The effect of masking on the acoustic reflex threshold

Nancy E. Aldrich

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Abstract

THE EFFECT OF MASKING
ON THE ACOUSTIC REFLEX THRESHOLD

by Nancy E. Aldrich

This study investigated the effect of masking noise on the threshold for stapedial reflex. It has been shown that masking which shifts the hearing threshold causes a loudness function typical of recruitment. It was hypothesized that the stapedial reflex threshold remains the same in a masked situation as in the unmasked situation. It was suggested that this demonstrates recruitment in that the presence of noise reduces the range between hearing thresholds and stapedial reflex thresholds.

Ten subjects, with no known hearing loss or pathology involving the ear or reflex arc were used in this study. A 1000 Hz tone was used as the pure tone stimulus and narrow band noise centered at 1000 Hz was used as the masking stimulus. Pure tone thresholds were obtained without masking. The amount of masking necessary to shift the pure tone threshold 30 dB was then found. Stapedial reflex thresholds were found without masking and in the presence of the masking stimulus at the intensity required to shift the hearing threshold 30 dB.
The differences in stapedial reflex thresholds obtained with masking and without masking were evaluated for significance, as were the differences in intensity above hearing threshold in each case needed to elicit the stapedial reflex. It was found that there was no significant difference in the stapedial reflex thresholds when those obtained without masking were compared with those obtained in the presence of masking. There was a significant reduction in intensity above hearing threshold at which stapedial reflex occurred when the results in the masked situation were compared with those obtained in the unmasked situation. It was concluded that the stapedial reflex threshold is not affected by the 30 dB effective masking used in this study, but that this masking stimulus can be applied to simulate a sensori-neural hearing loss and recruitment in the study of stapedial reflex thresholds.
THE EFFECT OF MASKING
ON THE ACOUSTIC REFLEX THRESHOLD
by
Nancy E. Aldrich

A Thesis in Partial Fulfillment
of the Requirements for the Degree
Master of Science in the Field of Audiology

June 1975
Each person whose signature appears below certifies that this thesis in his opinion is adequate, in scope and quality, as a thesis for the degree Master of Science.

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A special thanks goes to the members of my family and to my friends for their unfailing encouragement.
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Chapter 1

INTRODUCTION

The measurement of the acoustic reflex is becoming more important in diagnostic audiometry. The acoustic reflex is the reflexive contraction bilaterally of the intratympanic muscles, notably the stapedius, in the presence of a high intensity acoustic stimulus applied to at least one ear. It occurs in the normal ear, assuming non-pathological neural pathways involved in the reflex arc. Lack of such reflexive contraction, or abnormal thresholds for eliciting the reflex, may be indicative of hearing loss or pathological conditions relating to the auditory pathways. Together with other diagnostic audiometric tests, the test for acoustic reflex thresholds may aid in locating the site of lesion in auditory or vestibular dysfunction or in facial paralysis. It may also indicate thresholds of hearing for subjects who do not give reliable behavioral responses, such as children, the mentally retarded and the malingerer.

Observation and measurement of this reflex is possible by using the impedance bridge, and apparatus which measures the change in the impedance/admittance characteristics of the middle ear on one side while the opposite ear is stimulated with a high intensity acoustic signal. This change in impedance/admittance reflects the action of the
middle ear muscles and usually occurs in response to acoustic stimulation of 70-90 dB above the hearing threshold level.

In finding acoustic reflex thresholds, just as in any diagnostic test, test conditions should be optimum in the sense that results do not reflect other variables than the one measured. Therefore, an environmental condition which might potentially influence the results should be examined to determine presence and extent of influence. Compensatory measures can then be taken to increase the validity of the test. Such an environmental condition might be the presence of ambient noise in the testing situation.

It has been shown that a masking noise stimulus influences the psychological aspect of sound, loudness, in such a way that it causes more rapid loudness growth of a test tone than in the case where no masking is present (Lochner, 1961). One may expect that such a loudness growth might have an effect upon the reflex threshold similar to that in recruitment, where the threshold of reflex activity is reduced relative to hearing threshold level.

**Statement of the Problem**

This study investigated the following question: Is there a relationship between the presence of a masking noise and intensity above the hearing threshold at which the acoustic reflex is elicited? That is, does the reflex threshold for a pure tone, in the presence of the masking stimulus, remain the same as in the unmasked situation or shift as does the hearing
threshold in the presence of this noise?

**Purpose**

The purpose of this study was to examine the relationship of the acoustic reflex threshold to the hearing threshold without masking and in the presence of a masking noise great enough to cause a 30 dB shift in the hearing threshold. The independent variable was the masking stimulus applied to change the hearing threshold level; the dependent variable, the amount of acoustic stimulus above the hearing threshold level needed to elicit an acoustic reflex.

**Hypothesis**

Because masking causes a recruitment-like loudness function and because the reflex threshold level seems to be related to loudness rather than intensity alone, it was hypothesized that the reflex threshold in the presence of a masking stimulus would remain the same as it was without masking. Thus, it would reflect recruitment as evidenced by a reduction in acoustic stimulus relative to hearing threshold necessary to elicit an acoustic reflex.

**Importance of the Study**

Such an effect of masking under investigation in this study may lead to an awareness of need for controlling masking stimuli present in the audiometric testing environment, primarily that of competing acoustic stimuli, such as ambient noise, in the measurement of acoustic reflex by impedance audiometry.
In addition, further information is added to the concepts of recruitment and hearing loss of cochlear etiology, since masking produces loudness growth similar to that of recruitment (Hellman and Zwislocki, 1964).

**Definition of Key Terms**

- **Admittance**: The measure of energy flow or ease of energy flow into or through a system; the reciprocal of impedance. (Newman, 1973).

- **Contralateral**: Referring to the opposite side.

- **Hearing Threshold (Threshold of Audibility)**: "Minimal value of sound-pressure which produces a tonal sensation." (Stevens, 1938).

- **Impedance**: "The difficulty with which energy can be made to flow through or into a system;" the reciprocal of admittance. (Newman, 1973).

- **Masking**: "Amount by which the threshold of audibility of a sound is raised by the presence of another (masking) sound." (Hirsh, 1952).

- **Recruitment**: The abnormal growth in loudness relative to increase in intensity of the acoustic stimulus. (Hirsh, 1952).

- **Sensori-neural hearing loss**: Hearing loss resulting from
pathology of the inner ear, the receptor hair cells or the auditory nerve carrying impulses to the brain. (Newby, 1972).
Chapter 2

REVIEW OF THE LITERATURE

This study is concerned with the stapedial reflex threshold and its relationship to loudness growth, particularly as it is affected by a masking stimulus. For this reason it is necessary to review these concepts:

1) The stapedial reflex as a bilateral reaction to monaural high intensity acoustic stimulation and a measurable indicator of auditory function.

2) Loudness, the psychological aspect of the intensity of a sound and having a characteristic function with intensity which differs in normal and pathological ears due to cochlear lesions.

3) Masking, another stimulus, in this study narrow band noise, capable of shifting the threshold of sensation of a sound and producing a loudness function curve typical of that seen in pathological ears.

Stapedial Reflex

The stapedial muscle is one of the two intratympanic muscles attached to the ossicles, the other being the tensor tympani. Although both muscles have been classed together in the intra-aural muscle reflex, studies of relative impedance measurements in patients with paralysis of the stapedial muscle and those with paralysis of the tensor tympani indicate
that it is the stapedius that is active and responsible for impedance change on acoustic stimulation. No impedance change could be demonstrated in the ear contralateral to acoustic stimulation in the cases of facial nerve paralysis (Jepsen, 1955), whereas normal impedance change occurred with trigeminal paralysis (Lindstrom and Liden, 1964). It is the contraction of the stapedius, therefore, that is of primary concern in this study.

This muscle, developing embryologically from the second branchial or hyoid arch, is supplied by the facial nerve and occupies a small cavity in the pyramidal eminence. Its tendon projects downward and medially in the middle ear cavity to join the posterior portion of the head of the stapes near its articulation with the lenticular process of the incus. The pennate nature of the muscle allows great tension with minimum displacement.

The reflex arc resulting in acoustically elicited stapedial muscle contraction consists of the sensory receptive area, afferent enervation to cranial nerve nuclei in the brain stem where synapses occur, and efferent nerve supply to the stapedial muscle itself. The cochlea and the cochlear portion of the VIIIth nerve comprise the receptor and afferent pathway respectively. The nerve continues to the dorsal and ventral cochlear nuclei in the pons and on to the superior olivary nucleus which is connected through the medial longitudinal fasciculus with various cranial nerve nuclei. Among these is the facial nuclei which supplies the stapedial
muscle through the facial nerve. (Jepsen, 1963). The neural conduction proceeds from afferent nerves to both homolateral and contralateral nuclei, thus allowing a bilateral muscle contraction. (Metz, 1951).

Because the contraction of the intratympanic muscles, particularly the stapedius, causes changes in the structure and in the acoustic transmission characteristics of the middle ear, observations can be made as to the presence and relative degree of contraction as it varies with intensity of acoustic stimulation. This can be done either by direct observation of the tympanic muscles in the case of perforation of the tympanic membrane or by utilizing an impedance bridge.

Djupesland (1963) describes some of his observations both directly through tympanic membrane perforations or during surgeries, and indirectly, observing changes of impedance measurements of the middle ear. He found spontaneous and conditioned muscle responses as well as electrically and cutaneously elicited ones and found that vocalization, change of facial expression, head movements and contraction of the periorbital muscles also cause intratympanic muscle responses. Auditory stimulation usually affects the stapedius alone at 65-115 dBHL, but with the added factors of unpleasantness and unexpectedness, eye blinking occurred with tensor tympani involvement including this muscle in the cochleo-palpebral reflex.

Since the contraction of the intratympanic muscles
brings a change in the tympanic membrane and thus in the impedance of the ear, Metz (1952) devised a method of measuring this impedance to determine threshold values of the acoustic reflex. Using this bridge, he compared or balanced the impedance of the ear to a variable acoustic impedance standard. With the system balanced the reflexive contraction of middle ear muscles again unbalanced the system, resulting in the presence of the tone which, therefore, indicated the reflex contraction. Reflex threshold was plotted at the same frequencies tested in pure tone hearing thresholds, plotting corresponding to the ear to which the bridge had been applied. Thus, a given reflex threshold for one ear showed the intact motor function of that ear and the proprioceptive function of the contralateral ear. Normal reflex thresholds proved to be from 70-90 dB above hearing thresholds. Middle ear pathology may affect the reflexes from decreasing the normal function (that is, increasing the stimulus necessary to elicit the reflex) to complete absence of activity measurable as in the case of otosclerosis. In the case of hearing loss due to sensori-neural impairment, however, (except in retrocochlear lesions where the reflex is absent) assuming the conductive component of the ear is intact, reflex activity may be present at reduced intensities relative to the amount above threshold of hearing where reflexes should be expected. Metz explained this as recruitment of loudness, and he felt that comparison of reflex thresholds with hearing
thresholds was a more objective way of determining the recruitment phenomenon than loudness balance tests.

Loudness

Loudness may be defined as the psychological dimension of a sound, a correlate of the physical dimension, intensity. The former is determined by discriminatory responses of the human observer; the latter, by measurements of energy or pressure. (Stevens and Davis, 1938). It is obvious to the observer that the loudness of an audible sound grows with intensity. Of concern to studies such as this is the relationship of the increase of intensity to the increase in perceived loudness. Various procedures have been employed to determine this relationship. Among them are, for example: 1) the estimation method, in which the observer assigns a numerical relation to two given loudnesses, 2) the fractionation method, in which the observer varies the loudness of one tone to set it at a fraction of another given tone, and 3) other methods which require the observer to indicate the midpoint of loudness of tones, to balance one tone with two combined tones, or to equate the loudness of a tone in one ear to the tone given in both ears. (Wever, 1949).

On the basis of the data derived from the above psychophysical methods to determine loudness relationships with intensity, loudness scales have been constructed by plotting loudness units such as sones, (1 sone = loudness of a 1000 Hz tone at 40 dB) or numerical assigned values,
Against the intensity unit, the decibel. Such a loudness scale indicates that when loudness and intensity of a sound are represented on logarithmic scales the normal loudness function is such that loudness increases very rapidly at low intensities decelerating at high intensities. (Hirsh, 1952).

From this data formulae have been extrapolated to predict change in loudness. Lochner and Burger (1961) reviewed one such formula of Stevens (1959) which accounts for loudness growth above 40 dB re 0.0002 d/cm²: \( L = K I^n \), where \( I \) is sound pressure or intensity, the exponent \( n = 0.6 \) for pressure and 0.3 for intensity, and \( K \) depends on the units chosen. They also cite Hellman and Zwislocki (1961) who state the curve for loudness function in the region between 30-100 dB follows a power function with an exponent of 0.54 for pressure, and that below 30 dB the curve is yet steeper. This steeper curve is attributed by Lockner to masking by physiological noise and he hypothesizes the loudness function as \( L = K (I^n - I_0^n) \), where \( I \) is pure tone intensity and \( I_0 \), the intensity at threshold, with \( n = \) about 0.27. This, he says, also describes the function of loudness with external masking noise applied. He concludes that the general form of the loudness function can be given by the formula \( L = K [I^n - (I_p + I_e)^n] \), \( I \) being the pure tone intensity; \( I_p \), effective intensity of physiological background noise and \( I_e \), intensity of external noise in the critical band. This accounts for summation of physiological noise with the intensity.
of the external noise in the critical band.

The loudness functions heretofore described have been those based on the auditory perception of normal subjects. In the hearing loss of cochlear etiology loudness function above the threshold of hearing is not the same as in the normal ear. In such an ear, as the Sensation Level of the tone increases in equal decibel steps the loudness of the tone increases more rapidly than in the normal ear at like Sensation Levels. Fowler in 1929 described this by using the term recruitment. (Hirsh, 1952).

Fowler (1950) reviewed the phenomenon of loudness recruitment typical of sensorineural hearing losses, those in which cochlear pathology is responsible for hearing loss. Typically, to such an affected ear smaller increments of intensity represent greater changes in loudness when compared with the normal ear in which there is a rather orderly logarithmic increase in loudness, until the same intensity in the affected and non-affected ear appears to be of the same degree of loudness. Fowler explained the perception of loudness in a physiological sense as being in proportion to the percent of capacity to which the neural mechanism is saturated with sound, not just the amount of stimulus applied. Therefore, the greater the percent to which the neural mechanism is occupied—even without the functioning of some of its elements—the greater the loudness. He pointed out other factors which produce and accentuate recruitment
of tones--those of fatigue and noise such as environmental noise.

Tests used clinically to point up recruitment are direct tests, such as loudness balance tests or indirect, such as difference limen tests. The monaural loudness balance test assumes near-normal thresholds for hearing in at least one frequency. The loudness at various levels at this frequency is matched with that of the affected frequency. The binaural loudness balance test assumes near-normal thresholds in one ear to balance loudness levels with the affected ear using the same frequency. Recruitment is evidenced by smaller intensity increments in the affected ear or frequency, as compared with those in the unaffected one, necessary to produce a given change in loudness. Difference limen tests assume that the more rapid increase of loudness in the affected ear allows a smaller than normal amount of intensity to be discerned as a noticeable difference in loudness and therefore is indicative of recruitment. (Hirsh, 1952).

All of these tests are, by nature, subjective and for this reason Metz (1952) proposed that a more reliable and accurate way of assessing recruitment was that of comparing pure tone thresholds with acoustic reflex thresholds. With reflex normally elicited at intensities from about 70-90 dB above the threshold of hearing, lower relative intensities eliciting the reflex would be indicative of recruitment. He
found that in unilateral deafness results of loudness balance procedures and stapedial reflex thresholds relative to pure tone thresholds corresponded highly in pointing up recruitment in the case of sensori-neural impairments while results were negative in acoustic neurinomas as would be expected.

Thomsen (1953) stated that in cases of hearing loss accompanied by recruitment the threshold for eliciting the stapedial reflex is in most cases identical to that found in normal ears, and that a stapedial reflex evoked by a stimulus less than 70 dB above the hearing threshold obtained represents recruitment.

Masking

When a sound causes another sound coexisting with it to become less audible or inaudible, the second sound is said to be masked by the first. Stevens and Davis (1938) discuss masking and its relationship to loudness. Masking is defined as the change of threshold of the one tone in the presence of the masking tone and is expressed in the number of decibels change. The fact that the threshold is raised suggests that some of the neural receptors on the basilar membrane are being excited by the masking stimulus. The amount by which the threshold for the tone is raised indicates the degree to which the masking stimulus is causing neural excitation. As it seems that the ear with cochlear-type hearing loss, with its characteristic recruitment loudness curve, occurs as a result
of a deficiency of neural elements, a hearing loss due to the presence of a masking sound should exhibit the same characteristic curve for loudness. The available supply of neural elements ordinarily contributing to the loudness of the tone would be reduced by being already activated by the masking sound, just as in the cochlear hearing loss where these neural elements would be reduced by actual damage. Experimentation along these lines tended to support these assumptions. Binaural loudness balance tests indicated that when the threshold was shifted in one ear by about 40 dB using masking, at higher intensities loudness was about equal in both masked and unmasked ears at equal intensities. Thus, the presence of masking yielded recruitment-like results, typical of the sensori-neural hearing loss. Hellman and Zwislocki (1964) in their study on loudness function of a 1000 Hz tone in the presence of a masking noise also concluded that the effect of masking on loudness function was essentially the same as the effect of a sensori-neural hearing loss, exhibiting loudness recruitment.

Summary

It follows that if masking which produces a threshold shift to simulate a hearing loss results in recruitment of loudness, as shown by loudness function typical of sensori-neural hearing impairments, this same phenomenon should be demonstrable by the method of comparing stapedial reflex thresholds with pure tone hearing thresholds. That is, the
reflex thresholds obtained without masking should remain unchanged when masking noise is applied. There would be, therefore, a reduction of the sensation level necessary to elicit an acoustic reflex.
Chapter 3

METHOD

Description of Sample

This study included ten subjects, two male and eight female, with ages ranging from 23 to 41 years of age, having no known pathological condition involving the ear or neural pathways involved in the acoustic reflex arc. Normal hearing criteria for this study were taken to be thresholds of 10 dB re audiometric zero or better for the frequencies 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz in the test ear and normal compliance values as indicated by tympanometry in the indicator ear. The ear to which the reflex producing stimulus was applied was designated the test ear; the ear to which the probe was applied, the indicator ear. Age and sex of the subjects were not considered to be of significance in this study as independent or moderator variables, so no attempt was made for uniform representation of such set groups.

Materials

Testing was done in the control room of an IAC Model #404 ACT sound treated audiological suite. A Maico MA 24 two-channel audiometer was used as the source of acoustic stimulus for the test ear. This provided a pure tone from the right channel and narrow band noise from the left channel which could be presented simultaneously by way of a mixer included
in the system. The signals were presented through a TDH-39 earphone to the test ear. Narrow band noise was calibrated in sound pressure level re 0.0002 d/cm²; pure tone signals, in reference to audiometric zero at each respective frequency (ANSI, 1969). Narrow band noise used in this study was centered at 1000 Hz.

A Grason-Stadler Model 1720 Otoadmittance Meter was used to determine changes in impedance/admittance of the middle ear, both in tympanometry screening of the indicator ear and in measuring stapedial reflex thresholds.

Procedure

The subjects were given a brief otoscopic examination to determine the presence of cerumen or other gross abnormalities of the external auditory meatus which might obstruct sound transmission. The earphone was placed on the test ear; the probe, in the indicator ear. The side designated as the test ear was randomized from subject to subject. With the probe tone off in the indicator ear, tones of 10 dBHL were presented to the test ear at the frequencies 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz to screen for normal hearing. The threshold value for 1000 Hz was found by bracketing the threshold using 5 dB steps. At this point the 660 Hz probe tone of the otoadmittance meter was turned on and tympanometry tracings were done for the indicator ear to screen for normal middle ear function in that side. The susceptance (B) and conductance (G) settings on the meter were used, indicating changes
in these constituents of admittance.

The probe tone was again turned off and the 1000 Hz pure tone stimulus set at 30 dB above the hearing threshold value found previously. The narrow band noise was presented by way of the mixer to the test ear and varied in intensity until a level was found at which the 1000 Hz tone could be just heard.

Finally, the probe tone was again turned on and stapedial reflex thresholds were obtained without masking and with the simultaneous presentation of narrow band noise at the intensity found previously necessary to cause a shift in threshold by 30 dB. The order of performance of these two procedures was randomized. The 660 Hz probe tone was used, with the susceptance setting (B) on the meter. The acoustic reflex sensitivity was used in monitoring the reflex. A pure tone stimulus was presented to the test ear at 5 dB increments until an intensity was reached which caused an obvious change in susceptance with presentation of the stimulus. The intensity was reduced by 5 dB and presentations of the tone were made using 1 dB increments until an intensity was reached which caused noticeable and repeatable deflections of the needle which monitored susceptance changes of the middle ear. The point where this first occurred was considered threshold for the stapedial reflex in that ear. Narrow band noise was introduced to the test ear at the intensity found to shift the hearing threshold by 30 dB. Stapedial
reflex thresholds were found by presenting the pure tone stimulus in the presence of this noise in increasing intensities using the same method as in the case where no masking was present and with the same criterion determining threshold.
Chapter 4

RESULTS

It was hypothesized that: 1) the stapedial reflex threshold values would remain unchanged when masking noise was applied, and 2) that the increase of intensity above hearing threshold necessary to elicit the reflex would be reduced. It was these values which were considered in the analysis of the data.

Stapedial reflex thresholds obtained in the unmasked situation ranged from 83 dBHL to 95 dBHL. The median was 87.5 dBHL. The mean was 87.5 dBHL, with a standard deviation of 4.0. Reflex thresholds obtained in the presence of the masking noise ranged from 81 dBHL to 95 dBHL. The median was 86 dBHL. The mean was 87 dBHL, with a standard deviation of 3.8. The differences in values of reflex thresholds obtained without masking and those obtained with masking ranged from -3 dB to +1 dB. The median was 0 dB. The mean was -0.4 dB, with a standard deviation of 1.4.

The intensity above hearing threshold necessary to elicit the stapedial reflex without masking ranged from 80 dB to 100 dB. The median was 92 dB. The mean was 92.5 dB with a standard deviation of 6.0. The amount of intensity above the masked threshold needed to elicit the stapedial reflex ranged from 50 dB to 70 dB. The median was 60 dB. The mean
was 60 dB, with a standard deviation of 6.1. The differences in amount of intensity above hearing threshold necessary to elicit the reflex in the unmasked and the masked situation ranged from 29 dB to 50 dB. The median was 30 dB. The mean was 32.3 dB, with a standard deviation of 6.3.

To analyze the significance of the difference values in question for support of the hypothesis, the Walsh Test (Siegal, 1956) was chosen. This is a non-parametric test which assumes symmetrical populations; that is, the mean representing the central tendency should be equal to the median. As can be seen by the data previously presented, these qualifications are met in determining the significance of difference in analysis of both parts of the hypothesis and this can be considered an appropriate method of analysis for the data. In each case the one-tailed test was chosen. In analysis of the difference in stapedial reflex thresholds it was predicted that there was no significant difference between reflex thresholds obtained without masking and those obtained in the presence of the masking stimulus. This prediction was well supported since the data shows no significant difference at the .05 level. In analysis of the difference in intensity above hearing threshold needed to elicit reflexes, it was predicted that there was a significant difference between these intensities in the situation where no masking was present and in the masked situation. Again, this prediction was well supported in that there was found
to be a significant difference at the level where \( p < 0.005 \).
The data provided in the course of this study support the hypothesis that a masking stimulus, at an intensity to cause a shift in the pure tone hearing threshold to a degree simulating a mild hearing loss, has no significant effect on the intensity of the pure tone stimulus at which there is the first noticeable stapedial reflex. It does, however, reduce the relative intensity above threshold of hearing needed to elicit this reflex, which will be referred to as the dynamic range. These conditions, of reduced dynamic range with normal stapedial reflex thresholds present when masking stimulus was applied, represent the recruitment phenomenon of the hearing loss due to sensori-neural impairment at the level of the cochlea. The qualifications of the Metz test for recruitment are met since hearing threshold is raised and the stapedial reflex threshold remains the same, resulting in a reduced dynamic range. Assuming the stapedial reflex threshold is dependent on loudness rather than intensity alone, it follows that recruitment is complete at or below the stapedial reflex threshold level for the reason that if loudness were increasing more rapidly in the masked ear at this intensity level one could expect reduced thresholds for the stapedial reflex in the masked ear.
The shift of pure tone hearing thresholds by masking seems to simulate the recruiting ear, at least as far as reflex thresholds relative to hearing thresholds are concerned. This implies that the normal ear, with masking applied, can be used to investigate the implications of the sensori-neural hearing loss and its functioning relative to stapedial reflex thresholds. Varying degrees and types of masking may be applied to simulate different degrees and frequency patterns of hearing loss. One caution is advanced which results from preliminary experimentation for this study using broad band noise to shift the hearing threshold 40 dBSL. Such high intensity levels necessary to shift the threshold may cause stapedial muscle tonus by the masking stimulus alone, causing compliance changes equal to those observable in the stapedial reflex thresholds. This may influence stapedial reflex thresholds as judged by a given amount of compliance change.

Stated in the introduction was the implication that ambient noise in the testing environment might change stapedial reflex thresholds. During electromyographic studies of the human stapedius muscle (Fisch, 1963) it was found that resting muscle tonus was present at the noise level of the operating room. It was also determined that threshold for stapedial reflex for a masking noise was about 70 dB, and was suggested that this level is frequently met in normal environmental conditions. However, from the present study, since there was no significant change in reflex
thresholds from a quiet situation to one with noise, one may draw one of two conclusions: 1) either stapedial muscle tonus present with noise was not significant at the level of the noise employed in the study, or 2) if this tonus was present it did not affect stapedial reflex threshold values at this level of noise.

Conclusions

The statistical analysis of the data provided in this study lead to the following conclusions:

1) The stapedial reflex threshold is not affected by 30 dB effective masking applied to simulate a mild sensori-neural hearing loss.

2) The application of 30 dB effective masking can simulate a sensori-neural hearing loss and recruitment in that the dynamic range is reduced.

Implications

On the basis of these conclusions the following implications are suggested:

1) The stapedial reflex threshold is above the level at which recruitment is complete in a mild sensori-neural hearing loss.

2) The normal ear with masking applied can be used to study the sensori-neural hearing loss relative to stapedial reflex thresholds.

3) The study does not support the premise that
ambient noise affects the thresholds of stapedial reflex activity.

Further Study Needed

This study suggests the necessity for further research as relating to masking and its effect on the stapedial reflex threshold. Possible variables of importance in such research are the following:

1) Frequency of the test tone for determining hearing threshold and stapedial reflex threshold.

2) Intensity of the masking stimulus employed, with the resulting increase in hearing threshold shift.

3) Type of noise or other acoustic stimulus employed as the masking stimulus.
BIBLIOGRAPHY


# APPENDIX

Hearing Thresholds, Stapedial Reflex Thresholds, and Dynamic Range of a 1000 Hz Tone in the presence and absence of masking for Ten Subjects

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<tr>
<td>1. M, 26</td>
<td>-5 dBHL</td>
<td>25 dBHL</td>
<td>90 dBHL</td>
</tr>
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<td>2. F, 23</td>
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<td>20 dBHL</td>
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<td>3. F, 30</td>
<td>0 dBHL</td>
<td>30 dBHL</td>
<td>89 dBHL</td>
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<td>4. F, 26</td>
<td>0 dBHL</td>
<td>30 dBHL</td>
<td>80 dBHL</td>
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<td>87 dBHL</td>
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<td>6. F, 32</td>
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<td>83 dBHL</td>
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<td>7. F, 26</td>
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<td>86 dBHL</td>
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<td>9. M, 41</td>
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<td>95 dBHL</td>
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<tr>
<td>10. F, 28</td>
<td>10 dBHL</td>
<td>40 dBHL</td>
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