SE_{MD}=4.31; t=6.04
For conditions C and D M.D.=23 ; SD_D=4.47 ; SE_{MD}=2.00; t=11.5

and retest conditions, were statistically insignificant at both 0.05 and 0.01 levels and the t-values were 2.14 and 0.30 for test and noise respectively. A correlation coefficient of +0.43 was obtained (for TTS produced by tone) for test and retest conditions, using product-moment correlation method, similarly a correlation coefficient of +0.77 was obtained (for TTS produced by noise) for test and retest conditions, that indicate the greater test and retest reliability.

Discussion and Conclusion

It is apparent from the results, that the narrow-band noise, centered around 4 KHz, produced more TTS than did the pure-tone at 4 KHz. This is against critical band hypothesis.

If critical band hypothesis were to be correct, TTS for tone should be more than that for noise, as in pure tone, energy is concentrated in a particular area of the basilar membrane, whereas for noise the energy is spread over a larger area. This study shows, that the TTS for noise (narrowband noise centered at 4 KHz) is more than the TTS for 4 KHz tone when presented at equal intensity (105 dB SPL) for equal duration (1 hr.). Thus the critical band hypothesis can be rejected. The difference in the amount of TTS produced by noise and tones when presented at equal intensity and for equal duration can be attributed to the action of middle ear muscles especially when tones and noise are below 2 KHz.

REFERENCES

1. **Jerger J. (1963). Modern** Developments in Audiology. New **York:** Academic **Press.**
2. **Tobias V. Foundationsof** Modern Auditory Theory, Vol. II. New York: Academic Press