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CONTRALATERAL THRESHOLD SHIFT AND REDUCTION IN TEMPORARY THRESHOLD SHIFT AS INDICES OF ACOUSTIC REFLEX ACTION

Capt J. L. Fletcher, MSC
M. Loeb, Ph. D.

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Authors

Capt J. L. Fletcher, MSC (Ph. D) — Audition Branch, Psychology Division

M. Loeb, Ph. D. — Chief, Audition Branch, Psychology Division

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ABSTRACT

CONTRALATERAL THRESHOLD SHIFT AND REDUCTION IN TEMPORARY THRESHOLD SHIFT AS INDICES OF ACOUSTIC REFLEX ACTION

OBJECT

To compare narrow band noise and clicks as AR eliciting stimuli and to correlate the contralateral TS and TTS reduction methods of estimating amount of reflex activation.

RESULTS

Contralateral shifts produced by the clicks and by the noise were of the same order of magnitude. However, considerable adaptation of the AR was observed for the noise stimulus, none for the clicks. Correlations between contralateral TS and TTS reduction were small and not statistically significant.

CONCLUSIONS

Click AR eliciting stimuli are superior to noise stimuli because no decrease in reflex activity (adaptation) is observed over a period of at least two minutes. Perhaps because of individual differences in susceptibility to noise, no relation can be observed between the TS a TTS methods of estimating AR activity.

RECOMMENDATIONS

Click stimuli should be used to elicit AR response because of their demonstrated nonadaptability over time. Additional research should be performed to investigate the reasons for the lack of correlation between two methods that apparently measure or estimate the same phenomenon.

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CONTRALATERAL THRESHOLD SHIFT AND REDUCTION IN TEMPORARY THRESHOLD SHIFT AS INDICES OF ACOUSTIC REFLEX ACTION

I. INTRODUCTION

Several different techniques have been used in the determination and measurement of the activity of the stapedius and tensor tympani muscles (acoustic reflex or AR). Among the methods employed were measurement of changes in cochlear microphonics (1-3), measurement of threshold shift in the contralateral ear (TS) (4, 5), and the temporary threshold shift (TTS) reduction technique (6). Other techniques that have been used include the impedance change method (7), and the manometric method (8). A more detailed account of other means of observing or measuring acoustic reflex contractions may be found in Wersall's excellent monograph (9).

Examination of the research in this area reveals that much ingenuity and considerable work has been directed toward the development of ways of detecting and measuring AR contractions in man and animals. But no research can be found where attempts have been made to relate data by one technique to those obtained through another method. This research will relate the data obtained by the TS method to that obtained using the reduction in TTS technique.

Previous research (6) has shown that reduction in TTS (protection) afforded by pure tones presented prior to exposure to loud impulse noises was of considerable magnitude. Recent research (10) has demonstrated that either narrow band noise (NBN) or broad band noise was more effective in arousing AR responses than were pure tones with NBN significantly better than the broad band noise. Preliminary findings from research undertaken prior to this experiment showed that clicks were more effective than NBN in producing TS in the contralateral ear. A similar determination should be made of the protective value of clicks and of NBN as AR eliciting stimuli.

Contraction of the AR serves to attenuate sound transmission through the middle ear. In general, the greater the magnitude of the muscle contractions (stapedius and tensor tympani, particularly the stapedius), the more the sound being transmitted through the middle ear will be attenuated (9). It is reasonable, therefore, to assume that a large TS for a given AR activating sound is indicative of a considerable AR contraction, and further, because attenuation by the AR is great, should be associated with a small TTS after exposure to loud impulse noise while protected by the AR so elicited.

The objective of this investigation, then, was to relate TS and TTS estimates of AR activity and to determine the relative efficiency of NBN and clicks as AR eliciting stimuli using both the TS and TTS methods.

II. METHOD, APPARATUS, PROCEDURE AND SUBJECTS

The experimental methods used were essentially those described by Loeb and Riopelle (4) and Fletcher and Riopelle (6), except that the reflex activating stimuli were presented througn earphones in both phases of this research. The TS method was utilized in Phase I of this experiment, while the TTS method was used in Phase II.

In Phase I, threshold for a 500 cps tone was obtained in the right ear (hereafter called the test ear) for 30 seconds with a Grason-Stadler Model E-800 Bekesy audiometer. At the end of the 30 second period the click stimuli or a narrow band noise was introduced in the other ear (referred to as the reflex ear). The subject meanwhile continued to track the 500 cps tone in the test ear. The reflex eliciting stimuli were continued for two minutes in the reflex ear, then terminated. The S, however, continued to track his threshold in the test ear for another 30 seconds following cessation of the AR eliciting sound in order to establish a post-exposure threshold for comparison with the threshold before and during presentation of the activating stimulus. Thus we have the S operating the audiometer to determine his threshold for a 500 cps tone for three minutes, with a 30 second threshold determination before presentation of the activating stimulus, two minute threshold determination during presentation of the eliciting stimulus, and a 30 second post-activation reference.

The NBN stimulus was provided by feeding the output of a General Radio random noise generator through a Krohn-Hite active filter. The cut-off values were set at 2000 and 2200 cps. Slope for the Krohn-Hite filter, as cited by the manufacturer is 48 db/octave.

Clicks were furnished by a Tektronix pulse generator with a rate of 15 per second and a duty cycle of 10%.

Data for Phase I were collected in an anechoic chamber with an ambient noise level of 28 db; while those for Phase II, (TTS) which involved firing, were obtained in a sound treated mobile laboratory whose ambient noise level was 35 db.

In both phases of this experiment the NBN reflex eliciting stimulus was set at 100 db sensation level (SL). In the TS phase clicks were presented at 100 and 110 db SL clicks; while only the 110 db SL clicks were used in the TTS phase.

With three exceptions, the TS data were collected prior to the TTS data.

The gunfire exposure sound, used in Phase II, was provided by a 30 cal. machine gun and consisted of the firing of 125 rounds singly, with random time intervals of 1-3 seconds between rounds. In Phase II the pre- and post-exposure thresholds were for sweep frequencies from 250-8000 cps. Reflex activating stimuli (110 db SL clicks or 100 db noise) were initiated 150 msec before each gunshot and terminated at the time of firing. Post-exposure threshold determinations were begun within 15-30 seconds after firing of the last round. The threshold obtained in Phase I was for a 500 cps tone only (this was in order to minimize possible masking effects due to bone conduction of the sound from the reflex ear to the test ear).

Sixteen subjects ranging in age from 19 to 53 were used in the experiment. No screening for hearing deficit was performed. There were three experimental sessions in both the TS and the TTS portions of the experiment and all Ss served under all conditions. A Latin square design was utilized to insure that within the group each stimulus appeared equally often first, second, or third in order. An exception to this provision was S No. 16, who was run first in order in both Phase I and Phase II.

III. RESULTS

Results of the TS portion of the experiment may be seen in Figure 1, page 4. Notice that "adaptation" or a decrease in attenuation occurred for the NBN reflex sound over time, while no such occurrence accompanied stimulation by either of the click stimuli. Initially, TS was the same for the NBN and the 100 db SL click. Two minutes later, however, they differed by over 8 db. Wilcoxon T tests were used to determine the statistical significance of the differences noted in Figure 1. Table 1, page 5, presents the results of the tests. Table 1 shows that the 110 db click reflex eliciting sound was significantly better than either the NBN or the 100 db SL click during exposure, and did not differ significantly from them upon termination of exposure. The decrease in TS over time found with NBN reflex arousal was of statistical significance, as was the difference between the reaction to the 100 and the

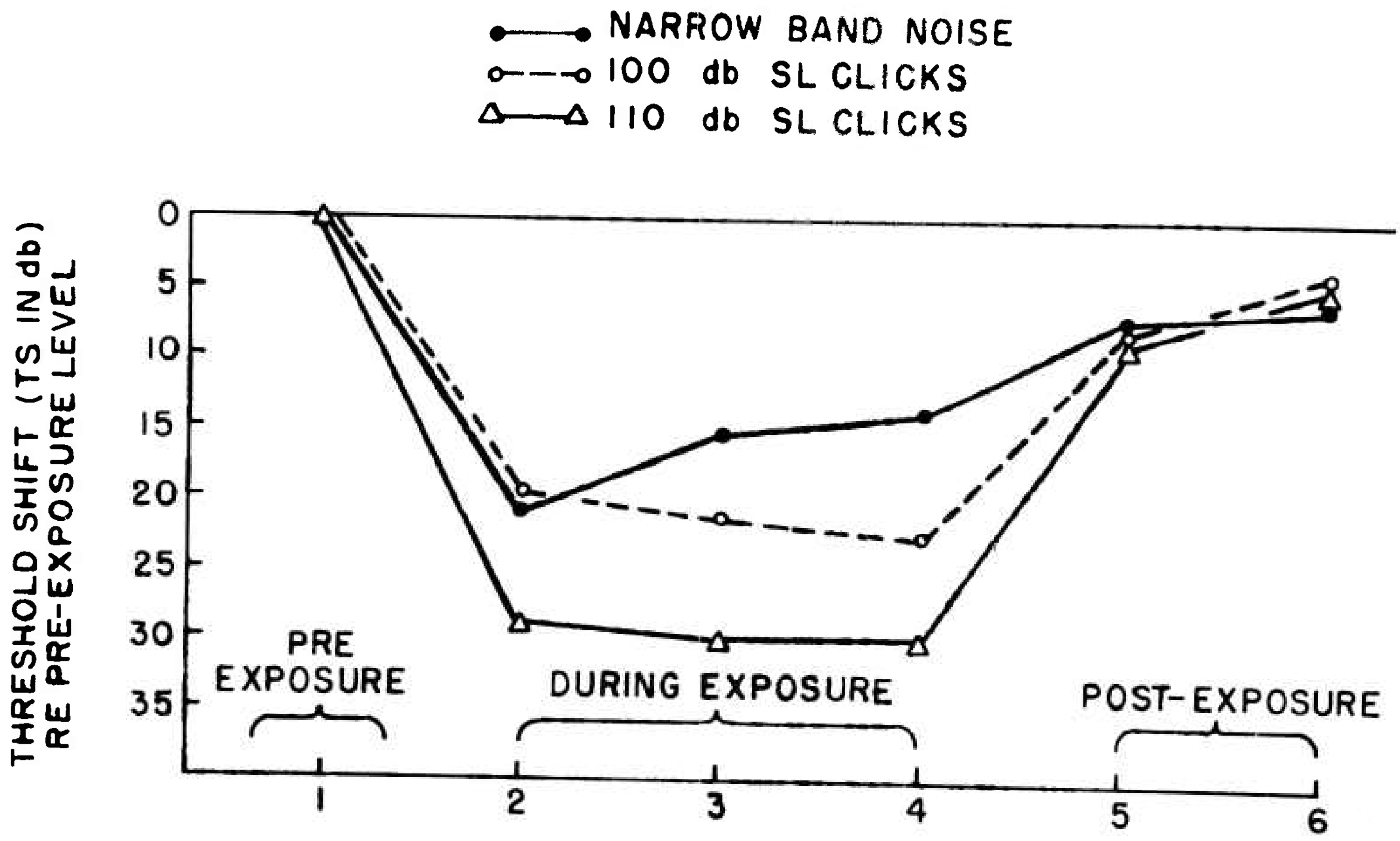

Fig. 1. Threshold shift during contralateral stimulation by click and noise.

TABLE 1

RESULTS OF THE WILCOXON T TEST FOR SIGNIFICANCE OF THE DIFFERENCES AMONG EXPERIMENTAL CONDITIONS

Stimulus	Conditions	Significance
NBN	1-6	**
NBN	1-5	**
NBN	2-4	**
NBN	4-5	**
NBN	4-6	**
100 db Click	1-6	**
100 db Click	1-5	**
100 db Click	2-4	**
100 db Click	4-5	**
100 db Click	4-6	**
110 db Click	1-6	**
110 db Click	1-5	**
110 db Click	2-4	NS
110 db Click	4-5	**
110 db Click	4-6	**
NBN - 100 db Click	2-2	NS
100 - 110 db Click	2-2	**
NBN - 110 db Click	2-2	**
NBN - 100 db Click	4-4	**
100 - 110 db Click	4-4	**
NBN - 110 db Click	4-4	**
NBN - 100 Click	5-5	NS
NBN - 110 db Click	5-5	NS
100 - 110 db Click	5-5	NS

** Significant beyond the 1% level of confidence.

110 db SL clicks. The negative adaptation (slight increase in attenuation) found during stimulation with the 100 db SL click was statistically significant but is of insufficient magnitude to be of practical importance. It is of interest to note that increasing the magnitude of the click 10 db resulted in a 10 db increase in the amount of TS produced. These results suggested that masking rather than, or in company with, reflex action could be occurring. This was checked by assuming 60 db attenuation through the skull and then having several subjects begin tracking their threshold to a 500 cps tone and adding a 50 db SL click in the same phone

used to determine threshold. This method indicated that about 10 db masking of the 500 cps tone resulted when a 50 db SL click was added. When the clicks were decreased to 40 db SL the masking was reduced to less than 5 db. Therefore we concluded that nearly all the 500 cps TS resulting from contralateral stimulation by the 100 db SL clicks is due to reflex action rather than masking. Similarly, the results from NBN are also reflex attenuation rather than masking, as the remote masking of a 500 cps tone by a narrow band noise of this nature should be negligible.

Results from Phase II, the TTS data, are shown in Figure 2. The

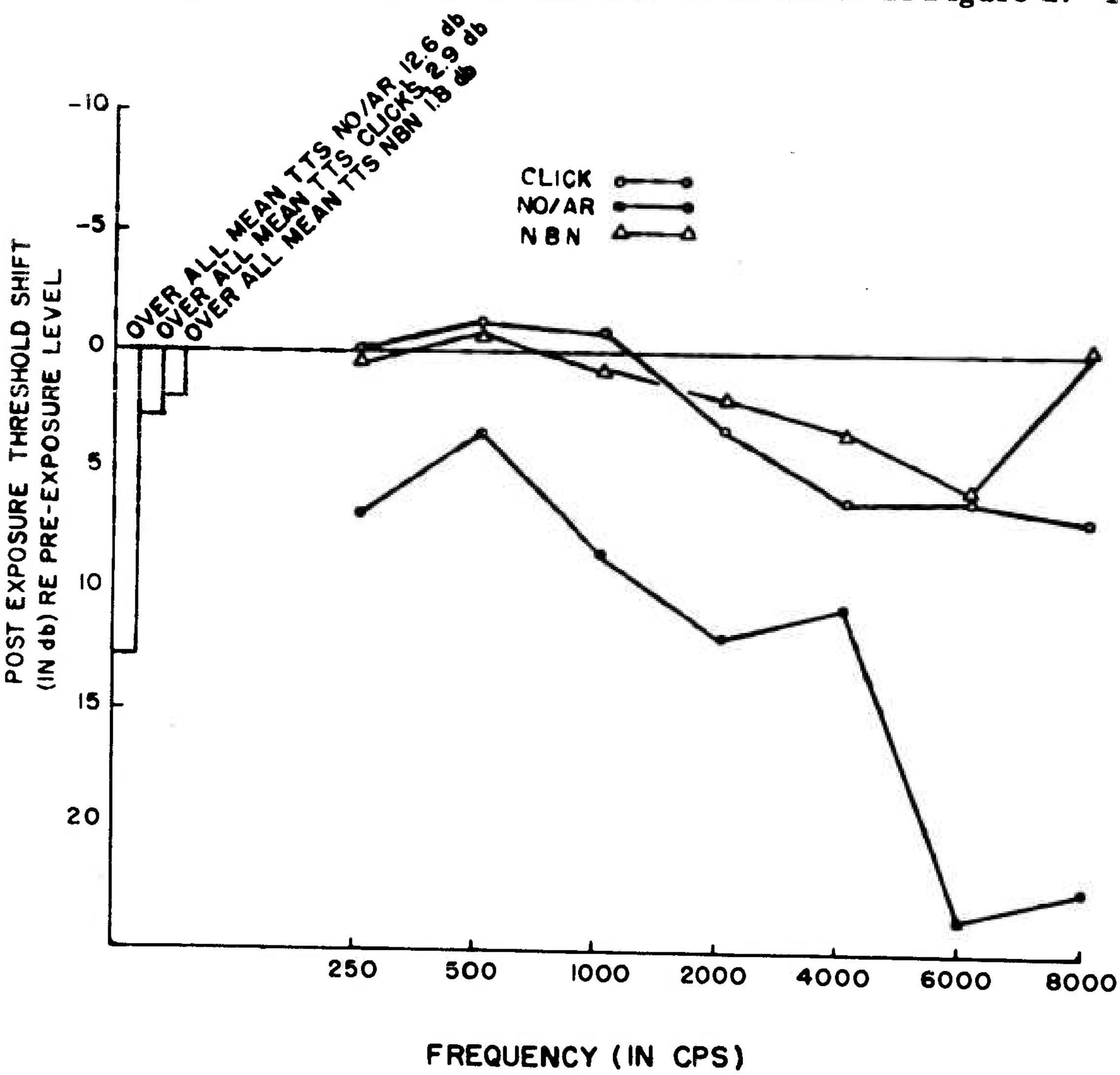

Fig. 2. TTS following firing without AR and with click and NBN AR stimuli.

"protection" (in db TTS) due to AR responses elicited by both the click and the NBN stimulus stimuli was statistically significant (see Table 2, summary of the analysis of variance). 'Protection", in this experiment,

TABLE 2

SUMMARY TABLE OF THE 3 X 7 X 16 ANALYSIS OF VARIANCE

Source	ΣSq.	df	$\bar{X}$Sq.	Error Term	F
Conditions (C)	9260	2	4630	5	13.81**
Frequencies (F)	5258	6	876.33	6	8.38**
Subjects (S)	7267	15	484.47	7	7.63**
C x F	2444	12	203.67	7	3.21**
C x S	10057	30	335.23	7	5.28**
F x S	9407	90	104.52	7	1.65**
C x F x S	11421	180	63.46	-	----

**Significant beyond the 1% level of confidence.

as in that of Fletcher and Riopelle (6), is defined as the number of db TTS difference between the TTS observed under the no AR experimental condition and that found following the same firing exposure with the AR activated by one or the other of the reflex activating stimuli.

Pearson product-moment correlations were calculated to determine the relationships, if any, obtaining between the TS and TTS data. The parametric conditions correlated were TS for the 110 db SL click and NBN and TTS for click and NBN at 1000, 2000, 6000, and 8000 cps. TS was also correlated with mean TTS and percentage TTS reduction. All such correlations were very low, and none were statistically significant.

IV. DISCUSSION

The "adaptation" effect noted in the TS portion of the experiment while stimulating with the NBN arousal sound could be of practical importance. It would certainly suggest using clicks rather than NBN in order to avoid lessening of AR action over time. It could also indicate the reflex stimulus itself is inducing auditory fatigue in the reflex ear, a situation in itself that is not desirable.

The failure to find TS and TTS correlated is somewhat disappointing but not necessarily unexplainable. Several possibilities come to mind. The range of TTS induced in this experiment was necessarily restricted.

Subjects were very carefully exposed to the gunfire in order that no one incur a permanent threshold shift. Because of individual differences in noise susceptibility, almost a third of the Ss had little or no TTS in the no AR condition, indicating they were insufficiently stimulated. Restriction of the range of the TTSs in the manner could serve to decrease the possibility of obtaining significant correlations with the TS method where the range of response was not so restricted. The restriction imposed, in effect, could magnify the relative contribution of chance variation to the total variance and in that manner reduce correlation. Another possibility is that two (or more) factors operate in determining TTS. One is amount of attenuation of ambient sound provided by AR action (indicated in our case by TS obtained in Phase I); the other is the relative sensitivity of the individual to noise induced threshold shifts. This sensitivity to noise induced threshold shift could be completely divorced from the size of the same person's TS to an AR arousal signal. Therefore, even if, in a specific case, S had a large TS, indicative of considerable AR attenuation of sound, the individual's noise susceptibility or sensitivity could be so great that the exposure sound still produced a large TTS. In this case then, random association of sensitivity to noise induced threshold shifts with AR attenuation might obscure the expected relation of TS and TTS.

The above reasoning suggests another important possibility for AR research. Perhaps we can study or possibly even predict noise sensitivity by determining AR action, then exposing S to noise and noting TTS. If TS were great and TTS great, this could indicate sensitivity to noise induced hearing loss. If TS were small and TTS small, one might predict the person has "tough" ears. Prediction would be difficult, however, in the mid-range of both TS and TTS. Certainly it would be worth while to investigate this possibility.

V. SUMMARY AND CONCLUSIONS

The purpose of the experiment was twofold: to compare the effectiveness of narrow band noise and a train of clicks in eliciting the middle ear acoustic reflex and to correlate two methods of estimating amount of reflex activation. One method involved measurement of increase in threshold in the contralateral ear; the other, measurement of reduction of TTS produced by a series of gun shots. Sixteen subjects were employed. Shifts produced by the clicks and noise were of the same order of magnitude (after correction for the direct masking effect by the clicks), but there was considerable reflex adaptation to the noise and none for the clicks. Correlations between contralateral threshold shift and reduction of TTS were small and not significant.

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1. Audition
2. Acoustic Reflex
3. Psychology

This experiment compared the effectiveness of noise and clicks in eliciting intratympanic acoustic reflex (AR) action and correlated the contralateral threshold shift (TS) and reduction of temporary threshold shift (TTS) methods of estimating amount of reflex activation. Shifts (TS) produced by the clicks and by the noise were of the same order of magnitude but considerable reflex adaptation to the noise was noted over a two-minute period while none was observed to the clicks. Correlations between the contralateral threshold shift (TS) and reduction of TTS methods were small and not statistically significant. Possible reasons for the lack of correlation were discussed.

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